UNITED STATES COMMISSION OF FISH AND FISHERIES.

Commissioner's Office.

PART VIII.

REPORT

OF

THE COMMISSIONER

FOR

1880.

A.—INQUIRY INTO THE DECREASE OF FOOD-FISHES.
B.—THE PROPAGATION OF FOOD-FISHES IN THE WATERS OF THE UNITED STATES.

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National Oceanic and Atmospheric Administration

Report of the United States Commissioner of Fisheries

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LETTER

FROM THE

COMMISSIONER OF FISH AND FISHERIES,

TRANSMITTING,

In compliance with law, his report for the year 1880.

JANUARY 14, 1881.—Ordered to lie on the table and be printed.

UNITED STATES COMMISSION OF FISH AND FISHERIES,
Washington, D. C., January 10, 1881.

GENTLEMEN: In compliance with the law of Congress I have the honor to transmit herewith my report for the year 1880, as United States Commissioner of Fish and Fisheries, detailing, first, the result of inquiries into the condition of the fisheries of the sea-coast and lakes of the country; and, second, the history of the measures taken for the introduction into its waters of useful food-fishes.

Very respectfully, your obedient servant,

SPENCER F. BAIRD,
Commissioner.

Hon. WM. A. WHEELER,
President of the United States Senate, and
Hon. S. J. RANDALL,
Speaker of the House of Representatives.

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REPORT OF THE COMMISSIONER.

A.—GENERAL CONSIDERATIONS.

1.—INTRODUCTORY REMARKS.

The present report is intended to give an account of the work of the United States Fish Commission during the year 1880; closing, as it does, the first decade of its existence. Originally organized by Congress simply for the purpose of making investigations into the condition of the fisheries of the sea-coast and lakes, the subject of the actual increase of the food-fishes of the country by means of artificial propagation was added in the second year of its existence, thus establishing a twofold function.

In each department the labor has increased year by year in proportion to the increasing favor shown by Congress, until, at the end of the decade in question, its work has become of pre-eminent magnitude among similar organizations throughout the world, the results, it is hoped, being in equal proportion. What the future may have in store for the Commission of course cannot be anticipated at present. Should its scope and importance increase within the next ten years as it has in the past, it will constitute a very important element of the operations of the Government looking towards the amelioration of the condition of the country at large.

The most noteworthy features of the year may be indicated as follows:

1. The production of the German carp in large numbers, and their distribution to the various parts of the country.

2. The production of shad on an increasing scale, and their dissemination in numerous localities where they were previously unknown.

3. The construction of a special steamer (the Fish Hawk) to serve as a floating hatching-house for the production of shad, herring, striped bass, etc., and which is capable of being moved to any place where the breeding fish can be found in sufficient quantity.

4. The introduction to the notice of the American fishermen, and the use on a large scale, of the gill-net with glass-ball floats, for the purpose of capturing codfish on their winter spawning-ground.

5. The co-operation with the United States Census Bureau in obtaining the history and statistics of the North American fisheries.

6. The preparation of the American exhibit for participation in the International Fisheries Exhibition at Berlin.

7. The use of the Fish Hawk in exploring the Gulf Stream and its fauna, especially in connection with the distribution of the tile-fish.

8. The extended exploration of the fisheries of the Atlantic coast of the United States, of the great lakes, of the Gulf of California, and of the entire coast of Western America, from San Diego to Point Barrow in the Arctic Ocean.

9. The collecting of complete series of the fishes of the sea-coast and the lakes for the National Museum, including large numbers of duplicates, especially on the shores of the Pacific, for distribution to public museums and educational establishments in the United States and elsewhere.

All of these subjects will be considered more at length hereafter under their proper headings.

The death of Mr. James W. Milner, which occurred on January 6, 1880, deprived the Commission of one of its most efficient assistants. Mr. Milner had been associated with the work of the Commission on the Great Lakes, on the Potomac river, and at Gloucester almost from its inception. After suffering from ill-health for several months, during which he sought for relief in various climates, he finally succumbed, and terminated his short but very useful career.

2.—PRINCIPAL STATIONS OF THE UNITED STATES FISH COMMISSION.

A brief statement of the principal localities at which the work of the United States Fish Commission was prosecuted during the year may serve as a suitable introduction to the more extended statement of the history of operations in general.

The division of research and investigation is naturally conducted most extensively at the summer station which the Commission selects for its field work; and Newport, as the point in question, constituted a center at which a large amount of labor was carried on.

Reference has already been made to the work done along the entire coast of the United States on both oceans, of the great lakes, and of the Gulf of Mexico, in connection with the fishery census of 1880. On these lines, as well as at Newport, the investigation into the natural history and statistics of the fisheries, the methods of their prosecution, and the general natural history of such animals and plants as are related directly or indirectly to the wants or luxuries of man, were carried on to a greater or less degree.

The stations connected with the propagation of the food-fishes were, as usual, quite numerous, and witnessed a great deal of labor on the part of the employés of the Commission. Of these the most important are as follows:

1. The hatchery on McCloud River, in California, of the California salmon.

2. The ponds for breeding the California trout, situated about five miles above the McCloud River salmon station.

3. The station at Northville, Mich., for hatching the white-fish taken in Lake Huron, Detroit River, and Lake Erie.

4. The Bucksport station, on the Penobscot River, for procuring and hatching the eggs of the Penobscot or Atlantic salmon.

5. The station at Grand Lake Stream for the land-locked salmon.

6. The station at Druid Hill Park for hatching eggs of the *Salmonidæ* and for the propagation of carp.

7. The station on Monument Lot, in Washington, for carp.

8. The station at the Arsenal, in Washington, also for carp.

In addition to these, which may be called permanent stations, there was also a station at the navy-yard, in Washington, for hatching out eggs of the shad obtained from the Potomac River.

There was also a similar station for taking and hatching shad-eggs at Havre de Grace, on the Susquehanna River.

Fuller details in regard to all these subjects will be found in subsequent pages of the present report.

3.—ASSISTANCE RENDERED TO THE COMMISSION.

The act of Congress establishing the Commission directs the Executive Departments of the government to render all necessary and practicable aid in carrying out its mission; and, as in previous years, it is my very agreeable duty to report the cordial manner in which this has been done.

Navy Department.—To the Navy Department, as before, the obligations are very great. It was not necessary this season to call upon the Department for a steamer such as was furnished during previous seasons in the Blue Light and the Speedwell, the Fish Hawk being sufficient for all necessary purposes. The Department did, however, in accordance with the law of Congress, supply the officers and crew of the Fish Hawk, as also two navy launches, for use specially at Havre de Grace and on the Potomac River. A number of flags were also issued to the Commission, to be used for the fitting up of the Fishery Exhibition at Berlin.

War Department.—To the Signal Office of the War Department the Commission is indebted for the supply of a large number of water thermometers to the light-houses and light-ships along the coast for the purpose of making observations upon the temperature of the water and its relationship to the movements of the fish. Copies of observations made by the regular observers of the Signal Service were also furnished as heretofore.

By order of General McDowell, a detail of soldiers was also supplied at the McCloud station for its protection against Indians and lawless whites.

Treasury Department.—The supervising surgeon of the Treasury Department, at the request of the Commission, instructed Dr. Guiteras to visit Key West and carry on some investigations into the cause of the great mortality among the fishes of the Gulf of Mexico. No report, however, has as yet been received upon this subject. Very effective aid in many ways was rendered by the Light-House Board.

Railroads.—The railroads of the country have continued to render a very important help in facilities extended to the messengers of the Commission in carrying fish throughout the country. As heretofore, all, called upon for the service, have issued orders to conductors and other employés to allow the messengers of the Commission to carry their fish-cans in baggage cars, with free access to them; also instructing them to allow the messengers to check empty cans as baggage to destination. To the Baltimore and Ohio, the Pennsylvania, and the Philadelphia, Wilmington and Baltimore special acknowledgments are due for carrying, free of expense, a large number of packages containing the exhibit for the Berlin Exposition.

The railroads, also, between Boston and Bangor carried a car-load of shad and its accompanying messengers free of expense.

Steamship lines.—To the foreign steamship companies the Commission is indebted for important service, especially to the North German Lloyds, which transported the entire fishery exhibit for Berlin from New York and from Baltimore to Bremen and back without any charge, the bulk amounting to nearly 12,000 cubic feet. It also, on several occasions, transported packages of eggs of fish intended for Germany and had them placed under the special care of the captain and steward.

A similar courtesy in the matter of transportation of fish-eggs was rendered by the French Transatlantic Steamship Company, by direction of its agent, Mr. Louis de Bebian.

District Commission.—Valuable help was received on various occasions from the engineer department of the District Commission, especially in connection with the laying out and construction of the carp ponds, of which Lieutenant Hoxie kindly accepted the direction.

4.—COURTESIES RENDERED BY THE COMMISSION TO FOREIGN COUNTRIES.

The applications from foreign countries for fish have continued to increase, and have always been met as far as possible. The exchange of courtesies between nations, looking towards their mutal benefit, is greatly to be encouraged; and although, so far as fish are concerned, the United States has perhaps more to give than to receive, it is none the less incumbent upon her to do what may be possible towards improving the food resources of other portions of the world.

Germany.—It is with Germany that the relationships in question have been most extended and are practically most mutual, she giving as well as receiving. In response to Herr Schuster, burgomaster at Freiberg, a number of eggs of the California salmon were forwarded from New York in apparatus of transportation specially furnished by him. A large number of eggs of the same species were also sent to Herr von Behr, president of the *Deutsche Fischerei-Verein*, and reached their destination in excellent condition. Of this lot about half were presented by him, in the name of the Fish Commission, to the Hungarian Government.

Two hundred and fifty thousand eggs of white-fish were also sent to Herr von Behr, per steamer Donau, on the 25th of December.

France.—In France the *Société d'Acclimatation* received a number of eggs of both land-locked salmon and California salmon. About 2,000 of the former hatched out, and were to be placed in Lake Chauvette, a very deep, clear, and cold lake in Auvergne. The California salmon, after being hatched out, were divided among six different rivers of France.

England.—England has, so far, shown very little interest in the American food-fishes, and, indeed, may be said to be much behind the greater part of continental Europe in relation to fish culture generally. A London company, however, made application for and received a number of eggs of the California salmon, which were sent to Mr. Capel, of the Cray Fishery, in Kent, to be hatched out.

Netherlands.—In response to an application from the Netherlands a number of eggs of the California salmon were forwarded and successfully hatched out.

Guatemala.—Correspondence was carried on with Dr. Fenner in reference to the introduction of useful food-fishes into Guatemala. None, however, were actually transmitted.

Ecuador and Guadeloupe.—A similar correspondence was entertained, in regard to Ecuador, with Mr. Frederick Wesson, of New York, and with Guadeloupe through Mr. Charles Bartlett, United States consul. An application from this island for eggs of the brook-trout was turned over to Mr. Livingston Stone to be filled.

Canada.—To Canada, as in previous years, many eggs of the California salmon were forwarded, as also a number of carp.

The minuter details of distribution of the special kinds of fish sent to foreign countries will be found in the proper portion of the present report. The transmissions to Europe have been greatly facilitated by the very liberal conduct of the French and German steamship companies in carrying the eggs free of charge and with the utmost possible care.

B.—BERLIN FISHERY EXHIBITION.

5.—ITS ORIGIN AND SCOPE.

In the year 1878 the *Deutsche Fischerei-Verein*, of Berlin, an organization having somewhat the same relationship to Germany that the United States Fish Commission has to the United States, determined, by permission of its Government, to invite the world to an international fisheries exhibition.

This was designed to include specimens of the animals and plants of the waters useful or injurious to man; illustrations of the apparatus by which they were pursued and captured or obtained; the machinery of utilization; the raw material and the manufactured products derived from such objects; and the methods and appliances of the production and multiplication of the species, whether by artificial means or otherwise. To these were added various subsidiary subjects, such as the clothing and the social condition of the fishermen, etc.

6.—PARTICIPATION BY THE UNITED STATES.

While many countries promptly responded to this invitation and sent their cordial acceptances, no action was at first taken by the United States, and it was not until the winter of 1879–'80 that the subject came actually before Congress for its consideration. At that period, in consequence of what was understood to be the urgent desire of the German Government for the participation of the United States, a bill was passed, becoming a law in February, making an appropriation of $20,000 to enable the United States Fish Commission to prepare an exhibit for the United States. I was notified to appear in connection with the subject, first, before the Secretary of State, and then before the Senate Committee on Foreign Relations.

Although the exhibition was to open on April 20, 1880, the bill introduced into Congress only became a law in February.

As may readily be imagined, but a very short time was left for the preparation of the exhibit and the cases to contain it, packing, shipment to Berlin, installation in the buildings in that city, and a general participation in the exhibition.

The law provided that the United States Fish Commissioner should represent the United States at Berlin, either in person, or by deputy to be appointed by the President, and, not being able to take part, I nominated Mr. G. Brown Goode as said deputy. This was promptly acceded to; Mr. Goode received his commission from the President, and immediately commenced the work of preparation.

Invitations were sent to the principal dealers in fishing-tackle and fishery supplies, to the manufacturers of articles of fish food and other economical substances derived directly or indirectly from fish, and generally to all those who were supposed to have anything to contribute on the occasion in question.

The large collections of a similar character prepared by the United States Fish Commission for exhibition at Philadelphia in 1876 were all available for the purpose, and were, for the most part, still packed in the boxes in which they had been returned from Philadelphia.

The next step was to prepare a detailed schedule of the articles necessary to constitute a fishery exhibition, and fortunately most of the articles found in the collection were available for the purpose. Additional articles were secured, especially of fish products, a field in which much progress had been made since the Centennial of 1876, and the collections were all properly packed and shipped. The cases which had been used in the Philadelphia exhibition were also available, having originally been made portable. These were also sent off. In great part, however, before shipment, the specimens were arranged in their intended cases and photographed, so as to show their relative position, and the more readily to admit of arrangement on reaching Berlin. Mr. Goode and his assistants, among whom may be mentioned Mr. F. W. True and Capt. H. C. Chester, worked day and night, sending off the first load on the 28th February, and the last one on the 24th March, or only twelve and thirty-seven days respectively after the passage of the act. The shipments from Washington were made by way of Baltimore, and those from the north were concentrated at New York, under the charge of Mr. E. G. Blackford, the well-known fish-dealer of New York, of 80 Fulton Market, at his establishment, and forwarded from that point.

With unexampled liberality the great railroads between Washington, New York, Philadelphia, and Baltimore, namely, the Pennsylvania Railroad, the Philadelphia, Wilmington and Baltimore Railroad, and the Baltimore and Ohio Railroad, agreed to transport these packages to the point of shipment and return them to Washington free of expense. The North German Lloyd Company was equally generous, carrying them from New York and Baltimore to Bremen and back free of cost, so that the entire mass of nearly 12,000 cubic feet cost nothing whatever for transportation between Washington and Bremen. The charges from Bremen to Berlin were paid for out of the appropriation.

Mr. Goode and his party left Washington on the 16th March, he being accompanied by Mr. G. H. Hobbs and J. E. Rockwell, as general assistants; Mr. F. W. True, in charge of a portion of the exhibition; Mr. Fred. Mather, as an expert in fish culture; Capt. J. W. Collins, in charge of the ocean fishery apparatus, and Mr. Joseph Palmer, in charge of the models and stuffed specimens. Reduced rates of transportation were given to the party by the North German Lloyd, on the vessels of which company they were taken to Bremen. Owing to the great care in packing and precaution in shipping at the various points of the journey, the collections, including a large series of plaster casts of fishes, reached Berlin in safety, and the entire exhibit was in place by the 20th April, the opening day of the exhibition.

The American display received universal attention, and was generally considered as by far the most interesting feature of the exhibition. Its various divisions were constantly thronged by admiring visitors, and furnished the text of many eulogistic and critical notices.

It was originally intended to continue the exhibition for one month only, or until the 20th May. The interest, however, of the public was such that it was determined to maintain it in active existence until the 1st July, or nearly six weeks longer than was originally calculated upon.

This of course necessitated an unexpected delay in the return of the party and the collections; and it was not until the middle of July that

Mr. Goode reached New York on his return. Most of his party came with him; Mr. Rockwell, alone, having been taken ill and left behind in London in charge of his brother.

The great superiority of the American exhibit, and the interest felt in it, were manifested by the assignment to the United States of the great prize of the Emperor William, consisting of a silver epergne of great artistic merit and costly character. Numerous medals of gold, silver, and bronze, and diplomas of honorable mention, were also issued to American exhibitors.

The number of such medals would doubtless have been much greater but for the fact that most of the articles exhibited had been purchased at the expense of the Government appropriation, and being the property of the United States could not enter into the special competition. Such firms and individuals as presented what they had to show to the United States for the purpose in question secured a large number of prizes; and many more would have been obtained had the numbers of such liberally disposed parties been greater.

As mentioned in a previous paragraph, the collections were shipped by way of Bremen to the United States, and, as already explained, came free of ocean or railway charges from Bremen to Washington. The remission of freight charges represented a contribution of many thousands of dollars; and without this the appropriation made by Congress for the purpose in question would have been entirely inadequate. The transfer from Germany of perishable articles, such as the plaster casts, to the United States was, unfortunately, not so satisfactory; many being broken and requiring a considerable amount of time for their restoration.

Much pleasant intercourse was had by the American representatives at Berlin with associates from other countries; and some valuable exchanges of specimens were made, which tend materially to enrich the collections of the National Museum.

Mr. Goode, since his return, has been actively engaged in making up his report, which it is hoped will be ready for presentation to Congress through the State Department at an early day.

C.—INQUIRY INTO THE HISTORY AND STATISTICS OF FOOD FISHES.

7.—FIELD OPERATIONS AT NEWPORT, R. I.

The central station, selected by the Commission for field work during the summer of 1880, was Newport, R. I., a point intermediate between Wood's Holl and Noank, the places which had been occupied in previous years. Quarters for the party were found in different parts of the city, while a wharf and factory building belonging to Mr. John A. Griswold furnished the necessary facilities for boats and for laboratory purposes. The building, erected for the manufacture of bullets, balls, and shot, furnished ample accommodations.

I left Washington with my party on the 8th of July; and in the course of a few days after arrival succeeded, with the assistance of friends in the city, in establishing satisfactory quarters for the season. Professor Verrill arrived on the 22d of July; Mr. Goode joining the party on the 17th, on his return from the fishery exposition at Berlin. As in previous years, the superintendence of the work connected with the marine invertebrates was in charge of Prof. A. E. Verrill, assisted by Mr. J. H. Emerton as artist, and Messrs. Sanderson Smith, B. F. Coons, and E. A. Andrews. Mr. Richard Rathbun, a member of the National Museum, was also a helper in the general work; while the fishes were specially cared for by Messrs. H. L. Osborn and Frederick Gardiner.

The Census branch of the Fish Commission also had its headquarters for the summer at Newport; the work being carried on, under the general direction of Mr. Goode, by Mr. Charles W. Smiley and a corps of assistants. Mr. T. B. Ferguson, Assistant Fish Commissioner, also had his headquarters at Newport. The various offices and laboratories, although widely separated in the city, were practically together in one establishment by means of connecting telephones.

The sea service of the Commission was performed by the Fish Hawk, which reached Newport on the 2d of August, and was fairly at work about the 7th. Mr. Griswold's wharf not being suitable, a permanent berth was obtained at the city wharf. Numerous trips were made during the season on the Fish Hawk, in the course of which all the region within 20 or 30 miles, including that about Block Island, was carefully examined.

Towards the close of the season several trips were made in the Fish Hawk to the edge of the Gulf Stream, and an extraordinary amount of animal life of a very varied fauna, differing from what was previously known on the American coast, was brought to light. The first of these trips was made in the end of September, and the second in the beginning of October; the vessel starting out in an afternoon, running all night, and reaching the ground in the morning; then spending the day, and returning to Newport the next night.

Vast numbers of species new to science were secured. Of mollusca alone, out of one hundred and seventy-five species collected, forty proved to be new to science. Twenty new species of deep-sea fishes were obtained.

The most important observations of the season in this off-shore region were those made upon the tile-fish, to which reference has been made in a previous report. The range of this valuable fish was greatly extended, and its existence in immense numbers satisfactorily determined.

For the purpose of investigating the tile-fish and its grounds from a fisherman's point of view, a Noank fishing-schooner was chartered and sent out with instructions to ascertain how readily the fish could be secured by means of the trawl line. Owing, however, to a threatening storm the vessel did not remain long enough to do much work, its principal capture being a huge sword-fish, weighing some 700 pounds, taken on a small hook at a depth of 100 fathoms.

On the 7th October the Fish Hawk took on board the apparatus and collections, and returned to Washington, stopping at New Haven long enough to leave the specimens for Professor Verrill, and at Wilmington, Del., for some repairs and apparatus. Before entering Chesapeake Bay a trip was made to the edge of the Gulf Stream, and additional collections of much interest were secured.

My own departure from Newport, *en route* for Washington, took place on the 8th October.

8.—THE STEAMER FISH HAWK.

Reference was made in the report of 1879 to the appropriation by Congress for the construction of a fish-hatching vessel according to the plans prepared by Mr. C. W. Copeland, the naval architect of the Light-House Board. This vessel, a full and detailed description of which will be given in the report for 1881, was completed in the early part of 1880, but too late to be employed at once for her special object—the hatching of shad. She was built, as stated, by Messrs. Pusey and Jones, of Wilmington, and when completed was registered at 484 tons of displacement. Her outfit included all the apparatus necessary, not only for the hatching of fish, but also for scientific research generally, including a hoisting engine of great capacity and a full equipment of dredges, trawls, deep-sea thermometers, etc.

After a successful trial trip, and a subsequent completing of her equipment, she reached Newport on the 7th August, and was shortly after constantly occupied in the explorations referred to on another page.

Three trips were made to the edge of the Gulf Stream south of Newport, as was also a fourth made off Delaware Bay. The vessel arrived at Washington on the 20th November, and on the 4th December went to St. Jerome's Creek, at the mouth of the Potomac River, to procure some oysters for the ponds of the Oyster Park. In returning to Washington she encountered ice in the Potomac River at Quantico, and was obliged to retrace her path and proceed to Norfolk for repairs, where she remained all winter.

The experience of the season proved the vessel to be very effective and well adapted to her work. It was, however, thought better to lengthen her a few feet, so as to obtain a larger fish-hatching surface, and an application was accordingly made to Congress for an appropriation to carry this into effect.

During the trip of the Fish Hawk to the Gulf Stream the great utility of a specially constructed vessel and of her apparatus for dredging was fully tested. Her usefulness for investigation, when not engaged in fish-hatching, will doubtless equal expectations.

9.—FISHERY CENSUS OF 1880.

In the report for 1879 an account was given of the arrangements entered into with General Francis A. Walker, Superintendent of the Tenth Census, for procuring an exhaustive review of the fish and fisheries of the United States. The plan of investigation which was there given in full has been steadily pursued, and a large amount of material accumulated.

Although Mr. Goode, who is in charge of this investigation, was very largely preoccupied, from February until July, by the preparation for the Berlin Exhibition and by his absence in Germany, the field-work was nevertheless continuously prosecuted by the various special agents, so that by October 1st the Great Lake region, the Gulf of Mexico, and the Pacific coast had been substantially completed. The work on the Atlantic coast had proved so much greater than anticipated that Messrs. R. E. Earll and Capt. J. W. Collins were obliged to prolong their field labors and to hurry over the latter part of their work more than they would have preferred to do.

Upon the return of Mr. Goode to Washington from Berlin he directed this investigation from Newport, as has already been intimated. Early in October his headquarters were moved to Washington, and the work of writing up the final report was energetically entered upon, several of the assistants reporting at Washington for this work as fast as their field duties were completed, and others compiling their data at such places as were most convenient to them.

Mr. Ludwig Kümlein being obliged by his business engagements to withdraw from the work, his notes were placed in the hands of F. W. True for compilation.

In addition to and co-ordinate with the field work, an extended line of inquiry had been pursued by means of circulars and lists of questions. A very large number of replies to these having been accumulated, those of one single inquiry numbering over 30,000, the work of arranging and compiling them was assigned to Mr. Charles W. Smiley, who, with several assistants, had had the entire charge of their issue. A force of from twenty to thirty clerks was detailed to his assistance from the Census Office by General Walker.

By the close of the year the reports on several subjects had been completed ready for the press, and many others were in a satisfactory state of advancement.

D.—THE PROPAGATION OF FOOD-FISHES.

10.—WORK ACCOMPLISHED IN 1880.

White-fish (*Coregonus albus*).

Northville Station.—For several years past the United States Fish Commission has ordered from Mr. Frank N. Clark, of Northville, supplies of eggs of the white-fish of the lakes, to meet requests from the State fish commissioners of California, Nevada, and other States, as also from Europe, Australia, and New Zealand.

The growing scarcity of white-fish in the Great Lakes, and the requests by prominent Congressmen that the United States should assist the fish commissioners of the Lake States in their work, induced me to secure all the facilities of the Northville Station, and to place Mr. Frank N. Clark in charge of it. This took place in August, 1880. A number of improvements were made in the works, in order to render the station commensurate with the proposed scale of operations. The stock of brook trout and of California mountain trout belonging to Mr. Clark was also secured, and arrangements made for their propagation.

One important feature of the Northville Station consists in a large supply of excellent spring water, quite sufficient to meet any expected demand. The temperature of the principal spring at its source is 47° Fahr., which represents far too great a degree of cold for many species of fish, but permits the proper temperature to be attained by a certain amount of exposure to the air.

Active operations were commenced in September by a visit to certain islands in Lake Erie for the purpose of arranging with the fishermen for the privilege of taking white-fish eggs from their pounds. This was also done at Alpena, Mich.

Endeavors to obtain eggs of the lake trout were considerably thwarted by the prejudice of the fishermen against this fish, claiming, as they do, that it is very destructive to the white-fish. This, however, in the opinion of Mr. Clark, is not well founded.

The actual catching of spawning white-fish commenced in the early part of November and continued for about three weeks on Lake Erie, and nearly the same length of time at Alpena.

The total number of eggs deposited in hatching boxes at Northville amounted to nearly 14,000,000, and the best of the lots taken yielded 95 per cent. of young fish.

Many interesting experiments were made by Mr. Clark in the course of his work, having special reference to the accelerating and retarding of the hatching of the eggs, whether by heat or by cold. These, with other details of the work, will be found in Mr. Clark's report in the appendix.

Of the total number of eggs taken, a little over 3,000,000 embryonized eggs were shipped to distant points; the remainder were held in the hatchery until their development, and were distributed by Mr. Clark, acting in behalf of the Commission, to the various lake waters within easy reach.

Special acknowledgments are due to the Flint and Père Marquette Railroad Company, the Michigan Central Railroad Company, the Lake Shore and Michigan Southern, and the Chicago and Northwestern, for gratuitous aid in moving the fish and their messengers.

Mr. Clark's report, in addition to the points already referred to, contains some important observations by Professor Forbes, of Normal, Ill., in regard to the food of the white-fish.

The Quinnat, or California Salmon (*Salmo quinnat*).

The McCloud River Station.—The work of the Commission at this station continues, under the direction of Mr. Livingston Stone, to be entirely satisfactory. With an almost unlimited capacity for production, no more eggs are taken than are called for by the requisitions from State commissioners of fisheries; including, of course, the two million or more annually hatched out at the station to be returned into the river to maintain the supply in the Sacramento.

It is well understood that the remarkable continuance of the abundance of the Sacramento salmon is due entirely to the work of the Fish Commission in stocking the waters artificially, and thus making good the enormous drain caused by the canneries.

Mr. Stone, in accordance with his custom, came east in the autumn of 1879; and as the season for active work approached returned to California, reaching the McCloud River on the 22d June. The water of the river was unusually cold for the season, showing a temperature of only 53°.

Mr. Stone pays a tribute of acknowledgment to the industry and fidelity of the Indians living on the reservation; no class of men, perhaps, being better able to render the service required.

A considerable amount of work was necessary to make perfectly safe roadways between the different parts of the station, the narrow mule-paths winding along the edge of steep precipices rendering locomotion extremely dangerous.

All these difficulties were finally surmounted, and on the 20th August the first ripe female salmon was taken. It was not, however, until the 31st August that the eggs were taken in any quantity; but from that date until the night of the 14th September, by which time 6,000,000 had been secured, the work was carried on uninterruptedly. After an interval of a few days the spawning was again resumed and 1,000,000 more eggs secured.

The work of taking the eggs of the salmon was interrupted by the arrival of parties to put up the telephone, which proved to be of very great service in facilitating work. The Indians were specially interested, and took great delight in talking to each other by means of it. Their poetical name for the apparatus was "Talking Spirit."

On the 1st October the work of packing and crating the eggs was begun, and in the course of three or four days 3,800,000 were packed, occupying 76 boxes and 38 crates. These were taken in wagons to Redding, Cal., and thence in a refrigerator car bound for the East. The car itself left on the 4th October, and arrived in the usual time at Chicago, where it was turned over to Mr. Ellis, who had been sent out to that point to take charge of the eggs and distribute them to their destination.

As usual, applications for the eggs had been received from many of the State fish commissioners and from private individuals in the United States. These were supplied as far as possible, and 810,000 were hatched at the stations of the United States Fish Commission. The principal foreign distributions consisted of 50,000 to Canada, 100,000 to France, 380,000 to Germany, and 200,000 to Holland.

Full details of the work done at the McCloud River station, with tables of the temperature of the water, the number of fish of different sexes taken from time to time, etc., will be found in the appended report of Mr. Stone.

The Rainbow, or California Mountain Trout (*Salmo irideus*).

The Crooks Creek Station.—As stated in previous reports, Mr. Stone's proposition to add the culture of California trout, *Salmo irideus*, to that of California salmon, on the McCloud River, was accepted, for which work suitable establishments and appliances were constructed about 5 miles above the salmon station.

No eggs were taken in 1879 at this new station, but between January 12 and May 26 of 1880 about 388,000 eggs were secured and properly treated for transportation. Of this number 261,000 were sent, for the most part, to the Eastern States and about 70,000 were hatched out and planted in the McCloud River for the purpose of keeping up the supply.

As soon as these operations were completed, sundry improvements to the establishment were made in the way of constructing stables, sheds, etc. The most important addition to the station was the connection made by telephone between it and the trout ponds, thus affording a ready means of communication between the two.

Later in the summer many trout were caught and put in the ponds The latest advices for the year from Mr. Stone announce that the accommodations at the station are very commodious, the hatching house having a capacity of several millions of eggs, and that the breeding ponds are large and convenient and now contain more than 2,000 breeding trout. These, it is hoped, will furnish a large supply of eggs in the future. The maintenance of these fish in the ponds throughout the year requires a considerable outlay of money for food, superintendence, etc.

In summer the food of these trout consists of boiled refuse salmon, and in the winter of venison, and occasionally a steer. The trout now in the ponds will eat a whole deer at two feeds.

Mr. Stone reports that the males have milt in them at two years of age, and that the females spawn during their third year. These periods are about one year in advance of the same operations in the case of the *Salmo fontinalis*.

Herewith appended is Mr. Stone's report, which will be found to contain some interesting details.

The Atlantic or Penobscot Salmon (*Salmo salar*).

The Penobscot River Station.—The intermission of collecting eggs of the Penobscot salmon at Bucksport, Me., and producing young fish for distribution to the various rivers of the United States, has already been adverted to, and also the fact that the final success of the first experiment induced its renewal during the season of 1880.

The established method of buying living fish from the fishermen, and of transferring them to an inland pond for preservation until the spawning season, was continued, 522 fish having been purchased—the first on June 10, the last on July 2. The aggregate weight was 6,787 pounds, or an average of about 13 pounds to each fish.

The spawning commenced on the 25th October and ended on the 10th November.

The total number of eggs taken amounted to 2,000,000.

As before, the expenses of the work were met by the United States in conjunction with the States of Maine, New Hampshire, and Massachusetts, the larger part of the funds being supplied by the United States, which, of course, received the largest proportion of eggs, its allotment amounting to about 1,250,000.

These were divided as stated in the appendix to Mr. Atkins's report, and will, it is hoped, produce a marked effect upon the salmon supply in our various rivers.

As heretofore, the work of the station was under the direction of Mr. Charles G. Atkins, with Mr. H. H. Buck as foreman.

Schoodic, or Land-locked Salmon (*Salmo salar*, subs. *sebago*).

Grand Lake Stream Station.—The work of collecting this fish and treating and distributing the eggs, as with the Atlantic salmon, continues in charge of Mr. Charles G. Atkins, with Mr. H. H. Buck as assistant.

The results of the season's work proved to be more successful than those of any previous year. A total of over 2,000 fish was taken, yielding nearly two and a half millions of eggs, or an average of 1,630 each. The capture of spawning fish commenced in the early part of November. Fuller details will be found in Mr. Atkins's report.

The demand for the eggs of the land-locked salmon continues to be very great, and a much larger number than we are likely to obtain for years to come could easily be disposed of.

Shad (*Alosa sapidissima*).

During the season of 1880 the stations operated were two in number, and located, respectively, at Havre de Grace, Md., and at the Washington navy-yard. The number of fish hatched at these stations and successfully planted was 29,296,000. Of these 11,578,000 were transplanted to other waters, 9,855,000 were returned to the Potomac River, and 7,863,000 were returned to the Susquehanna River. The details of this distribution will be found in the table appended to this report, and more fully in Appendix G, Article XXV, p. 553. This production of nearly 30,000,000 shad is a very gratifying increase of some 14,000,000 over 1879.

The Albemarle Sound Station, operated last year, was not continued. The field, however, was well occupied by the North Carolina State commission. The work on the Potomac River, instead of being scattered at various stations, was concentrated at the navy-yard—an arrangement which became possible through the courtesy of the Commandant of the Yard and of the Chief of the Bureau of Yards and Docks.

Havre de Grace Station.—This station, at Spesutie Narrows, on the Susquehanna River, was operated conjointly with the Maryland commission, and under the direction of T. B. Ferguson, Maryland commissioner, who placed in charge of the entire work Mr. John S. Saunders, who had been employed the previous year at the Albemarle Sound Station.

On the 29th of April two barges, containing the machinery and quarters for the men, were taken from Baltimore to the Narrows. e taking of eggs commenced on the third of May and continued until the tenth of June, at which time the fishing ceased, in accordance with the Maryland laws. During that period 13,355,000 eggs were secured. These were obtained by means of the co-operation of the fishermen, who allowed their fish to be stripped before being taken to market.

The use of the floating apparatus made it possible, and very advantageous, about the 30th of May, to move the station to a point about five miles above where the barges were first moored. This was made necessary by the apparent change in the movements of the fish, due perhaps to an influx of salt or brackish water, which a continued prevalence of southerly winds forced up the river.

The price paid the fishermen for the privilege of removing the eggs from the shad was slightly reduced from that paid in previous years; and yet, as the production was more than twenty per cent greater than in 1879, there was a material gain to the fishermen.

On the 12th of June an accident occurred, the barges being driven from their moorings by a severe storm of wind and rain. This caused a premature deposit of some 800,000 or 900,000 fish and eggs in the river, and delayed a proposed car-shipment of a million of shad to the Penobscot and Kennebec Rivers, in Maine.

A few days later, however, the number was made up by assistance from the Washington station, and the car was moved, by the courtesy of the Philadelphia, Wilmington and Baltimore Railroad Company and the connecting lines, to Bangor, where Mr. Stilwell, a commissioner of that State, took charge of the depositing of the fish. Another car-load of eggs was successfully transferred to the Nanticoke River, and 1,000,000 young fish were deposited near Seaford, Del. A half a million of eggs were delivered to J. P. Creveling, a commissioner of Pennsylvania, which were deposited by him in the upper waters of the Susquehanna River.

At the close of the season a part of the equipment was moved to Baltimore and a part was taken to Tangier Sound to be used in experiments with reference to oyster propagation, while two barges were left at the station to be used the following year.

Washington Navy-Yard Station.—A station was organized this year for the first time at this point, by permission of the commandant of the yard, with a view to bringing the eggs from the various points at which they were taken upon the river to a common rendezvous, for hatching. Accordingly the steamer Lookout was placed in service for communicating between the fishing grounds and the station. Mr. Frank N. Clark, of Northville, Mich., was placed in charge of the station, not only for the purpose of conducting the hatching operations, but also for making certain experiments in connection with this service. Messrs. W. P. Sauerhoff and William Hamlen took charge of the collection of the eggs.

The season opened on May 4, at which date 650,000 eggs were secured from 400 shad, at Captain Skidmore's fishery, Moxley's Point. Four days later, these, having been successfully hatched, were deposited in the Potomac. On the 9th of May additional shad-eggs were obtained, and also 1,220,000 herring-eggs from the same fishing-shore. More than one million of these herring were hatched and returned to the river. Later, 180,000 herring were hatched and deposited at Cumberland, Md. Shad-eggs continued to be taken nearly daily until the close of the season, June 27. The total number of shad handled was 11,790, from which 20,749,000 eggs were obtained, and 18,550,000 fish hatched. Of these, 14,350,000 were returned to the Potomac, and 4,200,000 were taken to other waters.

On the 23d of May, Superintendent Wilkins provided a baggage-car, which was loaded with two million shad, which were deposited in rivers of South Carolina and Georgia. On June 16, a car was again sent to Kentucky with 700,000 young fish, which Dr. Griffith, a commissioner of that State, deposited in suitable waters.

Transportation of shad.—The policy of distribution was changed. During previous years deposits of a few hundred thousand each were made in as many different streams as possible. This year fewer streams were stocked, but with much larger installments of fish. The success in shipping by car-loads was very gratifying, and leads the Commission to anticipate the almost exclusive use of this method hereafter. This has been rendered possible by the increased production of young fish, whereby a million of fish can be accumulated in time to forward them in one shipment before the yelk-sacs have been absorbed.

Several things, however, are very essential for a car suitable to transport the fish. Among these may be named, first, arrangements for keeping a constant temperature; second, capacity for storing special carrying vessels; third, arrangements for changing the water and aeration; fourth, comfortable accommodations for the messengers, so that they may be constantly at their post of duty. A car can be specially constructed to supply these facilities, and thus greatly enhance the power of the Commission for moving young fish to remote waters.

Experiments.—In order to determine the feasibility of hatching shad in hydrant water a series of cones, forty-six in number, were set up at the navy-yard, and were in constant use during the season. The water was supplied from a hydrant, and the eggs as they arrived by the Lookout were placed therein. The experiment proved entirely successful, the loss being scarcely appreciable. Experiments were also conducted for determining the smallest amount of water in which young shad could be kept, as it is often found necessary to economize water during their transportation. Mr. Clark found that less than one-fourth of the usual amount of water would answer, if suitable facilities for aeration were provided.

The Carp (*Cyprinus carpio*).

Ponds in Washington.—The report of the Commissioner for 1879 gives an account of the gradual increase in efficiency in the carp ponds in Washington, the production of a considerable number of fish, and their distribution to different parts of the United States.

Various improvements in grading and leveling have had their effect. For the purpose of draining the ponds more readily, or transferring the water from one point to another, a very efficient rotary steam pump, worked by a coil boiler, was constructed by the Herreshoff Manufacturing Company, at Bristol, R. I. It is mounted on four wheels, weighs but little over a ton, and can be readily drawn by hand to any desired point. It is capable of elevating and discharging a stream of water amounting to 1,400 gallons per minute. It was put to use in the early part of May, and has been efficiently employed at various times during the year.

The connection of the ponds with the city telephone system has placed the office of the Commission in close communication with the superintendent, and greatly aided in carrying on operations at that station.

An appropriation of $5,000 was made by Congress in December, 1877, for the improvement of these ponds, and another of $2,200 in the spring of 1878. The District Commissioners kindly agreeing to take charge of the work, Lieutenant Hoxie prepared the plans.

A contract was made, and the first work done was the construction of a dam across the outlet of the large space between the present ponds and the river, thus converting this into a close reservoir. Advantage was taken of a very low tide to close the narrow outlet, kept open until the last moment, and after the water had all run out.

The pond, however, soon filled up to a considerable degree with rain-water, of much better quality than that which formerly backed into the pond from the mouth of the sewer.

Several drains were laid in various parts of the grounds under the direction of the water registrar. It is hoped that the work may be entirely completed during the coming year.

For the purpose of assorting the fish and removing such as were not of an eligible quality, the different ponds were drained successively, the easternmost one being emptied on the 24th April. In addition to about 100 carp, some weighing from eight to ten pounds, and a few tench and golden ides, a large number of mud-shad (*Dorosoma*), cat-fish, and sunfish were obtained; these, in all probability, having been introduced through the water-pipes.

The subsidiary pond at the Arsenal was drained on the 23d October, and a large number of carp obtained for distribution.

The south pond was drained on the 8th November.

The details of distribution of the carp will be found in another part of the report. In many cases the fish commissioners of the different States came to Washington to receive their supply; among others, Mr. B. F. Shaw, of Iowa, on the 27th May. An entire car-load was shipped to the fish commissioner of Missouri, at Saint Louis, on June 1st, and another, on the 25th October, to the commissioners of Wisconsin.

Säibling (*Salmo salvelinus*).

As a return for the service rendered by the United States to the *Deutsche Fischerei-Verein* in the transmission of eggs of the California salmon and the California trout, Herr von Behr, president of the *Verein*, forwarded from Bremen 100,000 eggs of the säibling (*salmo salvelinus*) by the steamship Neckar of the North German Lloyd line, reaching New York on the 1st February, 1880. Only about 6,000 of them survived.

At the suggestion of Mr. Livingston Stone they were sent to Mr. W. L. Gilbert, of Plymouth, Mass., to be hatched out. A brief note upon them will be found in Volume I of the Fish Commission Bulletin.

The Gourami (*Osphromenus olfax*).

In previous reports of the United States Fish Commission mention has been made of the gourami (*Osphromenus olfax*) (see Part II, page lxxvii) as a most desirable species of fish for introduction into the warmer portions of the United States.

This fish belongs to the family of Labyrinthoids, and, like other allied species, is able to endure deprivation of water for a considerable time, the peculiar arrangement of the gills holding the water like a sponge and remaining moist a long time.

Its characteristics, as already explained, are extreme excellence of flesh, large size, and herbivorous character, although well provided with teeth by which it is enabled to cut and feed upon vegetables.

It is also one of the nest-bearing species, the male preparing a depository, weaving together water plants and grasses, for a receptacle in which the female lays her eggs. These eggs, as well as the young when hatched, are sedulously protected by the male until the latter are able to shift for themselves, in this respect resembling the black bass. On this account the increase of this fish is assured even under unfavorable circumstances.

The gourami thrives best in warm waters; indeed, its introduction into ponds or rivers the surface of which is likely to be frozen over is not considered desirable. A moderate degree of cold, however, can be resisted if the bottom of the receptacle be muddy so that the fish can bury themselves in the same manner as the carp.

The gourami is a native of Cochin China, and has been transferred, among other localities, to portions of the East Indian regions, to the Mauritius, and to Guiana. They can be kept in very limited inclosures, and indeed are very often reared in tubs, where they are fed with vegetable food of any description.

The *Société d'Acclimatation* of Paris has succeeded in bringing in a few of these fish into France; but, for some reason or other, they do not appear to thrive, and it is not certain that the experiment will succeed in any part of the United States. The value of the fish, however, is so great as to warrant a special effort on the part of the Commission. On this account application was made to the *Société d'Acclimatation* for any suggestions as to the best mode of obtaining a supply and transmitting them to the United States; and the secretary, M. Raveret-Wattel, very kindly undertook to write to the agent of the society at Saigon, the capital of Cochin China, and have a small number sent by way of Hong-Kong to San Francisco.

On the application of Mr. B. B. Redding, the able Fish Commissioner of California, Mr. Stubbs, the agent of the O. and O. S. S. Company, plying between San Francisco and China, agreed to instruct Mr. Charles H. Hazwell, jr., the agent of the company at Hong-Kong, to receive and forward any fish that might be sent to him for the purpose. It is hoped, therefore, that at the proper time some of these fish may be safely landed in San Francisco, where they will be taken in charge by Mr. Redding and probably introduced into a lake of warm water, near San Gabriel, Los Angeles County, abounding in vegetation and possessing all the other characteristics necessary for a successful experiment.

E.—ABSTRACT OF CONTENTS OF THE APPENDIX.

11.—ANALYSIS.

The appendix to the present volume will be found to include a number of formal reports of the Commission in reference to different branches of operations too detailed in their character to be presented in the present general statement of work attempted and accomplished. It also contains translations, for the most part, of treatises published abroad in regard to the general fisheries and to fish and oyster culture, having direct relationship to the work in the United States, and furnishing important hints for action on our part.

A brief notice of some of these articles may not be inexpedient. They are arranged under certain heads, as follows:

A.—GENERAL CONSIDERATIONS.

This includes a statement of the proposed plan of the joint inquiry of the United States Fish Commission and the Census of 1880 into the fisheries of the United States: also an account, by Mr. Goode, of the work accomplished during the first ten years of the United States Fish Commission.

B.—DEEP-SEA RESEARCH.

In this Professor Verrill gives an account of the apparatus used by the United States Fish Commission in dredging off the coast of New England.

C.—THE SEA FISHERIES.

In this appendix are given articles upon the Icelandic, Swedish, and Norwegian fisheries in general, and upon the methods and results of certain special fisheries, such as the spring herring, sardine, and the capelin.

It also has a paper by Mr. N. P. Scudder on the halibut fishery in Davis's Strait. This gentleman was sent by the Commission in 1878, on a Gloucester halibut schooner, for the purpose of gaining information on the subject.

D.—ECONOMIC RESEARCH.

A very important communication by Prof. W. O. Atwater is here presented of an investigation into the chemical composition and economic values of the fish and invertebrates used for food. This work was initiated at the expense of the United States Fish Commission, and will be continued in the future.

E.—NATURAL HISTORY.

Mr. Goode presents an account of what is known of the various species of sword-fish in general, especially of the three belonging to the coast of the United States. Mr. R. E. Earll, of the United States Fish Commission, gives an account of his observations in regard to the hatching of Spanish mackerel in Chesapeake Bay.

An elaborate contribution to the biology of the Rhine salmon, by Mr. Rüsch, is included in this appendix.

F.—PROPAGATION OF FOOD-FISHES.

A report by Mr. Raveret-Wattel, secretary of the *Société d'Acclimatation*, of Paris, upon the condition of fish-culture in foreign countries, especially as represented at the Berlin Fishery Exhibition, will be found to contain many interesting statements on the subject. A paper by Mr. J. P. J. Koltz,* translated from the French, reproduces one of the earliest

* The second edition of 1859.

systematic treatises on fish-culture published in Europe. Among other special points it contains an account of the methods of hatching fish by means of floating boxes similar in general principle to the shad-hatching box of Mr. Seth Green.

G.—Special Fish-culture.

This contains a series of reports of the specialists of the United States Fish Commission on their work during the season. Mr. Frank N. Clark, upon the white-fish; Mr. Livingston Stone, upon the salmon and rainbow trout; Mr. Atkins, on the Penobscot and Schoodic salmons; on the propagation and distribution of shad. Also an article by Max von dem Borne, upon the carp.

H.—The Oyster.

This represents perhaps the most important portion of the appendix, containing, as it does, a reproduction of all the principal French and German treatises on the theory and practice of the artificial culture of the oyster. This is a subject to which the attention of the Fish Commission has lately been attracted, and which it hopes to develop as it has many other divisions of its work. By showing the present state of our knowledge on the subject in foreign countries, we shall be better able to take it up afresh in our own country. The principal papers in this appendix are by Professor Möbius, of Germany, and by Messrs. Coste, de Bon, Bouchon-Brandely, Renaud, and Hausser, of France, together with a report of the work done in the Netherlands in regard to the oyster and its cultivation.

J.—Miscellaneous.

The appendix closes with a list of patents issued in the United States during 1879 and 1880, by Dr. Robert G. Dyrenforth, examiner-in-chief of the United States Patent Office.

12.—TABLES OF THE DISTRIBUTION OF FISH AND EGGS.

In the following tables, numbered I to VIII, and which have been prepared by Mr. Charles W. Smiley, will be found the condensed record of the distribution of white-fish, California salmon, California trout, Penobscot salmon, Schoodic salmon, shad, and carp. Fuller details will be found in various papers of the appendix: In XX, Mr. Clark's account of white-fish operations; in XXI, Mr. Stone's account of California salmon operations; in XXII, Mr. Stone's account of California trout operations; in XXIII, Mr. Atkins' account of Penobscot salmon operations; in XXIV, Mr. Atkins' account of Schoodic salmon operations; in XXV, the account of shad operations.

TABLE I.—*Distribution of white-fish eggs by the United States Fish Commission during season of* 1880.

States.	Destination.	Number of eggs.
California	B. B. Redding, San Francisco	500,000
Iowa	B. F. Shaw, Anamosa	500,000
Kentucky	William Griffith, Louisville	500,000
Maine	E. M. Stillwell, Bangor	1,000,000
Minnesota	R. O. Sweeny, Saint Louis	250,000
Nevada	Mrs. H. C. Fenstermaker, Eureka	25,000
New Jersey	Fred. Mather, Newark	250,000
Pennsylvania	S. Weeks (for H. B. Wright), Corry	100,000
		3,125,000

TABLE II.—*Distribution of California salmon eggs by the United States Fish Commission during season of* 1880.

States.	Destination.	Number of eggs.
Illinois	Geneva Lake	100,000
Kansas	D. B. Long, Ellsworth	100,000
Maryland	Oakland, Garrett County	200,000
Do	Druid Hill Park, Baltimore	200,000
Missouri	Silas Woodson, Saint Joseph	200,000
Do	J. E. Humes, Versailles, Morgan County	10,000
Minnesota	R. O. Sweeny, Saint Paul	200,000
Nebraska	Nebraska Fish Commission, South Bend, Cass County	400,000
New Jersey	James Annin, jr., Caledonia, N. Y	300,000
North Carolina	S. G. Worth, Morganton, N. C	200,000
South Carolina	do	200,000
West Virginia	C. S. White, Romney, care agent Green Spring Run	150,000
	FOREIGN.	
Canada	S. Wilmot, Newcastle, Ontario	50,000
France	Fred. Mather, for Raveret-Wattel, *Société d'Acclimatation*, Paris	100,000
Germany	Fred. Mather, for Von Behr, *Deutsche Fischerei-Verein*, Berlin	300,000
Do	Fred. Mather, for F. Busse, hatching ponds, Bremen	50,000
Do	Fred. Mather, for Carl Schuster, hatching ponds, Freiburg	30,000
Holland	Fred. Mather, for Von Pestel, Government of the Netherlands, in charge of Zoological Society of Amsterdam	100,000
Do	Fred. Mather, for C. J. Botteman, hatching ponds, Bergen-op-Zoom	100,000
United States	William P. Sauerhoff, for Upper Potomac River	810,000
		3,800,000

TABLE III.—*Distribution of California trout eggs by the United States Fish Commission during season of* 1880.

States.	Destination.	Number of eggs.
California	R. Klotz, Shasta County	10,000
Illinois	N. K. Fairbanks, Chicago	2,500
Iowa	B. F. Shaw, Anamosa	3,500
Maryland	T. B. Ferguson, Baltimore	175,000
Michigan	M. Metcalf, Battle Creek	1,500
Do	J. G. Portman, Pokagon	2,500
Do	F. N. Clark, Michigan	2,500
Minnesota	R. O. Sweeny, Saint Paul	2,500
Missouri	J. G. M. Steedman, Saint Louis	39,000
New Hampshire	S. Webber	2,500
Ohio	Hon. E. D. Potter, Toledo	4,000
Pennsylvania	Seth Weeks, Corry	4,000
West Virginia	C. S. White, Green Spring River, Baltimore & Ohio Railroad	10,000
Wisconsin	W. Welsher	2,500
		262,000

TABLE IV.—*Distribution of Penobscot salmon eggs by the United States Fish Commission during the season of* 1880.

States.	Number of lots.	Streams stocked.	Number of fish.
Connecticut	6	Connecticut River	245, 631
Maine	25	Penobscot, Saco, Kennebec, Androscoggin, Machias, Dony's, and Presumpscot Rivers.	529, 356
Maryland	7	Octorara and Elk Rivers, Great Northeast Creek and Potomac.	123, 432
Massachusetts	1	Merrimac River	48, 000
Minnesota	6	Saint Croix, Cannon, and Mississippi Rivers, and Prior Lake	60, 000
New Hampshire	2	Merrimac River	395, 000
New Jersey	5	Delaware River	128, 643
North Carolina	3	Catawba River	11, 000
Pennsylvania	4	Susquehanna River	99, 335
Wisconsin	1	Illinois River	1, 000
	60		1, 641, 397

TABLE V.—*Distribution of Schoodic salmon eggs by the United States Fish Commission during the season of* 1880.

States.	Number of lots.	Destination.	Number of fish.
California	1	B. B. Redding, San Francisco, Cal	25, 000
Colorado	2	W. E. Sisty, Denver, Colo., and Thos. Morrison, Morrison, Colo.	15, 000
Connecticut	5	H. J. Fenton, Windsor, Conn., and Geo. Jeliffe, Westport, Conn.	496, 500
Iowa	1	B. F. Shaw, Anamosa, Iowa	25, 000
Kansas	1	D. B. Long, Ellsworth, Kans	25, 000
Kentucky	1	Wm. Griffith, Louisville, Ky	25, 000
Maine	2	F. C. Hewey, Phillips, Me., and E. M. Stilwell, Bangor, Me.	64, 000
Maryland	2	T. Hughlett, Druid Hill Hatchery, Baltimore, Md	55, 000
Massachusetts	3	E. A. Brackett, Winchester, Mass	310, 000
Michigan	2	J. G. Portman, Pokagon, Mich., and M. Metcalf, Battle Creek, Mich.	85, 000
Minnesota	1	R. O. Sweeny, Saint Paul, Minn	25, 000
Mississippi	1	C. A. Johnston, Columbia, Miss	2, 000
Missouri	1	Silas Woodson, Saint Joseph, Mo	10, 000
Nevada	1	H. G. Parker, Carson City, Nev	10, 000
New Hampshire	2	A. H. Powers, Plymouth, N. H	124, 000
New Jersey	2	E. J. Anderson, Trenton, N. J., and P. H. Christie, Verbank, N. Y.	30, 000
New York	1	E. G. Blackford, Fulton Market, New York	25, 000
North Carolina	3	H. H. Cary, Atlanta, Ga., and S. G. Worth, Morganton, N. C.	35, 000
Ohio	1	L. Leppelman, Fremont, Ohio	5, 000
Pennsylvania	2	Seth Weeks, Corry, Pa., and James Duffy, Marietta, Pa	30, 000
Rhode Island	1	H. W. Mowry, Oak Lawn, R. I	5, 000
Vermont	1	J. M. Haven, Rutland, Vt	5, 000
Virginia	1	Col. M. McDonald, Lexington, Va	25, 000
West Virginia	1	H. B. Miller, Wheeling, W. Va	25, 000
Wisconsin	1	N. K. Fairbank, Chicago, Ill	20, 000
Canada	1	W. H. Barber, Andover, New Brunswick	50, 000
France	1	Fred. Mather, 25 Hill street, Newark, N. J	40, 000
	42		1, 541, 500

TABLE VI.—*Distribution of shad from May 7, 1880, to June 27, 1880, by the United States Fish Commission.*

States.	Number of lots.	Streams stocked.	Number of fish.
California	1	Sacramento	215,000
Delaware	3	Christiana Creek, Jones Creek, Nanticoke	1,350,000
Georgia	5	Oconee, Yellow, Chattahoochee, Flint	1,188,000
Indiana	1	Wabash	200,000
Kentucky	1	Salt	700,000
Maine	2	Kennebec, Mattawamkeag	675,000
Maryland	30	Susquehanna	7,863,000
Do	34	Potomac	9,855,000
Do	7	Patuxent	3,775,000
Do	3	Bush, Little Youghiogheny	485,000
Do	6	Experimental purposes	670,000
Missouri	8	Osage, Salt, Chariton, Gasconade, Grand, Platte, 202, Nodaway.	200,000
Ohio	1	Sandusky	200,000
Pennsylvania	2	Susquehanna	450,000
South Carolina	9	Broad, Seneca, Catawba, Wateree, Lynch's Creek, Big Pedee, L. Pedee. Turned over to Butler & Huske.	1,310,000
Virginia	1	Appomattox	160,000
	114		29,296,000

TABLE VII.—*Distribution of German carp to individuals, from October 28, 1879, to December 31, 1880, by the United States Fish Commission.*

[NOTE.—So few of these fish were reared in 1879 that no statement was incorporated in the annual report for that year in reference to their distribution, and is consequently herein included.]

States.	Number of applicants supplied.			Number of different localities into which carp were introduced.			Total number of fish sent to the applicants.		
	1879.	1880.	Total.	1879.	1880.	Total.	1879.	1880.	Total.
Alabama	8	13	21	8	7	15	180	259	439
Arkansas	....	1	1	....	1	1	....	15	15
California	2	....	2	2	....	2	72	....	72
Colorado	14	11	25	6	7	13	306	134	440
Connecticut	....	42	42	....	20	29	....	830	830
Dakota	....	1	1	....	1	1	....	50	50
Delaware	4	7	11	4	4	8	160	220	380
District of Columbia	2	3	5	1	2	3	70	65	135
Florida	1	....	1	1	....	1	77	....	77
Georgia	34	62	96	20	16	36	582	1,364	1,946
Illinois	2	7	9	1	6	7	40	130	170
Indiana	5	14	19	5	12	17	114	254	368
Iowa	....	2	2	....	2	2	....	20	20
Kansas	1	11	12	1	7	8	16	104	120
Kentucky	8	105	113	5	51	56	124	2,018	2,142
Maine	....	4	4	....	4	4	....	75	75
Maryland	73	280	353	47	116	163	1,734	10,228	11,962
Massachusetts	....	37	37	....	33	38	....	765	765
Michigan	....	8	8	....	8	8	....	128	128
Minnesota	....	6	6	....	6	6	....	90	90
Mississippi	7	57	64	5	21	26	170	1,309	1,479
Missouri	11	23	34	6	14	20	214	330	544
Nebraska	....	2	2	....	2	2	....	40	40
New Hampshire	....	3	3	....	3	3	....	60	60
New Jersey	2	65	67	2	28	30	80	1,235	1,315
New York	18	97	115	13	64	77	390	1,707	2,097
North Carolina	....	22	22	....	12	12	....	482	482
Ohio	4	62	66	2	43	45	88	1,462	1,550
Pennsylvania	6	63	69	5	48	53	144	1,031	1,175
Rhode Island	1	14	15	1	4	5	20	283	303
South Carolina	19	....	19	11	....	11	886	....	886
Tennessee	8	72	80	4	83	87	205	1,184	1,389
Texas	30	93	123	19	30	49	776	1,868	2,644
Vermont	....	7	7	....	6	6	....	120	120
Virginia	11	148	159	10	72	82	185	2,692	2,877
West Virginia	2	21	23	2	14	16	70	688	758
Wisconsin	....	11	11	....	11	11	....	208	208
Total	273	1,374	1,647	181	717	898	6,203	31,443	37,646

TABLE VIII.—*Distribution of German carp to State commissioners and agents for propagation or distribution, and which are not included in the foregoing table.*

State.	1879.	1880.	Total.
Alabama	....	400	400
California	228	....	228
Colorado	....	476	476
Delaware	225	695	920
Illinois	....	800	800
Kansas	....	100	100
Kentucky	....	1,000	1,000
Maryland	....	3,000	3,000
Michigan	40	800	840
Minnesota	....	500	500
Mississippi	750	300	1,050
Missouri	1,500	1,000	2,500
Nebraska	....	200	200
New York	....	1,300	1,300
North Carolina	....	200	200
Ohio	....	2,500	2,500
South Carolina	1,000	750	1,750
Texas	....	5,000	5,000
Virginia	1,000	....	1,000
Total	4,743	19,021	23,764

13.—LIST OF RAILROADS GRANTING FACILITIES IN 1880.

During the present year a still larger number of railroads have accorded the facilities for carrying fish in baggage cars and for stopping trains at bridges so as to deposit young fish. The list of railroads is given herewith, and the most hearty acknowledgment of their interest and co-operation is hereby made.

Alabama Great Southern Railroad Company. Charles P. Ball, general superintendent, Chattanooga, Tenn.

Alabama Central Railroad Company. W. L. Lanier, president, Selma, Ala.

Atchison, Topeka, and Santa Fé Railroad. George O. Manchester assistant general manager, Topeka, Kans.

Atchison and Nebraska Railroad. George H. Nettleton, general manager, Kansas City, Mo.

Atlantic, Mississippi and Ohio Railroad Company. N. M. Osborne, secretary, Petersburg, Va.

Atlanta and Charlotte Air-Line Railway. C. J. Foreacre, general manager, Atlanta, Ga.

Atlanta and West Point Railroad. A. J. Orme, general passenger agent, Atlanta, Ga.

Baltimore and Ohio Railroad Company. E. K. Hyndman, superintendent Pittsburgh division; C. H. Hudson, superintendent Trans-Ohio division; W. M. Clements, master of transportation.

Boston and New York Air-Line Railroad Company. J. H. Franklin, superintendent, New Haven, Conn.

Boston and Albany Railroad. C. O. Russell, superintendent, Springfield, Mass.

Boston and Providence Railroad Company. A. A. Folsom, superintendent, Boston, Mass.

Carolina Central Railroad. W. Q. Johnson, general superintendent, Wilmington, N. C.

Central Railroad of New Jersey. James Moore, general superintendent and engineer, Elizabeth, N. J.; F. S. Lathrop, receiver.

Central Railroad and Banking Company of Georgia. William Rogers, general superintendent, Savannah, Ga.

Central Pacific Railroad Company. F. H. Goodman, general passenger and ticket agent, San Francisco, Cal.; A. N. Towne, general superintendent.

Central Vermont Railroad Company. J. W. Hobart, general superintendent, Saint Albans, Vt.

Charlotte, Columbia and Augusta Railroad Company. I. R. Macmurdo, general passenger agent, Richmond, Va.

Chesapeake and Ohio Railway Company. William S. Dunn, engineer and superintendent, Richmond, Va.

Chicago, Rock Island and Pacific Railroad Company. A. Kimball, general superintendent, Davenport, Iowa.

Chicago and Alton Railroad. J. C. McMullin, general manager, Chicago, Ill.

Chicago, Saint Louis and New Orleans Railroad Company. W. H. Osborn, president; J. C. Clarke, vice-president and general manager, New York.

Chicago and Northwestern Railway. M. Hughitt, general manager, Chicago, Ill.

Chicago, Burlington and Quincy Railroad Company. T. J. Potter, assistant general manager, Chicago, Ill.

Chicago, Milwaukee and Saint Paul Railway Company. W. C. Van Horne, general superintendent, Milwaukee, Wis.

Chicago, Saint Paul and Minneapolis Railroad, North Wisconsin Railroad. E. W. Winter, general superintendent, Saint Paul, Minn.

Cincinnati, Hamilton and Dayton; Dayton and Michigan; Cincinnati, Hamilton and Indianapolis; and Cincinnati, Richmond and Chicago Railroads. L. Williams, general superintendent, Cincinnati, Ohio.

Cincinnati Southern Railway. S. Woodward, superintendent, Cincinnati, Ohio.

Cincinnati, Sandusky and Cleveland Railroad. Charles Howard, superintendent, Springfield, Ohio.

Cleveland, Columbus, Cincinnati and Indianapolis Railway Company. E. B. Thomas, general manager, Cleveland, Ohio.

Cleveland, Mount Vernon and Columbus Railroad Company. G. A. Jones, superintendent, Mount Vernon, Ohio.

Connecticut Valley Railroad Company. Samuel Babcock, agent for trustee and superintendent, Hartford, Conn.

Connecticut River Railroad. J. Mulligan, superintendent, Springfield, Mass.

Connecticut Central Railroad. D. D. Warren, president, Springfield, Mass.

Delaware and Chesapeake Railway. O. S. Sanford, superintendent, Easton, Maryland.

Delaware, Lackawanna and Western Railroad. Samuel Sloan, president, New York.

East Tennessee, Virginia and Georgia Railroad. John F. O'Brien, chief engineer and superintendent, Knoxville, Tenn.

European and North American Railroad. F. W. Cram, superintendent, Bangor, Me.

Fitchburg Railroad Company. John Adams, general superintendent, Boston, Mass.

Flint and Pere Marquette Railway. Sanford Keeler, superintendent, East Saginaw, Mich.; H. C. Potter, receiver.

Fort Wayne and Jackson Railroad Company. M. D. Woodford, general superintendent, Jackson, Mich.

Galveston, Harrisburg and San Antonio Railroad Company. T. W. Peirce, president, Boston, Mass. James Converse, general superintendent.

Galveston, Houston and Henderson Railroad. H. M. Hoxie, vice-president and manager, Galveston, Tex.

Georgia Railroad Company. E. R. Dorsey, general freight and passenger agent, Augusta, Ga.

Gulf, Western Texas and Pacific Railroad. M. D. Monserrate, general superintendent, Cuero, Tex.

Hannibal and Saint Joseph Railroad Company. W. R. Woodward, superintendent, Hannibal, Mo.

Houston and Texas Central Railroad. G. Jordan, vice-president, Houston, Tex.

Indianapolis and Saint Louis Railroad Company. E. B. McClure, general superintendent, Indianapolis, Ind.

Illinois Central Railroad Company. Joseph F. Tucker, traffic manager, Chicago, Ill.

International and Great Northern Railroad. H. M. Hoxie, general superintendent, Palestine, Tex.

Jacksonville, Pensacola and Mobile Railroad. Edgar Vliet, master of transportation, Tallahassee, Fla.

Kansas Pacific Railway. S. T. Smith, receiver and general superintendent, Kansas City, Mo.

Kansas City, Lawrence and Southern Railroad Company. T. F. Oakes, general superintendent, Kansas City, Mo.

Kansas City, Saint Joseph and Council Bluffs Railroad. I. F. Barnard, general superintendent, Saint Joseph, Mo.

Keokuk and Saint Louis Line. H. B. Blood, general freight and passenger agent, Keokuk, Iowa.

Little Rock and Fort Smith Railway. Theodore Hartman, general superintendent, Little Rock, Ark.

Long Island Railroad. Thomas R. Sharp, receiver, Long Island City, N. Y.

Louisville, Cincinnati and Lexington Railway Company. William Mahl, general superintendent, Louisville, Ky.

Louisville and Nashville Railroad. D. W. C. Rowland, general superintendent, Louisville, Ky.

Lake Shore and Michigan Southern Railroad. Charles Paine, general superintendent, Cleveland, Ohio.

Montgomery and Eufaula Railroad. Lyman Wells, treasurer, Montgomery, Ala.

Macon and Brunswick Railroad. George W. Adams, general superintendent, Macon, Ga.

Marietta and Cincinnati Railroad. J. H. Stewart, superintendent, Cincinnati, Ohio.

Memphis and Little Rock Railroad. Rudolph Fink, general manager, Little Rock, Ark.

Memphis and Charleston Railroad Company. John A. Grant, general superintendent, Memphis, Tenn.

Missouri Pacific Railway. A. A. Talmage, general superintendent, Saint Louis, Mo.

Missouri, Kansas and Texas Railway. C. M. Sheafe, superintendent of transportation, Sedalia, Mo.

Mississippi and Tennessee Railroad. M. Burk, general superintendent, Memphis, Tenn.

Mobile and Montgomery Railway Company. Edmund L. Tyler, vice-president and superintendent, Montgomery, Ala.

Mobile and Ohio Railroad. A. L. Rives, general manager, Mobile, Ala.

Morgan's Louisiana and Texas Railroad. Charles A. Whitney, manager, New Orleans, La.

Nashville, Chattanooga and Saint Louis Railway. J. W. Thomas, general superintendent, Nashville, Tenn.

New York, Lake Erie and Western Railroad. E. S. Bowen, general superintendent, New York.

New York and New England Railroad Company. J. H. Wilson, vice-president, Boston, Mass.

New York, New Haven and Hartford Railroad Company. E. M. Reed, vice-president, New York.

New York, Pennsylvania, and Ohio Railroad. P. D. Cooper, general superintendent, Cleveland, Ohio.

Northern Central Railway Company, Baltimore and Potomac Railroad, and Alexandria and Fredericksburgh Railway. L. P. Farmer, general passenger agent, Philadelphia, Pa.

Northeastern Railroad Company. A. F. Ravenel, president, Charleston, S. C.

Ohio and Mississippi Railway Company. W. W. Peabody, general superintendent, Cincinnati, Ohio.

Old Colony Railroad Company. J. R. Kendrick, superintendent, Boston, Mass.

Pennsylvania Company. J. D. Layng, general manager, Pittsburgh, Pa.

Pennsylvania Railroad Company. L. P. Farmer, general passenger agent, Philadelphia, Pa.

Petersburgh Railroad Company. R. G. Pegram, receiver, Petersburg, Va.

Pittsburgh, Cincinnati and Saint Louis Railway Company. D. W. Caldwell, general manager, Columbus, Ohio.

Philadelphia, Wilmington and Baltimore Railroad. H. F. Kenny, superintendent, Philadelphia, Pa.

Richmond and Danville Railroad Company. I. R. Macmurdo, general passenger agent, Richmond, Va.

Richmond and Petersburg Railroad Company. Theo. D. Kline, general superintendent, Richmond, Va.

Richmond, Fredericksburg and Potomac Railroad Company. E. T. D. Myers, general superintendent, Richmond, Va.

Savannah, Griffin and North Alabama Railroad. Wm. M. Wadley, President, Savannah, Ga.

Savannah and Memphis Railroad Company. W. S. Greene, general superintendent, Opelika, Ala.

Savannah and Charleston Railroad Company. C. S. Gadsden, engineer and superintendent, Charleston, S. C.

Savannah, Florida and Western Railway Company. H. S. Haines, general superintendent, Savannah, Ga.

Seaboard and Roanoke Railroad Company; Raleigh and Gaston Railroad Company; Raleigh and Augusta Air Line Railroad Company; Baltimore Steam Packet Company; Albemarle Steam Navigation Company. John M. Robinson, president, Baltimore, Md.

Selma, Rome and Dalton Railroad. Norman Webb, general superintendent, Selma, Ala.

Southwestern Railroad of Georgia. W. G. Raoul, superintendent, Macon, Ga.

South Carolina Railroad. John B. Peck, general superintendent, Charleston, S. C.

Saint Louis and San Francisco Railway. C. W. Rogers, general manager, Saint Louis, Mo.

Saint Louis, Iron Mountain and Southern Railway. A. W. Soper, general superintendent, Saint Louis, Mo.

Saint Joseph and Denver City Railroad. L. D. Tuthill, general manager, Saint Joseph, Mo.; William Bond, receiver.

Saint Paul, Minneapolis and Manitoba Railway. Jas. J. Hill, general manager, Saint Paul, Minn.

Texas and Pacific Railway Company. Jno. Noble, general superintendent, Marshall, Tex.

Texas and New Orleans Railroad. J. F. Crosby, vice-president and general manager, Houston, Tex.

Union Pacific Railway. S. H. H. Clark, general manager, Omaha, Nebr. F. L. Kimball, general passenger agent.

Vandalia Line; Terre Haute and Indianapolis Railroad Company. John E. Simpson, general manager, Saint Louis, Mo.

Vicksburg and Meridian Railroad Company. E. F. Raworth, general superintendent, Vicksburg, Miss.

Wabash, Saint Louis and Pacific Railway. Jno. C. Gault, general manager, Saint Louis, Mo.

Washington City, Virginia Midland and Great Southern Railroad. Peyton Randolph, general superintendent, Alexandria, Va.; John S. Barbour, receiver.

Western and Atlantic Railroad Company. William MacRae, general manager, Atlanta, Ga.

Western North Carolina Railroad. Jas. W. Wilson, president, Morganton, N. C.
Western Railroad of Alabama. Cecil Gabbett, general manager, Montgomery, Ala.
West Jersey Railroad Company, passenger department. L. P. Farmer, general passenger agent, Philadelphia, Pa.
Western Maryland Railroad Company. J. M. Hood, general manager, Baltimore, Md.
Wilmington and Weldon, and Wilmington, Columbia and Augusta Railroads. A. Pope, general passenger agent, Wilmington, N. C.
Wisconsin Central Railroad Company. F. N. Finney, general manager, Milwaukee, Wis.

APPENDIX A.

GENERAL.

I.—PLAN OF INQUIRY INTO THE HISTORY AND PRESENT CONDITION OF THE FISHERIES OF THE UNITED STATES.*

TABLE OF CONTENTS.

* The pamphlet here reprinted was prepared by G. Brown Goode and was published by the Census Bureau with the following title-page: [7-040] | U. S. Fish Commission and Census of 1880. | — | (44) | Plan of inquiry | into the History and Present Condition | of the | Fisheries of the United States | — | Washington: | Government Printing Office. | 1879. 8vo. pp. 54 (2 blank pages).

U. S. COMMISSION OF FISH AND FISHERIES, AND CENSUS OF 1880.

SPENCER F. BAIRD, *Commissioner of Fisheries.*
FRANCIS A. WALKER, *Superintendent of Census.*
G. BROWN GOODE, *Assistant in charge of Fishery Investigation.*

At the request of the Superintendent of the Census, the U. S. Commission of Fish and Fisheries has undertaken the task of preparing a report on the fishery industry of the United States, which will be printed as a part of the general report of the Superintendent of the Census of 1880. The accompanying preliminary schedule has been prepared for the instruction of the assistants who shall take part in the investigation. It is arranged in the form of an analysis, and is intended to show the scope of the proposed investigation. It is necessarily far from complete; many of the headings might be expanded much more fully if it were thought necessary. The work of canvassing the fishing towns will be placed in the hands of trained investigators, who will be expected to devise methods of their own, suited to the field which they are working up. The headings are intended as suggestions. Every suggestion should be considered with reference to every community under investigation, and where there is an opportunity of gaining information upon any subject it should be followed up in as great detail as possible. In many cases, however, one or more classes of suggestions will be found inapplicable, and may be omitted. The scheme has been made as comprehensive as possible; and it is the intention that the report shall take into consideration every subject which is connected with the history, prosecution, and maintenance of the fisheries.

ORGANIZATION.

The plan of organization provides for the employment of the following assistants.

Superintendent of the Investigation.
Disbursing Agent.

Assistant canvassing Gulf Coast.	Field assistants.
" " Atlantic Coast.	
" " Great Lakes.	
" " Pacific Coast.	
" In Oyster investigation.	
Assistant in charge of Correspondênce.	Office assistants.
" " " " Natural History work.	
" " " " Computation.	
Copyist.	
Stenographic clerk.	

Also, the employment of experts to make reports on special subjects of local extent, as, for instance, the trade statistics of certain large cities or individual branches of the fishery.

INSTRUCTIONS.

A.—Of the Field Assistant.

1. To visit every settlement in the district assigned to him.

2. To consider each general heading in the accompanying schedule with reference to that particular settlement.

3. To eliminate those subjects which cannot have reference to the settlement under consideration.

4. To obtain every possible item of information relating to those branches of fishery or fishery manufactures there prosecuted in the present or past. Hints as to the best means of obtaining information on these topics are given below.

5. To make the investigation complete for each town or community, and to forward the full notes to headquarters as soon as convenient; the notes should be very full, and should be written up in the field. Partial memoranda, taken with a view to future elaboration, are unsatisfactory and generally unreliable. The advantage of frequent communication with headquarters is too evident to require recommendation.

6. To keep a journal of daily work, giving the incidents of the trip,

the names, in every case, of persons interviewed, etc. This may subsequently be expanded into a report of the reconnaissance, to be published by its author as a contribution to the history of the fisheries. His full notes will, of course, be available for use in working up his report.

7. To report to headquarters every change of location, giving time of departure by last mail before leaving a place and time of arrival by first mail after reaching next station. This is obviously desirable for convenience of communication from headquarters.

8. For his own sake to keep a careful record of expenditures, and to render accounts in accordance with the regulations of the Treasury Department, a copy of which is given below.

9. To pay as much attention to collecting marine animals as is consistent with the other work, in accordance with special instructions to be given to each assistant; to obtain samples of all fishery products, fishery apparatus, models of peculiar fishing boats, etc., for the fishery collections of the National Museum; and also to investigate shell heaps, mounds, etc., for aboriginal remains, and to collect such whenever it is possible without too much delay.

10. To obtain the names of all intelligent persons, interested in the fisheries, to be inserted in the Directory, for use in future correspondence.

B.—Postage, Mail Arrangements, etc.

Letters sent from headquarters or addressed to the Commissioner of Fisheries may be inclosed in envelopes with printed frank. Other official letters must have official stamp attached. Letters relating to this investigation should be marked (indorsed on the envelope) F. C. & C.

C.—Expenditures.

The manner of keeping accounts is described in Appendix A. All accounts must be presented on the blank forms of the Census Office.

D.—Assignment of Districts.

Each assistant will be furnished with a list of the settlements to be visited by him, and with a set of maps on which to record the position of weirs, ship-yards, factories, etc. For the Northern Atlantic Coast the last edition of the Coast Pilot will be used; for other regions the charts prepared by the U. S. Coast Survey.

SOURCES OF INFORMATION.

The general plan of the work proposed may be summarized as follows:

A.—CORRESPONDENCE.

The Directory, prepared for the use of the Commission, now records the name of every post-office within three miles of the sea-coast, and gives the names of several hundred persons, fishery-capitalists, manufacturers, skippers, fishermen, collectors of customs, postmasters, and light-house keepers. All of these have signified their willingness to correspond with the Commission, and most of them have already communicated answers to the various circulars sent out. In Appendix C is given a list of seaboard counties, with statement of number of seaboard townships and post-offices within three miles of tide-water.

This directory should be expanded in its scope so as to include the river and lake townships. An effort should be made to secure one reliable correspondent in each town. The postmasters who have not yet responded should be again addressed, the appeal being strengthened by a special recommendation from the Postmaster-General. In some instances it may be desirable to secure as a correspondent one of the clergymen of the place. This can easily be done through the conference members. A new circular (No. 41) will at once be sent out to every post-office on any considerable body of water. This propounds six questions, *viz.:*

1. Are there any fishing-vessels owned in your township?
2. Are there any pounds, traps, or weirs?
3. Are there any professional fishermen?
4. Are the fish-markets supplied in part or wholly from fisheries in your vicinity?
5. If not, whence is obtained the supply?
6. Will you answer other questions on this subject?

A short circular like this will elicit may answers which would not be called out by a longer one. By this means the list of correspondents will be much increased. A still more important end to be gained is the elimination of a larger number of localities, and a great contraction in the number of towns with which it would be desirable to carry on further correspondence. A negative answer to questions 1 and 2 with reference to any town will practically throw it out of consideration. It is manifestly impracticable to treat unprofessional pond and river fishing otherwise than in a general way and by estimate.

After the answers to the preliminary circular have been received and digested, a rough classification of towns by the kind of fishing carried on should be made, and other circulars should be sent out, for the purpose of ascertaining what points it is desirable to investigate further by letter or by a personal canvass.

B.—Canvassing.

In many instances, especially in out-of the-way inland towns, or where a capable, willing correspondent is found, it will not be necessary to send a canvasser. All needful information may be gained by correspondence. The process of elimination, already referred to, will probably throw out three-fourths of the towns named in the directory. This will save much time and expense in the work of canvassing, it being quite unnecessary to send a canvasser to places where there are known to be no fisheries.

There are, however, certain stretches of coast which will require much careful investigation by men acquainted with fishermen and the natural history of fishes. These are—

1. The coast of Maine, with its peculiar system of semi-professional fishing, and its varied river and harbor fisheries.
2. The coast of Massachusetts, with its extensive commercial fisheries.
3. The coast of Southern New England and New York, with its pounds and weirs, and its New York market fishery.
4. The coast of the Middle States, to Cape May.
5. The Gulf Coast.
6. The Great Lakes.
7. The salmon fisheries of the Pacific Coast.

Much has already been accomplished with 2, 3, and 6; the most pressing needs are with 1 and 5. It is strongly recommended that work in these districts be begun at once.

The cheapest and most satisfactory manner of traversing these districts is by small vessels, which can be chartered at very reasonable rates.

The other districts may be undertaken in the progress of the work.

C.—Reports of large markets.

Daily reports of the fresh-fish trade of New York are obtained from the bookkeepers of the eighteen firms represented in the New York Fishmongers' Association, and similar reports are received from Boston and Washington. This system of gathering information, which is proving so satisfactory in these cities, should be extended. Reporters should be secured in other centers of distribution, and particularly in—

Boston (salt-fish trade),
Portland, Me.,
New London, Conn.,
Providence, R. I.,
New York (oyster trade),
Philadelphia (oyster trade),
Baltimore (oyster trade),
Norfolk and vicinity (oyster trade),
Charleston, S. C.,

Chicago (general fish trade),
San Francisco,
and other cities.

D.—Custom-house Returns.

Much valuable information will be obtained from the new system of circulars requiring information on specified points from vessels in the off-shore fisheries. These were put in use in September, 1878, and in 1880 their results will be available for a period of two years.

A fuller schedule of questions has been prepared for the use of collectors of customs in gathering statistics of the shore fisheries. It is to be hoped that this will be adopted; its use will add largely to the store of information regarding the products of the fisheries.

E.—Special Investigations.

Certain branches of trade which are in the hands of a distinct class of men are well worthy of special investigation. Chief among these is the oyster trade, which absorbs more capital than all the other branches of the fisheries, and which has never been thoroughly studied. A special canvasser should devote several months to the oyster trade.

The sponge trade also deserves a study of two or three months by a competent investigator. The subject of the whale fishery has been exhausted in some of its phases, but requires much additional study.

The menhaden fishery and its relations to agriculture also deserve further attention.

F.—Material Already Accumulated.

The Fish Commission has in its possession 20,000 or 30,000 pages of manuscript, which may be directly utilized in this investigation, since these represent work accomplished in the various lines of investigation already spoken of.

Several circulars have already been sent out relating to the general subject of the fisheries, the fishery marine, and the special history of the cod, herring, mackerel, manhaden, mullet, etc. The answers to these circulars are now awaiting collation.

G.—Compilation.

Much has already been done toward compiling as fully as possible a statistical history of the fisheries. The reports of the Treasury Department, of the Bureau of Statistics and Navigation, and of the various special commissions and experts who have studied the fisheries, are to be utilized to the fullest extent, as well as all published accounts of the American fisheries from the earliest times.

SCHEME OF INVESTIGATION.

GENERAL ANALYSIS.

I. Natural history of marine products (the objects of the fisheries).
II. The fishing-grounds (places of prosecution of the fisheries).
III. The fishermen and fishing towns (the men engaged in the fisheries.)
IV. Apparatus and methods of capture (manner of prosecution of the fisheries).
V. Products of the fisheries (first results of the fisheries).
VI. Preparation, care of, and manufacture of fishery products (elaboration of results.
VII. Economy of the fisheries (financial organization and methods).
VIII. Protection and culture (oversight by government).

NOTE.—The following headings are arranged with reference to the manner in which they will be discussed in the final report. At the end of each section are given suggestions regarding methods of investigation and subjects which are particularly important.

I.—NATURAL HISTORY OF MARINE PRODUCTS.

MANNER OF DISCUSSION IN REPORT.

Each species in the following groups which is in demand for, or available for, food or other economic uses, should be considered separately. An outline engraving may be given for the sake of identification, and the popular names in use in different parts of North America. A brief abstract should be given of the important facts in its natural history, telling what is known of (a) its geographical distribution; (b) size; (c) abundance; (d) migrations, if such occur; (e) food and rate of growth; (f) mode of reproduction; (g) economic value and uses:

Seals.
Whales.
Turtles.
Fishes.
Lobsters, crabs, shrimps, ecrevisses, &c.
Oysters, clams, mussels, &c.
Sponges.
Marine plants.
Inorganic products of the sea.

These being products of the sea and properly to be considered in a treatise upon the fisheries.

METHOD OF INVESTIGATION.

When opportunities occur, the stomachs and genitalia of marine animals should be examined, to ascertain the nature of their food and the times of reproduction. Instructions will be given regarding points of special interest which require investigation. Collections of marine animals, particularly fishes, should be made, when occasion offers, especially in the markets of the Southern Atlantic, Gulf of Mexico, and Pacific coast. In Appendix B are given schedules of questions regarding the habits of various groups of fishes. When practicable, it will be well to interview persons acquainted with the habits of fishes and methods of the fisheries, and write down their views and experiences. For this purpose a supply of these circulars will be included in each outfit.

A list of the common food-fishes of North America is here inserted for convenience of reference and to be used in checking the species observed in the markets:

Fishes (Eastern Coast).

File Fish (*Balistes capriscus*).
American Sole (*Achirus lineatus*).
Flat Fish (*Pseudopleuronectes americanus*).
Smooth Flounder (*Pleuronectes glaber*).
Rusty Flounder (*Limanda ferruginea*).
Pole Flounder (*Glyptocephalus cynoglossus*).
Plaice (*Hippoglossoides platessoides*).
Sand Flounder (*Lophopsetta maculata*).
Turbot Flounder (*Pseudorhombus dentatus*).
Four-spotted Flounder (*Pseudorhombus oblongus*).
Halibut (*Hippoglossus americanus*).
Newfoundland "Turbot" (*Platysomatichthys hippoglossoides*).
Pollock (*Pollachius carbonarius*).
Cod (*Gadus morrhua*).
Tom-cod or Frost Fish (*Microgadus tomcodus*).
Haddock (*Melanogrammus aeglefinus*).
Hake (*Phycis chuss*).
Squirrel Hake (*Phycis tenuis*).
Cusk (*Brosmius brosme*).
Whiting or Silver Hake (*Merlucius bilinearis*).
Rose-fish or Red Perch (*Sebastes marinus*).
Tautog or Black Fish (*Tautoga onitis*).
Chogset or Cunner (*Tautogolabrus adspersus*).
Sword Fish (*Xiphias gladius*).
Spear Fish (*Tetrapturus albidus*).
Sail Fish (*Histiophorus americanus*).
Mackerel (*Scomber scombrus*).
Chub Mackerel (*Scomber colias*).
Bonito (*Sarda pelamys*).
Tunny or Horse Mackerel (*Orcynus secundi-dorsalis*).
Little Tunny (*Orcynus alliteratus*).
Spanish Mackerel (*Cybium maculatum*).

Cero (*Cybium caballa*).
Striped Cero or Florida King-fish (*Cybium regale*).
Crevalle (*Carangus hippos* and *Paratractus pisquetus*).
Pompano (*Trachynotus carolinus*).
Short Pompano (*Trachynotus ovatus*).
Long-fin Pompano (*Trachynotus glaucus*).
African Pompano (*Trachynotus goreensis*).
Butter-fish (*Poronotus triacanthus*).
Tile (*Lopholatilus chamæleonticeps*).
Squeteague (*Cynoscion règalis*).
Spotted Squeteague or Sea Trout (*Cynoscion carolinensis*).
Silver Squeteague (*Cynoscion nothus*).
Drum (*Pogonias chromis*).
Spot (*Liostomus philadelphicus*).
Silver Perch or Yellow-tail (*Bairdiella argyroleuca*).
Red Fish or Spotted Bass (*Sciaenops ocellatus*).
King Fish (*Menticirrus nebulosus*).
Southern Whiting (*Menticirrus alburnus*).
Croaker (*Micropogon undulatus*).
Sailor's Choice (*Lagodon rhomboides*).
Sheeps-head (*Archosargus probatocephalus*).
Scuppaug or Porgy (*Stenotomus argyrops*).
Grunts or Hog-fish (*Hæmulon arcuatum*, &c.).
Gray Snapper (*Lutjanus caxis*).
Red Snapper (*Lutjanus Blackfordi*).
Mangrove Snapper (*Lutjanus stearnsii* and *Rhomboplites aurorubens*).
Grouper (*Epinephelus morio*).
Spotted Grouper (*Epinephelus Drummond-Hayi*).
Black Grouper (*Epinephelus nigritus*).
Jew Fish (*Promicrops guasa*).
Sea Bass or Southern Black-fish (*Centropristris atrarius*).
Squirrel (*Diplectrum fasciculare*).
Striped Bass or Rock Fish (*Roccus lineatus*).
White Perch (*Morone americana*).
Moon Fish (*Parephippus quadratus* and *P. faber*).
Triple-tail (*Lobotes surinamensis*).
Blue Fish (*Pomatomus saltatrix*).
Striped Mullet (*Mugil albula*).
White Mullet (*Mugil braziliensis*).
Silver-Sides or Friar (*Chirostoma notatum*).
Silver Gar Fish (*Belone longirostris, B. hians, B. latimanus* and *B. notata*).
Skipper (*Scombresox saurus*).
Mummichogs or Killey-fish (*Hydrargyra majalis*, &c.).
Capelin (*Mallotus villosus*).
Smelt (*Osmerus mordax*).
Salmon (*Salmo salar*).

Trout (*Salvelinus fontinalis*).
Tarpum (*Megalops cyprinoides*).
Menhaden or Pogy (*Brevoortia tyrannus*).
Shad (*Alosa sapidissima*).
Alewife, Branch Herring, or Gaspereau (*Pomolobus vernalis*).
Blue-back or Glut Herring (*Pomolobus aestivalis*).
Tailor Herring (*Pomolobus mediocris*).
Herring (*Clupea harengus*).
Mud Shad (*Dorosoma Cepedianum*).
Anchovy (*Engraulis vittatus*, &c.).
Sea Eel or Conger (*Conger oceanica*).
Eel (*Anguilla bostoniensis*).
Sturgeon (*Acipenser sturio*, &c.).
Lamprey Eel (*Petromyzon marinus*).

Fishes (fresh water).

Burbot or Lawyer (*Lota maculosa*).
Fresh-water Drum (*Haploidonotus grunniens*).
Small-mouthed Black Bass (*Micropterus achigan*).
Large-mouthed Black Bass (*Micropterus pallidus*).
Rock Bass (*Ambloplites rupestris*).
Sacramento "Perch" (*Archoplites interruptus*).
Sun-fish (*Eupomotis aureus*).
Black-eared Sun-fish (*Lepiopomus auritus*).
"Bream" of Southern States (*Eupomotis, Lepiopomus, Enneacanthus, Chaenobryttus*, numerous species).
Strawberry or Grass Bass (*Pomoxys nigromaculatus* and *P. annularis*.)
Yellow Perch (*Perca fluviatilis*).
Yellow Pike-perch (*Stizostedium vitreum*).
Gray Pike-perch or Sauger (*Stizostedium canadense*).
Striped Bass or Rock-fish (*Roccus lineatus*).
White Bass (*Roccus chrysops*).
Short-striped Bass (*Morone interrupta*).
Lake Pike (*Esox lucius*).
Pickerel (*Esox reticulatus, E. americanus, E. cypho*, &c.)
Masquallonge (*Esox nobilior*).
Eastern Salmon (*Salmo salar*).
Land-locked Salmon (*Salmo salar*, subsp. *sebago*).
Brook Trout (of eastern slope) (*Salvelinus fontinalis*).
Brook Trout (of western slope) (*Salmo iridea*).
Black-spotted Trout (*Salmo Clarkii*).
Oquassa Trout (*Salmo oquassa*).
Smelt (*Osmerus viridescens*).
Salmon Trout or Mackinaw Trout (*Cristivomer namaycush*).
Siscowet (*Cristivomer siscowet*).
Missouri Trout (*Salmo Lewisi*).

White Fish (*Coregonus clupeiformis*).
Lake Herring or Cisco (*Argyrosomus tullibee* and *A. artedi*).
Black Fin of Lake Michigan (*Argyrosomus nigripinnis*).
Michigan Grayling (*Thymallus tricolor*).
Mountain Grayling (*Thymallus montanus*).
Standard Bearer (*Thymallus signifer*).
Shad (*Alosa sapidissima*).
Glut Herring (*Pomolobus aestivalis*).
Inland Alewife (*Pomolobus chrysochloris*).
Branch Herring, Alewife or Gaspereau (*Pomolobus vernalis*).
Tailor Herring or Hickory Shad (*Pomolobus mediocris*).
Suckers (of eastern slope) (*Catostomus teres*, &c., *Myxostoma aureola*, &c.).
Suckers (of western slope) (*Catostomus occidentalis*, &c.).
Fall Fish (*Semotilus rhotheus*).
Chubs (of eastern slope) (*Semotilus corporalis*, &c.)
Chubs (of western slope) (*Lavinia exilicauda*, *Algansea*, sp., &c.).
"Pike" or "Salmon Trout" of California (*Ptychocheilus grandis*, &c., *Pogonichthys inæquilobus*, &c.).
Dace (*Ceratichthys biguttatus*, &c.)
Buffalo Fish (*Ichthyobus bubalus*).
Shiner (*Notemigonus americanus*).
Carp (*Carpiodes cyprinus*, &c.).
Catfishes (*Amiurus catus*, *A. nigricans*, &c., *Icthaelurus cœrulescens*, &c., and many other siluroid fishes).
Sturgeon of the lakes (*Acipenser rubicundus*).
Shovel-nose Sturgeon (*Scaphirhynchops platyrhynchus*).
Eastern Sturgeon (*Acipenser sturio*, etc.).

Fishes (Western Coast).

Flounders (*Platichthys stellatus*, *Lepidopsetta umbrosa*, &c.).
"Soles" (*Parophrys vetulus*, *Psettichthys melanostictus*, &c.).
Halibut (*Uropsetta californiana*, *Hippoglossus*, sp., &c.).
Tom-cod (*Microgadus proximus*).
Cod of Alaska (*Gadus macrocephalus*).
Rock Fish or "Rock Cod" (*Sebastomus rosaceus* and species of *Sebastosomus*, *Sebastichthys*, &c.).
Rock Trout (*Chirus constellatus*).
"Cod" of San Francisco (*Ophiodon elongatus*).
Black Fish or "Sheeps-head" (*Pimelometopon pulcher*).
"Perch" (numerous species of *Embiotoca*, *Holconotus*, &c.).
"Bass" (*Atractoscion nobilis*).
Cognard or Little Bass (*Genyonemus lineatus*).
San Francisco "Smelt" (*Atherinopsis californiensis*).
Pacific Smelt (*Osmerus elongatus*).
Salmon (*Oncorhynchus quinnat*, &c.).
Oulachan (*Osmerus pacificus*).

Sardine or Pilchard (*Pomolobus cœruleus*).
Herring (*Clupea mirabilis*).
Sturgeon (*Acipenser acutirostris*, &c.).
Columbia River Sturgeon (*Acipenser transmontanus*).

II.—FISHING GROUNDS.

MANNER OF DISCUSSION IN REPORT.

On a general map should be indicated the geographical distribution of all animals, &c., which are sought by fishermen; also the location of the principal fishing grounds. On charts of minor scale should be indicated in detail the location of all

Off-shore fishing banks and shoals.
In-shore fishing grounds and ledges.
Seining flats and reaches.
Stations for gill and fixed nets.
Locations of weirs, traps, and pounds.
Seal rookeries.
Lobster crawls.
Oyster and clam beds.
Sponge reefs.
Moss ledges (for "Irish moss").

Each important fishing ground should be described with reference to its topography and climate, location, area, depth of water, character of bottom, temperature of water, currents, character of invertebrate life, etc.

METHOD OF INVESTIGATION.

As has already been stated, maps of the coast will be supplied, drawn on a scale sufficiently large to admit of marking in the various kinds of fishing grounds mentioned above.

Each fishing station should be carefully designated on the map, with its local name, notes on depth of water, and on the kind of fish and invertebrates commonly to be found there. The names of those species best taken there should be underscored.

Temperature observations are daily being taken at about thirty stations on the coast, principally light-ships and signal-service stations. Where convenient it will be well to take surface and bottom temperatures on any good fishing grounds, the date, time of day, state of the clouds and tide being carefully noted. For this purpose a thermometer will be furnished.

When a person engaged in taking observations on temperature is encountered he should be encouraged and his attention called to the importance of keeping the records of the movements of fishes in the last column of the blank (No. 35) furnished them.

III.—FISHERMEN AND FISHING TOWNS.

MANNER OF DISCUSSION IN REPORT.

A.—*General statistics.*

For each of the seaboard, lake, or river townships of the United States, the following statement should be obtained, to be summed up for each State, and for each river, lake, or stretch of coast:

Total population.*
Number of professional fishermen.
Number of semi-professional fishermen.
Number of fitters and owners (fishery capitalists).
Number of clerks and others employed in curing fish and preparing them for market, or in factories of oil, guano, &c.
Number of sail-makers and riggers and caulkers.
Number of seine-makers.
Number of salt-dealers and employés.
Number of ship-carpenters and ship-smiths.
Number of shop-keepers dependent on fishermen.
Number of fishermen's widows and orphans.
Number of families dependent upon fishermen.

B.—*Social, vital, and other statistics.*

To be worked out as fully as convenient in each community of fishermen of considerable size.

Nationality; ancestry; how many fishermen of foreign birth.
Hereditary profession.
Health, diseases—at sea, on shore.
Disasters, past and present years—numerical statements.
Longevity of fishermen and fishermen's wives.
Age of marriage.
Fertility.
Effects of seasons of plenty on birth rate.
Dwellings.
Character of food—at sea, on shore.
Manner of living.
Education.
Amusements—at sea, on shore.
Religious proclivities; morals.
Manner of providing for bereaved families.
Financial profits of active fishermen.

In a town engaged in manufacturing fish, fish-oil, &c. (*e. g.* Boothbay or Lubec, Me.), the same investigation to be prosecuted.

* This will be ascertained by the enumerators in the census.

MODE OF INVESTIGATION.

Each of these topics suggests a line of research which would be more or less instructive in different communities.

The manner of working up these points must be left to the discretion and ingenuity of the investigators. In many instances it will be quite impossible to gain definite information; in others much that is valuable may be obtained which is not even hinted at above. The headings are simply suggestions. *This line of investigation cannot be too fully followed up.*

In working up this division, as well as those which follow (viz: divisions IV, V, VI, and VII), much may be learned by the methods mentioned below.

A.—By interviewing as many practical fishermen as possible.

B.—By interviewing fishery capitalists, owners and fitters of vessels. When there is any chance of success, they should be asked to allow an inspection of their books, for the purpose of obtaining accurate statistics of trade in present and past years. Bookkeepers and clerks may be paid for services in searching records. It is not the object of the investigation to pry into the secrets of private business, and pledges may be given that information obtained from persons engaged in business will be kept secret, and used only in preparing the general statistics of the industry.

C.—By interviewing the "oldest inhabitants," retired fishermen, sea-captains, &c., and obtaining from them reminiscences of former methods, seasons of abundance, &c. The value of information thus obtained cannot be overestimated. Especial attention should be given to it. The following subjects are especially to be studied in this manner:

1. The introduction of new methods of fishing, with dates.
2. The early history of all branches of the fishery prosecuted in that vicinity.
3. Supposed increase and decrease of abundance of fishes.
4. Changes in size and model of fishing-vessels.

D.—By interviewing the local clergymen and physicians with reference to vital and social statistics of fishing population. In the case of clergymen, those who have been for the longest time permanent residents of the community should be visited as well as those who, from more recent acquaintance, may have clearer and stronger impressions.

E.—By obtaining what information may be available from the storekeepers patronized by the fishing population.

F.—By gaining access, as often as possible, to files of local papers preserved in the offices or in town libraries. *This method cannot be too strongly commended.* A week or two might be well spent in ransacking the back numbers of local papers of any fishing town.

IV.—APPARATUS AND METHODS OF CAPTURE.

METHOD OF DISCUSSION AND INVESTIGATION.

NOTE.—In this division it seems scarcely practicable to separate the method of treatment and method of investigation. They are therefore discussed together.

A.—Apparatus in general use.

Special apparatus to be described under the head of methods of the fisheries, with reference to its manner of application.

Vessels and boats:

A description of each kind of vessel or boat, with diagrams illustrating peculiarities of rigging or outfit, positions of ice-houses, baits, bins, wells, "slaughter-houses," &c. The different kinds of vessels may be illustrated by engravings.

Whaling ships and schooners.
Sealing schooners.
Cod vessels.
Halibut vessels.
Mackerel vessels.
Oyster vessels.
Block Island boats.
Menhaden steamers, &c.

Circular No. 10 and blank No. 11, which are reproduced in Appendix B, should be used in every fishing port, and should be thoroughly worked out. These require—

1. Name of vessel.
2. Description of rig.
3. Tonnage. (This may be ascertained from the custom-house registers of all vessels of over ten tons; so need not be filled in at the time.)
4. Date of building.
5. Place of building.
6. Number of crew.
7. What fishery engaged in. What kind of outfit.
8. Mode of fishing pursued at different periods.
9. Disposition made of the fish.

A set of these will be furnished with every outfit. Sketches should be made of any peculiar vessel or boats and of the arrangements on deck and below deck.

Also answer the following questions:

10. During how many months of the year, and what months, are these vessels laid up? Are they engaged in other service part of the year?

11. State the seasons at which any of them are engaged in special kinds of fishing.

12. What baits do they use at different seasons? Where and how are they obtained?

13. What is the average length of a trip in the case of vessels on the high seas? Specify for each kind of fishery.

SHORE AND BOAT FISHING.

Answer the following questions for each town:

1. How many small fishing-boats of less than ten tons burden?
2. How many men engaged in boat fishery in summer from dories, rowboats, sailboats?
3. How many in winter?
4. How many, besides those professionally engaged in fishing, make part of their living by fishing?
5. How far from the shore do they fish?
6. Are hand-lines or trawls used? Describe methods of anchoring, bait, trawls.
7. What kinds of fish are chiefly taken? State for different seasons.
8. Estimate the average daily, in the season, and annual catch of a man fishing with hand-lines.
9. Make the same estimate for a man fishing with trawl-line.

STATIONARY APPARATUS.

Attention should be paid to the various kinds of stationary apparatus:

Traps.
Weirs.
Pounds.
Gill-nets.
Seines.
Slides.
Baskets, &c.

These should be described in detail, illustrated with drawings, and with accounts of the methods of working. The local peculiarities of setting and hauling them should be described also.

Material of construction.
Relation to bars, tides, &c.

Mark the location of each pound, weir, or trap on a chart; also make a diagram of the shape and location of some of the most characteristic, giving—

1. Dimensions of bowls.
2. Length of leader.
3. Material and manner of construction.

Depth of water where they are constructed; dependence on tides, &c.

Answer these questions:

POUNDS AND TRAPS.

1. How many pounds and traps are there in the township?
2. How many and during what months are they kept down?
3. How many men are required to work each one?
4. What are the principal kinds of fish taken?
5. Estimate the average annual catch.
6. Estimate the average daily catch. Usual hours of the day for removing the fish.
7. How many fyke-nets are in use, and how many men are employed in this branch of the fishery?

GILL-NETS.

8. How many gill-nets are in use? Are they drift-nets or stationary nets?
9. What is the usual length and depth?
10. What is the size of mesh?
11. How many and during what months are they used?
12. What kinds of fish are taken in them?
13. How many nets are usually set by one boat?
14. Estimate the average catch to a boat—daily and annually

SEINES.

15. How many drag-seines are in use?
16. What is their length and depth?
17. What is the size of mesh?
18. How many men are required to man a seine?
19. During what months are they used?
20. What kinds of fish are taken in them?
21. Estimate the average annual catch of a seine. Give instances of large hauls.

FISH-POTS AND EEL-POTS.

22. Are any fish-pots or baskets in use?
23. Are any eel-pots in use?
24. Are any lobster-pots in use?
25. What baits are used?
26. State how many men are engaged in each of these branches of fishing; how many pots they use, and what is their average annual catch.

PERSONAL EQUIPMENT.

The peculiar costume and personal appliances of fishermen in different parts of the country.

BAITS.

The whole question of bait, its obtaining, its preservation, and its use.

OYSTER AND CLAM FISHERY.

1. Are there oyster or clam banks in the vicinity?
2. Have there ever been any?
3. Mark their locations on the chart.
4. How many men are employed in this fishery?
5. How many boats?
6. What disposition is made of them, &c.?
7. Describe boats and implements in use.

B.—*Manufacture and trade in the apparatus of the fisheries.*

Boat factories.
Ship yards. (Source of lumber.)
Marine railways. Spar yards.
Rigging and sail lofts.
Anchor foundries.
Ship and boat fitting factories.
Canvas factories.
Cordage factories.
Line and net factories.
Hook factories.
Shipsmiths.
Block factories.
Manufacture of rubber boots, &c.
Manufacture of oil-clothing.

For each of these classes of articles the following facts should be noted:

Location of each factory.
Centers of consumption and drift of trade.
Capital invested.
Men employed.

In case only part of the articles manufactured are consumed in the fisheries, a proportionate estimate should be obtained.

The salt trade, its statistics and history. Early manufacture of salt for use in the fisheries. History.

Search should be made for any traces of ancient salt-works.

C.—*Methods of the fishery.*

Under this head should be described in detail the methods at the present time employed in the various branches of the fishery, with detailed accounts of the peculiar apparatus employed and the manner of its use. Among many other branches, the following may be mentioned as typical (these need not be touched except at special request):

The Whale Fishery.
The Antarctic Seal and Sea-Elephant Fishery.
The Alaska Seal Fishery.
The Off-Shore Halibut Fishery.
The Greenland and Grand Bank Halibut Fishery.
The Flounder Fishery.
The Block Island and Noman's Land Cod Fishery.
The George's Bank Cod Fishery.
The Grand Bank Cod Fishery (baiting).
Do. do. (shacking).
The New England Boat Cod Fishery.
The Hake Fishery.
The New York Market Fleet.
The Boston Market Fleet.
The San Francisco Market Fleet.
The Charleston Market Fleet.
The Alaska and Siberian Cod Fishery.
The Sword-Fish Fishery.
The Mackerel Fishery (seining).
Do. do. (gilling).
Do. do. (jigging).
The Bluefish Fishery.
The Bonito Fishery.
The Scup Fishery.
The Striped Bass Fishery.
The Sea-Bass Fishery.
The Red-Snapper Fishery.
The Smelt Fishery.
The White-fish Fishery.
The Eastern Salmon Fishery.
The West-coast Salmon Fishery.
The Menhaden Fishery.
The Shad and Alewife Fishery.
The Herring Fishery.
The Eel Fishery.
The Mullet Fishery.
The Eastern River Sturgeon Fishery.
The Lake Sturgeon Fishery.
The Eastern Weir and Pound Fishery.
The New England Coast Line-Fishery.
The Middle States Coast Line-Fishery.
The South Atlantic Coast Line-Fishery.
The Gulf Line-Fishery.
The Havana Market Fishery.

The Eastern Fresh-water Fishery.
The Western Fresh-water Fishery.
The Great Lakes General Fishery.
The Green Turtle Fishery.
The Lobster Fishery.
The Crab Fishery.
The Prawn and Shrimp Fishery.
The Oyster Fishery and Oyster Culture.
The Long Neck Clam Fishery.
The Little Neck Clam Fishery.
The Bait Clam Fishery.
The Scollop Fishery.
The Squid Fishery.
The Sponge Fishery.
The Irish Moss Trade.
The Sea-Sand Trade.

V.—PRODUCT OF THE FISHERIES.

METHOD OF DISCUSSION IN REPORT.

Annual yield to be specified by separate articles and in total, with estimated values for the year 1880.

To be specified also by districts, with estimated values.

Yield in past years, returns to be made as complete as possible, and also to be supplemented by authentic accounts of productiveness of particular localities in past years.

(Here might be considered the question of decrease or increase of abundance of individual species.)

(In this chapter may be included much historical matter.)

Comparisons of yield of fisheries of the United States with those of other countries.

METHOD OF INVESTIGATION.

These returns are already provided for in the case of New York, Boston, and Washington. *In every other settlement the study of the markets is the most important thing, especially if there be any shipments of fish to other points.* The New York market blanks (20) or the New England market blanks (31) should be used in making up estimates of the annual product, and the opinions and estimates of several capable men should be obtained. Intelligent estimates may be safely founded upon (1) the study of the number of men or boats employed in each fishery; (2) the number of months the fishing continues; and (3) the estimated average daily catch. *No point should be left until this estimate of the annual product of the local fisheries has been obtained.* In some instances the following table may be more convenient.

Please mark after each kind, in the columns prepared for the purpose, your estimate of the total annual catch, stating definitely whether the estimate is in numbers of fish or barrels; also stating whether the estimate is founded upon records.

	Amount in numbers.	Amount in pounds.	Amount in barrels.
Flounders and Flat Fish			
Halibut			
Turbot			
Cod			
Tom-cod or Frost Fish			
Haddock			
Pollock			
Hake			
Cusk			
Whiting or Silver Hake			
Redfish or Norway Haddock			
Rock Fish (W. coast)			
Tautog or Black Fish			
Chogset or Cunner			
Perch (W. coast)			
Sword Fish			
Mackerel			
Bonito			
Tunny			
Crevalle			
Spanish Mackerel and Coro			
Pompano			
Dollar-fish or Butter-fish			
Squeteague or Weakfish			
Red or Channel Bass (S. States)			
Drum			
King Fish and Whiting			
Spot and Croaker (S. States)			
Sheepshead			
Porgy, Scup or Scuppaug			
Sailor's Choice (S. States)			
Grunts and Red-mouths (S. States)			
Sea or Rock Bass or Black-fish (South)			
Red Snapper (S. States)			
Striped Bass or Rock-fish			
Black Bass			
Breams and Pond Fish			
White Perch			
Yellow Perch			
Pike Perch			
Blue-Fish, Skip-Jack, Horse-Mackerel, or Tailor			
Mullet			
Pickerel, Pike, Muskalonge			
Smelt or Frost Fish			
Salmon			
Sea-Trout			
White-Fish (Lakes)			
Lake Trout			
Menhaden, Mossbunker, Porgy, or White-Fish			
Shad			
Alewife or River Herring			
English or Sea Herring			
Tailor Herring, Hickory or Sea Shad			
Suckers, Carp, Buffalo Fish			
Eel			
Sturgeon			
Lamprey			
Squid			
Lobster			
Shrimp			
Crabs			
Clams			
Turtles			
Terrapins			
Alligators (hides)			

VI.—PREPARATION, CARE, AND MANUFACTURE OF FISHERY PRODUCTS.

METHOD OF TREATMENT IN REF[illegible]

Here should be described the methods of the various devices for utilizing fish after they are caught, with statistics of capital, men employed, etc., as fully in detail as possible. Some of the methods are as follows:

Food.—Uses:

- Preservation of living fish—
  - Well-smacks.
  - Cars and live-boxes. Fish and lobster.
  - Fish-ponds.
- Refrigeration—
  - The trade in iced fish.
- Sun-drying—
  - Kench-curing codfish.
  - Pickle-curing codfish.
  - Preparation of boneless fish.
  - Preparation of desiccated fish.
- Smoke-drying—
  - Herring-smoking.
  - Halibut-smoking.
  - Sturgeon-smoking, etc.
- Brine-salting—
  - Mackerel-curing.
  - Whitefish-curing.
  - Swordfish-curing.
  - Bluefish-curing, etc.
- Pickling—
  - Pickling eels, herring, salmon, etc.
- Canning—
  - Canning sardines, etc.
  - Canning salmon.
  - Canning codfish-balls, etc.
  - Canning oysters, cooked and raw.
  - Canning lobsters.
  - Canning clams.
  - Canning crabs, anchovies.

Use in the arts:

- Leather and fur-dressing. Seal-skins.
- Whalebone preparation.
- Isinglass manufacture.
- Ambergris.
- Murexides.
- Carbazotates.
- Fish guano. Menhaden guano.

Oil rendering.

Whale-oil and its applications.
Menhaden oil.
Cod-liver oil.
Other fish-oil.

METHOD OF INVESTIGATION.

Every manufacturing establishment should be visited, and as fully described as may be possible. When practicable, statistics of the business should be obtained. Secrecy may be promised when necessary. Where the parties interested in manufacturing are unwilling to impart information, estimates should be obtained from their neighbors.

Answer specifically these questions:

1. What are the principal markets for the fish?
2. Are there establishments for canning fish? Are there establishments for canning lobsters? Are there establishments for canning oysters?
3. Are there establishments for smoking?
4. Are there establishments for oil manufacturing?
5. Are there establishments for guano manufacture?
6. Are there establishments for isinglass manufacture?
7. Enumerate these, and obtain statistics as fully as possible.
8. Are the roes of cod saved for use as bait or to be exported? If so, get statistics.

VII.—ECONOMY OF THE FISHERIES.

METHOD OF TREATMENT IN REPORT.

The following questions to be considered in all their bearings for each report. *They should be worked out very fully.*

A.—*Fishery capital and capitalists.*

Building vessels or purchase.
Capital invested in vessels:
In gear or outfit;
In stores for trip or season.
Manner of insurance:
Relations to crew;
Manner of "lay" or copartnership system.
Disposition of fish:
Whether sold fresh or cured by the owners of vessels.

B.—*Labor in the fisheries.*

Relations of crew to "fitters-out."
Shares in the "lay" or copartnership.

Wages; where "lay" system is not in use.

Relations of captain to employer; to vessel; to crew.

Share of crew in catch of fish.

Chance of crew for promotion.

Relation of fishermen's family to shoresmen; are goods advanced on credit?

These questions to be worked out for each community.

C.—*Commerce of the fisheries.*

Market prices, past and present.

Lines of traffic and centers of consumption for individual articles. (This subject will be covered by Circular No. 42, relating to interior fish trade and consumption of fish.)

Exports of fishery products.

Imports of fishery products.

Duties.

(Here may be considered the past commercial history of the fisheries, utilizing the vast amount of statistical material already tabulated.)

Answer specifically these questions:

1. How many capitalists, owners, or fitters are there in the township or port, as the case may be?
2. Are the vessels owned wholly or in part by any of the crew?
3. Describe the "lay" or business arrangements by which the fishermen are remunerated and the vessels fitted out.
4. Are the fish to be cured by the owner, or are they sold to firms making a special business of curing fish?
5. How many wharves are there where fish are cured or salted? Mention them by name.
6. How many wharves or establishments where fish are iced for immediate shipment?
7. Describe the usual method of insurance of vessels.

METHOD OF INVESTIGATION.

Each of the topics suggested above should be investigated. Both capitalists and employés of all grades should be consulted, and their views given as fully as practicable. The subjects mentioned in Section C will be studied by the office assistants.

VIII.—PROTECTION AND CULTURE.

METHOD OF TREATMENT IN REPORT.

A.—Fishery laws, past and present; their effect.

B.—Bounties; their history and results. Drawbacks on salt, &c.

C.—Fisheries treaties and their results. Seizure of fishing vessels.

D.—Public fish-culture; its results, its present status, and its prospects.

METHOD OF INVESTIGATION.

The Sections B and C should be inquired into with much care and reported on very fully.

APPENDIX A.

INSTRUCTIONS FOR MAKING OUT ACCOUNTS.

It is desirable, in order to avoid confusion in and rejectment of accounts, that the following suggestions be adhered to:

1. Vouchers must be signed in ink, and by the person in whose name the account is made—not "per" any agent or clerk—and the amount expressed both in writing and figures.

2. In the case of partnerships, the name of the firm, nothing more, should be signed by one of its members.

3. When an account is made out in the name of an incorporated company it should be signed by one of its officers with his official character in the company appended.

4. Signatures by mark must be witnessed. If John Smith has a bill and he is unable to write his name, it should be written for him, and then he should place his mark—thus: John + Smith, his mark. Witness: David O'Neill.

5. Accounts for traveling expenses should give the places of departure and destination, supported by subvouchers, such as hotel bills, &c. Each day's expenses should be mentioned under its date.

6. Hotel bills should give the dates of arrival and departure and the rate per day. Thus a person arriving before breakfast June 20, and leaving after dinner June 24, will have been at the hotel four and a half days, which, at $3 per day, would amount to $13.50, and should so express it in the account.

7. Laundry bills and baths will not be allowed.

8. Vouchers for supplies must be in detail, showing the nature, quantities, and rate, as well as the amount, namely: 5 pounds nails, at 5 cents, 25 cts.

9. Accounts for service must give the dates, stating whether inclusive or not, on which such service was performed, and the rate of pay, thus: A man employed from June 28 to July 10, inclusive, would have served 13 days, which, at $1.50 per day, would amount to $19.50.

10. Accounts involving subvouchers, some or all of which, for good reasons, cannot be furnished, must be signed by the party, and then taken to a notary public or justice of the peace and sworn to as being correct and for the purpose indicated.

The seal of the officer before whom an account is sworn should be affixed.

APPENDIX B

The following circulars previously issued by the Fish Commission are appended for the information of persons receiving this prospectus:

(10.)

STATISTICS OF THE FISHERY MARINE.

CIRCULAR.

In the absence of any law requiring the registry of fishing-vessels, the statistics of the coast and deep-sea fisheries of the United States are very incomplete, and it is found impossible to gain any definite idea of their extent and value. The present registry-lists, although including all vessels of more than five tons burden, do not indicate the manner in which they are employed.

It is very desirable to obtain full lists of the *fishing*-vessels of the United States, with tonnage, number of men employed, and information regarding their movements which shall be of service in estimating the extent of the various fisheries in these waters; also, similar lists of vessels engaged in the *whale* and *seal* fisheries, in the *lobster* and *oyster* trade, and in the *fish-carrying* trade.

I therefore beg leave to call attention to the accompanying blank tables which have been prepared for this census. They may be filled out as fully as is practicable, although tonnage, date, place of building, and name of master are of less importance than the other data desired, and should be mailed to the U. S. Commission of Fish and Fisheries, Washington, D. C. The method of registry is illustrated by the table on the opposite page.

The information thus obtained will be embodied in a report to Congress, in which full credit will be given to all contributors.

SPENCER F. BAIRD,
Commissioner.

SMITHSONIAN INSTITUTION, *Washington, D. C.*

(11.)

STATISTICS OF THE FISHING VESSELS OF THE UNITED STATES.

SAMPLE TABLE.

Port of OLDTOWN, CONN., *October* 1, 1875.—Recorded by George W. Jackson, collector of customs.

Name of vessel.	Tonnage.	Description of rig.	When built.	Where built.	Name of master.	No. of crew.	What fishery engaged in.	Mode of fishing.	Where fishing.	Disposition made of fish.
Breeze	24	Sloop	1871	Mystic	Peter Wilbur	5	Cod	Line	Nantucket Shoals	Carried in ice to New York.
White Squall	75	Schooner	1865	Noank	Samuel Fish	8	Halibut	Trawl	George's Banks and Seal Island.	Carried in ice to New York.
Aden	32	Schooner	1868	Hanover	John Smith	7	Cod and haddock.	Line	Nantucket Shoals in summer.	Carried in ice to New York.
							Black Fish, &c.	Line	Coast of South Carolina in winter.	Charleston market.
Verbena	28	Schooner	1872	Gildersleeve	Simeon Fish	5	School-fish	Pound	Menemsha Bight	Shipped in ice from Oldtown to New York.
Mary Jane	31	Schooner	1860	Oldtown	John Pike	6	Cod in summer	Line	Nantucket Shoals	Shipped in ice from Oldtown to New York.
							Mullet, &c., in winter.	Seine	Tampa Bay, Fla., and Tortugas.	Mobile market.
Dauntless	31	Schooner	1865	Oldtown	Peter Black	6	Groupers and snappers.	Line	Cuba	Carried in well to Havana.
Nightingale	14	Sloop	1861	Oldtown	Simeon Smith	2	Blue Fish	Gill-net	Long Island Sound.	Shipped in ice from New London.
Placoid	30	Steamer	1873	New York	G. A. Littlejohn	8	Menhaden	Purse seine	Long Island Sound.	Chapman's factory at Nepeague.
J. F. S.	20	Sloop	1870	Oldtown	Henry Spicer	9	Menhaden	Purse seine	Long Island Sound.	Chapman's factory at Nepeague.
Acacia	20	Sloop	1863	Oldtown	John Washington	2	Striped bass	Line	Block Island Sound	New London market.
Desdemona	30	Schooner	1869	Mystic	J. H. Thompson	10	Mackerel	Line and purse seine.	Bay of Chaleur	Salted, taken to Boston market.
Gabriel	3	Sloop	1874	Mystic	Robert Henry	2	Lobsters	40 pots	Oldtown Harbor	New Bedford market.
Herbert Gill	40	3-masted schooner	1856	Hackensack	George Hamilton	7	Oysters	Carrying from	York River, Va., to	Boston.
Bluelight	200	Ship	1850	New Bedford	I. K. Trumbull	12	Whale		North Pacific	Oil sold at New Bedford.
Lenape	80	Schooner	1809	Haddam	P. Q. Nickerson	10	Fur-seal		S. Shetland Islands	Sold at New London.

(28.)

QUESTIONS RELATIVE TO THE COD AND THE COD FISHERIES.*

OFFICE OF U. S. COMMISSION OF FISH AND FISHERIES,
Washington, D. C.

The most important of the marine food-fishes of Eastern North America is the Cod (*Gadus morrhua*). The fresh fish are extensively sold in Northern markets, while salted and dried they form a staple of great commercial importance.

It is considered very desirable to obtain a full account of the habits, migrations, &c., of this fish, as well as complete statistics of its capture and commercial relations. The statistics of the fisheries of Labrador and the Grand Banks of Newfoundland are particularly desired. I beg leave to call attention to the inclosed table of questions, and to request answers to as many as practicable, to be addressed to the U. S. Commission of Fish and Fisheries, Washington, D. C. This circular may also apply to the codfish of the Pacific coast of North America. Replies should be made on foolscap paper, if equally convenient, and written on one side only of the page.

The information thus obtained will be embodied in a report to Congress, in which full credit will be given to all contributors.

Many very full and satisfactory communications have already been received in response to a former circular containing questions about the cod fisheries. Thanking those who have already responded for their efficient aid, I beg to call their attention to this revised series of questions, and to ask that they will read them attentively and add any new suggestions which may occur to them. Attention is especially requested to the questions relating to migrations and schooling (18–32, inclusive), and very especially to No. 29, which is introduced to elicit information regarding the large schools which have appeared on our coast during the autumn and winter of 1877.

I would also request new answers to questions 62–90, inclusive. The former circular failed to draw out all the information desired upon the statistics of the fisheries.

SPENCER F. BAIRD,
Commissioner.

SMITHSONIAN INSTITUTION, *Washington, D. C.*

A.—*Name.*

1. Is the cod ever known by any other name?
2. Are there names for special varieties of the cod?

* These questions may also apply to the other fishes of the cod family, the haddock, pollock, hake, and cusk, and to the halibut and flounder, also scup, sea-bass, and tautog.

50. Is there any marked change in the shape or color of either sex during the breeding season; or any peculiar development of or on any portion of the body, as the mouth, fins, scales, &c.?

51. Are there any special or unusual habits during the spawning season?

52. At what age does the male begin to breed; and at what age the female?

YOUNG FISH.

53. What was the size of the smallest codfish you ever saw?

54. At what season do the young fish appear?

55. What is their food?

56. Are their habits like those of the old fish?

G.—*Enemies, fatalities, &c.*

DISEASES.

57. Are diseased or deformed codfish ever seen?

58. Can you describe them?

59. Have dead fish ever been seen in any quantity?

PARASITES.

60. Are crabs, worms, lampreys, or other living animals found attached to the outside or on the gills of these fish?

ENEMIES.

61. Do other animals, such as whales, seals, birds, and other fish attack or prey upon the cod; can you mention any instances?

H.—*The fisheries.*

IN-SHORE FISHERIES.

62. At what season of the year and for how many months are cod taken so near to your shore that the fishermen can be at home every night?

63. What are the favorite grounds, what is the depth of water, and what the nature of the bottom?

64. How many men are engaged in this fishery, and when not so engaged how are they employed?

65. How many boats, and what kind?

66. How many men do they carry?

67. What kind of gear is used? If trawls or long lines, describe length of line, of gaugings, and of buoy-lines; number and kind of hooks, anchors, and buoys, and manner and time of setting. If hand-lines, describe lines, hooks, and leads.

68. What bait is used; is it different at different seasons; how and where do they get it; how much does it cost?

SCHOOLING.

25. Do cod associate in schools, or are they independent? Answer for the whole year or for particular seasons.

26. Are there different schools in your waters at different seasons?

27. Are there different schools in different places?

28. Do males, females, and young associate together in the same schools?

29. Have any schools of unusual size been observed at any time, particularly in the winter of 1877; if so, at what time did they come and go? Were there any peculiarities in their shape or movements? Were any hooks of a peculiar character found in them which would indicate where they came from?

30. Are the movements of the schools affected by the presence of food, or other fish preying upon them?

31. Are they affected by the ebb and flow of the tide?

32. Do cod at any time refuse to take the hook; if so, why?

ABUNDANCE.

33. Are cod as abundant now as they were five, ten, twenty, and thirty years ago?

34. If not, how do you account for their decrease?

35. Have their haunts and habits been changed by the influence of man?

36. Have their numbers been decreased by overfishing?

37. Will the mother fish take the hook freely?

38. Is the trawl more destructive than the hand-line; if so, why?

39. Do you regard the practice of throwing gurry overboard as injurious to the cod fishery?

E.—*Food.*

40. What do the cod feed upon?

41. What is found in their stomachs?

42. Are they ever seen feeding at the surface; if so, can you describe their movements?

43. Is their food different in different seasons and localities?

F.—*Reproduction.*

SPAWNING HABITS.

44. Where do the cod spawn, and when?

45. Have you ever seen the operation?

46. What is the depth of water in the spawning-grounds?

47. Do the eggs sink to the bottom, or float?

48. What is their color and size? (Compare with sizes of shot.)

49. Do the eggs and the milt ever run from the fish after it is caught?

B.—*Characteristics.*

SIZE.

3. What is the average length and weight of the cod?
4. What is the weight of the largest individuals?
5. Are the longest always the heaviest?
6. Is there any difference in the size of males and females?
7. Can you estimate the annual rate of growth?
8. What is the length of a cod one year old, two years old, &c.?

SHAPE AND COLOR.

9. Are there differences in different fish in the shape and color of body, fins, head, nape, and other parts?

10. Can you describe these differences?

11. Do these differences depend upon age, sex, season, habits, food, or kind of bottom?

12. Do the fish taken at different seasons or in different places vary in shape and color.

13. Are there names for these different kinds or schools?

C.—*Distribution.*

14. Are there any places on your coast where the cod are not found?

15. How far from the shore, and in how deep water do they occur?

16. How close to the shore, and in how shallow water?

17. Are they ever known to enter brackish water at the mouths of rivers?

D.—*Movements, &c.*

MIGRATIONS.

18. Do the cod remain with you throughout the year, or are they absent for a time?

19. If they remain throughout the year, are they to be found always in the same places, or do they approach and recede from the shore with the change of seasons?

20. If they approach and recede from the shore, when do these movements occur, how long a time do they occupy, and how far do they extend?

21. Can you explain the cause of these movements?

22. If they are *entirely* absent at certain seasons, please state carefully at what time they go, how long they are absent, and when they return.

23. Where are they supposed to go, and for what purpose?

24. By what route do they leave the shore and return?

69. What is the average annual and daily catch to a man?

70. Is this greater or less than in former years?

71. What would be a large catch for one man now and twenty years ago?

72. Are seines ever used in your vicinity to catch cod?

OFF-SHORE FISHERIES.

73. How many vessels from your vicinity are engaged in the off-shore and bank fisheries; what is their tonnage, rig, and cost? Can you give their names?

74. How are they owned and fitted out; what proportion of cost of outfit is borne by owner, captain, and crew, and what share of the returns? Describe the kind of "lay" customary.

75. How many men do they carry? Are there any officers besides the captain? What proportion of the fishermen are foreigners? Are the men paid wages?

76. What banks do they frequent, and at what seasons?

77. What is the average length of a voyage, and how many voyages in a year?

78. At what depth do they fish?

79. Do they use hand-lines or trawls? Describe the length of these, and the manner of rigging and setting.

80. What bait do they use at different seasons; where and how do they get it? If they buy it, how much does it cost? How much do they take on a trip, and how do they stow it? How long do the different kinds of bait last?

81. How much salt and ice do they carry? Where do these articles come from; how much do they cost?

82. What would be small average and large returns for a vessel for a voyage, and for a year? Estimate in the same way for a single fisherman.

83. Is the number of vessels engaged in this fishery greater or less than it was five, ten, twenty, thirty, and forty years ago?

I.—*Products and fisheries.*

84. What quantity of fresh cod is annually brought to your place? What is its average price? What proportion is brought in vessels engaged in the off-shore fisheries?

85. What quantity of cod is iced for shipment to other places? Where is it sent to?

86. What are the principal markets for salt cod? Do the owners of the vessels dry them, or are they dried by merchants who buy them from the vessels? What is the usual price of salt cod; does it vary much?

87. Are any packed in drums or casks?

88. Are the livers saved? Describe the process of making oil; how much is usually obtained by one vessel during a voyage or year?

89. Are the roes saved? What quantity? Are any exported? To whom are they sold? What are they worth?

90. Are the tongues, sounds or bladders, and napes saved? What are they worth? To whom are they sold?

NAME AND ADDRESS OF OBSERVER:

DATE OF STATEMENT:

(32.)

QUESTIONS RELATIVE TO THE MACKEREL AND THE MACKEREL FISHERIES.*

OFFICE OF U. S. COMMISSION OF FISH AND FISHERIES,
Washington, D. C.

One of the most important of the marine food-fishes of the North Atlantic is the mackerel (*Scomber scombrus*). The fresh fish are extensively sold in Northern markets, while salted they form a staple of great commercial importance.

It is considered very desirable to obtain a full account of the habits and migrations of this fish, as well as complete statistics of its capture and commercial relations. The statistics of the fisheries of the Gulf of Saint Lawrence are particularly desired. I beg leave to call attention to the inclosed table of questions, and to request answers to as many as practicable, to be addressed to the United States Commission of Fish and Fisheries, Washington, D. C. Replies should be made on foolscap paper, if equally convenient, and written on one side only of the page. The information thus obtained will be embodied in a report to Congress, in which full credit will be given to all contributors.

Many very full and satisfactory communications have already been received in response to a former circular containing questions about the mackerel fisheries. Thanking those who have already responded for their efficient aid, I beg to call their attention to this revised series of questions, and to ask that they will read them attentively and add any new suggestion which may occur to them. Attention is especially requested to the questions relating to migrations and schooling.

I would also request new answers to questions 61–78, inclusive. The former circular failed to draw out all the information desired upon the statistics of the fisheries.

SPENCER F. BAIRD,
Commissioner.

SMITHSONIAN INSTITUTION, *Washington, D. C.*

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*These same questions may apply to the swordfish, bluefish, weakfish or squeteague, and the other sea fishes which visit our coast in summer.

A.—*Name.*

1. Are there names for any special varieties and schools of mackerel?
2. What names are used fort he young mackerel at different stages of growth?

B.—*Characteristics.*

SIZE.

3. What is the length and weight of the largest mackerel?
4. Are the mackerel now caught larger or smaller than those of five, ten, or fifteen years ago?
5. Is there any difference in the size of males and females?

SHAPE AND COLOR.

6. Are there differences in different fish, in the shape and color of body, head, fins, and other parts? Can you describe them?
7. Have you ever observed a film over the eyes of the mackerel? If so, at what season of the year? Does it make them blind? Why do you think so?

C.—*Migrations and movements.*

8. At what date did the mackerel appear in your vicinity in 1878? Was this earlier or later than usual?
9. At what date were the first mackerel taken by the southern fleet in 1878? Was this earlier or later than usual?
10. At what date did the mackerel disappear in 1878? Was this earlier or later than usual?
11. Have mackerel ever been taken in winter in your vicinity? Can you give dates and circumstances?
12. Where do mackerel go in winter? For what purpose?
13. When the mackerel appear in the spring, do they come at once or in separate schools? How long are the intervals between the schools? Are the first largest?
14. Do the schools swim high or low? Do they make a ripple on the water? Do they attract birds? If so, what kinds? Do they attract other fish, porpoises, or whales?
15. By what route do they come in to the coast, and what are their subsequent movements?
16. Is their appearance on the coast regular and certain, or do they ever fail for one or more seasons at a time, and then return in greater abundance? If so, what is the reason?
17. Are their movements affected by the ebb and flow of the tide?
18. What are the favorite localities of these fish?
19. What depth of water is preferred by these fish, and how low do they swim?
20. How far from the shore have they been seen?

21. How close to the shore and in how shallow water?

22. Do they ever enter brackish water at the mouths of rivers?

23. Does the temperature of the water appear to affect them?

24. Are there different schools in your waters at different seasons of the year?

25. Are the fish in the same school usually of the same size?

26. Are the movements of the schools affected by the presence of other fish preying on them?

27. When do the fish leave the coast, and is this done by degrees or in a body?

28. By what route do they leave the coast.

29. How far south have you known mackerel to occur?

D.—*Abundance.*

30. Have mackerel decreased or increased in abundance within the past ten years?

31. Does their extensive capture affect their abundance?

32. When small mackerel are abundant in any given year can you predict a supply of large ones in a year or two? Can you give any instances?

33. Has the weather of any given summer any influence on the abundance of the fish in the following year.

34. Can you mention any years in which the mackerel were remarkably abundant?

E.—*Food.*

35. What do mackerel feed upon?

36. Are they ever seen feeding at the surface? If so, can you describe their movements?

37. Is their food different in different seasons and localities?

38. Does their food ever burn their stomachs after their capture, and prevent their keeping when iced or salted? What kind of food has this effect?

F.—*Reproduction.*

SPAWNING HABITS.

39. Where do mackerel spawn, and when?

40. How long does the breeding season continue?

41. What is the depth of water on the spawning grounds?

42. Do the eggs sink to the bottom, or float?

43. What is their color and size? (Compare with sizes of shot.)

44. Have you ever seen the eggs and milt running from the fish after they were caught? Where and under what circumstances?

45. Are there any changes in shape or special habits during the breeding season?

G.—*Enemies, fatalities, &c.*

DISEASES.

46. Are diseased, deformed, or "logy" mackerel ever seen?
47. Are dead fish ever seen in considerable numbers?

PARASITES.

48. Are crabs, worms, lampreys, and other living animals ever found attached to the mackerel?

ENEMIES.

49. Do other animals, such as whales, seals, birds, and other fishes attack or prey upon the mackerel? Can you mention any instances?

H.—*The fisheries.*

OFF-SHORE FISHERY.

50. How many vessels from your vicinity went mackereling in the summer of 1878? Can you give their names?
51. How are they employed this winter?
52. How many of them joined the southern mackerel fleet in the spring?
53. How many went to the Gulf of Saint Lawrence?
54. How many carried purse-seines?
55. When did the first vessel start for the gulf and when did it return?

IN-SHORE FISHERY.

56. How many men are employed in your vicinity in fishing for mackerel with small boats?
57. How many mackerel gill-nets are employed in your vicinity? Can you give their dimensions and size?
58. How many weirs or pounds in your vicinity catch mackerel? Can you name their owners?

APPARATUS.

59. By whom and when was the purse-seine introduced on vessels from your port?
60. By whom and when was the mackerel-jig introduced?
61. By whom and when was the gill-net introduced?
62. Are mackerel-gaffs ever used by your fishermen?

I.—*Products of the fisheries.*

63. Do the vessels from your port carry mackerel, fresh, to market at any season of the year? If so, at what season and to what place?
64. Are any mackerel iced in your vicinity for shipment to other places?

65. Are there inspection laws in force in your State and at your port?
66. To what markets are your salted fish carried?
67. Can you estimate the quantity of mackerel taken by boat-fishermen in your vicinity for home consumption?

NAME OF CORRESPONDENT:

ADDRESS:

DATE OF COMMUNICATION:

(29.)

QUESTIONS RELATIVE TO THE ALEWIFE AND THE ALEWIFE FISHERIES.*

OFFICE OF U. S. COMMISSION OF FISH AND FISHERIES,
Washington, D. C.

Among the most valuable of the fish of the eastern coast of North America is the *Pomolobus pseudo-harengus* or fresh-water herring, which enters the mouths of rivers early in the spring, a little in advance of the shad, and ascends the waters to a greater or less extent, usually known as the herring south of Long Island. It is called alewife throughout the greater portion of New England, and gaspereau in the British Provinces.

For the purpose of eliciting such information as may be procurable relative to the alewife the present circular has been prepared by Mr. Charles G. Atkins, of the United States Fish Commission, who has been charged with the preparation of a report on the subject, to be based in great measure on the answers to be received.

Replies should be made, when possible, on foolscap paper, and written on one side only of the leaf. The questions need not be repeated, but reference made merely to their number, respectively.

Replies should be addressed to United States Fish Commission, Washington, D. C.

SPENCER F. BAIRD,
Commissioner.

SMITHSONIAN INSTITUTION, *Washington, D. C.*

Questions relative to the alewife, river herring, or gaspereau (*Pomolobus pseudo-harengus*).

A.—*Name and varieties.*

1. By which name is the fish known in your neighborhood?
2. Does there appear to be more than one variety? If so, what names

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*These same questions may be applied to the shad and other fishes of the herring family, also to the mullet and striped bass.

are given to the different kinds, and how do they differ from each other? Which is the principal or most abundant variety?

3. Which variety shall you have in mind in your answers to the following questions?

B.—*Characteristics.*

4. What is their average size (both length and weight), or how many to a barrel or bushel?

5. Are they all about of the same size? If not, how much do they vary?

6. Do those of the same "school" or "run" vary in size?

7. What is their color when seen in the water?

C.—*Abundance.*

8. How abundant are they compared with other fish?

9. Have they increased or decreased in numbers since ten, twenty, or thirty years ago? If so, to what extent?

10. If either, what is supposed to have been the cause?

D.—*Movements.*

11. At what date do the alewives first appear in the spring?

12. When are they plentiest?

13. When do they disappear?

14. Are they present during the whole time from their first appearance to their final disappearance, or are there separate "runs" with intervals between?

15. If separate "runs," are the fish of the separate "runs" alike in appearance, size, and behavior? If not, state the difference.

16. Is the water of the district of which you speak salt, fresh, or brackish?

17. How far do they ascend such rivers (naming the rivers) as you are acquainted with?

18. Do they ascend to any lakes and ponds (if so, name them), or run into any brooks?

19. Have their movements up the rivers and streams been interfered with by dams or in any other way, or can they now ascend as far as they were ever accustomed to do?

20. Has there been any change in their habits in any other respect?

21. At what date do old fish leave the fresh waters?

22. Do they appear to go right off to sea, or do they linger awhile about the shores?

23. How far out to sea are they ever found?

24. Are they ever found in the stomachs of cod, hake, pollock, or other fish caught at sea? If you can mention any instances, state where and when the fish were caught.

25. Are they ever taken in seines or gill-nets along with mackerel, menhaden, or other fish? If so, mention instances of date, distance, &c.

26. Where do they spend the winter?

27. In entering a bay or the mouth of a large river at the beginning of the season, where do they first strike the shore? At the point nearest the sea or farther up?

28. Is it known from what direction they arrive when first coming in from sea, or which way they go when returning to it?

29. Do they swim near the surface or bottom?

30. What effect have the weather and tides on their movements?

31. Do they appear to move about by night the same as by day?

32. Have any observations been made as to the temperature of the water at the time they arrive or during their stay, or at the time they ascend fresh-water streams? Will you not, if possible, make such observations?

E.—*Food.*

33. Do you know any facts about the food of this fish?

34. Do they feed while ascending the rivers or while descending?

35. Are they generally feeding while in your vicinity?

F.—*Reproduction and growth.*

36. How do the male alewives differ from the females?

37. Which sex is plentiest, take the season through?

38. Do both sexes come along together in the spring and ascend the fresh-water streams together? If not, which is first, and how much difference in time?

39. Are any of them found in the spring without spawn or milt? If so, how do they compare in size and condition with those that have spawn and milt?

40. Where and at what date do alewives lay their eggs? Mention any facts known to you relative to the act of reproduction.

41. Can you tell anything about the kind of ground selected by them for this purpose and their mode of laying their eggs; whether the eggs stick to plants or stones, and how soon they hatch?

42. Do they ever lay their eggs in brackish water, and do such eggs prosper?

43. About what date are the young hatched?

44. When do they begin to go down toward the sea?

45. How large are they then?

46. Do these young fish swim in schools or singly, near the shore or near mid-stream, at the surface or below it?

47. How fast do they travel?

48. If you have observed at any particular place, state the date at which the young alewives pass that place, and the size of the first and of the last.

49. State any other facts about the behavior of the young fish.

50. How large are they when they reach the sea?

51. Do they go right off to sea and disappear at once, or do they linger about the shores?

52. What is the very latest date at which they are seen on the shore, and their size at that time? Can you furnish a few specimens in alcohol?

53. How large do they get to be in a year?

54. Do they come back to the bays and rivers when a year old, or at any time before they are full grown?

55. In how many years do they attain full size? Give all the facts on which your opinion is based.

G.—*Enemies, fatalities, &c.*

56. Have you observed or heard of any epidemic or other disease afflicting them?

57. Do they ever die in large numbers without apparent cause?

58. Are deformed fish ever seen?

59. Are crabs, lice, worms, lampreys, or other living animals found attached to any part of these fish?

60. What fishes and other animals prey upon the alewife?

H.—*Capture.*

61. By what mode are these fish caught in your vicinity?

62. Give all the facts you can about the different modes of fishing—how the different nets, traps, pounds, &c., are constructed, and how they are worked; the date when they begin to operate, and when they close operations.

63. How many of each of these implements are in use in the district over which your knowledge extends? State definitely the limits of the district included, and give the number of implements exactly if you can.

64. Is the number of such implements greater or less than it was 5, 10, 20, or 30 years ago.

65. Are any of these implements used exclusively or mainly for the capture of alewives?

66. What other kinds of fish do the same implements catch?

67. Name the kinds of fish, if any, which are considered by the fishermen of more importance to them than the alewife, that is, which bring them in more money.

68. Make an estimate, as exact as possible, of the number of alewives caught in each of these modes of fishing; how many to each weir, pound, net, &c., in a season.

69. What is the total catch for the whole district included within the limits given in answer to question 63?

70. What are the local regulations or restrictions in regard to the capture of these fish, the persons authorized to take them, the number allowed, &c.?

I.—*Curing and marketing.*

71. What proportion of the alewives caught are consumed by the fishermen and their families?

72. Where is the surplus marketed?

73. What proportion are sold fresh, salted, or smoked? Give the proportion sold in each way, or better still, if you can, the exact quantity sold in each way, and the purposes to which applied, especially the quantity used as bait.

74. Describe the process of salting and smoking, and in what sort of packages they are sent to market.

75. Where are these marketed fish finally sold to consumers?

76. What are the prices obtained by the fishermen for fresh, salted, and smoked fish?

77. What are the prices paid by the consumers in different districts?

78. Are alewives used to any extent for manure, or any other purpose except food for man?

79. If there is a fishery for alewives in your neighborhood managed by a town or other municipality, state the rules governing the catching and distribution of the fish.

J.—*Sources of information.*

80. To what extent are the above statements drawn from your personal experience and observation? Please to state what opportunities you have had for observation.

81. Can you name any persons who have made a study of the habits of these fish, or collected statistics in reference to them, or any fishermen who have kept records of their catch? If so, please furnish their address.

82. Are there any published statements that bear on this subject?

NAME OF OBSERVER:

OCCUPATION:

P. O. ADDRESS:

DATE OF STATEMENT:

Here furnish the names and addresses of any persons in your neighborhood engaged in the capture and curing of this fish.

(30.)

QUESTIONS RELATIVE TO THE SMELT AND THE SMELT FISHERIES.*

OFFICE OF U. S. COMMISSION OF FISH AND FISHERIES,
Washington, D. C.

The American smelt, of which there are perhaps several species (the best known being the *Osmerus viridescens*), is a fish of considerable

*These same questions may also be applied to the various species related to the alewife, the salmon, lake trout, whitefish, &c.

importance in the fisheries of the United States and of the British Provinces. It is sometimes called frost-fish, from the fact that it makes its appearance in cold weather; but it must not be confounded with another fish known as the Tom-cod (*Microgadus tomcodus*), which resembles the true cod.

The determination of the different species and varieties of this fish, their geographical distribution, habits, statistics, &c., is considered very desirable, and answers to the following questions, prepared by Mr. Charles G. Atkins, will greatly aid in accomplishing this object.

The transmission to the Smithsonian Institution at Washington, from numerous points, of a few perfect specimens of both sexes, preserved in alcohol, will be of much importance in solving the problem.

Answers to the queries should be addressed to the United States Fish Commission, Washington, D. C.

SPENCER F. BAIRD,
Commissioner.

SMITHSONIAN INSTITUTION, *Washington, D. C.*

A.—*Name and varieties.*

1. Is the smelt known in your vicinity by any other name?

2. Does there appear to be more than one variety of smelt in your neighborhood? If so, how do the several varieties differ from each other, and which is the principal one?

3. Which variety shall you have reference to in the following statement?

B.—*Characteristics.*

4. What is the *average* length and weight of the smelts caught in your neighborhood? State whether your answer to this question is founded on an actual weighing and measuring of the fish, or upon an estimate.

5. What is the greatest size of the smelts nowadays caught in your neighborhood.

6. Are the fish as large as they were years ago? If not, how much difference is there?

C.—*Abundance.*

7. How abundant are the smelts in comparison with other fish?

8. Are they as abundant now as they were five, ten, twenty, or thirty years ago.

9. If they have increased or decreased, how do you account for it?

10. Have their haunts and habits been changed by the influence of man?

11. Have their numbers been decreased by overfishing?

D.—*Migrations and movements.*

12. Are smelts caught in your neighborhood at all seasons of the year? If not, state as definitely as you can the portions of the year when they are caught.

13. Is the water there salt, fresh, or brackish?

14. Do the smelts in your neighborhood appear to be moving in any general direction? If so, which way are they going?

15. Do they seem to belong to one general body, or are there successive runs of them, as though they belonged to separate schools? If the latter, is there any difference in the appearance of the different schools?

16. What fresh-water rivers and streams that you can name do smelts ascend, and how far? And at what dates?

17. Do they ever ascend to lakes and ponds?

18. Have their movements up the rivers been interfered with by dams or in any other way, or can they now ascend as far as they were ever accustomed to do?

19. Has there been any other change in their range?

20. How far out to sea do smelts go?

21. Are they ever caught in seines along with mackerel, menhaden, or other fish? If so, mention any instances you know of, and state where they occurred.

22. Are smelts ever found in the stomachs of cod, hake, pollock, or other fish caught at sea? If you can mention any instances, state where and when the fish were caught.

23. Have any observations been made on the temperature of the water at the time when smelts are present in your neighborhood? If not, can you not make and report them?

24. When they leave your neighborhood where do they go?

25. What effect have the tides and weather on their movements?

26. Do they appear to move about by night the same as by day?

27. State any further facts you may know about the movements of smelts, such as the direction they appear to come from when they arrive in your neighborhood, which way they go when they leave, how fast they travel, whether they swim near the surface or bottom, in schools or singly, &c.

E.—*Food.*

28. What do smelts feed on?

29. Do they feed at the time of spawning?

F.—*Reproduction and growth.*

30. How do the male smelts differ from the females?

31. Which sex is the plentiest the season through?

32. Do the sexes always go in company or does one of them precede the other, especially at the time when they ascend the streams or visit their spawning places?

33. Are barren smelts, that is, containing neither spawn nor milt, ever found?

34. Where and at what date do smelts lay their eggs?

35. Can you tell anything about the kind of ground selected by them

for this purpose, and their mode of laying their eggs? Are these loose, or do they adhere to each other and to sticks, stones, earth, &c.?

36. When are the young hatched? How long is this after the eggs are laid?

37. Do the young begin to go down to the sea as soon as hatched, or do they stay in the streams awhile, and how long?

38. Do they go off to sea while growing up, or stay about the shores?

39. How fast do the young smelts grow? Give, if you can, their length at hatching, and at one, two, three, and sixth months, and one year old.

40. Do the young move about singly or in schools?

41. Are they found in company with the old fish or not?

G.—*Enemies, fatalities, &c.*

42. Are smelts ever afflicted with epidemics or other diseases?

43. Are they ever found dead in any considerable numbers without apparent cause?

44. Are crabs, lice, worms, lampreys, or other living animals ever found attached to the outside or on the gills of smelts?

45. What fishes or other animals have been known to prey upon smelts? Can you mention instances?

H.—*Capture.*

46. By what mode are smelts caught in your vicinity?

47. Give all the facts you can about the different modes of fishing, how the different nets, traps, pounds, &c., are constructed and how they are worked; and at what date each sort of implement comes in use, and how long it is used each year.

48. How many of each of these implements are in regular use in the district over which your knowledge extends? State definitely the limits of the district included, and give the number of the implements exactly if you can; but if this is impracticable, make the best estimate or general statement you can.

49. If they are taken at all by hook and line, state in what months this is done, whether on the ice or otherwise, whether in brackish water or fresh.

50. How many persons, if any, follow smelt fishing with hook and line as a regular occupation?

51. Do they fish under tents or huts, or in the open air?

52. What sort of places are most favorable for hook and line fishing? Depth and character of water, character of bottom, &c.

53. Describe the hooks and lines.

54. What bait is used?

55. What time of day and of tide are most favorable?

56. What other kinds of fish are taken on hooks along with the smelts?

57. Is hook and line fishing as productive as it used to be, and what number or weight would be an average day's result?

58. If hook and line fishing for smelts has been abandoned with you, or has become less productive than formerly, state how long ago it was abandoned or when the yield began to fail, and give reasons therefor if you can.

59. If any of the weirs, pounds, nets, seines, &c., mentioned by you as being used in the smelt fishing catch other fish, please to state which kinds of implements, and what other kinds of fish they catch, and which are the most important.

60. Can you make an estimate of the number of smelts caught, or the number of pounds' weight, by each sort of implement mentioned, in a year, and the total annual catch of the district you are speaking about, within the same limits as given by you in the answer to question number 48?

I.—*Markets and consumption.*

61. What proportion of the smelts caught are sold and what proportion consumed by the fishermen?

62. To what market or markets are those sold mostly sent?

63. How are they prepared for market?

64. In what sort of packages are they sent?

65. What prices do they bring? How do these prices compare with those of former years?

66. To what extent are smelts used as bait for other fish?

J.—*Sources of information.*

67. To what extent is the above information drawn from your personal experience and observation? Please to state what opportunities you have had for observation.

68. Can you name any persons who have made a study of the habits of smelts or collected any statistics in reference to them, or any fishermen who have kept records of their business?

69. Are there any published statements that bear on this subject?

NAME OF OBSERVER:

OCCUPATION:

P. O. ADDRESS:

DATE OF STATEMENT:

APPENDIX C.

LIST OF SEABOARD COUNTIES, WITH STATEMENT OF NUMBER OF SEABOARD TOWNSHIPS AND POST-OFFICES WITHIN THREE MILES OF TIDE-WATER.

State.	County.	Townships, number.	Post-offices, number.
Maine	Washington	24	32
	Hancock	32	62
	Waldo	9	19
	Knox	13	16
	Lincoln	18	30
	Sagadahoc	10	14
	Cumberland	10	31
	York	8	21
		124	225
New Hampshire	Rockingham	11	17
	Strafford	4	6
		15	23
Massachusetts	Essex	20	39
	Middlesex	6	6
	Suffolk	1	1
	Norfolk	6	18
	Plymouth	11	27
	Barnstable	14	59
	Nantucket	1	1
	Dukes	5	7
	Bristol	11	22
		75	180
Rhode Island	Newport	7	9
	Bristol	3	5
	Providence	5	13
	Kent	2	9
	Washington	4	19
		21	55
Connecticut	New London	10	26
	Middlesex	8	15
	New Haven	7	18
	Fairfield	9	27
		34	86
New York	Suffolk	9	78
	Queens	6	51
	Kings	6	10
	Westchester	7	16
	Richmond	5	15
		33	170
New Jersey	Cumberland	5	16
	Salem	4	7
	Gloucester	2	3
		11	26
Delaware	Newcastle	6	16
	Kent	5	10
	Sussex	9	23
		20	49

APPENDIX C.—*List of seabord counties, &c.*—Continued.

State.	County.	Townships, number.	Post-offices, number.
Maryland	Worcester	6	9
	Somerset	9	15
	Wicomico	5	9
	Dorchester	14	26
	Caroline	2	7
	Talbot	5	13
	Queen Anne	4	6
	Kent	5	16
	Cecil	7	19
	Harford	8	18
	Baltimore	4	8
	Anne Arundel	7	21
	Calvert	8	9
	Saint Mary's	6	20
	Prince George's	5	14
	Charles	9	20
		94	230
Virginia	Accomack	......	25
	Northampton	......	13
	Fairfax	......	4
	Prince William	......	7
	Stafford	......	5
	King George	......	13
	Westmoreland	......	14
	Richmond	......	7
	Essex	......	11
	Northumberland	......	6
	Lancaster	......	9
	Middlesex	......	10
	Matthews	......	5
	Gloucester	......	7
	King and Queen	......	4
	King William	......	5
	New Kent	......	2
	James City	......	3
	Charles City	......	4
	Prince George	......	4
	Surry	......	4
	York	......	3
	Warwick	......	1
	Elizabeth City	......	8
	Isle of Wight	......	2
	Nansemond	......	4
	Norfolk	......	7
	Princess Anne	......	0
	Alexandria	......	1
		......	189
North Carolina	Currituck	......	8
	Camden	......	6
	Pasquotank	......	2
	Perquimans	......	5
	Chowan	......	3
	Gates	......	2
	Hertford	......	4
	Bertie	......	6
	Martin	......	3
	Washington	......	4
	Tyrell	......	8
	Dare	......	8
	Hyde	......	10
	Beaufort	......	14
	Pitt	......	5
	Pamlico	......	4
	Craven	......	5
	Jones	......	3
	Carteret	......	8
	Onslow	......	0
	Pender	......	9
	New Hanover	......	2
	Brunswick	......	7
	Columbus	......	8
		......	138

APPENDIX C.—*List of seaboard counties, &c.*—Continued.

State.	County.	Townships, number.	Post-offices, number.
South Carolina	Horry	....	7
	Georgetown	....	2
	Charleston	....	7
	Colleton	....	9
	Beaufort	....	11
		....	36
Georgia	Chatham	....	2
	Effingham	....	5
	Screven	....	6
	Bullock	....	2
	Bryan	....	1
	Liberty	....	3
	McIntosh	....	3
	Wayne	....	1
	Glynn	....	6
	Camden	....	8
	Charlton	....	2
		....	39
Florida	Nassau	....	6
	Duval	....	7
	Clay	....	2
	Saint John's	....	5
	Putnam	....	16
	Volusia	....	8
	Brevard	....	5
	Dade	....	3
	Monroe	....	3
	Manatee	....	3
	Hillsborough	....	4
	Hernando	....	1
	Marion	....	1
	Levy	....	2
	La Fayette	....	4
	Taylor	....	1
	Wakulla	....	3
	Franklin	....	2
	Liberty	....	6
	Calhoun	....	2
	Washington	....	2
	Walton	....	2
	Santa Rosa	....	3
	Escambia	....	8
		....	99
Alabama	Baldwin	....	4
	Mobile	....	3
		....	7
Mississippi	Jackson	....	6
	Harrison	....	5
	Hancock	....	3
		....	14
Louisiana	Saint Tammany	....	5
	Orleans	....	4
	Saint Bernard	....	1
	Plaquemines	....	11
	Jefferson	....	3
	La Fourche	....	4
	Tangipahoa	....	1
	Livingston	....	2
	Ascension	....	1
	Saint John Baptist	....	2
	Saint James	....	4
	Saint Charles	....	3
	Terre Bonne	....	1
	Saint Mary's	....	8
	Assumption	....	5
	Iberia	....	4
	Vermillion	....	2

APPENDIX C.—*List of seaboard counties, &c.*—Continued.

State.	County.	Townships, number.	Post-offices, number.
Louisiana	Cameron		2
	Calcasieu		4
			67
Texas	Orange		1
	Jefferson		2
	Chambers		4
	Galveston		4
	Brazoria		3
	Matagorda		5
	Calhoun		2
	Refugio		2
	Aransas		3
	San Patricio		2
	Nueces		2
	Hidalgo		1
	Cameron		2
			33
California	San Diego		4
	Los Angeles		4
	Ventura		2
	Santa Barbara		5
	San Luis Obispo		5
	Monterey		3
	Santa Cruz		6
	Santa Clara		1
	San Mateo		9
	San Francisco		2
	Alameda		11
	Contra Costa		5
	Solano		4
	Sonoma		5
	Marin		9
	Mendocino		12
	Humboldt		9
	Del Norte		2
			98
Oregon	Curry		3
	Coos		10
	Douglas		1
	Lane		
	Benton		4
	Tillamook		4
	Clatsop		8
	Columbia		6
	Multnomah		8
	Wasco		1
	Umatilla		1
			46
Washington Territory	Walla Walla		1
	Klikitat		8
	Skamania		2
	Clarke		4
	Cowlitz		7
	Wahkiakum		4
	Pacific		8
	Chehalis		2
	Clallam		8
	Jefferson		3
	San Juan		5
	Whatcom		9
	Island		4
	Snohomish		5
	King		4
	Pierce		3
	Mason		4
	Kitsap		4
			75
Total number of townships and districts from Maine to Maryland inclusive		427	
Total number of post-offices			1,885

II.—THE FIRST DECADE OF THE UNITED STATES FISH COMMISSION: ITS PLAN OF WORK AND ACCOMPLISHED RESULTS, SCIENTIFIC AND ECONOMICAL.

[Read at the Boston meeting of the American Association for the Advancement of Science, August, 1880.]

By G. Brown Goode.

There are nine departments of the government devoted, in part or wholly, to researches in pure and applied science—the Geological Survey; the Coast and Geodetic Survey; the Naval Observatory; the National Museum; the Department of Agriculture; the Entomological Commission; the Tenth Census, with its special agencies for the study of the natural resources of the country; the Smithsonian Bureau of Ethnology, and the Commission of Fish and Fisheries. The Smithsonian Institution, established upon an independent foundation, should also be mentioned, as well as the Medical Museum of the Army, and the various laboratories under the control of the Army and Navy Departments.

The Geological Survey is not now carrying on any of the schemes of zoölogical and botanical investigation engaged in by its predecessors.

The work of the Entomological Commission and that of the Census, though of extreme importance, are limited in scope and duration, while that of the Agricultural Department is necessarily, for the most part, economical.

The work of the National Museum is chiefly confined to the study of collections made by government surveys or individual collectors and sent in to be reported upon.

The work of the Fish Commission, in one of its aspects, may perhaps be regarded as the most prominent of the present efforts of the government in aid of aggressive biological research.

On the 9th of February, 1874, Congress passed a joint resolution which authorized the appointment of a Commissioner of Fish and Fisheries. The duties of the Commissioner were thus defined: "To prosecute investigations on the subject (of the diminution of valuable fishes) with the view of ascertaing whether any and what diminution in the number of the food-fishes of the coast and the lakes of the United States has taken place; and, if so, to what causes the same is due; and also whether any and what protective, prohibitory, or precautionary measures should be adopted in the premises, and to report upon the same to Congress."

The resolution establishing the office of Commissioner of Fish and Fisheries required that the person to be appointed should be a civil officer of the government, of proved scientific and practical acquaintance with the fishes of the coast, to serve without additional salary. The choice was thus practically limited to a single man, for whom, in fact, the office had been created. Professor S. F. Baird, at that time Assistant Secretary of the Smithsonian Institution, was appointed and entered at once upon his duties.

The summer of 1880 marks the tenth season of active work since its inception in 1871. The Fish Commission now fills a place tenfold more extensive and useful than at first. The present essay aims to show, in a general way, what it has done, is doing, and expects to do—its purposes, its methods, its results.

The work is naturally divided into three sections:

1. The systematic investigation of the waters of the United States and the biological and physical problems which they present. The scientific studies of the Commission are based upon a liberal and philosophical interpretation of the law. In making his original plans the Commissioner insisted that to study only the food-fishes would be of little importance, and that useful conclusions must needs rest upon a broad foundation of investigations purely scientific in character. The life-history of species of economic value should be understood from beginning to end, but no less requisite is it to know the histories of the animals and plants upon which they feed or upon which their food is nourished; the histories of their enemies and friends, and the friends and foes of their enemies and friends, as well as the currents, temperatures, and other physical phenomena of the waters in relation to migration, reproduction, and growth. The necessary accompaniment to this division is the amassing of material for research to be stored in the National and other museums for future use.

2. The investigation of the methods of fisheries, past and present, and the statistics of production and commerce of fishery products. Man being one of the chief destroyers of fish, his influence upon their abundance must be studied. Fishery methods and apparatus must be examined and compared with those of other lands, that the use of those which threaten the destruction of useful fisheries may be discouraged, and that those which are inefficient may be replaced by others more serviceable. Statistics of industry and trade must be secured for the use of Congress in making treaties or imposing tariffs, to show to producers the best markets, and to consumers where and with what their needs may be supplied.

3. The introduction and multiplication of useful food-fishes throughout the country, especially in waters under the jurisdiction of the general government, or those common to several States, none of which might

feel willing to make expenditures for the benefit of the others. This work, which was not contemplated when the Commission was established was first undertaken at the instance of the American Fish-Cultural Association, whose representatives induced Congress to make a special appropriation for the purpose. This appropriation has since been renewed every year on a more bountiful scale, and the propagation of fish is at present by far the most extensive branch of the work of the Commission, both in respect to number of men employed and quantity of money expended.

Although activity in this direction may be regarded in the light of applied rather than pure scientific work, it is particularly important to the biologist, since it affords opportunities for investigating many new problems in physiology and embryology.

The origin of the Commission, its purposes, and methods of organization, having been described, it now remains to review the accomplished results of its work. In many departments, especially that of direct research, most efficient services have been rendered by volunteers; in fact, a large share of what has been accomplished in biological and physical exploration is the result of unpaid labor on the part of some of the most skillful American specialists. Although it would be interesting to review the peculiar features of the work of each investigator, the limits of this paper will not allow me even to mention them all by name.

Since the important fisheries center in New England, the coast of this district has been the seat of the most active operations in marine research. For ten years, the Commissioner, with a party of specialists, has devoted the summer season to work at the shore, at various stations along the coast, from Connecticut to Nova Scotia.

A suitable place having been selected, a temporary laboratory is fitted up with the necessary appliances for collection and study. In this are placed from ten to twenty tables, each occupied by an investigator, either an officer of the Commission, or a volunteer. From 1878 to 1879, important aid was rendered by the Secretary of the Navy, who detailed for this service a steamer to be used in dredging and trawling, and this year the steamer built expressly for the Commission is employed in the same manner.*

* The number of dredging and trawling stations on record is as follows:

1871.	Wood's Holl	345
1872.	Eastport, 200 by hand, 35 by steamer	235
1873.	Portland	149
1874.	Noank	223
1875.	Wood's Holl	169
1877.	Salem	378
	Halifax	
1878.	Gloucester	
1879.	Provincetown	
	Total in round numbers	1,500

The number of seine hauls is about 600.

The regular routine of operations at a summer station includes all the various forms of activity known to naturalists—collecting along the shore, seining upon the beaches, setting traps for animals not otherwise to be obtained, and scraping with dredge and trawl the bottom of the sea, at depths as great as can be reached by a steamer in a trip of three days. In the laboratory are carried on the usual structural and systematic studies; the preparation of museum specimens and of reports. Since the organization of the Commission, the deep-sea work and the investigation of invertebrate animals has been under the charge of Professor Verrill, who had, for many years before the Commission was established, been studying independently the invertebrate fauna of New England.

In addition to what has been done at the summer station, more or less exhaustive investigations have been carried on by smaller parties on many parts of the coast and interior waters. The fauna of the Grand Banks, and other off-shore fishing grounds, has been partly explored. In 1872, 1873, and 1874 dredging was carried on from the Coast Survey steamer Bache, by Professor Packard and Mr. Cooke, Professor Smith, Mr. Harger, and Mr. Rathbun. In 1879 Mr. H. L. Osborn spent three months in a cod-schooner collecting material on the Grand Banks, and Mr. N. P. Scudder as long a time on the halibut grounds of Davis' Straits.

A most remarkable series of contributions have been received from the fishermen of Cape Ann. When the Fish Commission had its headquarters at Gloucester, in 1878, a general interest in the zoölogical work sprang up among the crews of the fishing vessels, and since that time they have been vying with each other in efforts to find new animals. Their activity has been stimulated by the publication of lists of their donations in the local papers, and the number of separate lots of specimens received, to the present time, exceeds eight hundred. Many of these lots are large, consisting of collecting-tanks full of alcoholic specimens. At least thirty fishing vessels now carry collecting-tanks on every trip, and many of the fishermen, with characteristic superstition, have the idea that it insures good luck to have a tank on board, and will not go to sea without one. The number of specimens acquired in this manner is at least fifty or sixty thousand, most of them belonging to species unattainable. Each halibut vessel sets, twice daily, lines from 10 to 14 miles in length, with hooks upon them 6 feet apart, in water 1,200 to 1,800 feet in depth, and the quantity of living forms brought up in this manner, and which had never hitherto been saved, is very astonishing. Over thirty species of fishes have thus been added to the fauna of North America, and Professor A. E. Verrill informs me that the number of new and extra limital forms thus placed upon the list of invertebrates cannot be less than fifty.

A permanent collector, Mr. Vinal N. Edwards, has been employed at Wood's Holl and vicinity since 1871, and many remarkable forms have also been discovered by him.

No dredging has yet been attempted by the Commission south of Long Island, though much has been done in shore work, especially among the fishes, by special agents and friends of the Commission, and by the parties stationed here and there in the work of fish-culture. Mr. E. G. Blackford, of Fulton Market, New York, by carefully watching the market slabs, has added at least ten species of fishes to the fauna of the United States. Mr. Fred. Mather is studying the fish of Long Island and the Sound. Dr. Yarrow, Mr. Earll, and others, have collected from Cape May to Key West. The Gulf States coast was explored last winter by a party conducted by Mr. Silas Stearns, who spent nine months in studying the food and the census. The entire Pacific coast has been scoured by Professor Jordan for the Commission and the census, and the ichthyology of that region has been enriched by the discovery of sixty species new to the fauna, forty of them being new to science. A similar investigation on the great lakes has been carried over a period of several years by Mr. J. W. Milner and Mr. L. Kumlien. The ichthyology of the rivers of the country has received much attention from the many experts employed by the Commission in fish-cultural work.

In addition to these local studies may be mentioned the general explorations such as are now being carried on, for the oyster by Mr. Ernest Ingersoll and Mr. John A. Ryder, for the shad by Colonel M. McDonald, for the smelt and the Atlantic salmon by Mr. C. G. Atkins, and the Quinnat salmon by Mr. Livingston Stone.

A partial indication of what has been accomplished may be found in the number of species added to the various faunal lists. Take, for instance, the cephalopod mollusks of New England. In Professor Verrill's recently published monographs, twenty species are mentioned, thirteen of which are new to science. Ten years ago only three were known.

I am indebted to Professor Verrill for the following estimate of the number of species added within the past ten years to the fauna of New England, mainly by the agency of the Commission:

	Formerly known.	Additions.	Now known
Crustacea	105	193	298
Pycnogonida	5	10	15
Annelida	67	238	805
Vermes	80	100	139
Mollusca	317	109	426
Echinodermata	47	41	88
Anthozoa	20	85	65
Tunicata	26	25	51
Polyzoa	56	91	147
Brachiopoda	5	0	5
Sponges	10	80	90
Acalephæ	102	78	180
Totals in round numbers	800	1,000	1,800

It is but just to say that many of these species were obtained by Professor Verrill in the course of his independent explorations in Maine and Connecticut previous to 1871.*

A similiar estimate for the fishes indicates the discovery of at least one hundred species on the eastern Atlantic coast within ten years; half of these are new to science. Forty species have been added to the fauna north of Cape Cod; sixteen of these are new and have been found within three years; seventeen have been described as new from the Gulf of Mexico; sixty and more have been added upon the western coast. The results of the summers' campaigns are worked in winter by the specialists of the National Museum, and under the direction of Professor Verrill, in New Haven.

One of the important features of the work is the preparation of life-histories of the useful marine animals of the country, and great quantities of material have been accumulated relating to almost every species. A portion of this has been published, more or less complete biographical monographs having been printed on the bluefish, the scup, the menhaden, the salmon, and the whitefish, and others are nearly ready.

Another monograph which may be referred to in this connection is that of Mr. Alexander Starbuck on the whale fishery, giving its history from the earliest settlement of North America.

The temperature of the water, in its relation to the movements of fish, has from the first received special attention. Observations are made regularly during the summer work, and at the various hatching stations. At the instance of the Commissioner, an extensive series of observations have for several years been made under the direction of the Chief Signal Officer of the Army, at light-houses, light-ships, life-saving and signal stations, carefully chosen, along the whole coast. This year thirty or more fishing schooners and steamers are carrying thermometers to record temperatures upon the fishing grounds, a journal of the movements of the fish being kept at the same time. One practical result of the study of these observations has been the demonstration of the cause of the failure of the menhaden fisheries on the coast of Maine in 1879—a failure on account of which nearly 2,000 persons were thrown out of employment.

Another important series of investigations carried on by Commander Beardsley, of the Navy, shows the error of the ordinary manner of using the Casella-Miller deep-sea thermometer; still another series, made by Dr. Kidder, of the Navy, and to be carried out in future, had for its object the determination of the temperature of the blood of marine animals.

Observations have also been made by Mr. Milner upon the influence

*A few days after the reading of this paper a new fauna was discovered about one hundred miles southeast of Newport, and several hundred numbers might now be added to this enumeration.

of a change from sea water into fresh water and from fresh water into sea water upon the young of different fishes.

Mr. H. J. Rice carried on a series of studies upon the effect of cold in retarding the development of incubating fish eggs.

A series of analyses have been made by Professor W. O. Atwater to determine the chemical composition and nutritive value of fish as compared with other articles of food. This investigation is still in progress.

In connection with the work of fish culture much attention has been paid to embryology. The breeding times and habits of nearly all of our fishes have been studied, and their relations to water temperatures. The embryological history of a number of species, such as the cod, shad, alewife, salmon, smelt, Spanish mackerel, striped bass, white perch, and the oyster, have been obtained under the auspices of the Commission by Messrs. Brooks, Ryder, Schæffer, Rice, and others.

The introduction of new species, in water in which they were previously unknown, is of special interest to the student of geographical distribution. Through the agency of the Commission, the German carp has already been placed in nearly every State and Territory, although the work of distribution has only just begun, and the tench (*Tinca vulgaris*) and the golden orfe (*Idus melanotus*) have been acclimated; the shad has been successfully planted in the Mississippi Valley and on the coast of California, and the California salmon in the rivers of the Atlantic slope. The maræna, or lake whitefish, of Europe, has been introduced into a lake of Wisconsin. It is not my purpose to speak of the great success in restocking with shad and salmon several rivers in which the supply was almost exhausted, and in planting the Schoodic salmon in numerous lakes. By an act of international courtesy, California salmon have been successfully introduced into New Zealand and Germany. The propagation work has increased in importance from year to year, as may be seen by the constant increase in the amount of the annual appropriation. A review of the results of the labors of the Commission, in increasing the food supply of the country, may be found in the annual reports; the rude appliances of fish culture in use ten years ago have given way to scientifically devised apparatus, by which millions of eggs are hatched where thousands were, and the demonstration of the possibility of stocking rivers and lakes to any desired extent has been greatly strengthened. This work was for six years most efficiently directed by the late Mr. James W. Milner, and is now in charge of Maj. T. B. Ferguson, also commissioner for the State of Maryland, by whom has been devised the machinery for propagation on a gigantic scale, by the aid of steam, which is now so successfully in use, revolutionizing the art of fish culture.

The investigation of the statistics and history of the fisheries has perhaps assumed greater proportions than was at first contemplated. One of the immediate causes of the establishment of the Commission was the dissension between the line and net fishermen of Southern New England with reference to laws for the protection of the deteriorating fisheries of that region. The first work of Professor Baird, as Commissioner, was to investigate the causes of this deterioration, and the report of that year's work includes much statistical material. In the same year a zoölogical and statistical survey of the great lakes was accomplished, and various circulars were sent out in contemplation of the preparation of monographic reports upon the special branches of the fisheries, some of which have already been published.

In 1877, the Commissioner and his staff were summoned to Halifax to serve as witnesses and experts before the Halifax Fishery Commission, then charged with the settlement of the amount of compensation to be paid by the United States for the privilege of participating in the fisheries of the Provinces. The information at that time available concerning the fisheries was found to be so slight and imperfect that a plan for systematic investigation of the subject was arranged and partially undertaken. The work was carried on for two seasons with some financial aid from the Department of State. In 1879 an arrangement was made with the Superintendent of the Tenth Census, who agreed to bear a part of the expense of carrying out the scheme in full. Some thirty trained experts are now engaged in the preparation of a statistical report on the present state and the past history of the fisheries of the United States. This will be finished next year, but the subject will hereafter be continued in monographs upon separate branches of the fisheries, such as the halibut fishery, the mackerel fishery, the shad fishery, the cod fishery, the herring fishery, the smelt fishery, and various others of less importance.

Hundreds, and even thousands, of specimens of a single species are often obtained. After those for the National Museum have been selected, a great number of duplicates remain. These are identified, labeled, and made into sets for exchange with other museums, and for distribution to schools and small museums. This is in accordance with the time-honored usage of the Smithsonian Institution, and is regarded as an important branch of the work. Several specialists are employed solely in making up these sets, and in gathering material required for their completion. Within three years fifty sets of fishes in alcohol, including at least ten thousand specimens, have been sent out, and fifty sets of invertebrates, embracing one hundred and seventy-five species and two hundred and fifty thousand specimens. One hundred smaller sets of representative forms intended for educational purposes, to be given to schools and academies, are now being prepared.

The arrangement of the invertebrate duplicates is in the charge of Mr. Richard Rathbun; of the fishes, in that of Dr. T. H. Bean.

Facilities have also been given to many institutions for making collections on their own behalf.

Six annual reports have been published, with an aggregate of 5,650 pages. These cover the period from 1871 to 1878. Many papers relating to the work have been published elsewhere—particularly descriptions of new species and results of special faunal exploration.

AN EPITOME OF THE HISTORY OF THE COMMISSION.

1871.

The Commissioner, with a party of zoölogists, established the first summer station at Wood's Holl, Mass., other assistants being engaged in a similar work at Cape Hatteras and the Great Lakes. He also personally investigated the alleged decrease of the fisheries in southern New England, taking the testimony of numerous witnesses.

1872.

This year the summer station was at Eastport, Me., particular attention being paid to the herring fisheries. The survey of the Great Lakes was continued. Dredging, under the direction of Professor Packard, was begun on the off-shore banks. At the instance of the American Fish-Cultural Association, Congress requested the Commissioner to take charge of the work of multiplying valuable food-fishes throughout the country. Work was begun on the shad, salmon, and whitefish, and the eggs of the European salmon were imported.

1873.

The summer headquarters were fixed at Portland, Me. The opportunities for research were greatly increased by the aid of the Secretary of the Navy, who granted the use of an eighty-ton steamer.

Explorations in the outer waters between Mount Desert and Cape Cod were carried on in the United States Coast Survey steamer Bache. Operations in fish culture were carried on upon an extensive scale.

1874—1875.

In 1874 the zoölogical work centered at Noank, Conn. The attempt was made to introduce shad into Europe. In 1875 the station was for a second time at Wood's Holl, where a permanent seaside laboratory, with aquaria, was now established. The number of investigations this year was about twenty. The increase in the propagation work was proportionately much larger.

1876.

This year the Commissioner was unable to take the fishes and useful invertebrates in behalf of the Commission field for fishery investigations, having been instructed to exhibit, in connection with the Philadelphia International Exhibition, the methods of fish culture and the American fisheries. Much, however, was accomplished by single investigators in various localities. The propagation work continued. This year the first carp were introduced from Germany.

1877.

The field of investigation was resumed at Salem, Mass., and later at Halifax, N. S. A larger steamer of 300 tons made deep-sea research possible. The Commissioner and his staff served as experts before the Halifax Fishery Commission. The propagating work was on the increase, and the government carp ponds were established in Washington.

1878—1879.

In 1878 the summer station was at Gloucester, Mass.; in 1879 at Provincetown. These centers of the fishing interests were selected that more attention might be devoted to studying the history, statistics, and methods of the sea fisheries; a plan for the systematic investigation which seemed yearly more necessary in view of the dissensions between the Governments of the United States and Great Britain. In 1879 a combination was formed with the Superintendent of the Tenth Census, by which the Commissioner was enabled to carry more rapidly forward this branch of the work. Specialists were dispatched to all parts of the country to study the biological, statistical, and practical aspects of the fisheries. In 1878 the breeding of cod and haddock was accomplished at Gloucester. In 1879 the propagation of the oyster was accomplished, by co-operation with the Maryland commission, under the direction of Major Ferguson, and the distribution of the carp throughout the country was begun.

1880.

The summer station is at Newport, R. I. The Fish Hawk, a steamer of 484 tons, constructed expressly for the work of the Commission, lies at the wharf, now equipped for scientific research, later to be employed in the propagation of sea fish such as the cod and the mackerel. Over fifty investigators are in the field in the service of the Commission. The season was opened by the participation of the commission in the International Exhibition at Berlin. The first-honor prize, the gift of the Emperor of Germany, was awarded to Professor Baird, not alone as an acknowledgment that the display of the United States was the most perfect and most imposing, but as a personal tribute to one who, in the words of the President of the Deutscher Fischerei Verein, is regarded in Europe as the first fishculturist in the world.

APPENDIX B.

DEEP-SEA RESEARCH.

III.—DESCRIPTION OF SOME OF THE APPARATUS USED BY THE UNITED STATES COMMISSION OF FISH AND FISHERIES IN DREDGING OFF THE NEW ENGLAND COAST.

By A. E. VERRILL.

[Prepared by request of Professor S. F. Baird, Commissioner of Fish and Fisheries.]

Since the organization of the United States Fish Commission, in 1871, dredging has been carried on extensively by it every summer, except that of 1876, in connection with the investigation of the marine fisheries. In addition to the ordinary form of the naturalists's dredge, which has, with minor modifications, been in constant use, several other forms of apparatus, some of them novel, have been used. The "beam-trawl" and "otter-trawl" have proved very efficient in this work, wherever the character of the bottom would admit of their use. By their use fishes in large numbers are always secured, and also very large quantities of crustacea, echinoderms, sponges, &c. For use on rough and stony bottoms, an improved form of "tangles," to be used without the dredge, was devised by the writer as early as 1871, and has done good service. In order to secure those creatures which burrow so deeply beneath the mud or sand as to be beyond the reach of the common dredge, which usually merely scrapes over the surface of the mud, or penetrates it but slightly, a "rake dredge" was constructed in 1871. This has proved very useful indeed for securing certain bivalve-shells, rare holothurians, and many annelids, &c., that might not have been obtained by the ordinary dredges. Owing to the enormous quantity of material brought up, especially by the trawls and rake-dredges, it became necessary to devise new forms of sieves, by means of which large quantities of mud or sand could be washed out rapidly, and the specimens properly cared for at once, without incumbering the deck. This necessity led to the invention of the "cradle sieve" in 1872, and subsequently, in 1878, of the large "table-sieve." The latter has proved to be one of the greatest improvements yet devised, giving great satisfaction to the officers and crew of the steamer, as well as to the naturalists, for it keeps a large proportion of the mud off the deck, and wonderfully facilitates the work of assorting and preserving a large haul of specimens.

Some other pieces of apparatus will also be mentioned below.

THE DREDGE.

Figure 1.

The common dredges used by the Fish Commission are mostly of two sizes. The larger size is the one ordinarily used on the steamer; the smaller one is intended for use with a sail-boat, especially if it has to be hauled in by hand. They differ only in size. An intermediate size has also been used to some extent. The rectangular frame has the side-pieces considerably flaring and moderately sharp. The net is of the stoutest twine procurable, with ¼ inch meshes, except toward the end, where the meshes are smaller. In many cases we have used the cylindrical form of net, the open lower end to be tied up when used. We have found the latter form most convenient for the large dredge. The net is protected by a bag of stout canvas, open at bottom, surrounding the net and extending somewhat beyond it. Whenever it has been found necessary to use any means to prevent the net from turning or twisting, a stout wooden stick lashed across the end of the net and canvas bag has proved sufficient. For weights, both for dredges and trawls, we have recently used a set made in 1877, of cast iron, each weighing about 40 pounds. They have the form of a cylinder flattened on one side and at each end, and with a hole in each end for lashings. The number needed will depend upon the strength of tide, drift of vessel, depth, &c., to be ascertained only by practice.

The following are the dimensions of the dredges now in use:

	Larger size.	Smaller size.
	Inches.	*Inches.*
Length of frame, outside	24	18.5
Breadth of frame, across front	8.75	8
Breadth of frame, across back	7.50	7
Length of arms	18	15
Diameter of arms	0.75	0.50
Diameter of end pieces of frame	0.75	0.60
Thickness of side pieces, at back	0.50	0.50
Width of side pieces	2.50	2
Size of holes for fastening net	0.36	0.36
Depth of net	36	27

The dredges and other iron instruments are painted with asphalt black, or, still better, coated ("galvanized") with zinc, to prevent rusting. One arm of the dredge is attached to the drag-rope (*d*) by a smaller rope (*e*), to diminish the danger of losing the dredge on rocky bottoms.

THE BEAM-TRAWL.

Figure 2.

The beam-trawls used by the Fish Commission have varied in size and somewhat in construction. Some have been made with a wooden beam, others have had a piece of large iron gas-pipe for a beam. The sizes most used have the beam 11, 15, and 18 feet in length, respectively. The wooden beam appears to be preferable to iron, and may be of ash or any other strong wood. The principal improvements made upon the original English pattern by us consist in making the runners considerably wider and higher, so as to admit larger specimens under the beam, and in making the "pockets" by putting in a separate piece of netting, instead of fastening the upper and lower sides together directly.

The largest size used by the Commission has the runners about 27 inches high, made of flat iron, about 3½ inches broad and ¾ of an inch thick; the beam is of hard wood, 18 feet long and about 6 inches in diameter; the net about 45 feet long. The net should be of very strong twine, the meshes about 2½ inches in the upper part, but not more than ¾ inch toward the end. It is open at the lower end, and must be tied up securely when used.

The rope for the "bridle" is about 4 inches in circumference. Those of smaller size have had the runners of relatively narrower and thinner iron, but it appears to be better to give increased weight to the runners, so that less weight will be required on the drag-rope. Moreover, the increased weight of the runners has a tendency to prevent the trawl from overturning in going down, an accident that occasionally happens where the currents are strong, or when the drag-rope is new and inclined to twist. The unusual breadth of the "shoe" of the runners is of advantage in preventing the runners from sinking too deeply into the mud. The leaded bottom line should recede in the middle 8 to 10 feet.

THE OTTER-TRAWL.

Figures 3, 4, 5.

The otter-trawls first used by the Fish Commission were imported from England, but those now in use were made in this country,* to order, after the English pattern.

The side pieces (*a*, *a*, Fig. 3) consist of pieces of thick hard-wood plank, bound all around with flat bar-iron, ½ inch thick. The rings (*d*, *e*, Fig. 4) to which the bridle-ropes are attached are of ¾-inch iron, and should be attached to the wooden side-pieces by strong ropes, arranged as shown in Fig. 4. The bridle-rope is 4 inches in circumference. The dimensions of the otter-trawl now in use are as follows:

Length of wooden side-pieces	35	inches.
Breadth of wooden side-pieces	24	"
Thickness of wooden side-pieces	2.5	"
Thickness of iron runners	0.5	"
Width of iron runners	2.5	"
Diameter of rings for bridle, inside	2.5	"
Length of ropes (*i*, *i*, Fig. 4)	12	"
Length of ropes (*o*, *o*, Fig. 4)	9	"
Length of ropes (*b*, *d*, Fig. 4)	24	"
Length of net	40	feet.
Breadth of net at mouth, when extended	30	"
Breadth of side-pieces of net	2½	"
Length of bridle-ropes, each half	84	"

The leaded rope (*d*, *d*, Fig. 3) should be longer than the upper rope (*c*, *c*), so as to recede considerably behind the latter when in use. The figure

* By the American Net and Twine Company, Boston, Mass.

is faulty in this respect. The rope (*c*, *c*) forming the upper side of the aperture of the net is provided with cork buoys, in order to keep the mouth of the net distended. The drag-rope is connected with the bridle by means of a stout swivel (*a*, Fig. 5) so as to allow the rope to twist without overturning the trawl.

THE RAKE-DREDGE.

Figure 6.

This instrument was devised in 1871 by the writer* for the special purpose of obtaining deep-burrowing species of bivalves, annelids, holothurians, crustacea, &c. It can be used only on muddy or sandy bottoms, and, of course, requires considerable force to draw it through compact mud or sand. In its original form, which is still in use, it consists of a strong A-shaped frame, made of flat bar-iron, and so bolted together that it can be folded up compactly when not in use, or for convenience in transportation. The rakes consist of two flat bars of iron, furnished with strong iron teeth (steel would, perhaps, be better) about a foot in length, with thin sharp edges and sharp point. The two rake-bars, when in use, are placed back to back and bolted to the ends of the side-pieces of the A-shaped frame. The cross-bar of the A projects beyond the side-pieces, and has a hole at each end, by which the arms of the dredge-frame are attached, so that the dredge follows the rake at a distance of about two feet. The net-frame for this instrument is made entirely of round iron, and as light as is consistent with the stiffness necessary to support the bagful of mud when being hoisted on deck. The length of the frame should be equal to or somewhat exceed that of the rake-bars. In the one now used by the Commission it was originally considerably larger, but owing to the too great weight of the load of mud it brought up it has been made smaller, so that it is now of about the same length as the rake-bars.

The net is similar to that of the common dredge, but deeper and with somewhat larger meshes, in order that a part of the mud may pass through more rapidly. The vast numbers of annelid tubes, often encountered in using the rake-dredge, frequently clog the net so as to prevent even the fine mud from passing through the meshes. As this form of dredge can only be used on smooth bottoms there is not so much need of a canvas protection as in the case of the common dredge, and we have often dispensed with it, but the net will doubtless last longer if protected with the canvas bag.

* Descriptions and figures (from drawings of Mr. J. H. Emerton, furnished by the Fish Commission) of the "rake-dredge," "wheel-tangles," "cradle-sieve," and other apparatus used by the Fish Commission were published in 1873, in the New York Tribune, by Mr. William C. Wyckoff. These were republished the same year in the Tribune Extra, No. 10, scientific series. They have also been described in several other articles. The writer also published a description of the rake-dredge, &c., in an article on "Deep-sea Dredging" in Johnson's Cyclopedia, Vol. I, 1875.

The dimensions of the rake-dredges of this pattern, used by the Fish Commission, are as follows:

	Inches.
Side-pieces of the A-shaped frame, length	30
Side-pieces of the A-shaped frame, width	2
Side-pieces of the A-shaped frame, thickness	7/8
Side-pieces of the A-shaped frame, hole for ring	3/4
Side-pieces of the A-shaped frame, hole for bolts	5/8
Cross-bar of the A-shaped frame, length	42
Cross-bar of the A-shaped frame, width	2½
Cross-bar of the A-shaped frame, thickness	3/8
Rake-bars (*d*), length	36
Rake-bars (*d*), width	2½
Rake-bars (*d*), thickness	3/8
Teeth of rake, length	8
Teeth of rake, width	1¼
Teeth of rake, thickness	3/8
Ring for drag-rope, diameter	3½
Ring for drag-rope, size of iron	5/8
Dredge-frame (*a*), length	38
Dredge-frame, breadth	7
Dredge-frame, length of arms	20
Dredge-frame, size of iron (round)	5/8
Depth of net (*b*)	48

These dimensions might be improved by making the teeth 10 inches long and at least one-half of an inch thick, if of soft iron, and they should have a forward curvature. The head, passing through the bar, should be square and about three-quarters of an inch thick. They might be fewer and farther apart without detriment, say, five teeth on a bar 3 feet long, leaving the spaces about 6 inches each. The use of steel, of low temper, would be better still. The round iron for the dredge-frame should be at least five-eighths of an inch in diameter for the size of net given.

During the present season another form of rake-dredge has been devised by Capt. H. C. Chester, of our party, and used with excellent success. In this the teeth are attached directly to the two sides of a strong and heavy rectangular iron frame, much like the frame of an ordinary dredge of large size. The teeth are curved well forward and about 10 inches long. The rake-frame is followed by a lighter net-frame, of the same size as in the one previously described.

THE TANGLES.

Figure 7.

The original form of tangles, constructed by the writer for the United States Fish Commission, in 1871, consisted of a bar of iron to which several small iron chains were attached, each about 14 feet in length.

Along these chains, at intervals of about three feet, the bundles of unraveled hemp rope were attached, as shown in the figure. The bar of iron carrying the chains was attached to the cross-bar of the A-shaped frame forming part of the rake-dredge, the rake-bars being removed. In 1873 a farther improvement was made by the writer. This consisted in supporting each end of the chain-bar in the center of a stout iron hoop or wheel, by bolting it to a central cross-bar, firmly bolted to the inner side of the wheel. The wheels are not intended to revolve, but merely to serve as runners and supports for the iron bar, in order to keep it off the bottom and diminish the chances of its getting caught among the rocks, as well as to keep it from breaking and destroying the specimens before the tangles themselves can touch them. An oval or elliptical form for these runners would answer the same purpose, but the circular form was adopted as the simplest, and perhaps the least liable to become caught among the rocks.

In practice we have found the tangle-frame hitherto used too light for use on the larger vessel now employed, for when rocks are encountered the chain-bar often comes up badly bent. In constructing new ones, I should recommend a round or square bar of iron at least twice as heavy as the one we have hitherto used. Our present size was first devised for use on a steam-launch. It was also used on the Blue Light, a tug of 80 tons, with good success. The chains proved to be unnecessarily long, and are now shortened. We have used tangles of this form with profit on the roughest cod-fishing ledges off the coast of Maine and Massachusetts, where the dredge could not be used with safety.

It is particularly useful in capturing star-fishes and sea-urchins, which frequent rocky bottoms. Several years ago the writer suggested the use of tangles of this or some similar form to capture star-fishes on oyster-beds, where they so often prove very destructive.

Dimensions of tangles.

	Present form.	Improved design.
Diameter of wheels outside	12 inches	14 inches.
Breadth of rim of wheels	2 inches	2½ inches.
Thickness of rim of wheels	½ inch	½ inch.
Width of cross-bar of wheels	2 inches	2½ inches.
Thickness of cross-bar of wheels	⅝ inch	¾ inch.
Length of chain-bar	48 inches	60 inches.
Width of chain-bar	2 inches	2½ inches.
Thickness of chain-bar	½ inch	1 inch.
Size of rings for drag-rope	3 inches	4 inches.
Size of iron of rings	⅝ inch	⅝ inch.
Size of iron of chains	¼ inch	⅜ inch.
Length of iron chains	10 feet	10 feet.
Length of hemp tangles	2.5 feet	3 feet.

The drag rope for the tangles should be very strong, to resist the frequent and sudden strains, when using them on rough bottoms.

TOWING-NETS.

Figure 8.

The rings of the towing-nets generally used by the Fish Commission are made of ¼-inch brass wire, with three loops of brass wire securely soldered to the ring, at equal intervals. Other modes of attaching the lines are equally good, and often used by us. The nets are usually made of rather open and strong "embroidery canvas." Sometimes, for special purposes, coarse Swiss muslin is used, when they are to be drawn by a row-boat. "Crinoline" is also suitable for these nets. The nets should be made deep and rather "full." We have not found any special advantage in attaching a bottle with its neck in the bottom of the net, as recommended by some writers. We have used several sizes of rings, varying from 8 to 14 inches in diameter. The smallest sizes can alone be used when a steamer or vessel has much headway.

THE CHECK-STOP.

Figure 9.

This arrangement was devised by Capt. L. A. Beardslee, for use on the "Blue Light," in 1873. Its purpose is to put the strain of the drag-rope (B) upon a weaker rope (C), which may be broken so easily, in case the dredge or trawl catches upon rocks, as not to cause damage to the apparatus, and at the same time to give sufficient warning to allow the slack of the drag-rope to be paid out before the headway of the vessel can be stopped. It has proved to be a very useful and simple expedient for these purposes. The figure shows the arrangement so well that no further description is necessary.

THE CRADLE-SIEVE.

Figures 10, 11.

This form of sieve was devised by the writer in 1872. It was so constructed as to afford the means of rapidly washing out the large quantities of mud often brought up by the dredge and rake-dredge, and at the same time to keep the mud and water off the deck as much as possible. It consists of two wooden end-pieces, in shape forming rather more than half a circle, united by two narrow, wooden, side-pieces set into the end pieces so as to leave a flush surface. The outside covering consists of two thicknesses of wire netting; the inner one with meshes of $\frac{1}{12}$ inch or less, the outer one of stout galvanized-iron wire, with ½-inch meshes. The outer netting is only to afford support and protection to the inner one. The outer netting is nailed to the edges of the wooden end-pieces, and to the side-pieces, and is farther secured by a strip of hoop-iron nailed over the edges all around. The inner lining of fine wire netting is tacked to the wooden ends and side-pieces, on the inside, so that it can easily be renewed when worn out. A strip of wood nailed across the bottom, from end to end, affords additional strength and protection from injury. Two stout iron straps fastened across each end-piece by strong screws, and terminating above the edge in rings, furnish the means of suspending this sieve against the side of the vessel, outside the rail. The mud is then placed in it, often filling it more than half full, and a gentle stream of water from the force-pump is turned upon it. In this way several bushels of mud may be washed out in a few minutes, with little trouble. Another sieve, with straight wooden sides about 6 or 8 inches high, just large enough to set partially into the frame of the cradle-sieve and rest upon wooden cleats provided for that purpose, has been sometimes used by us in connection with the cradle-sieve. Its bottom is made of strong, galvanized-wire netting, with meshes of ½ inch. It serves to separate the coarser specimens and stones from the smaller and more delicate species.

In our own work the table-sieve, described below, has, to a considerable extent, superseded the cradle-sieve. The latter is still used, however, when there is only a moderate quantity of mud, or when the table-sieve is already full of unassorted specimens.

Dimensions of cradle-sieve.

	Inches.
Length	36
Breadth	18
Depth	12
Width of side pieces	4
Thickness of side pieces and ends	1

During the past season a much larger cradle-sieve has been constructed, with an intermediate frame, covered with wire netting with ¼-inch meshes. The upper sieve has flaring sides, 1 foot wide, but the ends are upright.

THE TABLE-SIEVE.

Figures 12, 13.

This piece of apparatus is the result of several successive improvements. In fundamental principle, it is like the cradle-sieve, much enlarged and raised on legs; but the form is entirely different. The sieve foundation consists of a large, rectangular, wooden frame (O, Fig. 12), with wide side-pieces (made of inch boards) supported on stout legs, at a convenient height. The bottom of this frame consists of stout, galvanized-wire netting, with ½ or ¾ inch meshes. Below this is a funnel-shaped, stout, canvas bag (S), which terminates in a large canvas tube (*t*). This serves to conduct the waste water to the scuppers. A light frame of wood (B) is made to fit loosely inside of the main frame, and its under surface is covered with fine wire netting of $\frac{1}{12}$-inch meshes. This constitutes the real bottom of the sieve, the coarse netting below serving only as a support for it. It is fastened to a movable frame, so that it can be taken out and its contents emptied upon the assorting table. This also allows the wire netting to be more easily renewed when it becomes worn. The upper or coarse sieve (A) is made with wide, flaring or hopper-shaped, wooden sides, upon which, at about the middle, there are cleats (*c*, *c*) that rest upon the edges of the main frame. The bottom of the "hopper" is formed of strong galvanized-wire netting, of $\frac{3}{4}$-inch meshes (Fig. 13, *b*, *b*).

Dimensions of table-sieve.

	Inches.
Main frame, height to upper edge	30
Main frame, length	66
Main frame, breadth	38
Main frame, width of side pieces	11
Main frame, thickness of side pieces	1
Hopper frame, width of side-pieces	13
Hopper frame, length at bottom	56
Hopper frame, length at top	66
Hopper frame, breadth at bottom	27
Hopper frame, breadth at top	37

This form of sieve, in its primary form, was invented by Capt. H. C. Chester and the writer, in 1877, but it was soon afterwards much improved by the addition of the canvas bag and pipe beneath it, which were devised by Mr. J. A. Smith, the executive officer of the Speedwell.

The original use of this sieve was to receive the contents of the trawl, instead of emptying it on deck, as had been done previously, but its advantages were soon found to be so great that it has also been used for washing the contents of the dredges whenever the quantity of mud was considerable. The legs are made of unequal lengths to correspond with the curvature of the deck.

EXPLANATION OF THE FIGURES.

[All the figures are from drawings by Mr. J. H. Emerton.]

FIG. 1.—The common dredge: *a*, *a*, the iron frame; *b*, *b*, outline of the net; *c*, *c*, the canvas bag; *d*, the drag-rope; *e*, light rope for the attachment of one arm.

FIG. 2.—The beam-trawl: *a*, *a*, the beam to which the upper edge of the net is attached; *b*, *b*, the runners supporting the ends of the beam; *c*, *c*, the leaded line attached to lower edge of net; *d*, the net; *e*, *e*, "pockets" in the net to prevent the escape of fish.

FIG. 3.—The otter-trawl, showing the mouth of net and side pieces arranged for use: *a*, *a*, the wooden side-pieces attached to bridle-ropes *b*, *b*, by means of four short ropes *i*, *i* and *o*, *o*, of which the pair marked *o*, *o* are the shorter; *d*, *d*, the leaded bottom line; *c*, *c*, the top line of the dredge-mouth, with cork buoys (this should have been drawn shorter and less curved backward than the bottom line).

FIG. 4.—Wooden side-piece of the otter-trawl to show the arrangement of the ropes: *d*, *e*, rings for the attachment of the bridle; *c*, ring for the attachment of

the cork-line of the net; *b*, ring for the attachment of the leaded line; *a*, *a*, lower edge of the side-piece.

FIG. 5.—End of drag-rope (*d*) attached to bridle (*b*) of the otter-trawl by means of the swivel (*a*).

FIG. 6.—The rake-dredge: *a*, *a*, the dredge-frame; *b*, *b*, outline of net; *c*, *c*, canvas-bag to protect the net; *d*, the rake-bars.

FIG. 7.—The wheel-tangles: *a*, the iron cross bar; *b*, *b*, the circular runners, or wheels, supporting the cross-bar; *c*, *c*, *c*, the chains to which the hempen tangles are attached.

FIG. 8.—The towing-net, in use.

FIG. 9.—The check-stop: A, A, the davit; B, the drag-rope; C, the check-stop applied to the drag-rope; D, D, side of vessel.

FIG. 10.—The cradle-sieve, suspended outside the rail, as when in use.

FIG. 11.—The cradle-sieve, end view.

FIG. 12.—The table-sieve: A, the "hopper" removed; *c*, *c*, one of the cleats on which it rests; B, the inner frame carrying the fine sieve; C, the main frame; *s*, the canvas-bag, beneath; *t*, the canvas waste-pipe.

FIG. 13.—Section of table-sieve; *a*, *a*, the hopper in position; *b*, *b*, the coarse sieve at bottom of hopper; *c*, *c*, the sides of main frame; *d*, *d*, the fine sieve; *e*, *e*, coarse wire netting on main frame; *s*, *s*, canvas bag; *t*, *t*, waste-pipe; *l*, *l*, legs of sieve.

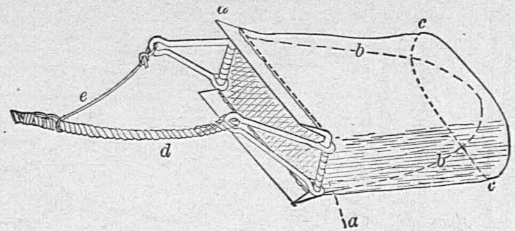

FIG. 1.—The Common dredge.

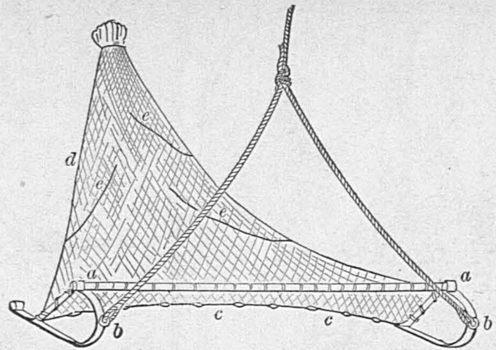

FIG. 2.—The Beam-trawl.

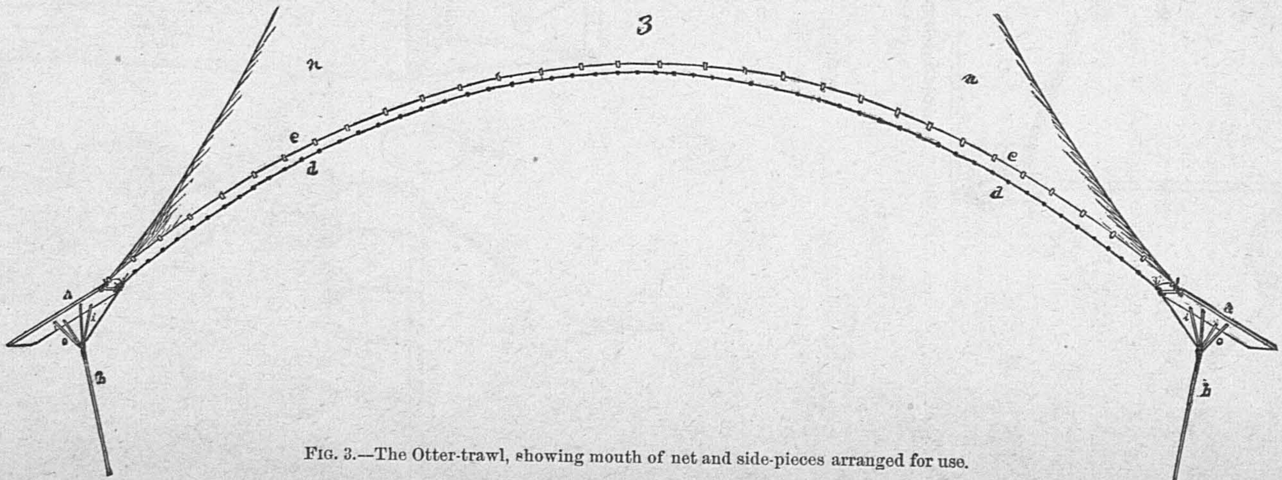

FIG. 3.—The Otter-trawl, showing mouth of net and side-pieces arranged for use.

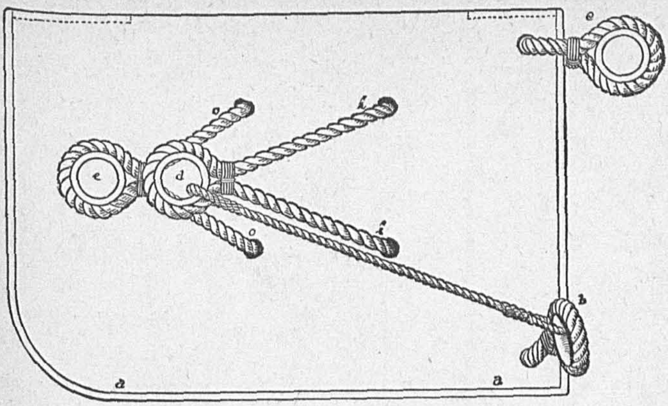

FIG. 4.—Wooden Side-piece of the otter-trawl.

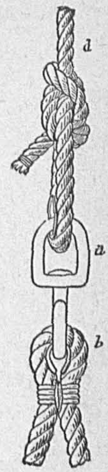

FIG. 5.—End of drag-rope.

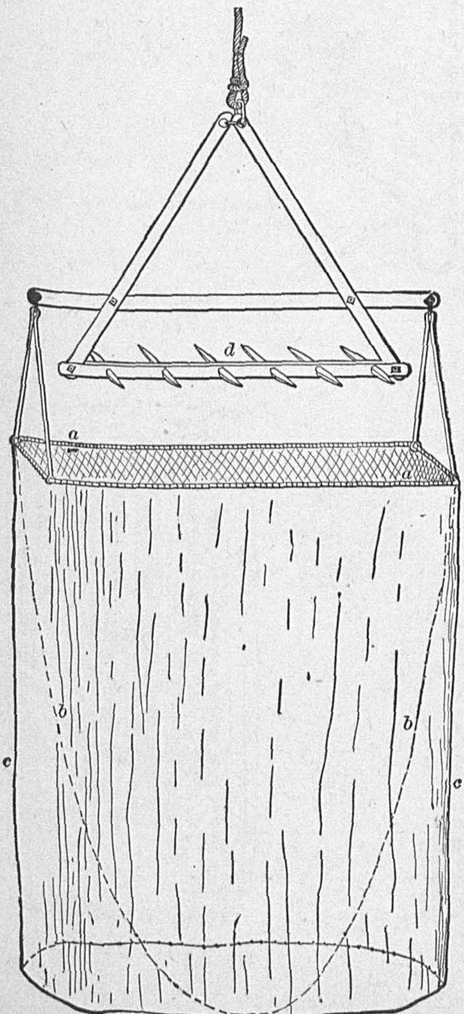

FIG. 6.—The Rake-dredge.

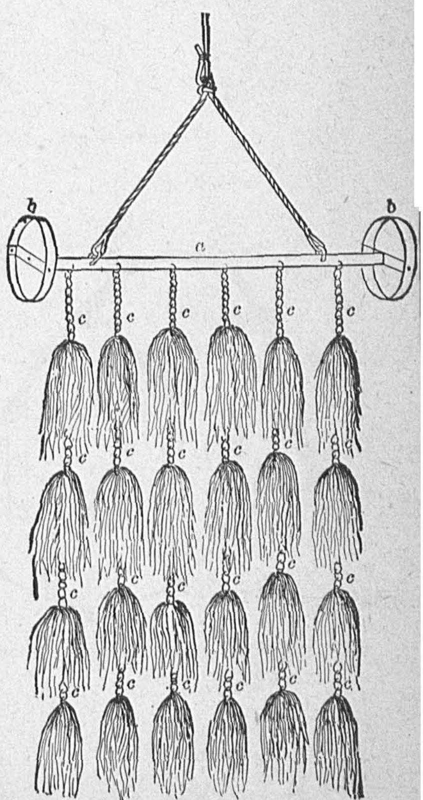

FIG. 7.—The Wheel-tangles.

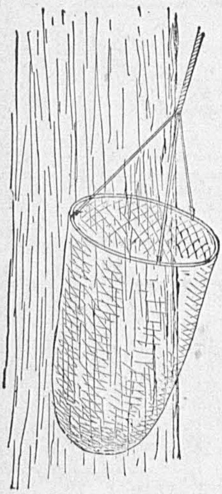

FIG. 8.—The Towing-net in use.

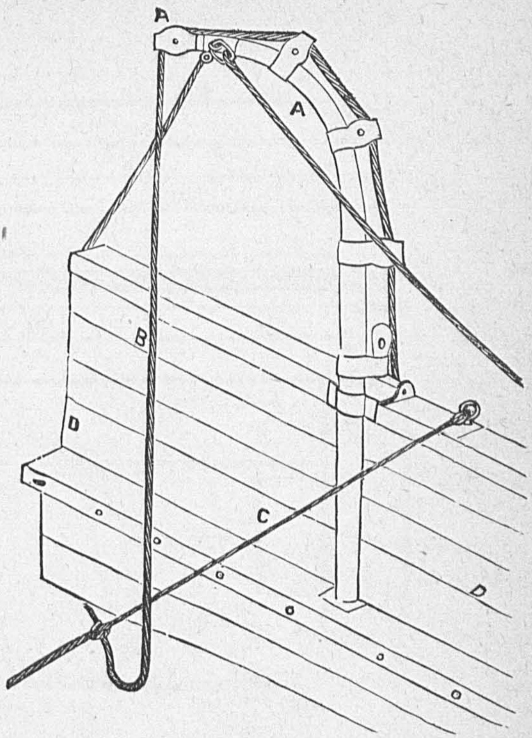

FIG. 9.—The Check-stop.

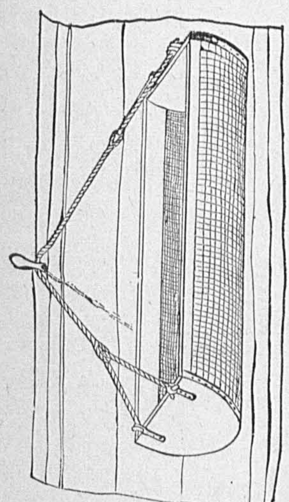

FIG. 10.—The Cradle-sieve.

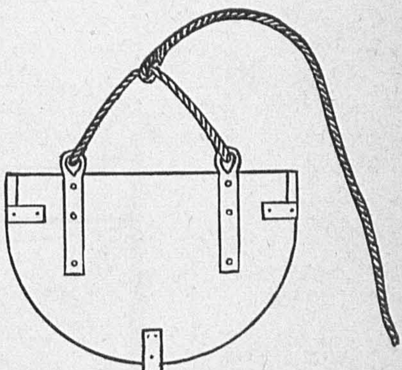

FIG. 11.—The Cradle-sieve, end view.

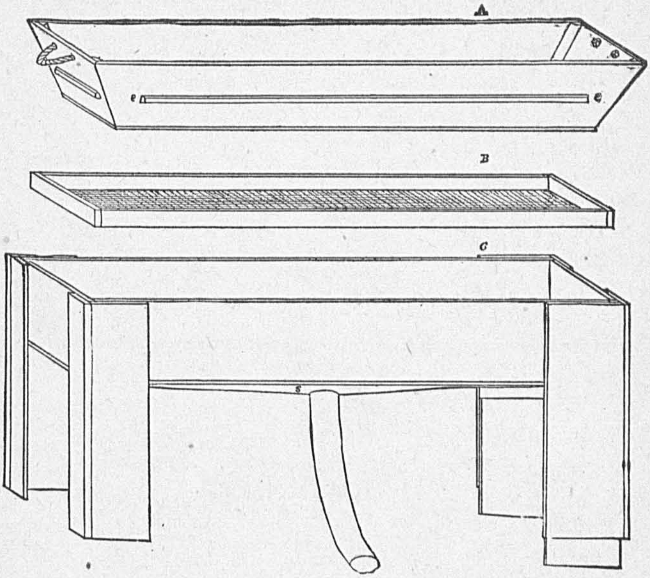

FIG. 12.—The Table-sieve with hopper removed.

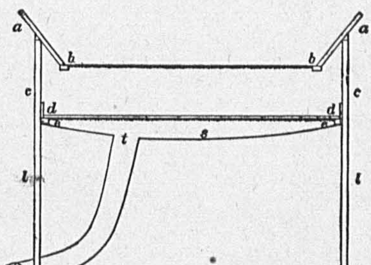

FIG. 13.—The Table-sieve, sectional view.

APPENDIX C.

THE SEA FISHERIES.

IV.—THE ICELAND FISHERIES.[1]

By C. TROLLE, *First Lieutenant, Danish Navy.*

[From Nordisk Tidsskrift for Fiskeri, vol. vii, part 3, Copenhagen, 1882.]

During my visit to Iceland, in 1880, with the schooner Ingolf, my attention was directed to the rich fisheries carried on by foreigners in Iceland waters, and to the comparatively small benefit which the country itself derived from the wealth of the sea. In order to draw the attention of the government to this unnatural state of affairs, I prepared a report on the herring fisheries carried on in the eastern fiords of Iceland by Norwegians, which I had occasion to observe in person. In consequence of this report the ministry for Iceland (in December, 1880) commissioned me to investigate the Iceland fisheries and gather such information regarding them as might be of importance for their future development, and also to make suggestions as to the best way of furthering the interests of these fisheries.

After having obtained a leave of absence for this purpose, I bought and fitted out a yacht of 88 tons during the present year, and with this vessel participated in the Iceland fisheries, in which way I gained a practical knowledge of their condition.

At the request of many ship-owners in this country (Denmark) I publish the results of my investigations, in view of the possible participation in the Iceland fisheries by Danish vessels, and also for the purpose of comparing the Iceland fisheries with our North Sea fisheries, which latter might yield much larger profits than they do at present.

A glance at the map shows us that the location of Iceland between extensive banks in the Northern Atlantic (which is famous for its wealth of fish), with its long line of coast and its numerous well-protected fiords, indicates the fisheries as the most natural source of income to this island. Foreign nations have known how to derive profit from the wealth of fish on the Iceland banks, but unfortunately this knowledge is confined to foreigners. Whilst English, French, Norwegian, and German vessels visit Iceland in large numbers, the Icelanders keep up the old boat-method; excepting, perhaps, a few merchant vessels in the western fiords employed in the fisheries for a few months during summer whilst waiting for cargo. The Iceland bank fisheries only yield profit to Danes and Icelanders in very few cases.

[1] Fiskerierne ved Island. Translated from the Danish by HERMAN JACOBSON.

And still we enjoy this great advantage over foreigners, that we can deposit and prepare the fish in Iceland and furnish a much more valuable and durable article than foreigners, who, moreover, have to travel about 250 (Danish) miles before they reach the fishing station. The reason why the Icelanders, who are by nature directed towards the sea as their principal source of income, are not benefited thereby as they might be, is the circumstance that they are not able to procure larger sea-going vessels. These are, as will be seen from the following, an essential condition, if the Iceland fisheries are to flourish; and when it becomes known what great advantages would accrue to the country from such vessels, it is to be hoped that the government will carry out my proposition and help the Icelanders by advancing a sum of money without charging interest, and thus relieve the lack of capital which makes itself painfully felt. It cannot be wondered at that such a lack of capital exists, if we bear in mind the fact that for centuries Iceland has labored under the most unfavorable financial conditions. It is impossible to overcome the baneful influences of monopolies and protection in a few short years.

It is very strange, however, that Danish capital has not long since been invested in so profitable an undertaking as the Iceland bank fisheries. Here is a vast field, which unfortunately has been allowed to lie fallow too long, and which ought to be reclaimed as soon as practicable.

I know full well that Danish merchant vessels have from time to time attempted codfishing in the Iceland waters, and that the result has been, that these fisheries "barely pay expenses." But these vessels *have carried cargo both going and coming.* The cargo has been the main object, and the fisheries only a matter of secondary importance, since only about six weeks can be devoted to them from the time the cargo is unloaded until a new cargo is taken. It is self-evident that it will not pay to fit out a vessel for fishing for so short a period, and, moreover, go to the expense of buying provisions and salt in Iceland. That the fisheries *will* pay, when made the principal object, I have found out this year, when I undertook my expedition without any regard to cargo. This does not imply, however, that it does not pay to take cargo, if only about five months—say from May to September, inclusive—can be entirely devoted to the fisheries.

I shall now speak separately of the two principal fisheries which are carried on near Iceland, viz, the cod fisheries and the herring fisheries. The reason why I shall not devote any time to other fisheries is simply this, that I have not, during this year, made any observations regarding them, and, moreover, none of them are of very great importance.

1.—The cod fisheries.

These fisheries are the principal source of revenue to the Icelanders. To show how little use is made of this source of income, owing to the fact that only open boats and very imperfect apparatus is employed, I shall quote a portion of the report on fisheries in the district of *Myra* and *Bargarfiorda*, made by the governor of said district, and then compare this report with the result of my expedition, taking into consideration the circumstances that this expedition was my first attempt in this direction, and would therefore not, in all probability, be accompanied by as favorable results as might be looked for from a second attempt.

The governor says in his report:

"The only place in this district where the fisheries may be said to form the principal source of income of the inhabitants is *Akranes* the outer point of which, the *Akraneslage*, stretches far out into the *Fase Bay*. The following remarks will, therefore, apply exclusively to that locality.

"As a general rule the fishing season at *Akranes* commences about March 1, and is divided into three periods, according to the seasons of the year, the first period comprising the winter fisheries, March 1–May 12, the second the spring fisheries, May 12–June 24, and the third the autumn fisheries, November 1–December 23. This division of the fisheries entirely agrees with that of the neighboring districts of *Kjösar* and *Gullbruiga*; it has probably been known for many years, and is also given in the Iceland Almanac.

"From the information which I have been able to gather, the following vessels were last winter engaged in the *Akranes* winter fisheries: 5 boats with 8 oars (7 to 9 men); 22 boats with 6 oars (5 to 7 men); 10 boats with 4 oars (4 to 5 men). After the 21st of April, 50 boats, with 2 to 3 men each.

"It may safely be assumed that the *Akranes* winter fisheries have, on the whole, employed about 350 men, and the spring fisheries 400 men. About half this number belonged to *Akranes*, whilst the other half came from the neighboring inland districts, as the farmers are in the habit of sending some of their farm hands to the coast during winter and spring. With the beginning of the spring fisheries (May 12) the use of the large boats with 8 oars ceases, whilst the other boats, with 4 to six oars, continue to be used, and the number of small boats (with 2 to 3 men each) is somewhat increased. All the boats, both large and small, belong to *Akranes*. Larger vessels have not been used, the fisheries being carried on entirely with the above-mentioned open boats, which have neither name nor number.

"The number of fish of all kinds caught by the *Akranes* fishermen during last winter's and spring's fishing season amounted to 250,000, valued at about 50,000 crowns ($13,400).

"Every time the boats come on shore, the fish are immediately divided among the crews of the different boats in the following manner: in boats with 8, 6, or 4 oars the owner receives two shares to every share given to each of the crew, whilst in the small boats the owner's share is equal to that received by each one of the crew. At *Akranes* it is the rule that each person prepares the fish which fall to his share. This preparation generally consists in cleaning and salting the fish and bringing them to market as "*Klip-Fisk.*" The smaller portion of the fish caught are prepared as "flat fish" and are sold for home consumption. Of all the fish caught at *Akranes* two-thirds are sold to *Akranes* merchants and one-third to *Reykjavik* merchants.

"In two other places in this district (*Alptanes* and *Hraunhreppar*) fisheries are carried on in spring, but not to any great extent, as they only form a leisure occupation of the inhabitants, who are principally engaged in sheep-raising and in agricultural pursuits; and I have consequently not deemed these fisheries important enough to make a report on them.

"I must, in conclusion, express my conviction, which is shared by all persons acquainted with the condition of our country, that the manner in which the Iceland fisheries have been carried on for a long time (and are still carried on) needs a radical reform, and that, therefore, it would be desirable to take the necessary steps for bringing about this much needed change as soon as possible."

As regards my own expedition I have to report as follows: After having fitted out my vessel, I left Copenhagen on the 8th April without a cargo; the crew (including myself) numbered six persons. Reached the *Færö Islands* April 14, and remained there till April 21; hired ten Færö fishermen. The reason why I staid so long at the *Færö Islands* was, that the fishermen of these islands, who only use English cutters in their bank fisheries, did not have much confidence in the sea-going capacity of my vessel, at least as far as its use for the fisheries was concerned. Instead of engaging these fishermen on the share plan, which is by far the best, as it makes them take some interest in their work, and as it does not necessitate the constant and wearisome superintendence of the owner, I was obliged to have them on the following conditions:

During the hand-line fisheries: 15 crowns ($4.02) per month; 6 crowns ($1.60) per 100 standard cod (upwards of 2 feet in length); 1½ crowns ($0.40) per 100 cod below the standard length (16 to 22 inches).

During the long-line fisheries: One-third of the total yield, divided among the whole crew.

In both cases the fishermen are found.

The fears entertained by the *Færö* fishermen were not well founded, as my vessel did just as well as the French fishing schooners, although not quite as well as the English cutters, which are narrow and pointed.

My Danish men were paid in the manner customary in Denmark, and received, moreover, 2 crowns ($0.53) for every 100 standard cod, and 1 crown ($0.26) for every 100 cod below the standard size. During the long-line fisheries, however, they preferred to work on the share plan.

Touched *Cape Reykjanæs* on the morning of April 27, and cast anchor on the banks off *Cape Skagen* during the forenoon of the same day.

From April 27 to July 1 we fished with hand-lines along the *Vester-*

and *Nordland* coast. The weather, especially during May, was very stormy and unfavorable, so that the fisheries were frequently interrupted.

From May 28 to May 31, staid in the *Isa Fiord*, where we laid up the first batch of fish, to be prepared as "*klip-fish*." Continued hand-line fishing till June 26. June 26 and 27, staid in the *Ömundar Fiord*, and June 28 to 30, the second batch of fish was laid up at *Isa Fiord*, where we had made an arrangement with a merchant to prepare our fish.

Left July 1, and went, in a northerly direction, to *Österlandet* to engage in the long-line fisheries, which are here carried on by a number of *Færö* fishermen. Fished on the way whenever there was a calm. Reached *Reyder Fiord* July 15, and commenced long-line fishing the same day.

In order to avoid any misunderstanding, it must be stated that boat-fishing from a ship, as the central station, cannot be compared with the Icelander's boat-fisheries from the shore.

From July 15 to September 20 we fished with long lines in the mouth of the *Reyder Fiord*. Left Iceland September 24, touched at the *Færö Islands* September 30, staid there till October 7, and arrived in Copenhagen October 14. The total result of our five months' fisheries was about 52,000 codfish, which were sold, either salted or prepared in other ways, for 11,700 crowns ($3,135.60). This year we only salted codfish, and did not prepare any other fish. The net revenue from our expedition was about 2,500 crowns ($670), and as my vessel represented a capital of about 10,000 crowns ($2,680), this would be about 25 per cent. on the capital invested; subtracting 10 per cent. for amortization, this would leave a net surplus of 15 per cent. for the first year; and this, in spite of the circumstances that the sailing of our vessel was considerably delayed by the exceptionally severe winter, that she took no cargo, and that the fishermen had been engaged under peculiarly unfavorable conditions.

By way of comparison, I will mention that a schooner from *Isa Fiord* with a crew of 18 men realized a net surplus of over 3,000 crowns ($804) during fisheries which only extended over a period of 2½ months.

The individual earnings of each man on my vessel averaged 50 crowns ($13.40) per month. If we compare the result of my expedition with the above-mentioned report from *Akranes*, it will be seen that 350 men in 2½ months, 400 men in 1½ months, or, which would be the same, 400 men in 3½ months, have during the present year, with 87 boats, only caught 250,000 fish of all kinds, with a total value of 50,000 crowns ($13,400).

The total income of every participant (not counting off the repairing, &c., of boats and apparatus) would, therefore, only be about 35 crowns ($9.38) per month, without board and lodging, whilst on my vessel every man on an average earned 50 crowns ($13.40) per month, besides being found.

If, however, we distribute the above-mentioned 400 men over 26 sea-going vessels with a crew of 15 men each, and two such vessels with a crew of 10 each, these would during the same time, *i. e.*, 3½ months, have caught: 26 vessels with 15 men, in 3½ months, 946,400 fish; 2 vessels with 10 men, in 3½ months, 24,500 fish—total, 970,900 fish, representing a value of 218,400 crowns ($58,531.20); in other words, all the conditions being equal, the result of the fisheries is four times as large when larger sea-going vessels are employed than with open boats, and the pecuniary result is over 4½ times as large.

No more convincing proof could be furnished of the superiority of larger sea-going vessels for deep-sea fisheries, over open boats; but there are still other circumstances which speak strongly in favor of larger sea-going vessels:

1. The Icelanders lose a great deal of time by being obliged to row several miles before reaching their fishing stations, and then having to row home again the same distance, whilst larger vessels can stay on the fishing banks for months.

2. Storms and waves often interrupt the fisheries, not to speak of the great danger to which open boats are exposed on the high sea, where a sudden storm may often compel the fishermen to cast nearly all the fish they have caught overboard in order to save their lives. On a sea-going vessel, however, the fisheries are not exposed to as many dangers. Regular rest, strengthening food and dry clothes, make the fishermen better fitted for work, than sleepless nights, poor food (or none at all), and wet clothes, such as fall to the share of the open-boat fishermen.

3. The fish can be much better prepared on larger vessels, where they are immediately killed, cleaned, and salted, and can thus be made into a much more valuable article than is possible in the open boats. The Icelanders never kill their fish in their boats; but often let them lie for one or several days, so that the blood coagulates, the fish turn dark in the brine, become less durable, and of course much less valuable. The best and fattest fish, moreover, are found far away from the coast, and every one, acquainted with the herring fisheries, knows that the so-called "yacht-fish" fetch a much higher price than "boat-fish."

It is not necessary to give further reasons against the use of open boats for deep-sea fishing, *i. e.*, when the boats are stationed near the shore. The comparisons given above will be amply sufficient to prove this: That the result of the fisheries, all other things being even, is four times as large when sea-going vessels are employed as with open boats. The former have, moreover, the great advantage, that with them fishing can be carried on all the year round, whenever the weather permits, as the schools can be followed up when they leave the coast.

The above-mentioned 400 men from *Akranes* and *Opland* would, *e. g.*, in seven months' great fisheries and two months' boat fisheries, reach the following results:

	Fish.
26 sea-going vessels, at 15 men (March 1 to October 1)	1,892,800
1 sea-going vessel with 10 men (March 1 to October 1)	49,000
87 boats (4 to 5 men each), November 1 to December 1	130,000
Total	2,071,800

valued at 470,000 crowns ($125,960), whilst the same number of men, in 5½ months' boat fisheries would only catch about 400,000 fish, valued at 83,000 crowns ($22,244), therefore not one-fifth of the revenue they might earn, if they used sea-going vessels.

In comparing the exportation of fish from Iceland during the last year, which was a good fish year, with the average yield of the cod fisheries carried on in Iceland waters by Frenchmen, it will become still more apparent that the Icelanders do not utilize this great source of revenue near as much as they might do.

According to the official reports, France annually sends about 230 vessels, most of them schooners and luggers of 100 tons burthen each, to engage in the Iceland fisheries. The crews number 400 in all, or on an average 17 men per vessel. The fisheries are generally carried on from March to September all round the island, beginning on the southern and western banks and finishing the season on the eastern banks. The annual yield amounts to about 12,500 tons or 25,000,000 pounds, representing in France a capital of about 5,500,000 crowns ($1,474,000), or 24,000 crowns ($6,432) per vessel.

The exportation of fish from Iceland during 1880 was as follows:

	Pounds.
To Spain	8,238,000
To Denmark	4,758,000
To England	2,920,000
Total	15,916,000

Calculating the home consumption at 6,400,000 pounds, Iceland's share of the cod fisheries in 1880 would be 22,316,000 pounds, representing a value of 3,500,000 crowns ($938,000), *i. e.*, 2,684,000 pounds less than the average yield of the French cod fisheries near Iceland. The small town of *Dunkirk* in France, which every year sends 105 fishing-vessels to Iceland, receives as many fish from the Iceland banks as the total amount of fish exported in 1878, viz, about 11,800,000 pounds.

If sea-going vessels were introduced by the Icelanders, matters would soon be changed, and the yield of their fisheries would be five times as large. Supposing that this development of the fisheries extended over the entire island, Iceland would be enabled to export six times as many fish as she does now, provided that the home consumption remained the same.

The yield of the fisheries would be five times as large: Therefore 5 × 22,316,000 pounds, 111,580,000 pounds; subtract home consumption, 6,400,000 pounds, would leave for exportation 105,180,000 pounds, whilst in 1880 the exportation only amounted to 15,916,000 pounds.

Taking the average price of fish, the quantity exported would represent the comfortable capital of about 16,000,000 crowns ($4,288,300), or about the same as Denmark's exportation of agricultural products in 1879.

Just as Denmark is intended by nature for an agricultural country, so is Iceland to be a fishery country; and the sea is to be the vast field where she can reap rich harvests even without sowing.

It need hardly be pointed out how much the financial condition of Iceland would be improved by such a development of the fisheries, and what indirect advantages would therefrom accrue to Denmark. We have in Denmark hundreds of vessels which are well adapted to the Iceland bank fisheries, and which might in these fisheries make more money than by the carrying trade, in which they will be thrown more and more into the shade by steamships.

2.—THE HERRING FISHERIES.

These have never been a great source of revenue to the Icelanders. Herring have been caught, in stationary nets, for bait and for daily use in the household, but as far as known they have never been prepared as an article of trade. This is partly owing to the circumstance that a rational method of fishing, which is an essential condition of the development of fisheries into a profitable industry, is unknown in Iceland, and partly to the lack of capital.

The attention of the Norwegians has meanwhile been drawn to the large schools of herring which visit the Iceland waters, and which, at certain seasons of the year, enter the fiords. During the last few years Norwegian fishermen have derived an income from a source which ought to have enriched Iceland.

The first expeditions were sent out from *Mandal* in Norway to *Seydis Fiord* in Iceland, in 1868.

The very imperfect method of fishing, however, in connection with a certain lack of energy shown by the persons participating in this expedition, caused the results to be less than they might otherwise have been. I shall briefly describe the method employed:

By means of heavy nets with narrow meshes the schools of herring are surrounded when they go into the fiords in autumn. These nets are from 50 to 150 fathoms long, 14 to 17 fathoms deep, and have generally 114 meshes to the fathom. Along the buoy-line, pieces of cork, each 8 inches long, are fastened every yard; whilst along the foot-line there is a stone of 6 pounds' weight to every fathom. Such a net is worked by about 16 men, 2 large boats in which the nets are piled up, and 5 to 6 small boats, 2 of which are furnished with a small capstan.

The foreman or "boss," supplied with a sounding-line and a telescope, generally rows out into the fiord every afternoon, accompanied by the net-boat and 4 small boats. Whenever he has discovered a school of herring (either by means of the sounding-line, which is let down till within a few feet from the bottom, so that he can *feel* the school when it pushes against the line; or by means of the telescope; or, finally, by seeing the commotion caused near the surface by the herring) he gives a sign to the net-boat to indicate in what direction the net is to be set so as to inclose the herring. One of the boats with a capstan takes the rope of the net, rows quickly towards the shore, casts anchor, joins the rope to the capstan, and commences to haul in the net; the net-boat meanwhile surrounds the school in a semi-circle, as far as the net will stretch, then rows towards the shore with the other rope and acts in the same manner as the capstan-boat. In order to hold up the buoy-line more floats are attached to it, and when both ends of the net are close to the shore the herring are surrounded without any hope of escape.

It is evident, however, that this method of catching fish depends altogether too much on accidental circumstances to give a safe and in any way calculable result. The proper home of the herring is the sea, and only every now and then do they go into shallow water for the purpose of spawning. The spawning process, however, may also go on in the deep sea, but only in exceptional cases when the temperature of the water in the fiords is too low.

The first condition for the Norwegian to catch herring is, therefore, that the herring come near the coast; secondly, that his attention is drawn to them, *i. e.*, that he either feels or sees them before the net is cast. Both these indications may mislead; and, although the Norwegians have of late years furnished the proof that by the above-mentioned method of catching fish the capital invested may be doubled, I would not advise any one but a capitalist to follow this method, for under unfavorable circumstances one may have to wait for years until the money invested pays any interest.

A much more rational method of fishing is that pursued by the Dutch and Scotch, viz, the drag-net method, as thereby one makes himself independent of the migrations of the herring and follows them to their home—the sea. With good sea-going vessels, cutters and luggers, the Dutch and Scotch fishermen go over a vast extent of sea with their drag-nets.

The Norwegian Association for the Advancement of the Fisheries has become fully convinced of the great importance of the drag-net method, and has sent Norwegian fishermen to the Netherlands and to Scotland to become acquainted with their methods of fishing.

To return to the Iceland herring fisheries in their present condition, I will quote the following from the official report of the Bergen Board of Trade:

"Three expeditions left Bergen for Iceland in 1880, one with two nets, fitted out by Mr. I. E. Lemhkuhl, one by the Bergen-Mandal Company, with one net, and one by a joint-stock company in Bergen, with one net.

"The first-mentioned expedition comprised one vessel of about 950 tons burden, with a crew of 16 men, which sailed for Iceland in the beginning of June, with materials for erecting a large salting-house; five nets with everything belonging to them; a large net-boat, and several small boats. Soon after the first vessel another one sailed taking out about 2,000 tons salt, one large net-boat, and other materials. In July these vessels were followed by a steamer and a yacht, with a crew of 12 men, both vessels carrying a cargo consisting of kegs, salt, &c.; three nets, boats, &c. Later during the season the steamer plied regularly between Iceland and Bergen, continuing her trips till the end of October, whilst the two sailing-vessels staid in Iceland, where they were were used as lodging-vessels, until the fishermen returned from the fisheries in November. The crews of these vessels, 28 men in all, had to do every kind of work, and act as sailors, fishermen, salters, carpenters, wheelwrights, &c. The captain and the foreman of the fisheries and of the salting, received respectively 48, 56, and 64 crowns ($12.86, $15 and $17.15) a month, and the rest of the men 20 to 24 crowns ($5.36 to $6.43); all of them were found. Besides this, every man received for every ton of herring shipped from Iceland to Bergen 1 öre (a little more than ¼ cent) additional on every four crowns of their monthly wages; the foremen thus got 12, 14, and 15 öre, and the rest of the men 5 to 6 öre additional on every ton of herring. The entire quantity of herring caught by this expedition was 5,952 tons.

"The Bergen-Mandal expedition comprised two vessels with 18 men, and was furnished with building materials, 5 nets, 2 large net-boats. This expedition was managed in exactly the same manner as the one described above. It also employed a steamer to carry the fish (9,500 tons) to Norway.

"The Southern Bergen expedition comprised two large vessels of 1,700 to 1,800 tons each, 20 men, 1 net, 2 net-boats, &c., but did not carry any material for erecting buildings. The nets and net-boats were not owned by the same parties as the vessels, but there was an agreement between them, that all the fish caught should be taken by the vessels at 8 crowns ($2.14) per standard ton, half of which was to go to the owners of the nets and the other half to the men, to be evenly divided among them. The crews of the vessels received in addition 8 crowns ($2.14) per month, and had to find themselves.

"This expedition, which caught about 4,500 tons of herring, took all its apparatus, boats, &c., back to Norway, partly in their own and partly in hired vessels, whilst the other expeditions left their boats in Iceland till the next year."

If we calculate the cost of fitting out an expedition of this kind at 20,000 crowns ($5,300), and the average yield in 1880 at 4,000 tons per expedition, we find that, counting the ton at 20 crowns ($5.36), the net result must have been at least 40,000 crowns ($10,600), *i. e.*, 200 per cent.

A joint-stock company which commenced work last year with a capital of 20,000 crowns ($5,300) made 125 per cent. Every share of 1,000 crowns ($268) paid 1,250 crowns. Of the 20 shares 10 were taken in Norway and 10 in Iceland.

The total quantity of herring caught by the Norwegians near Iceland in 1880 is estimated at 100,000 tons, valued at 2,000,000 crowns ($536,000).

By directing the attention of my countrymen to the above facts, I hope to stir them up a little to take a more active interest in the deep-sea fisheries, as a large portion of our merchant marine might be much more profitably engaged in the fisheries than in the carrying trade. It would doubtless be advantageous if in that case 5 to 10 ship-owners would form a sort of joint-stock company, as various advantages could thereby be secured, especially with regard to the sale of the products of the fisheries. Considering the difficulties involved in the carrying out of such an undertaking, I have proposed to the government to appoint an officer in the capacity of official adviser who could give all the advice needed.

In conclusion, I would ask our North Sea fishermen to seriously consider if the introduction into their fisheries of larger sea-going vessels would not prove as much of a benefit to them as to the Icelanders Open boats for deep-sea fisheries will hardly answer the purpose anywhere, and if the proposed harbor should be established on the west coast of Jutland there would be a very strong inducement to derive as much benefit from our deep-sea fisheries as other nations from theirs; as they certainly are, when carried on in the proper manner, a rich source of revenue and consequent national prosperity.

V.—THE BOHUS-LÄN SEA FISHERIES AND THEIR FUTURE.

By Axel Vilhelm Ljungman.

[From "*Aftonbladet*," Nos. 6 and 43, January 9 and February 21, 1882.]*

Bohus-län doubtless occupies the front rank among all the Swedish provinces, both as regards the development and extent which the fishing industries have reached there, and the great fame which one of its fisheries—the great periodical herring fishery—has justly obtained. But as, of late years, the Bohus-län sea fisheries have decreased, whilst on the other hand a new great-herring period seems about to begin after an interval of nearly seventy years, it will not seem strange if we invite the attention of the public to some facts regarding the Bohus-län sea fisheries and their future, and to those measures which we consider necessary for their proper development. In order, however, to understand the latest and most important phase in this development, and in order to make some calculations regarding the periodical herring fisheries, and the peculiar course and economical importance of these fisheries, it will be necessary to give a brief historical review of the more important facts relative to the herring periods. As there are no accurate data regarding our periodical herring fisheries till the latter half of the sixteenth century, it will be necessary to complete the review of the herring periods by means of the knowledge which we possess regarding the herring fisheries on the west coast of Norway during the middle ages. It is well known to what an extent, especially in olden times, the herring fisheries contributed to the material well-being of the nation, and how ruinous was their cessation. In reviewing all that we know certainly relative to the great herring fisheries on the coasts of Bohus-län and Western Norway, we shall soon find that the herring fisheries never flourished on both these coasts at one and the same time, but that they had begun, or at least were about to begin, on the one coast when they had ceased or were about to cease on the other.

The oldest notice we find of the Bohus-län herring fisheries is a prohibition by *Olof the Saint*, in 1017, of the exportation of herring from *Viken* to *Vestergötland*, contained in the "Chronicles of the kings." The herring must, therefore, have come near the coast of Bohus-län at that time; and as the same chronicles tell us that there was much suf-

* "*Bohus läns hafsfiske och dess framtid.*"—Translated from the Swedish, by Herman Jacobson.

fering in Norway during the reign of the sons of *Gunhild* (961–970), owing, among other things, to the failure of the fisheries, it is reasonable to suppose that by these fisheries we are to understand those which at the time were the most important for Norway—the so-called spring-herring fisheries; and also that the Bohus-län herring period began soon after, and continued till the end of the reign of *Olof the Saint*.

During the first decade of the twelfth century, and especially during the reign of *Sigurd Jorsalafar* (1100–1130), we find that in *Southern Viken* there was an unusual development of all the material interests, and more especially at *Konungahella*, because it was the most important commercial place of the entire north. As, shortly before the destruction of *Konungahella* by the *Vinds*, in August, 1135, a number of merchants emigrated from there to Bergen, it would not seem out of the way to suppose that the herring fisheries contributed their share to the flourishing condition of *Konungahella*, and that the cessation of the herring fisheries on the coast of Bohus-län and their beginning on the western coast of Norway formed the real cause—not mentioned in the chronicles—of the emigration above referred to. Unless this was really the cause, it would seem difficult to understand why this emigration took place to Bergen and not to *Tönsberg*, *Oslo*, or *Sarpsborg*, whose trade resembled that of *Konungahella* much more than that of Bergen. Supposing this to be correct, this herring period would have begun during the last decade of the eleventh century.

Southern Viken shows us a still more striking revival of the herring fisheries during the first half of the thirteenth century, after a most devastating civil war of nearly a hundred years' duration. From *Hakan Hakonsson's Saga* (chapter 333) we know that during the long reign of this famous king, *Marstrand* and other desert islands near the coast were cultivated; that the *Öcker Islands* were colonized and received a church of their own; that the convent of *Tönsberg* was moved to *Dragsmark*, and that *Gullholm* was colonized. Although the last-mentioned measures may have been taken to furnish a convenient commercial highway from Norway to Lake *Venern*, which might take the place of the insufficiently protected former highway by *Konungahella;* the rapid increase of population in the *Öcker Islands*, necessitating a special church, certainly indicates rich herring fisheries, principally carried on near the central and southern coasts, as no place on the northern coast is mentioned. During the latter part of *King Hakan "the Olds"* reign (from 1250) no more herring came to the coast of Bohus-län, so that during the second half of summer the Bohus-län people were in the habit of going down the sound to participate in the *Skåne* herring fisheries. This herring period of the first half of the thirteenth century has, by Axel Boeck, and others following in his footsteps, been incorrectly considered the same as the great Bohus-län herring fisheries of the fourteenth century.

From well-authenticated documents we know that the herring which during the first half of the fourteenth century had ceased to come to the Norwegian coast near Bergen, again came to the coast of Bohus-län in large numbers; but the exact location where the fisheries were carried on is not known, although there are indications that about this very time *Marstrand* was in an exceptionally flourishing condition. During this herring period the government allowed the Hanse cities to participate in these rich fisheries, which privilege, however, was very probably abruptly ended by the great plague.

About the middle of the fifteenth century herring again visited our coasts in large numbers, and it is well known that from this time the herring fisheries began on the coast of *Vestergötland*, where the government levied a tax on the fishermen. The great herring fisheries had now become an important source of revenue to the government. During this period *Marstrand* was incorporated as a city (1442), and its church was completed (1460). As the Hanse cities petitioned the government to have their privileges renewed, it is probable that they likewise participated in these fisheries.

From the middle of the sixteenth century herring again came to the coast of Bohus-län in very large numbers near *Marstrand*, and as far as the *Homborg Sound*. These fisheries continued till about the year 1556, which was not many years before the northern or spring-herring fisheries near the western coast of Norway came to an end, as the historian *Peder Claussön Friis*, who is well acquainted with this herring period, expressly says in his history. From printed documents in the Norwegian archives it appears that in 1561 the herring fisheries were principally carried on near *Marstrand* in 1564 (when they began September 6), also at three stations on the island of *Orust—Rokersvik*, *Mollösund* and *Svanesund*, and in 1565, in nearly the same localities, *Hermensund* and *Mollösund* being mentioned as important herring places. In 1572, when the fisheries commenced somewhat later in autumn, a superintendent of customs was appointed at *Marstrand*, and customs officers were stationed in various places on the island of *Orust*. In 1576, when the fisheries did not begin till some time in November, large numbers of herring made their appearance north of *Marstrand*. It may be presumed that principally towards the close of the herring period, fisheries were also carried on near *Vette* and near the *Hval Islands* on the coast of Norway; but in those localities they do not seem to have reached a sufficient degree of importance to cause the government to establish a customs station for the purpose of deriving revenue from these fisheries, which began to decline about 1580 and ceased entirely in 1590. During this period the herring were almost exclusively caught with seines and stationary nets, which began to be introduced towards the end of the period, but were strictly prohibited in 1583. As a general rule these herring were smaller and leaner than the Norwegian so-called "spring herring," but the sum of 40 marks had to be paid for the privilege of salting them. The so-called "round salted" herring (herring salted while bloody in flat-bottomed vessels) were only prepared for home consumption or for exportation to Sweden.

Foreigners were allowed to participate in these fisheries by special grant from the King, for which, however, they had to pay a certain sum, just like the natives. Peter Clausson, the historian, testifies to the importance of these fisheries by saying in his work that "several thousand vessels and boats from Denmark and Holstein, as well as from the western and northern portions of Norway, came there to fish, besides those belonging to the place. Thereby thousands of people from neighboring countries have been induced to settle there. They have built themselves houses and cottages, where they live with their wives and children and make a good living through the fisheries. Noblemen, merchants, and farmers have here erected many large and beautiful houses two to three stories high; some of them so large that enormous quantities of herring can be hung up to dry. Thus the coast for 8 to 9 miles is lined with many thousand of houses and cottages, and many people live all along the fiords and inlets and on every island along this coast, as far as the herring extend their migrations. Here are annually seen many thousand ships from Germany, Denmark, Holland, England, Scotland, and France, which come to buy herring; all of them are amply supplied, and take the herring to far-off countries to serve as food for men."

In the beginning of the second half of the seventeenth century large numbers of herring seem again to have approached our coasts. When, in 1658, Bohus-län was united with Sweden, and the herring fisheries attracted the attention of the authorities, regulations were issued in 1666 for these fisheries, in which it was said, among other things, that the preparation of herring should only be carried on in *Gottenburg*, *Kalfsund*, *Marstrand*, *Mollösund*, *Gullholmen*, and *Lysekil*, which clearly indicates that, at that time, the herring principally visited the central and southern coasts. About the year 1670 the herring ceased to come to the southern coast, but continued to visit the central coast till the end of that herring period, which was about 1680, or, according to some, in 1697. Nothing is known regarding fisheries on the northern coast during this period, but it is probable that herring also came there. The herring fisheries, which were greatly disturbed by the political condition of the country, were also, during this period, carried on with nets.

About the middle of the eighteenth century the herring again came to the coast of Bohus-län in large numbers. In a report on the fisheries from the year 1758 we read the following: "In 1747 and 1748 the herring again commenced to visit the northern coast of Bohus-län in large numbers. A few years later they went as far south as *Marstrand*, and from 1752 on they made their appearance at *Gottenburg*." In the report of the Royal Fish Commission, dated April 22, 1761, we read: "From the year 1750 the herring had their station on the southern coast, between *Gottenburg* and *Marstrand*, and about 3 to 4 miles north of the last-mentioned city." In the report of the same commission of 1764 we read that "in autumn the herring were generally found on both sides of *Marstrand*. Some years they appeared in large numbers near *Gottenburg* and also on the *Halland* coast. In autumn and towards winter they went a little nearer to the northern end of the *Gullmarsfiord* and the Norwegian frontier." In a pamphlet published in 1765 we read "of the necessity of having superintendents of fisheries appointed in the districts of *Gottenburg* and Bohus-län." The herring must, therefore, have staid on the southern and central coasts, which also appears from various laws and reports published about that time. In the report of the Royal Commission of Fisheries of January 15, 1770, it is said that "the herring fisheries continued, without interruption, on the coast of Bohus-län for twenty years; the only observable change being that they appeared more plentiful on the northern portion of the coast during the latter part of this period than during the first part." The comparatively insignificant fisheries on the northern coast during the first years of the period are hardly mentioned in any reports from that period, but from 1750 or 1752 we find more frequent data regarding the fisheries. According to the so-called "oil-refuse act" (*Trangrums-akten*), the herring seem at that time to have made the *Gottenburg* coast their principal place of sojourn, whilst later in the period they were not seen there so frequently. In 1773 the herring were reported to have made their appearance and to have been caught, late in autumn, or rather in the beginning of winter, as far north as *Strömstad*, and from 1778, also, near the *Hval Islands*, on the coast of Norway. From the above-mentioned "*Trangrums-akten*," passed in 1784, it also appears that the principal oil refineries were, during the seventh and in the beginning of the eighth decade of the eighteenth century, found in the neighborhood of *Uddevalla* and *Marstrand*, on the *central* portion of the coast of Bohus-län. A report of 1788 says, that about that time the herring were found principally near the *Ellös* and *Elgö* fiords, also on the central portion of the coast. In the same report we read that at that time the herring fisheries began about the end of October, when the most northerly points where herring were caught were *Gullholmen* and *Lysekil;* and that the fisheries generally commenced near *Marstrand*, *Klädesholmerna*, and in the neighborhood of the *Brunskärsfiord*, where the largest number of herring were caught; and that as winter approached the herring went farther north and were caught in large numbers near *Grafvarne*, *Hunnebostrand*, *Fläskö*, and towards the end of the season near *Saltö*, which is about one mile south of *Strömstad*. The same conditions continued till the end of the herring period, in the winter of 1808.

In order to fully understand the importance of the experience gained from the last great herring period (1748–1808), it will be necessary to state, *first*, that the fisheries commenced, in 1753, September 29; 1757, September 3; 1762, August 16; 1766, September 9; 1769, October 3; 1773, October 14; 1778, November 4; 1781, October 24; 1783, November 3; and thereafter gradually later and later, till finally they did not commence till the middle of December; and, *second*, that in 1755 the fisheries yielded 75,000 tons of herring, in 1760 upwards of 200,000, about the year 1785 1,000,000 tons, and in 1795, when the fisheries were at their greatest height, nearly 2,000,000 tons;* from that year, however, the quantity of fish caught rapidly decreased. The reason why so few fish were caught in the beginning of the fisheries was, simply, that there was a lack of experienced fishermen and improved apparatus, and also a lack of a proper market; but not, by any means, that fewer fish came near the coast. An experienced fisherman, who had taken an active part in the fisheries ever since 1754, says in 1809: "After the year 1767 the number of herring on our coast was not as large as prior to that year, but our fishermen have gained more experience; we have better nets, boats, and salting-houses, and more men to take part in the fisheries, so that as many herring were caught and prepared as were needed, till the latter part of the herring period, when the approach of winter greatly interfered with the fisheries." From trustworthy sources we learn that, during that portion of the herring period when the fisheries were at their greatest height, the herring came near the coast in such enormous numbers that those which were caught only represented a *very* small portion of the total number of fish on the coast; and that each season the fisheries came to an end, not because there was a lack of herring, but because no one could be found who was willing to pay anything for them, all demands having been fully satisfied. From the fishery report of 1788 we learn that, in 1787, there were on the coast of Bohus-län 338 salting-houses; 429 oil-refineries with a total of 1,812 vats, which used 13,662 tons of fresh fish every time oil was made, or 40,986 tons per day; 358 large nets; †2,100 herring-boats, &c. It is evident that these fisheries were very profitable. *Granberg* says, in his "*History of Gottenburg*," that the city of Gottenburg owed its flourishing condition, during the latter part of the eighteenth century, "to its East India trade and the herring fisheries." According to the same author, the exportation of herring and oil gave a new impetus to commerce, and exercised a beneficial influence on all branches of trade and industry. The large sums of money which flowed into the country aided in furthering the development of many different industries, and that this had really been the case became still more evident when the source of wealth became exhausted with the close of the herring period. To give a better idea of the flourishing condition of Bohus-län when the fisheries were at their height, and of the misery and suffering caused by the decline of the fisheries, we will quote the following from a work on the Bohus-län fisheries by Rev. O. Lundbecks: "Any one who knew the coast of Bo-

*It should be remembered that the Swedish ton holds 209.4 liters, and that the herring are measured in flat vessels, which were filled to repletion; and that during that summer people commenced to calculate how many fresh fish were required for a ton of oil, for large masses of herring were used for that purpose. By way of comparison we will mention that the total yield of the Scotch fisheries in 1880 was 1,473,000 crans, of about 170.2 liters each (of which 1,201,105 crans fall to the share of the east coast, and 272,495 to that of the west coast).

†In the beginning of the period both floating and stationary nets were employed, but as the fish caught were not of the most valuable kind, they were soon replaced by common seines, which paid much better.

hus-län twenty-five years ago (this was written in 1831), and were to see it again at the present time would hardly be able to refrain from shedding tears. Twenty-five years ago our coast presented a lovely picture. Massive and costly walls and bulwarks supporting extensive salt-houses and oil-refineries rose from the very sea; further inland could be seen spacious warehouses and busy workshops, and on the brow of the hills handsome residences and small but comfortable houses for the fishermen and mechanics. The shore swarmed with people, and the sea was crowded with white sails. Every night the coast presented a magnificent scene, when the many thousand lights were reflected in the waves. Everywhere there was life and bustle, and the revenues were counted by tons of gold. Now, nothing remains of all this splendor but bare ruins. Here and there is seen a dilapidated cottage, which awakens the same feelings in the visitor as a neglected cemetery. Would that the former times so ardently sighed and prayed for by many thousands of people might soon return!"

With the beginning of the winter 1877–'78, the *genuine sea-herring*, which had been observed near *Skagen* since the autumn of 1875, again came to the coast of Bohus-län in large numbers; and as last year they began to come *earlier* and go *further south* than during the previous year, it seems evident that the old and well-known cycle repeats itself.

It remains to briefly indicate those measures which should be taken in order to derive the greatest possible benefit from that source of wealth which the return of the herring to our coast has opened, and to further the development of other sea fisheries in connection with that of the herring.

As regards the method of preparing herring, the selection of the proper place for the necessary establishments is of great importance. The experience gained during the former herring periods indicates clearly that the *central* portion of the coast (the coast from *Marstrand* to *Soten*) offers on the whole the most favorable locations for such establishments during the entire herring period; whilst the southern coast is most favorable during that part of the period when the herring come early during the year, and are particularly well suited for salting. The northern coast, where the herring come towards the end of the year, and where they frequently stay longest, is therefore very well suited for selling fresh herring for immediate consumption. As the herring, however, during the greater portion of the period when they come late in the year, do not come regularly every year to the *Gottenburg* coast, and as only those herring which are caught towards the close of autumn can be bought at a price which allows of their being used on a large scale for the manufacture of oil, glue, manure, &c., it is evident that the central coast is best suited for such establishments, and next to it the northern coast, where the herring come later, and are, on the whole, somewhat leaner.

As regards the different ways of preparing herring, it needs no proof that it will be most advantageous to utilize the herring in every possible way, as thereby the chance of selling them in different markets will be largely increased. This is a very important consideration, as it is well known from former herring periods that the number of fish caught is limited by no other reason than that there is no ready market for them. Moreover, in such large fisheries it frequently happens that large masses of herring are brought on shore which cannot be consumed in a fresh condition, and which, from some cause or other, are not suited for salting or smoking. Such herring could possibly be sold if prepared in a different way—that is, steamed, and then passed through a machine which separates the firm from the soft portions. From the latter oil, artificial butter, glue, and from the former fish-flour, guano, &c., can be manufactured. During the last fishing period all that was done was to separate the fat by boiling the herring—all the rest of the fish was thrown away; and it is not long since a more improved method of preparing the "menhaden" (a kind of herring found on the coasts of America) has been adopted in the northeastern part of America. During those years, when the fisheries of the last herring period were at their height, 30,000 to 60,000 barrels of oil were produced every year (15 to 20 large barrelsful of herring being required to make one barrel of oil).

As a ready sale of fish, and of the products of the fisheries, is an essential condition for an increase in the number of fish caught, it will be necessary to extend the market for our herring. In this connection it should be remembered that an increase in the sale of fish will cause a greater development of the entire fish industry by making it possible to introduce improved methods, to use better materials, and inducing more persons to engage in this industry. The sale of our herring could be greatly increased if the government would take the proper steps for spreading a knowledge of the different methods of preparing herring, and of the herring trade in general; and would see to it that the salting of herring is properly regulated and superintended. It would also prove a great benefit if the means of communication could be increased and improved, and especially a better connection be established between the outer coast and the railroad system of the interior; this being one of the most efficient means of developing deep-sea fisheries. Widely different as are the opinions regarding the various methods of improving and developing the deep-sea fisheries, there is no difference, or rather there has been none for the last 20 or 30 years, as to the vast importance of railroads to the sea fisheries. All the foreign fish commissions have, without exception, testified to the vast benefits accruing to the sea fisheries from the introduction of railroads, as it thereby becomes possible to carry fresh fish a very considerable distance, and as it tends to increase the material well-being of the entire coast population by building up all the industries, and by furthering the commercial intercourse of the coast with the rest of the country.

The railroads have already proved a great benefit to the Bohus-län herring fisheries by opening up new markets, and have at the same time enabled the greater portion of our poor throughout the country to obtain at a cheap price a wholesome article of animal food. The importance of the railroads to the herring fisheries increases in the degree as people accustom themselves to use herring in the household and as the railroads open up new districts. As the herring are principally obtained on the central and northern coasts of Bohus-län during the cool season, when they can, of course, best be transported fresh, the lack of suitable railroad connections and a good outer harbor in each of these portions of the coast render it necessary at present to send them all the way to Gottenburg (a journey sometimes occupying several days), in order to ship them to other places in the country by rail. The herring, therefore, are liable to be spoiled, and, even under the most favorable circumstances, their prices will be raised and their usefulness as a cheap and wholesome article of food for the masses will be considerably diminished.

Contrary to the opinion here expressed that the herring fisheries might be improved principally by opening up new markets for their products and improving the means of communication, leaving the rest to follow the natural course of their development, some people have advanced the opinion that now, at the very beginning of the herring period, before suitable markets for our goods have been found, and before we have a body of men trained and experienced in all that pertains to the herring fisheries and the herring trade, we should use new and expensive apparatus—drag-nets after the Scotch and Dutch model. But as drag-net fisheries in the open sea require a larger capital than we can afford at the present time, and demand skill and experience in preparing herring as well as a ready sale of the fish at a price which will cover the expenses incurred in procuring new apparatus, and as, moreover (as we know from the last fishing period), such fisheries cannot compete with the seine fisheries (more especially at this time, when the herring period is just beginning and the herring approach the coast earlier in the season), it will need no further proof to show how impractical are these opinions. At any rate, there is time enough to introduce drag-net fisheries on a large scale during that part of the herring period when the herring come to the coast later in the season; when only fish of a poorer quality are caught in the seines; when more capital has accumulated; when our people have become more skilled in preparing herring,* and when new markets have been opened for the products of our fisheries. Nor would it be wise, at the present time at least, to excite the competition of foreign nations, as the consequences of such a step might be detrimental to the prospects of our fisheries. The drag-net fisheries in the open sea are free to all, and

*The introduction of the Scotch fishing methods and apparatus demands as careful a preparation of the herring as that in vogue in Scotland, if the herring caught in drag-nets are to bring a reasonable price; for fresh herring can with us only be sold in comparatively small quantities at such a price as to pay the extra expense incurred in buying new and expensive fishing apparatus.

Sweden has no suitable places to form a basis for these fisheries in the Kattegat and the Skagerack. It should be our aim to make the herring fisheries in our seas, as was the case during the last herring period, an exclusively *Swedish* industry, and to prevent foreigners from enjoying those natural advantages which by right belong to us.

Any measures intended to further the sea fisheries should therefore not only aim at remedying those evils which made themselves felt during the former herring periods, but at bringing to the utmost degree of development all the great sea fisheries, all of which may be reached by improved means of communication, and by concentrating the fishing industries in certain favorably situated places on the coast. The creation of a regular fish trade, and of a body of experienced fishermen and salters, &c., will only be possible in places where the very location points to the sea fisheries as the most natural and profitable industry, such as Bergen, Yarmouth, Grimsley, &c., for only in such places can capitalists be found who take enough interest in the matter to invest their money in the fishing industries. Through such a concentration of the fishing industries the Bohus-län fisheries would become more thoroughly Swedish and would supply the Swedish nation with a cheap and wholesome article of food; whilst, if nothing is done to promote the fishing interests, there is great danger that the Swedish deep-sea fishermen (as is already the case to some extent with the *Aalesund* fisheries) will cease to be independent fishermen, and become the servants of foreigners, from whom we would thus continue to import the greater portion of the fish which we consume. The salting of fish caught in the deep-sea fisheries which has been much neglected during the last ten years, should again be taken up energetically, and the endeavors made with such good success in the years 1857–1865 should be repeated and applied to the sea fisheries, more especially if the proposed new railroads make it possible to carry both fresh and slightly salted fish to any part of the country.

From these brief indications it will be evident that all that our Bohus-län fisheries need in order to be brought to their proper height, is, above everything, increased means of communication by railroads connecting ing the various important harbors on our coast, and by a line connecting this coast railroad with the railroad system of the kingdom.

Such measures, if properly carried out, will infuse new life not only into the Bohus-län sea fisheries, but also into all our industries, and will moreover vastly increase the business of all our railroads, and soon repay all the money invested.

Whatever opinions one may entertain as to the importance of our Bohuslän fisheries, and their value to our whole country, it will, under all circumstances, be very desirable that the indifference our people manifest at present to this great industry should be overcome, and that they should be induced, by every possible means, to take an active interest in this matter.

VI.—WHAT SHOULD BE DONE BY THE GOVERNMENT WITH REGARD TO THE GREAT BOHUS-LÄN HERRING FISHERIES.

A MEMORIAL ADDRESSED TO THE COUNCIL OF STATE AND THE HEAD OF THE ROYAL CIVIL DEPARTMENT.

By AXEL VILHELM LJUNGMAN.

Page.

THE DUTY OF THE GOVERNMENT WITH REGARD TO THE GREAT BOHUS-LÄN HERRING FISHERIES.†

[A memorial addressed to the Department of the Interior by Axel Vilhelm Ljungman.]

As the course of the so-called "landing" of the herring near the coast of Bohus-län agrees in every particular with the experience of former herring periods, and our knowledge of the development of the great Bohus-län fisheries during former centuries, we are justified in looking forward with a tolerable degree of certainty to the growth of these fisheries and their continuance for thirty or forty years; and as both

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*The drag-net so frequently referred to in the following pages is probably the form of gill-net so extensively used in Holland, Germany, and Scotland.—EDITOR.

†*Om offentliga åtgärder med hänsyn till det | rika bohuslänska sillfisket. | En vördsam promemoria | till | statsradet och chefen för Kongl. civil-departementet. | Af | Axel Vilh. Ljungman.* | Gottenburg, 1882. Translated from the Swedish by HERMAN JACOBSON.

the experience of our former herring periods and the great herring fisheries in foreign countries have shown in the most incontrovertible manner that the herring fisheries may be greatly furthered and benefited by administrative measures, and that the aid and intervention of the government are absolutely necessary, if a great branch of industry such as these fisheries is to be raised to its proper height, especially in places like Bohus-län where the beginning, development, and close of the fisheries are (as to time) comprised in comparatively narrow limits. I consider it proper to describe those measures which are required in order to further the fisheries; although it will, of course, be impossible, owing to the extent and the peculiar difficulties of the work, to give, in the near future, a detailed description of the scientific investigations regarding the herring and the herring fisheries, which, with government aid, I have carried on without many interruptions since the beginning of July, 1873. It must be borne in mind that even those investigations which, with much greater aid from the government, have been carried on in Norway since 1861, and in Germany since 1871, have not yet been brought to a close, even after the purely theoretical and practical difficulties connected with the sea fisheries had been overcome; although the object in view was more limited, a greater number of persons were engaged in the investigations, and the difficulties were not so great.

Since there is good reason to believe that the present herring period will not last longer than forty years, and as it is well known how slowly such an industry develops, when left entirely to itself, and how hard it is to correct existing abuses, especially in places like Bohus-län, where these herring periods come at very irregular intervals and assume a different character according to the different natural conditions, it is all the more necessary to direct the efforts from the very beginning into the proper channel, which will *develop the fisheries to the greatest possible degree,* and which will *cause the least trouble and inconvenience both during the fishing period and toward and after its close.*

The measures that should be taken should relate to the *fisheries*, and the *transportation*, *preparation*, and *sale* of fish.

As regards *the fisheries*, it is of the utmost importance that they should commence as soon as possible after the fish have come near the coast (have "landed"). For this reason fishing with drag-nets should be carried on on a comparatively limited scale, with government aid, so as to ascertain whether the herring have really approached the coast; a fact which is of course of the greatest importance both for fishermen and scientists (see my memorial on experiments with drag-nets of February 12, 1878). As an implement for carrying on the herring fisheries on a large scale these nets should not be encouraged, at least not beyond the use which has been made of them during this and the past century. These nets are economically the least advantageous of all implements used in the herring fisheries, and should therefore only be employed where no other convenient implement can be obtained, especially as

Sweden does not possess any places in the Skagerack and Northern Kattegat which are convenient for fishing with drag-nets. These nets are particularly ill adapted to periodical fisheries, such as those of Bohuslän, as they, in proportion to the number of fish caught, require a much larger number of fishermen, whom it is difficult to supply with a suitable living at the close of the fishing period. Drag-net fisheries on a comparatively small scale, however, for catching a more valuable kind of herring for smoking or to be sold fresh, carried on with such boats as can be found and with smaller cheap nets, prior to the beginning of the ordinary net fisheries in autumn, might possibly be more profitable, without involving the same difficulties. But for catching herring beyond the outer coast it might prove highly valuable to have some experiments made with the purse seine (so highly prized by the Americans), an implement which, in contradistinction to the drag-net, is adapted to fishing both on the outer coast and in the narrow fiords, and to the catching of a larger number of fish of different sizes. The introduction of these purse seines would, moreover, prove a great benefit by supplying the fishermen with fish suitable for bait. The use of the purse seine would make the transition to other fisheries at the end of a fishing period much easier than would be the case with the drag-net. In North America, of whose great fisheries we can learn so much, drag-nets are not used at all, whilst purse seines and seines are constantly used with the best results.

Our rich coast fisheries in our fiords and inlets need proper regulation and an efficient coast-police, which would soon cause them to flourish more than ever before.

Not only the herring fisheries on our outer coast, but our entire sea fisheries and navigation on the coast of Bohus-län stand in urgent need of a number of *light-houses* placed in suitable localities. The places which more than others need light-houses are (1) the northern entrance to *Uddevalla* near the *Islandsberg Cape*, (2) the entrance to *Kungshamn*, (3) to *Grebbestad-Krossekärrshamn*, and (4) to the harbors in the *Koster fiord*. To make the entrance to the last-named fiord passable at night-time, it would, however, be necessary not only to place a light-house at a suitable point near the central portion of the fiord, but the so-called "*Koster lights*" should be moved to the southernmost point of the *Koster* coast, *i. e.*, to *Ramskär*. This measure has been talked of for a long time, and is urgently needed. The *Koster fiord* is not particularly adapted to herring fisheries during the dark season of the year, long after they have come to a close in the southern part of Bohus-län, but numerous merchant vessels pass there on their way to and from Norway. Other lighthouses than those mentioned may become necessary in time to come, but for the present those which have been enumerated will suffice.

As the fishermen have to follow the herring from place to place in their wanderings, and as the fish have to be transported to the places where they are prepared, or to the markets, the intercourse between the different stations along the coast becomes a matter of great importance, and there is a great lack of proper means to indicate shallow and dangerous places.[1] The coast of Bohus-län has been treated in a very step-motherly manner in this respect, as compared with the east coast of Sweden. This mistake should be corrected, all the more as a new and very considerable branch of industry will be largely benefited thereby.

For this intercourse along the coast it will, moreover, be necessary that several *routes for ships* should be plainly marked, and that two canals should be constructed, to avoid the necessity of sailing along an extensive stretch of coast exposed to the full fury of the sea. An investigation of this matter was made last summer at the expense of the province, and an estimate drawn up of the extent and cost of the work.[2] The most dangerous places are (1) near *Tjurpannan*, (2) near *Soten*, and (3) the coast near the *Hjerterö* and *Marstrands* fiords. The two first-mentioned places require the canalization of considerable portions of land; whilst—as will be shown below—the requirements of the northern coast (mentioned under No. 3) will be most satisfactorily met by the construction of a railroad from *Uddevalla* to *Grebbestad-Krossekärr*, with a branch line to the southern end of the *Sannäs fiord*, in case the proposed canal between the last-mentioned place and *Krossekärrshamn* should not be constructed. Both the canals referred to above should, in order to meet all requirements, be at least 12 or 15 feet deep, and broad enough to allow two steamers to pass each other without inconvenience. They would therefore involve a very considerable expense, without satisfying half the demands of Northern Bohus-län for better means of communication. It is moreover feared that, on account of the strong current, sailing vessels could but rarely pass through them. The dredging of the inner route between the *Bottna* and *Joreds fiords*, however, should be done at once, as it will only involve a comparatively small expense, would connect the southernmost part of the northern coast with the terminus of the above-mentioned railroad, and could be taken both by steamers and sailing vessels. As regards the avoiding of the last-mentioned portions of the coast, this could easily be accomplished by dredging and widening the existing channel inside the *Hjerterö fiord*,[3] and by dredging the sound between *Tjörnskalf* and *Tjörnshufvud*. As the last-mentioned work would make one of the best outer harbors of Bohus-län, *Kalfvehamn*, accessible from the south, the sound referred to should be made at least 15 feet deep. This subject was discussed several years ago; all the preliminary investigations were made, when the whole project fell through, because it was feared that the new channel would offer special facilities for smuggling. As the herring fisheries, both during the last century and during the present fishing period, were most productive south of *Soten*, and as all herring

[1] See "*Göteborg's och Bohus läns Landstings Handlingar,*" 1879, No. 15; 1880, No. 14.
[2] See the same, 1878, No. 9, p. 10; No. 15, p. 3–4; No. 30, p. 4: 1880, No. 24, p. 1.
[3] See the same, 1880, No. 15.

vessels and steamers coming from the north or going north would be greatly benefited by having an uninterrupted channel past the western coast of *Tjörn*, and as the movements of the fishermen in following the herring in their migration from one side of *Tjörn* to the other would be greatly facilitated, the importance of the work, which, moreover, would not be very expensive, will readily be seen. Besides this work, some other plans have been proposed, such as the dredging of the *Björn Sound* as far as its northern inlet to *Uddevalla*, as well as an inner channel along the *Koster fiord*, south of *Strömstad*, but all these plans are not of so great importance to the fisheries. The proposed improvements will prove a benefit not only to the herring fisheries and to navigation, but also to the coast defence.

In order to facilitate the *sale* of fresh and prepared herring, both at home and abroad, it is of great importance to get a legally fixed standard for measuring herring, as the present unsettled condition of these measures causes much inconvenience. During the great herring fisheries of the eighteenth century, matters were better in this respect. According to the regulations then in force, *the standard ton of fresh herring* must hold 164.9 liters. In 1786 this standard was changed to 209.4 liters, for no other cause than to benefit the owners of salting establishments. This last-mentioned measure was nominally in use till 1865, although it had long since given way to the greatly varying measures peculiar to the different portions of the coast. In Scotland, where at present the herring fisheries have reached the highest degree of development, the ton of fresh herring (called "cran") must contain "45 gallons old wine measure," or 37½ imperial gallons, i. e., about 170⅓ liters. In Norway the fresh herring are at present measured with the same ton as grain, which (according to the law of April 25, 1863, § 17) must contain 140 liters. With us, in Bohus-län, there are at present three tons which are in general use, viz, one of 125.6 liters, one of 157 liters, and the ton used by the *Gottenburg* herring merchants of 209.4 liters These different measures have frequently caused mistakes and difficulties, which certainly are of no benefit to the trade. As by a "*ton of fresh herring*" we understand the average quantity of fresh herring which are required to make a *ton of prepared herring*, the ton containing 157 liters would probably be the most convenient; but as the metric system is soon to be introduced, a ton of fresh herring containing 150 or perhaps 160 liters would be preferable, particularly in view of the considerable exportation of fresh herring to Norway, Denmark, and Germany. A ton containing 160 liters comes nearest to the so-called "six cubic feet ton" known all over the county. Its introduction would, therefore, not offer any special difficulties. For convenience sake, it would also be well to again introduce the gauged measures for measuring fresh herring, which were in use during the eighteenth century.

Nothing can be of greater importance for furthering the herring trade than *the preparation of the herring for the market*, as thereby the fisherman is enabled to get a higher price for his fish, and the trader finds a better market for his goods. The object in view can best be reached by regulating the methods of preparing herring so as to obtain a uniform article marked with the government mark. For this purpose a complete knowledge of all the approved methods should be more generally spread. Such regulations regarding the salting of herring are in force in Holland and Scotland, and have contributed their share towards the development of the herring trade, by producing a uniform article which gradually has found its way into many foreign markets, where it is highly esteemed. Since 1859, however, the gratuitous marking by the government officials of every ton of herring has been abolished, and it is now made optional with every salter whether by paying a small tax he will have his tons stamped with the government mark. Experience has shown that the official marking of the goods is an incalculable benefit to the trade; and, though optional, it is quite general. The opposition, which every now and then has been raised against this system by some of the large Scotch salters, has not found favor either with the public or with the Fishery Commission, and the official marking therefore continues in use to this very day, as a strange exception from free trade principles in the land of their birth. It is evident, however, that the system of marking would never have come into such extensive use if it had not in the beginning been introduced by extraordinary measures, and had thus brought about a uniform preparation of the Scotch herring, which, in consequence, are highly prized in nearly all the markets of Europe. In Holland, whose herring have for centuries enjoyed a world-wide reputation, and where the salting is in the hands of a few firms, the official marking of the herring, after having been obligatory for a long time, has recently (1878) been entirely abolished, which, possibly, was caused, in part at least, by the circumstance that the herring on the east coast of Scotland, where most of the Dutch herring are caught, became inferior in quality. As, especially in the beginning of a herring period, when a new herring is first brought into the market it may cause incalculable injury to the future of the trade if it gets the reputation of being an inferior article (because a lost reputation is very difficult to regain); and as the experience of our former herring periods proves in the most unmistakable manner that the herring best suited for salting are obtained a few years after the beginning of the period, it becomes our imperative duty to derive the greatest possible benefit from the experience of foreign countries, especially Scotland, and to take those administrative measures relative to the preparation of herring which will enable us to produce as soon after the beginning of the period as possible an article of uniform and generally recognized excellence. Even if during the latter part of the period the natural quality of the herring should become inferior, as has been the case on the east coast of Scotland, the reputation once gained would carry us safely to the end of the period.

The question which should be decided as soon as possible is the fixing by law of the cubic measure of a ton of herring, so that the buyer may at least know how much the ton contains which he has bought, for the uncertainty, which at present prevails in this respect, is most injurious to the trade. Our old ton contained 125.6 liters; but since 1843 the Norwegian ton, with a capacity of 115.8 liters is also frequently used in Sweden, and as the decree of 1865 relative to weights and measures fixed no legal limit of the ton of herring even the Scotch ton of 121 liters capacity is often employed with us. Under these circumstances it would be best to adopt that ton, which is the favorite measure in foreign markets, *i. e.*, the Scotch ton, all the more as it stands midways between the Norwegian and the old Swedish tons. But, as the metric system of measures will doubtless soon be introduced in Sweden, and as for this reason it will be most convenient if the number of liters contained in a ton is a product of ten, it would be best to make the capacity of the ton 120 liters, as this would come very near to the Scotch ton, and would be the right medium between the two extremes. There is some prospect that this ton (of 120 liters capacity) may in the future become the international measure for herring. (See my treatise on the subject in *Nordisk Tidsskrift for Fiskeri*, vi, p. 328, in *Deutsche Fischerei, Zeitung*, 1881, No. 35, p. 282, and in *Fisker Bladet*, Frederikshald, 1881, No. 4.) Even if this hope should not be realized, much would be gained if at least Norway and Sweden could agree upon a common ton for herring, so that, in case of necessity, the salters of one nation could make use of the tons of the other nation. If we do not get a certain fixed measure for herring, and if our salters cannot have tons marked by the government officials, there is great danger that complaints will come from foreign markets that our tons are too small, or that they greatly vary in size, which of course will not raise the reputation of the Swedish herring. As it is evident that a new regulation regarding a certain legally fixed capacity of the tons cannot be made until sufficient time has elapsed to use up the old tons, it will be seen that the matter brooks no delay.

As our great Bohus-län herring fisheries, in all probability, will not continue for a very long period, it would seem eminently proper and useful that the government should cause to be prepared a popular guide, giving a full description of everything relating to the great herring industry in all its branches, for that portion of our people most interested in this subject, and unable to obtain or read foreign works, and who, considering the shortness of the herring period, cannot afford to lose any time in experimenting. Such a work should contain drawings of the buildings and apparatus used, and should be written in such a style as to prove useful, even to a common fisherman. It ought to be clear and concise, and based exclusively on the best and most reliable authorities. In order to derive the greatest possible profit from the fisheries, salting and smoking ought not to be the only way in which herring are prepared; but every method in which herring can be prepared for the market should be taken into consideration. Not only the refuse resulting from the various ways of preparing herring, but also fish which from some cause or other are not fit for food, or which owing to their superabundance cannot find a market anywhere, ought to be made use of. A work like the one referred to above should therefore also describe the different methods of making oil, guano, &c. It is not sufficient, however, to learn from the experience of other countries, but technical and chemical investigations should be made at the expense of the government, so as to extend our experience in this comparatively new field of knowledge, and to discover new methods of utilizing the herring. Millions of dollars might in this way be saved to our country. It has already become evident that the fisheries will have to be limited, owing to the lack of a ready market for our products. The first and foremost object should therefore be, *not how to increase the fisheries by the introduction of new implements and methods, but how to extend our markets.* Competent persons, possessed of the necessary experience, should therefore be enabled to study the whole question in all its bearings, and be specially commissioned to aid by their experience in raising the herring industry to its proper height.

As the coast of Bohus-län, through this new industry, becomes economically of greater importance than hitherto, a more rapid and regular *postal service* becomes a necessity. At present the greater portion of the Bohus-län coast receives mails only twice a week, so that letters and papers are old when they reach the addresses; which, of course, must have an injurious influence on a growing and constantly extending trade.

The experience of Norway and Scotland has demonstrated in the most unmistakable manner, that the herring fisheries urgently require a sufficient number of *telegraph stations* along the coast. Connection by telegraph between the best harbors on the coast of Bohus-län and the telegraph net of the kingdom is a positive necessity, both for supplying the fishermen and traders with the latest news as to the weather and the fisheries by telegram, and for general business purposes. The police telegraph plays an important part in superintending the fisheries and in keeping good order on the coast; and no fisheries can flourish without it. Telegrams relating to the fisheries furnish the fishermen and the captains of the herring vessels with much needed information regarding the places where the herring make their appearance or to which they have migrated, and regarding the prices, which are principally governed by the quality and quantity of the fish caught, and are therefore invaluable to the traders in making their calculations. Telegrams relating to the weather will prove of the greatest usefulness to both fishermen and traders by enabling them to estimate their chances of success. It will hardly need any proof, that a sufficient number of telegraph stations for sending and receiving simple business telegrams of every kind, are absolutely indispensable to the fishermen, the captains of vessels, and to tradesmen. In the northern portion of the coast there are telegraph stations at *Strömstad* and *Fjellbacka;* between these two places a new telegraph station should be established at *Grebbestad,* which has become a place of considerable importance as the terminus of the proposed new railroad as a port of call for steamships, and as a business and watering place. From *Grebbestad* there should be a telephone connection to *Hafstenssund,* which is an important station for pilots and steamships. In the southern portion of the northern coast a new telegraph station should be established at the fishing and steamship station of *Bovallstrand,* between *Fjellbacka* and *Sotehufvud,* at the mouth of the important *Bottna fiord.* In the central portion of the coast there are telegraph stations at *Lysekil, Uddevalla,* and *Marstrand.* North of *Lysekil* a new telegraph station is needed at *Kungshamn,* which is surrounded by quite a number of important fishing stations; is one of the best outer harbors of the province; has a pilot station and a light-house, and is passed by all the steamers and sailing vessels plying along our coast. The telegraph line to *Kungshamn* could easiest be constructed by continuing the line to *Bovallstrand* in a southerly direction past the fishing station of *Hunnebostrand.* On the portion of the coast between *Lysekil* and *Marstrand,* which according to the testimony of seven centuries has always been the principal seat of the herring fisheries, several new stations (4 or 5) are needed, owing to the circumstance that the coast-line is broken by the two great islands of *Orost* and *Tjörn.* For the coast belonging to these islands the following lines of telegraphs would be required: From *Uddevalla* in a westerly direction to the steamship station of *Sund-Sandvik,* from which place a submarine telegraph should go across the narrow sound to the island of *Vindö,* which is connected with *Orost;* thence the line should be continued in a southerly direction (if possible near to the steamship and trading station and watering place *Hendn*) to the tavern of *Vräland* (from which place *Toggestad* could be reached by a short telephone line); at *Vräland* the line should branch out in two directions, the western passing the post-office of *Horleby* and the *Ihleberg* station and continuing to the northern end of *Boxviks inlet* (whence a private telegraph or telephone line might be constructed to the important trading place *Nösund*), and beyond, past the fishing station of *Hallen*[4] to the town of *Mollösund,* which of late years has become a place of considerable importance as a steamship and fishing station. The eastern branch should go from *Vräland* in a southerly direction past *Varekil* and *Skopesund* to *Tjörn,* and reach its terminus at *Kalfvehamn,* which is the center of many important fishing stations. In this neighbor-

[4] If the railroad from *Uddevalla* to *Ellös* should not be built, a telegraph or telephone line should be constructed from *Hallen* to *Ellös,* running in a northerly direction past the fishing station of *Hällvikkstrand.*

hood there were located, during the great fisheries of the last century, a very considerable number of salting and smoking establishments, among them the largest and best known of the entire province (see *Handlingar rörande sillfisket*, Stockholm, 1843, p. 4). In the northwestern portion of the coast there should of course be a telegraph station at the terminus (either *Eilös* or *Fiskebäckskil*) of the proposed railroad from *Uddevalla*. On the inner coast there should be a telegraph station at *Stenungssund*, which is an important place both as a fishing station and as a watering place. A telegraph or telephone station could, with very little expense, be established at *Tjufkil*, whence a submarine cable goes to *Marstrand*. In the southern portion of the coast there are telegraph stations at *Gottenburg* and on the islands of *Brännö* and *Vinga*. For the benefit of the herring fisheries a new telegraph station should be established at *Juthamn*, on the southwestern point of the island of *Hisingen*, which is most favorably located for the herring fisheries and the herring trade; lies on the high road for all the steamers plying along this coast; is the center of a large number of fishing stations, and is moreover the terminus of a proposed railroad from *Gottenburg*. The southern part of the south coast has easy access to *Marstrand* or *Tjufkil*, and the southern part can easily be reached from the *Brännö* station. Of the eight new telegraph stations which have been proposed in the above, four will probably soon be established, viz: *Grebbestad*, *Kungshamn*, *Mollösund*, and *Juthamn*.

Of the greatest importance, however, not only for our herring and other sea fisheries, but for the welfare of our coast and our whole province will be the establishment of *railroad connections* between some of the most favorably located outer harbors and the railroad system of the country. The experience of other countries has clearly shown the beneficial influence of railroads on the sea fisheries; and in proof of this assertion we quote the following from one of the most recent and best English works on the fisheries, which shows of what great importance railroad connections are considered to be, in their relation to the sea fisheries. *Holdsworth*, a man of great experience, after having given a brief review of the British fisheries for the last twenty or thirty years, says:[5] "The main cause of the great change in our fisheries is the extension of our railroad system. At present the cost of carrying fish a hundred miles is very trifling, and the railroads, whose lines run along the coast, or which from the interior of the county extend to places on the coast where fish are landed, have had the good sense to encourage the transportation of fish in every possible way, because they saw that thereby a regular and profitable carrying trade might be built up. The means thus obtained, of bringing a large quantity of fish, whilst they are still fresh, into many different markets, and in a condition which years ago would have been considered an impossibility, encouraged the

[5] BRITISH INDUSTRIES: Sea fisheries by *E. W. H. Holdsworth;* Salmon fisheries, by *Archibald Young*. London, 1877, pp. 4, 5.

fishermen to ply their trade with renewed energy. The change has not been less noticeable because it has been brought about gradually; *for in every case where a railroad has reached the coast the fisheries have increased, the fishermen have got better pay for their day's work, and a hitherto unknown impetus has been given to the fishing industries.*" Instances are not wanting where rich sea fisheries have sprung up on coasts, where they were formerly unknown, simply by the construction of a railroad to a harbor which hitherto had had no connection with the interior of the country, or where the condition of the fishermen was miserable to the last degree, simply because they could not sell the fish they caught, owing to the lack of proper means of communication. This whole subject is well understood in other countries, and in the large and comparatively sparsely settled Dominion of Canada the sea fisheries, which are an important source of revenue to that country, have been very materially aided by the construction of railroads, which were needed for the transportation of fish. The fish commissioners of other countries have in the most urgent manner pointed out the great importance of railroads to the development of the sea fisheries. Quite recently the Danish fish commission has recommended the construction of a number of short lines of railroad, which will doubtless—especially if the Swedish railroads proposed below are not built—cause the larger portion of the great *Skagerack* sea fisheries to pass into the hands of the Danes. The construction of railroads is a much more efficient means of furthering the development of the fisheries than the system of premiums, which was so common with us during the eighteenth century and in Scotland during the first thirty years of the present century. It should, moreover, not be forgotten (and this assertion hardly needs proof) that the increase of any fisheries presupposes a corresponding demand for fish and other products of the fisheries, and that a higher price for fish will, more than anything else, encourage the fishermen in their work, and will enable them to employ improved (and more expensive) apparatus and methods. There is not the slightest doubt that the yield of the Bohus-län fisheries could be doubled and trebled, and that the condition of our coast population would be vastly improved in every respect, if there was proper railroad connection with the interior of the country. The Bohus-län sea fisheries would thereby prove of national benefit, and would be able to supply the greater portion of Sweden with good and cheap fish. At present Sweden imports fish and products of the fisheries to the amount of many millions of crowns per annum. All the fish required by our country could be supplied by the Bohus-län fishermen, and if there were proper railroad connection between the interior and the coast of Bohus-län the fish would reach our population in a fresh and healthy condition. Without such railroad connections there is great danger that not only our sea fisheries but also our fish trade will, in great part at least, pass into the hands of foreigners. It will not do to say that Bohus-län, with its comparatively good water communication, needs no railroads, for experience has sufficiently proved that the former can never replace the latter; for which reason railroad lines have been constructed to most of the fishing stations on the east coast of Scotland, a country which, especially in the northern portions, is but sparsely populated and by no means wealthy; and this has been done in spite of the fact that navigation there is never (as is the case with us) impeded by ice. The Scotch sea fisheries have, through these railroads, increased in the most wonderful manner; and they must certainly be considered as the principal cause of the present flourishing condition of these fisheries. The first and foremost condition of the well-being of the sea fisheries is *a well-regulated fish trade*, implying *a rapid and regular sale of the fish* soon after they are caught.

Among the benefits which the herring fisheries in particular will derive from short lines of railroads connecting the outer harbors with the railroad system of the country, we must mention the consequent competition, which will keep the price of fresh fish at a profitable height, the decrease of the steamship traffic, which is calculated to more or less disturb the coast fisheries, and the greater ease with which the coast can receive the products of agriculture and forestry from the interior of the country. As the population of the interior learns to use the herring as a regular article of food, the transportation of fresh fish from the coast to the cities and towns of the interior will increase correspondingly. Such railroads will also serve to *concentrate* the *herring industry* and cause every kind of business to flourish at the fishing stations; there will be better order at these places, more chances than formerly for the fishermen to earn a living during that part of the year when there is no fishing, and every industry connected with the fisheries, and trade and navigation in general, will flourish more, and whenever the fishing period comes to an end the railroads will, more than anything else, tend to compensate the population for the losses which such an event will cause.

As the experience of former fishing periods has shown that rich herring fisheries are apt to injure to some extent the agricultural interests of our province, it will be evident that this could be, to a considerable degree at least, counteracted by constructing the lines of railroad in such direction as will prove useful to agriculture, which, after all, is the principal source of revenue not only of our province, but also of the entire kingdom. Another benefit would accrue to our people if these lines of railroad were constructed in such a manner as to unite as much as possible the widely-separated districts of our province, and to create a livelier intercourse not only between these districts, but also between the province of Bohus-län and the rest of Sweden. All these objects would be reached by the construction of the railroads proposed, all of which should have the same gauge as the other Swedish railroads.

The proposed lines of railroad would also prove a benefit to the interior of Sweden by furnishing a way for importing the products of foreign countries, and exporting Swedish products directly to and from the interior by way of well-located outer harbors. These railroads would, especially if the gauge of the line *Uddevalla-Venersborg-Herrljunga* is changed to the normal Swedish gauge, prove of immense benefit not only to trade industry, but also for the defense of the country by greatly facilitating the connection between Sweden and Norway west of *Lake Venern.*

In examining the different plans, special attention should be paid to the length of the proposed lines of railroad, the technical conditions, the cost of construction, the prospects of answering the purpose in view, and of paying, to the requirements of the sea fisheries, the coast, the province, and the whole country, and finally to the construction of such lines as will most successfully work together with the rest of the railroads of the country. In determining the termini of such lines of railroad regard should be had to the location of the harbors, as to their nearness to a large number of fishing stations, to already existing railroads, to the number of fish consumers at home, to their being unobstructed by ice during winter, to their capacity, entrance, &c. The experience of other countries, especially Great Britain, teaches us that the trade in fresh sea fish demands outer harbors, connected with the rest of the country by railroads, whose water (even at the surface) is so salty all the year round that large sea fish, as well as lobsters and oysters, may be kept alive in inclosed waters. It is well known that *Gottenburg* and the harbors near the mouth of the *Göta River* are just as inconveniently located for this branch of the fish trade as London and its outer harbors on the Thames. The same applies, though in a less degree, to *Strömstad* and *Uddevalla.* Taking all these conditions into consideration, it will be seen that the two lines of railroad which will best answer all reasonable purposes are the following:

(1.) A line from *Uddevalla*, past *Herrestad* and *Qvistrum*, to *Grebbestad-Krossekärr* (with a branch line to the southern point of the *Sannäs fiord* in case the projected canal between that point and *Krossekärrshamn* is not constructed); and

(2.) A branch line from *Herrestad* either to *Fiskebäkskil* or (and this would be preferable) to *Ellös.*

The first line would be about 60 to 65 kilometers in length, and the last 32 to 35; therefore, both together, about 100 kilometers, a length which cannot be considered excessive, in view of the fact that Bohuslän, one of the most densely-populated provinces of the country in proportion to its extent, and at the same time one of the most fertile, has so far had but little benefit from the most important means of communication of our times, the length of the Bohus-län railroads being less than that of any other provinces of the kingdom, with the exception of *Norrbotten* and *Vesterbotten.* The Economical Association of Bohus-län has furnished the means for a preliminary survey of both lines.

The terminus near the sea of the first-mentioned line (*Grebbestad-Krosse-*

kärrshamn) has by competent authorities (see the pamphlet, "*Om den stora bergslagsbanan*," Stockholm, 1870, p. 45 to 47) been determined as follows: "Requested by the commission for the proposed railroad *Falun-Krossekärr* to give an opinion as to the most suitable terminus on the coast of said railroad, we have carefully examined the most recent maps of this coast prepared by the Coast Survey, the hydrographic descriptions of the same, and other documents relating to the subject, and give it as our opinion that the harbor of *Grebbestad* and the harbor of *Krossekärr*, close to it, the latter a winter harbor for those vessels which during the period when the former harbor is full of ice cannot come close to the coast, are the most suitable points for the purpose in view."

The reasons for our opinion are as follows:

"The harbor of *Grebbestad* is completely sheltered from the sea; its depth varies between 4 fathoms in the inner to 11 fathoms in the outer portion; it is of easy access from the sea from the north, west, and south, and can, if light-houses are erected in suitable places, be safely entered and navigated even at night-time; it is so near to the sea that there is perfectly safe anchorage half a nautical mile from the outer coast, and that the innermost portion of said harbor is hardly more than one nautical mile from the outer coast-line; it is very spacious and has convenient anchorage for a large number of vessels, which here are thoroughly protected from the fury of the sea; it offers every facility for constructing extensive embankments, close to which the largest vessels may safely ride at anchor; and it possesses all the above-mentioned advantages to a higher degree than any other harbor on that coast. The harbor of *Grebbestad* is located on the south and southeastern side of the peninsula, on whose western side is the harbor of *Krossekärr*, the distance between the two being hardly more than half a nautical mile. United by a canal, sheltered from the sea, these two harbors may practically be considered as one, and the entrance to them from the sea is only half a nautical mile distant. This entrance will be perfectly safe by placing buoys and marks in proper places. From reports by the commission for the *Falun-Krossekärr* railroad and the naval officers of the squadron which visited this coast last summer it appears that even during severe winter weather the *Krossekärr* harbor remains entirely free from ice. This is a great advantage, for during the period when the *Grebbestad* harbor is frozen the near *Krossekärr* harbor may be used as a winter harbor for the comparatively small number of vessels which during the winter months keep up trade connections with the North Sea.

"The *Krossekärr* harbor offers nearly the same advantages of depth and protection from the sea; but it is smaller, and can, therefore, not give shelter to as many vessels, although, in our opinion, its capacity is amply sufficient for any vessels that may enter it during winter.

"If compared with the harbor of *Strömstad*, we find that the harbor of *Grebbestad* has the advantages of being of easier access from the sea and being larger, so that, for the additional reason that the neighboring harbor of *Krossckärr* remains free from ice, we must decidedly give the preference to the harbors of *Grebbestad* and *Krossekärr* above that of *Strömstad.*

"Stockholm, January 9, 1871.

TH. ARVIDSSON.
FING. v. SYDOW."

The importance of the railroad *Uddevalla-Grebbestad-Krossekärr* to northern portion of Bohus-län will appear from the following extract from the report adopted by the Bohus-län Economical Association at its last annual meeting: "A glance at the map will show at once that the coast of Bohus-län is divided in two portions by the *Soten* inlet, which is entirely open towards the sea; the northern of which, owing to its insufficient means of communication, is in its development far behind the southern. On the coast north of the *Soten* inlet *Grebbestad* is undoubtedly the most central and convenient place for the terminus of a railroad, and a railroad extending to that harbor was already under contemplation when the construction of the *Bergslagernas* railroad was first discussed. *Grebbestad* has a most convenient and advantageous location not only with regard to navigation, but also with regard to the sea fisheries; and there is no doubt that if the contemplated railroad is constructed, *Grebbestad* will become a great center for the fish trade. Northwest of *Grebbestad* is *Koster;* southwest, *Väderö;* and west, the so-called *Pers-grounds*, all places which are exceedingly rich in fish, and which are specially adapted to winter fishing, to bank-fishing, and to great sea-fisheries, all of which could here be carried on to great advantage, provided they would receive the much-needed impetus which a railroad would give. A railroad from *Grebbestad* to *Uddevalla*, besides connecting the central point of the northern coast with the railroad system of the country, would benefit not only the coast, but also the entire northern portion of the province of Bohus-län, as it would bring into closer connection all the widely-separated divisions of the province. The proposed railroad, the greater portion of which has been surveyed at the expense of the association, would be identical (for a considerable portion) with a line which doubtless will sooner or later have to be constructed along the entire length of the province, and from which short branch lines in both directions could easily be constructed." It must also be taken into consideration that, in all probability, the northern coast of Bohus-län, after having become properly connected with the natural center of the province, will develop its herring fisheries more than is possible now, owing to its remoteness from the principal city of the province.

As regards the end-points of the other line which has been proposed, viz, either *Fiskebäckskil* or *Ellös*, both located in the western district of *Orost*, it must be remarked that there are no other suitable harbors near the starting-point of the line at *Uddevalla*, where connection should be made with the railroad system of the country; and that the above-mentioned harbors, as will be seen from the Coast Survey maps, possess in the highest degree all those advantages which are required. Nor is there any outer harbor on the central coast of Bohus-län to which a railroad might be constructed, which, in point of space, depth, accessiblility, &c., could compete with them (with the possible exception of *Kråksunds* harbor, in the western district of *Orost*, which, however, is farther from *Uddevalla*. Both harbors being desirable, mere excellence cannot decide which of the two shall be chosen. The harbor of *Ellös*, which is one of the most spacious harbors in the kingdom, offers special advantages, because if the railroad terminates there it would not only become of great importance in a military point of view in connection with our system of coast defenses, but it would also get all the local trade of the populous and fertile island of *Orost*. The two above-mentioned harbors are centrally located both as regards the middle portion of the coast of Bohus-län, and the entire coast of the province. They are surrounded by the most important fishing stations of the province, and are located near a portion of the sea which for seven centuries has during the herring period been justly considered as one of the most important fishing waters. They are particularly adapted to act as outer harbors for a great portion of central Sweden, both for the import and export trade. In view of the fact that the watering places on the coast of Bohus-län are annually visited by a large number of people, and that many steamships ply along this coast, the connecting of one of these outer harbors with the railroad system of the country will prove another inestimable advantage. None of the other lines of railroad which have been proposed offer any such advantages, both as regards the sea fisheries and navigation and trade, as a line ending either at *Ellös* or *Fiskebäckskil*, and we must repeat it, *that the construction of such a line is absolutely necessary if the sea fisheries on the middle portion of the Bohus-län coast are to reach the highest possible degree of profitableness.*

As regards other measures tending to encourage the herring industry we must mention, in conclusion, the great necessity for some sort of manual giving all *the different methods of preparing herring*. Many a person is afraid to go into the herring industry, simply because he fears that his ignorance of suitable methods of preparing herring will cause losses, and in the light of the experience of the year 1878 such a fear is not entirely unfounded. Although the compiling and publishing of such a manual may be attended with many difficulties, the idea ought certainly to be carried out as soon as possible. The official reports of our consuls in foreign countries, and extracts from the reports of other governments, would furnish much valuable material. Special attention should be paid to everything in such reports which is calculated to throw light on the reasons why many of our competitors succeed in keeping Swedish herring out of foreign markets. Reports on the herring fisheries and the herring trade should from time to time be published in a number of our newspapers having a large circulation. This should be done at government expense, and there is no reason to doubt that the effect would be very beneficial to our herring industries. Proper measures should be taken by our authorities to prevent the exportation to foreign countries of an inferior article, for a few mistakes in this direction may prove fatal to the entire export trade. The herring trade will also be greatly encouraged by furnishing our outer harbor with all the conveniences belonging to first-class ports, and by granting certain customs privileges to ships bringing articles necessary for the herring industry, or taking the products of these industries to foreign countries. The desire for such privileges has been repeatedly expressed even during the eighteenth century.

Any measures taken by the government should aim at lessening the disadvantages which accompany the fisheries, and which make themselves felt at the close of the fishing period. This object will, amongst the rest, be reached by (1) developing the fishing industry in such a direction as to combine the most profitable financial results with the least possible sinking of capital, and to limit the number of persons engaged in said industry; (2) by concentrating this industry as much as practicable in a small number of favorably located ports; (3) by limiting the sale of liquor during the fishing season, and by issuing all the necessary rules and regulations, and by entrusting the maintenance of law and order to an efficient coast police; (4) by extending and encouraging the activity of churches and schools; (5) by establishing savings banks, insurance and other beneficial associations; (6) by encouraging, as much as possible, the various industries connected with the herring fisheries, *e. g.* the other sea fisheries and navigation; (7) by establishing new and better means of communication, and by encouraging agriculture and all industries throughout the province. It is well known from former herring periods how much the slow financial development of the province was disturbed by the rich herring fisheries, and that drunkenness and immorality, fostered by the great ease with which money was made during the fishing season, finally caused poverty and suffering among the lower and middle classes of our coast population, who had become unfit for any other occupation. Agriculture suffered seriously, as labor, which was urgently needed, was drawn away to the fisheries during the very time of the year when it could hardly be dispensed with for agricultural purposes. The government should, therefore, use all the means in its power to prevent, or at least to lessen, the injurious effects of these disadvantages which are inseparably connected with the fisheries.

It is evident that much will be gained by limiting as far as possible the number of persons engaged in the herring industry. It will, under all circumstances, be hurtful to the best interests of a people, if a large number of persons scattered along a great extent of coast are dependent for their living on, so to speak, accidental and sudden work. This disadvantage makes itself peculiarly felt in a country like ours, where the fishermen cannot, when the Bohus-län fisheries come to an end, move to another part of the kingdom and there follow their accustomed avocation; and where we do not find a population well acquainted with the fisheries moving with them from place to place; but where, at the beginning of every fishing period, new hands have to be trained. That under these circumstances the employment of seines offers great advantages over drag-nets will not be astonishing. A single fact will prove this assertion, viz, that about 6,000 Bohus-län seine fishers could, during the most favorable portion of the last herring period, catch more fish during one fishery than 47,000 Scotch drag-net fishers during the fisheries of an entire year. The value of the Scotch fishing vessels for the year 1880 was officially reported at £556,946, and that of the drag-nets at £619,012, making a total of £1,175,958; whilst the boats and the apparatus of our Bohus-län fishermen during the same period were hardly worth more than about £40,000 to £50,000. As our fisheries positively come to an end after a certain number of years, it is highly important that the number of men who, by such an event, are suddenly deprived of their means of earning a living should be as limited as possible; and that the capital invested in boats, apparatus, &c., should be as small as possible. In judging of this matter, one should not be led astray by the childish and utopian proposition, showing anything but knowledge of the subject, that our fishermen should, after generally adopting the drag-nets for fishing on our coast, follow the herring in their migrations, and, if necessary, be ready at once to engage in the so-called great fisheries in the North Sea according to the Dutch method. The above-mentioned nets, which require boats specially adapted to them, are not suited to our circumstances and our remote location. Wherever they have been introduced, sometimes at a great expense, *e. g.*, in other parts of Sweden, Denmark, Norway, and Germany, they have not led to any desirable results as far as the herring fisheries are concerned. From this reason it will be advantageous if the sale of fresh fish in our own country could be encouraged as much as possible; and if the remaining portion of the fish could be prepared for the market by employing as few persons as possible in this process. Our herring industry during the eighteenth century had a great advantage in this respect over that of the sixteenth century; for the manufacture of oil required a much smaller number of persons than the salting and smoking of the herring. Another inconvenience is occasioned by the circumstance that since Bohus-län has been united with Sweden we have no longer a sufficiently large population which is thoroughly acquainted with the process of salting herring. This is another reason for making the chemical and technical investigations above referred to, viz, that of finding out the most approved methods of deriving the proper benefit from the large quantity of herring caught, by preparing them in other ways besides salting.

As has been said, the herring industry would be greatly benefited if it could be concentrated in a limited number of favorably located ports, which would gradually assume the importance of cities or towns, as has been the case in Scotland, where in this manner many of the inconveniences were avoided which followed our great fisheries in the sixteenth and eighteenth centuries. The advantages of such a concentration, both as regards the keeping of good order in the fishing stations, and the gradual building up of industries connected with or springing from the herring fisheries, which at the close of a herring period will furnish a means of gaining a living to our coast population, is so self-evident that it does not need further proof. It is not so clear, however, in what way such a concentration shall be brought about. To do so by forcible means, as in olden times, is at present out of the question; a good deal, however, might be accomplished by granting special rights and privileges to the most favorably located ports, and by introducing various improvements, such as establishing telegraph stations, building embankments, improving the harbors, reducing the customs duties, &c. The most important means of reaching the object in view, but which of course will only apply to a small number of places, is the construction of railroads connecting such parts with the rest of the country, especially if thereby a regular trade in fresh fish can be built up. It is more than a mere conjecture that a town will spring up at such a port, and that, if it is judiciously selected, the fishing industries of that whole neighborhood will be concentrated there. In selecting a place for building salt-houses and other establishments needed for the herring industry, care should be had to find a place where there are telegraph post, steamship, railroad, and custom-house stations, and suitable dwellings for the workmen, from the same reason that people move into cities to follow various trades and industries, in spite of the fact that ground costs a great deal more there than in the country. If the herring industries could be concentrated in the way indicated above, and if new towns could be made to rise on our coast, the present herring period would leave a lasting memento behind it, and would be forever memorable in the history of Bohus-län.

It will be evident that so vast and so peculiar an industry as our periodical herring fisheries cannot be properly regulated by our existing laws, which all apply to normal and not to extraordinary conditions. Exceptional cases demand exceptional legislation; amongst the rest with regard to the vice of drunkenness, which during the last herring period prevailed to such an alarming extent. There is urgent need to limit the right of selling liquor on the coast during the fishing season. Proper regulations as regards the maintenance of good order, the appointment of vigilant and energetic police officers and inspectors, will, as the fisheries continue to grow in importance, also prove of incalculable benefit.

No one will deny that the influence of churches and schools is indispensable to the proper development of our coast; and this influence will be heightened by concentrating the herring industry in a comparatively small number of favorably located ports, where churches and schools would give to the young growing up during the great fishing period an education which would fit them to successfully grapple with the difficulties which will doubtless confront them at the close of the herring period. The school of navigation at *Strömstad*, a place which has never played an important part in the history of our herring fisheries, should be moved to a more central location—central not only with regard to its geographical location on our coast, but also with regard to the herring fisheries. The high school for farmers at *Tyft*, founded and richly endowed by the late mayor of *Lund*, Mr. *L. Billström*, and which is located near to one of the principal places where herring fisheries are carried on, might easily arrange its course of instruction in such a manner as to give to our coast population a suitable education beyond that which they receive in the elementary and intermediate schools. The establishment of technical schools where the young people could be instructed in various trades should also be encouraged.

Savings banks and loan institutions, where the fishermen could deposit their savings, and where they could borrow the necessary money for fitting out boats and buying apparatus, would also prove highly beneficial, as they would tend to free the fishermen from the cruel clutches of usurers. The founding of life insurance and mutual benefit associations among our coast population would aid in avoiding much trouble, and would make the future brighter and more promising to our fishermen. In order that such institutions may do the greatest possible good, it would be well for the government to publish in pamphlet form an account of their working in other countries.

One of the principal causes of the misfortunes which followed the close of our last great herring period, must be found in the circumstance that the persons engaged in the herring fisheries made these fisheries the only and exclusive source of their living; and when the herring left our coast, and our fishermen could not follow them, the natural consequence was great and general suffering among the coast population. One of the first duties of the hour is, therefore, to prevent the recurrence of such misfortunes at the end of the present herring period, and in the above various hints have been given as to the best way in which this should be done. We must once more point out in this connection the great importance of the railroads which have been proposed, as thereby an undoubted impetus will be given to the deep sea fisheries, whose continuance at all times, at least on the middle and northern coast, is sufficiently guaranteed. If by a judicious concentration of the herring industry new towns are established on the coast, many other industries will spring up, through which the fishermen can earn a living during that part of the year when the herring are away from the coast, and which at the close of a herring period will in some manner compensate them for the losses which such an event will cause even under the most favorable circumstances.

It is well known that during the herring periods agriculture was sadly neglected in Bohus-län; but this undoubted evil would be greatly lessened, if not altogether remedied, by opening new ways of communication, which would benefit not only the fisheries but also the agricultural interests, and by concentrating the herring industry in a limited number of towns, which would become good markets for agricultural produce. As agriculture advances, it will be better able than hitherto to compete with the herring fisheries in engaging labor. Much of the refuse from the herring industry could be utilized in agriculture to a much higher degree than is the case at the present time; and a great deal might be accomplished in this direction if the government would make investigations and experiments relative to this matter, and publish the results.

The importance of the above considerations should not be underrated for the reason that none of those evils which beset the fisheries during the last century have as yet made their appearance; for they can hardly be loooked for until the herring fisheries have in the course of years reached a high degree of development.

As in the above I have only mentioned such measures whose beneficial influence cannot be doubted, and which would prove beneficial to other industries after the close of the herring period, I feel convinced that they will receive the attention which they deserve.

Tjörn, December 12, 1881.

AXEL VILHELM LJUNGMAN.

APPENDIX.

I.

ATTEMPTS TO CATCH HERRING WITH DRAG-NETS.

To the Council of State and the Chief of the Department of the Interior:

In reply to a request by telegram of the 9th instant, to give my opinion as to the desirability and practicability of attempts to catch herring in the Skagerack with drag-nets, with the view of increasing our knowledge of the herring, and as to the benefit such attempts would confer on the Bohus-län herring fisheries, I have the honor to report as follows:*

(1.) *The importance to science and industry of attempts with drag-nets.—*

*The great haste with which this report had to be drawn up, under the most unfavorable circumstances, must serve as an excuse for its fragmentary character. The same subject has been treated more fully in the article in the Gottenburg *Handels-och Sjöfarts-Tidning*, referred to below.

Attempts with drag-nets in the Skagerack have several times been proposed and actually made, partly with the view of thereby increasing our knowledge of the course and migrations of the herrings, and partly to ascertain whether the number of herring was large enough to warrant the establishment of drag-net fisheries. Owing to the limited extent of these experiments and the unsatisfactory apparatus with which they had to be made, they have not led to the desired result. It will however, even in spite of these failures, hardly need any proof that such experiments, made with drag-nets and other fishing apparatus, are indispensable for gaining a more satisfactory knowledge of the nature of the herring and more especially of its course and migration. In view of the great expectations which have been raised by the rich herring fisheries of the present winter, and in view of the hopes that they may prove the beginning of another great herring period, such experiments should be made on a large scale, in order, *first*, to gain some more certain knowledge relative to the future migrations of the herring from our coasts,[7] and to the portion of the sea which they visit after leaving our coasts, more especially whether they go into the North Sea; and *second*, to ascertain late in summer or in autumn whether a large number of herring are approaching our coast. This second object is of course the more important of the two to our fishermen, as they need to be apprised of such an event in good time; and as it occurs later in the season, it will allow of making all the necessary preparations; attempts with drag-nets might also finally lead to the establishment of drag-net fisheries, if it should be proved that such fisheries can be carried on to advantage.

(2.) *Experiments with drag-nets.*—With regard to the experiments with drag-nets, special attention should be given to time and place of such experiments, to the quality of the boats and nets, and to their extent and probable benefit to science.

As to the *time* when such experiments should be made, spring and early summer will not yield many practical results. During spring our own coast herring spawn near the coast, and in the early part of summer mackerel fisheries are carried on with drag-nets. The latter part of summer and autumn, on the other hand, will doubtless, as far as the Skagerack is concerned, be the most suitable time for searching after herring. If, moreover, the present winter fisheries should prove the beginning of another great herring period, the approach of the herring would have to be looked for, at the latest, about the end of November. During winter, herring are most plentiful off our coast, and sometimes in close proximity to it; but the winter season with its darkness, its frequent fogs and violent storms and the consequent dangers to navigation, will render drag-net fisheries in the Skagerack (at least

[7] The herrings which at present are still found near the coast in large numbers may, after a short time, go out to sea again.

on a large scale) difficult, and probably practically impossible.[8] It must be remembered that drag-net fisheries must be carried on at night, as during daytime the herring do not go into the nets.

As regards the proper *place* for such experiments, it would not be advisable to confine oneself to that portion of the Skagerack which is nearest to the coast of Bohus-län; but these experiments should be extended to more distant portions of the Skagerack and to the adjoining portions of the North Sea and the Kattegat.

As regards the quality of the *boats and nets*, our Bohus-län mackerel boats will be well adapted to the purpose[9] during the mild season, whilst for winter stronger and more comfortable boats, such as are used by the Yarmouth fishermen, are required. Suitable nets can be ordered in England. The proposition, which has been made several times, to employ Swedish drag-nets and boats from our southern provinces (*Skåne* and *Blekinge*) shows an utter ignorance of the subject. The net must correspond to the capacity of the boat; and the open boats used by our *Skåne* and *Blekinge* fishermen, adapted as they are to the waters where they are used, are too weak for the Skagerack with its waves and violent storms.

As regards the *extent* and *the benefit to science* of the experiments with drag-nets, it is evident that, if they are to yield any valuable results, they must be made by a number of boats, properly superintended and continued for a number of years. The experiments made with Dutch, Scotch, and German herring boats, with the view of gaining a more extended knowledge of the herring and its habits, have shown very clearly that no great results may be looked for from experiments made with one or only a few boats, manned with sailors who are entirely unacquainted with the peculiarities of the Skagerack. In order to gain more rapid results and to save labor, as also to better superintend the experiments, a steamship would be exceedingly useful.

(3.) *The introduction of drag-nets as one of the apparatus for catching herring in the Skagerack.*—If drag-net fisheries in the open sea are to be made profitable there is required (1) that an even and good kind of herring, which, both fresh and prepared, can fetch a sufficient price to pay the great expenses of such fisheries, shall come regularly and plentifully during a considerable portion of the year; (2) that the fishermen

[8] Herring fisheries carried on in the open sea during winter with drag-nets have not flourished in any place where they were introduced. See O. N. LÖBERG: *Norges Fiskerier*, Christiania, 1864, p. 36.—*Report by the Commissioners of the Fishery Board, Scotland, of their proceedings in the year ended December* 31, 1880, Edinburgh, 1881, p. 4; "The winter herring fishery did not contribute much to the returns of the year. A herring fishery can never be prosecuted at that season upon the outer coasts of Scotland, except at intervals, the frequent severity of the weather preventing it."

[9] As also for the fisheries in the few fiords on our coast where it can be done. See C. U. EKSTRÖM: *Praktisk afhandling om lämpligaste sättet att fiska sill, torsk, långa, makrill, hummer och ostron;*" Stockholm, 1845, pp. 98, 99, and A. V. LJUNGMAN: "*Preliminär berättelse för* 1873–'74, *öfver de beträffande sillen och sillfisket vid Sveriges vestkust anställda undersökningarna.* Upsala, 1874, pp. 68, 69.

should be men of skill and experience; (3) that the conditions as to season, weather, current, &c., should be favorable; and (4) that the fish can at all times find a ready market.

As regards the first condition, it is hardly probable that it can be fulfilled except during a new great herring period, for herring of a really *superior* quality have, so far, at least, only been noticed in comparatively small numbers near our coast; the second condition will doubtless be fulfilled gradually, if the herring come in large numbers and the fisheries consequently become more extensive. The conditions as to season, weather, current, &c., will hardly be favorable with us, as at present the herring approach our coast in large numbers during the winter season.[10] As regards a ready market, there would be no great difficulty, as the Swedish-Norwegian railroads, and, in a still higher degree, the Jutland railroads offer considerable facilities for bringing the herring into the markets of Norway, Denmark, and Germany, both fresh and slightly salted; and as a really good and well prepared article will, though gradually, gain for itself the place which it deserves. Under the present circumstances, however, when herring of really *superior* quality are comparatively scarce on our coast, the general introduction of the drag-net in our fisheries will (as I have said in my preliminary report on the scientific investigations of 1873–'74) hardly be advisable.[11]

(4.) *The employment of drag-nets during a possible herring period.*—If, however, our so-called "old" north-sea herrings should again, as in former times, visit the Skagerack for a longer period, it will be evident that the first and foremost condition of successful drag-net fisheries—viz, large numbers of herring coming near the coast—would be fulfilled. But this by no means implies that these fisheries (with drag-nets) would be profitable or desirable for Sweden. On our coast other apparatus will always be more or less employed, and will yield the by far greater portion of all the herring caught in our waters, and, therefore principally determine the price of Bohus-län herring in the market, and the method to be pursued in our herring fisheries and industries.[12] *Swedish* drag-net fishers will probably find ruinous rivals in the seine fishers,[13] as the expenses

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[10] This would of course be different if, as was the case during the great herring periods of the sixteenth and the eighteenth centuries, the herring came near the coast at the end of summer, or in the beginning of autumn, in which case they would also be of much better quality.

[11] See A. V. LJUNGMAN: *Om sillsaltning och sillhandel* in the Gottenburg *Handels- och Sjöfarts-Tidning*, December 9, 1881.

[12] Which for the present aims at bringing into the market a *cheap* herring, and products prepared from such cheap herring. See the Gottenburg *Handels-och Sjöfarts-Tidning*, January 14, 1879.

[13] This also happened during the great fisheries of the eighteenth century, as experiments with drag-nets on a large scale, though subsidized by the government, did not yield a sufficient result to warrant their continuance. The experiments in the Kattegat were made in autumn, and the principal station for the herring vessels was at Käringo.—See *Den Svänska Mercurius*, February, 1756, pp. 454–457, 459–460; also *Nya Handlingar of Kongl. Wetenskaps-och Witterhets-Samhället, Göteborg*, Gottenburg, 1808, p. 46.

of these latter are very small as compared with those of the drag-net fishers, leaving out of the question the fact that they will have to combat much greater difficulties and dangers.[14] As, moreover, the open sea is free to all, drag-net fisheries, if once introduced in the Kattegat, would soon be carried on also by the fishermen of other nationalities, who, in most cases, could do this under *more favorable* circumstances than we. Denmark is much more favorably located in this respect than Bohus-län, and those nations whose herring already enjoy a high reputation in the great markets of the world, and who have the most experienced and skilled fishermen, will certainly, if drag-net fisheries are introduced in the Skagerack, soon outstrip us in the race. They will suffer much less than our own drag-net fishermen from competition with the herring caught near the coast, which, as far as our Bohus-län fisheries are concerned, will (during a herring period) naturally determine the reputation of the herring.[15] The Bohus-län herring, no matter whether they are caught with nets or seines, will most assuredly only gain the reputation of a second-rate article; for if the fisheries on our coast yield an exceptionally large number of herring, people will not be careful in preparing them; and with coast-fisheries like ours the exportation of badly salted and prepared herring would hardly occur in any large quantities or for any length of time,[16] as our herring would very soon lose their reputation, all the more as the other nations who participated in these fisheries with us would doubtless find it to their advantage to decry our goods.

The meeting in the Skagerack of numerous fishermen of different nationalities would also in many other respects cause unpleasantness, and if during stormy weather many of the foreign fishermen should be compelled to seek shelter in the harbors on our coast it would often be extremely difficult to maintain good order.

Drag-net fisheries would also have this disadvantage for Sweden that they would draw a large number of persons from other and far more important trades, which would thereby suffer. During the most productive periods of our last great herring fisheries of the eighteenth century about 6,000 seine fishers caught a much larger number of herring per annum than more than 45,000 catch in Scotland at the present time.

The outfit of the seine fishers is moreover much less expensive. As regards the supposed injurious character of the different apparatus, just as great, if not greater, objections could be raised against the drag-nets as against the *large* seines.

The supposed *advantages* of drag-net fisheries over seine fisheries—viz,

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[14] See A. V. LJUNGMAN: *Sillfiskefrågan* in the Gottenburg *Handels-och Sjöfarts-Tidning*, 1879, No. 10.

[15] The experience gained during the winter herring-fisheries on the west coast of Norway goes to confirm this.

[16] See O. N. LÖBERG: *Norges Fiskerier*, Christiania, 1864, pp. 51–52, 54–55, 63, 65; A. V. LJUNGMAN: "*Sillfiskefrågan* in the Gottenburg *Handels-och Sjöfarts-Tidning*," 1879, Nos. 10 and 11, January 14 and 15.

that they are calculated to educate good seamen, and thereby benefit navigation and supply experienced sailors for the navy—are certainly exaggerated; and, as the experience of Norway and Great Britain fully proves, are by no means real.

Tjörn, February 12, 1878.

AXEL VILHELM LJUNGMAN.

II.

THE CARE OF THE SICK ON THE COAST OF BOHUS-LÄN DURING THE HERRING FISHERIES.

To the Committee of the Gottenburg and Bohus-län provincial parliament for regulating the care of the sick in these provinces:

In view of a notice from the committee, in the papers, the undersigned ventures to lay before the members of said committee a plan (in briefest outline) *for regulating the care of the sick on the coast of Bohus-län, more especially during the expected great herring fisheries.*

The large number of persons who, during great periodical herring fisheries, gather in that portion of the coast where the fisheries are carried on, the majority of whom are strangers unaccustomed to the mode of life and climate of our coast during the cold season, are therefore more liable to diseases than the natives. This circumstance certainly deserves the attention of our sanitary authorities. It should be borne in mind that the number of strangers who visited our coast for a greater or less period during the most productive season of the last great herring fisheries is supposed to have been about 50,000 (see *Handlingar rorände sillfisket i bohuslänska skärgården*, Stockholm, 1843, p. 11). In Norway, where, till within about ten years, there have been similar large herring fisheries, special physicians were appointed to attend the sick on the coast, and sick-houses or hospitals were established at various points along the coast. But as the Bohus-län herring fisheries (as far as we can judge from former fishing periods) are mainly carried on in a much more limited stretch of coast which is more densely populated, and where the fisheries therefore are much more concentrated than is the case on the west coast of Norway, the care of the sick during the fisheries could with us be easily combined with the permanent and general care of the sick on our coast. This might be done in the following manner: In the *first* place, the physicians in the sea-ports of the province and in the town of *Lysekil* should attend to the sick in the neighborhood of these places, and new district physicians should be appointed for *Tjörn* and the southwestern coast of *Orost*, and stationed near *Kyrkesund* (or *Hallsbäck*). These should only be increased by one or at most two extra physicians during the fishing season, who might be stationed in suitable places on the coast, or on the guard vessels which are generally ordered to these waters during that season. In the *second* place, new sick-houses, or at the less important fishing stations so-called sick-rooms,[17] should be established, where the sick find better care than in their accidental and often narrow and inconvenient dwellings. Such sick-houses should be established in (1) *Grebbestad*, (2) *Lysekil*, (3) *Kyrkesund*, and (4) *Marstrand*.[18] If the fisheries, as was the case during the greater portion of the last herring period, *should principally be carried on on the southern and central portions of our coast*, a sick-house would be required, at least during the fishing season, in some place on our southern coast; the most suitable place for such a sick-house, or at least for a physician during the fishing season, would be *Kalfsund*, or, if a railroad should be constructed to the southwestern coast of *Hisingen*, someplace on that coast.[19] The sick-bays or rooms in the above-mentioned places could easily be attended to by the resident physicians for a comparatively small compensation.

As the herring fisheries, however, are as yet so little developed, and as their future is uncertain, in the beginning only the adoption of such measures can come into question as would be of decided benefit and are positively demanded by the circumstances. Among such measures we must here mention the appointment of a district physician, to be stationed at *Kyrkesund*, and the establishment of sick-rooms near *Grebbestad*, *Lysekil*, *Kyrkesund*; even the general demand for sick-houses would thereby be fully met for a long time to come. An essential condition for the carrying out of these measures will be that the expenses are kept within reasonable limits, and that the physicians stationed in the respective districts would attend the sick-rooms, so that there would be no necessity for appointing special physicians. If, however, the most northerly of the proposed sick-rooms should be established, *e. g.*, in *Fjellbacka* or some other place far from any resident district physician, it might be necessary to appoint an extra physician. Under all circumstances, however, it should be considered whether the establishing of the three above-mentioned sick-rooms would be more advantageous and would benefit a larger extent of coast than a larger sick-house with a special resident physician in some place between *Uddevalla* and *Strömstad*.

As regards the appointment of an extra district-physician for *Tjörn* and the southwestern coast of *Orost* (*i. e.* a district having a population

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[17] See C. GRILL: *Om sjukvården på landsbygen*, Hedemora, 1869.

[18] In case one or several railroads should be constructed, at whose terminal points on the coast the fisheries would naturally be concentrated, these points would also be the most suitable places for establishing sick-houses or sick-rooms, or for stationing physicians.

[19] It is to be regretted that, in view of the possibility of great herring fisheries in the near future, the quarantine buildings at *Känsö* have not been transferred to the coast of *Hisingen*, as they would have made excellent hospitals during the fishing season.

of about 12,000), it would be well to bear in mind how difficult, not to say impossible, it would be for one physician alone to attend to the wants of so large a district in the proper manner. The experience of former physicians stationed in this district tells us that this is well-nigh impossible. The neighboring districts have, for this very reason, been recently subdivided into smaller districts, and this may very soon also become necessary for the district comprising *Orost* and *Tjörn*.[20]

Tjörn, April 28, 1879.

AXEL VILHELM LJUNGMAN.

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[20] In subdividing the provincial district of *Orost* and *Tjörn* it becomes indispensable that one of the physicians should live near the sea on either island, so that he is just as easy of access by sea to the coast population as by land to the inland population.

VII.—REPORT ON THE PRACTICAL AND SCIENTIFIC INVESTIGATIONS OF THE SPRING HERRING FISHERIES DURING THE YEAR 1880, SUBMITTED TO THE DEPARTMENT OF THE INTERIOR.

By O. S. JENSEN,
*Curator of the Bergen Museum.**

Having been commissioned by the Department of the Interior to make a practical and scientific investigation of the spring herring fisheries, I left Bergen on the 11th of February for Haugesund, and on the 13th of February arrived at the fishing station of *Udsire*. Here I remained till the 9th of March, when I went to *Rövær* to continue some investigations of the spawning of the herring. After a short stay at *Akrehavn* and *Skudesnæs*, where I had an opportunity to gather (from some experienced fishermen) further information relative to the occurrence and nature of the spring herring during recent years, I returned to Bergen on the 20th of March.

As I had occasion to be present during the latter portion only of the spring herring fisheries, and as during the greater part of my stay the weather was unusually stormy, my investigations had necessarily to be more imperfect than they would otherwise have been. The seine fisheries, which have been in operation for some years, and which present features of special interest to the investigator of the spring herring fisheries, were over when I arrived. No fish whatever were caught in seines during my stay at the fishing stations, and fishing was only carried on with stationary nets. During the last two years these fisheries have begun to revive, which is a welcome sign that the spring herring will again follow their usual course along our coasts. These old fisheries, therefore, promise again to be of considerable importance in our own times. A historical investigation of the occurrence of the herring, during the last ten years, also brings to light other phenomena, indicating that a new period of spring herring fisheries is about to be ushered in.

Since Dr. A. Boeck published his classic work, *Om Silden og Sildefiskerierne* (The herring and herring fisheries), in 1871, no work of import-

***Indberetning | til | Departementet for det Indre | om de i 1880 udförte, | praktisk videnskabelige Undersögelser over Vaarsildfisket | af | O. S. Jensen, | Conservator ved Bergens Museum. | Christiania, | 1881.*—Translated by HERMAN JACOBSON.

ance, at least of a scientific nature, has been published, during the last few years, on the history of the spring herring fisheries. Dr. Boeck and Prof. G. O. Sars have written articles on certain special features of these fisheries, but these articles are far from exhausting their subjects, and, moreover, these two scientists have not had occasion to observe these features in connection with phenomena which only became known during the last few years, and which enable us to understand the former correctly. The herring, during the last ten years and even till quite recently, have exhibited the most remarkable changes, which are not isolated, but form a continuous *development*, one stage of which is closely connected with the other. These changes have been very rapid, and it is only to be regretted that they have not been made the subject of scientific investigations. By examining the numerous reports relative to the course of the fisheries during the fishing season, and by conversing with experienced fishermen, whose recollection of all the circumstances was still vivid, I was, however, enabled to obtain a tolerably correct idea of the history of the last ten years' fisheries, and I shall in this report endeavor to present to the reader its most important features. Till the year 1874 I chiefly based my observations on the reports of the superintendents of fisheries, which form a most valuable source of reliable and unbiased information. One would think that oral reports from different parts of the coast would be likewise reliable with regard to phenomena which have occurred at a comparatively recent period of time, and relating to a subject which long experience should have led the fishermen to examine into closely, viz, the greater or less degree of maturity in herring, their size, weight, &c. These last-mentioned sources, however, I have used with great caution, and shall for the present only refer to them in a general way.

The development of the spring herring, above referred to, has not yet reached its terminal stage. As this development is still going on, it may be expected that several of the phenomena which have characterized its early stages will occur again, and that therefore by a closer examination of such phenomena more light may be thrown upon the early part of this development.

The very remarkable occurrence of herring in unusually large masses during the first years of the last decade has a parallel in the herring fisheries of *each* year. I here refer to the "new herring," or mixed herring, which appeared in enormous numbers prior to the arrival of the spring herring in 1870, but which also appeared during the following years, and whose schools chiefly consisted of so-called "*straalsild*," ray herring, or "*blodsild*," blood herring. It is a well-known fact that these herring appear regularly every year in small numbers, immediately before the arrival of the spring herring. Here, therefore, there still seems to be a chance to make direct observations relative to the more important phenomena of the herring fisheries of the last few years.

The dependence of the herring on the temperature of the sea, which is a most important item in the daily life of the herring, has already formed the subject of investigations by Boeck, and it was my intention to continue these investigations begun by him. With a Negretti & Zambra's deep-water thermometer, which, through Professor Mohn's kindness, was loaned me by the Meteorological Institute, I took a number of observations of the temperature, but unfortunately these were made too late in the season to throw much light on the course of the herring during the present fishing period. These observations, however, furnish results relative to the temperature of the sea at different depths, which are important for us to know in connection with this whole herring question, and which became specially interesting when compared with Boeck's earlier observations.

The observations of the temperature, and other meteorological investigations, made near the coast and with reference to the more or less mature spring herring, are of course as yet an incomplete work, and the most important question connected with the herring problem, the cause of the disappearance of the herring from our coast for years at a time, is probably still far from a satisfactory solution. In order to ascertain whether the temperatures and currents of the sea are really the principal causes of this phenomenon, these meteorological conditions, and their influence on the course of the herring, should be observed *outside* of the spawning season, or during summer, when the herring are out in the open sea. This investigation still belongs to the future. We do not even know for certain where the herring have their summer stations, but only suppose that we know the places where in all probability they must be looked for (see Sars's reports, especially the one for 1873). The first and most important thing to do would be to go through these places with seines, which perhaps would not be very difficult. If such an expedition were made whenever a change should take place in the spring herring fisheries, we would get a good deal nearer to a solution of the above-mentioned most important question—the periodical disappearance of the herring from our coast.

I shall now proceed to give a brief review of the observations made this year, and in doing so I shall have to speak first of the history of the spring herring fisheries in recent times, and in connection therewith of the present condition of the spring herring; and secondly I shall have to add some remarks on the temperature of the sea during the fishing season.

By unceasing and most meritorious labor Boeck has succeeded in showing a certain regularity in those changes to which the fisheries are subject during a so-called "herring period."* According to Boeck's investigations, this irregularity principally consists in the circumstance that during the first part of a "herring period" the fisheries gradually

*Although this term is not entirely justified, I will nevertheless employ it in this report, as from very good causes it has become quite generally adopted.

commence earlier every year, whilst towards the end of the period they gradually begin later. With regard to localities, the herring fisheries move in a certain direction, thus, *e. g.*—according to Boeck—in Bohuslän and in our southern spring-herring district, in a northerly direction, till they reach a point where the fisheries cease.

Similar changes of a regular character have not only been observed on our coast, but also on the coast of Scotland. According to Mr. Winther* the herring fisheries in the Sound were, during the herring period that ended in 1875, gradually extended later into the season. In the Great Belt a gradual northward movement of the herring has been observed.† In France a similar phenomenon is said to have been observed during the sardine fisheries, and it therefore seems that these phenomena are of a more general character.

In our *southern spring-herring district* the following changes as to the time of commencement of the fisheries have been observed:‡ In 1808, therefore, in the beginning of our last herring period, the fisheries at *Skudesnæs* commenced on the 6th February. During the following years they gradually commenced earlier, in 1814 on the 1st of February, in 1815 on the 31st of January, in 1817 on January 30th, and from that time on they began in January—the dates varying somewhat—for a long number of years. During the years 1844 to 1847 the fisheries commenced partly in January and partly in December. From 1848 the first herring were regularly caught in December, and this lasted till 1859. From 1860 the herring again commenced to arrive in January, and in 1869 the *spring-herring fisheries* proper did not commence till the 3d February. As regards locality, it was observed that during the latter part of the "herring period" the herring left their southern spawning places near *Skudesnæs* and the *Hviting* Islands, and gradually moved farther north, so that towards the end of the period the principal fisheries were carried on near Karmoe.

The year 1869 was distinguished by the late arrival of the herring, and by the fishing stations being far north, as well as by other peculiar features. From 1860, when the herring fisheries for the first time during the "period" commenced late in the season, considerable masses of herring came near the coast, and for several years the fisheries were very good. Even as late as 1868 there were exceedingly successful spring herring fisheries in the southern district, about 500,000 barrels of fish being caught. A significant change, however, took place in 1869. Lieutenant *Heyerdahl*, the superintendent of the southern district, says: "It was very generally noticed in the our district that the schools of herring were not of the same size as in former years this must have

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* *Tidsskrift for Fiskeri*, new series, iii, 1.

† In the Sound there can hardly be any such movement, as it contains only one favorable spawning place.

‡ See BOECK: *Om Silden og Silde-fiskerierne*, and the reports of the different superintendents.

been the actual fact, unless one supposes that the largest school of herring approached the coast in places where there was no one to observe them. Even at *Udsire*, which is a favorite resort of the herring, the schools were much smaller than usual." In reviewing these fisheries at the present time, we find that these observations were entirely correct. The quality of the herring during that year also goes to corroborate them, for during these fisheries an unusual number of small herring were caught with the spring herring. Generally these small herring only make their appearance after or near the close of the fishing season, and their appearance is always considered as a sign that the schools of spring herring are decreasing in size, and are disappearing from the coast. This mingling of small herring with the spring herring during the fishing season of 1869 has its parallel in the Bohus-län fishing period, which came to a close in 1808, the last years of which likewise distinguished themselves by the frequent mingling of small herring with the larger herring.

From the reports of the superintendents we learn that, in 1869, the schools of herring were often followed by large numbers of coal-fish, which were often noticed in the very middle of such schools. This was the case not only in the southern, but also in the northern district. Fishing was very uneven during this year.

The superintendent of the northern district reports that, in 1869, the number of herring which approached the coast was hardly less than in former years, and that no small herring were found among the spring herring. Soon afterwards, however, the same phenomena undoubtedly began to show themselves in the northern district, although they were not as closely observed as in the southern district, where the year 1869 marks the end of the rich spring herring fisheries. Whilst in 1869 355,000 barrels of fish were caught in the southern district, the spring-herring fisheries proper only yielded 55,000 barrels in 1870. Although this last-mentioned number is probably too low (see report of the superintendent for 1871), the fact remains that the yield was much smaller than in 1869. In 1870 the first school of herring, composed purely of spring herring, were observed on the 20th January, but fishing did not commence till the 10th of February, some of this delay, it is true, having been caused by unusually stormy weather and heavy seas. The fisheries during this season were short and irregular, and the same was the case during the three following years, when only an average quantity of 14,000 to 15,000 barrels was caught. The herring made their appearance sometimes in January and sometimes in February, but it was impossible to fix the exact date of the arrival of the spring herring, as they were very much mixed with "new herring," from which it was difficult to distinguish them. (With regard to these herring more will be said.)

In 1874 the southern spring-herring district only yielded the very small quantity of 3,000 barrels. During this and the preceding years it was proved in the most convincing manner that the cause of this sudden and rapid decrease could not possibly be found in any meteorological change which took place near the coast, and which might have prevented the usual number of herring approaching; but that there was, on the whole, no indication that any considerable number of herring had come near the coast. In the beginning of the "period" the prospect seemed very favorable, but these hopes soon vanished. Thus, in 1873 and 1874 only few herring were noticed near the coast during the months of January and February, when generally the more important spring-herring fisheries are going on. The same experience was met with at the outermost station of *Udsire.* As in 1869, so also in 1870, the schools of herring were accompanied by an unusually large number of coal-fish and cod, both in the southern and in the northern district. The same phenomenon was observed in a still more noticeable degree in 1871, both during and after the fishing season. At present I have no data to show to what degree this was observed during the following two years. In 1874, however, the superintendent reports that but few cod were observed; the schools of herring had also decreased in size to such an extent that the cod, the inveterate enemy of the herring, had no special inducement to follow the schools. It has been supposed that an extraordinary increase in the number of the enemies of the herring might be the cause of their disappearance. But there is not sufficient cause to justify this supposition, and it would at any rate be too hasty a conclusion to give this as the principal cause of the disappearance of the herring from our coasts.

The mingling of small herring with the spring herring rapidly assumed larger dimensions. In 1871 it was considered doubtful whether any genuine spring herring were caught; and many experienced fishermen expressed it as their solemn conviction that no genuine spring herring had approached the coast in the southern district during that year. From the report of the superintendent it also appears that the number of small herring was larger than at any previous time; and this was the case both in the northern part of the district, near *Brandesund*, and in the southern part, near *Rövær.* The average size of the *Rövær* herring was determined by "standard barrels," each of which held 620 to 680 herring. In 1872 such a barrel comfortably held 660 to 720 herring, and there is no longer any talk of unmixed spring herring. But during all these years, even from the season of 1869–'70, other phenomena were observed, which were followed by an increase of spring herring. Of these phenomena I shall have occasion to speak later.

In the *northern district* the spring herring approached the coast gradually, just as in the southern district, towards the end of the last "herring period." From the reports of the superintendents, it appears that in 1852, 1853, and 1854 the first herring were caught in December; in 1855 on the 8th of January; in 1856 on the 15th of January; in 1857 on the 13th of January; during the two following years again on the 15th of January; in 1860 on the 19th of January, and later always after the 19th of January.

As I have already observed, there was hardly any decrease in the size of the schools of herring in the northern district, not even at *Söndmöre*. The total yield in the northern district was 255,000 barrels, and at *Söndmöre* 70,000 barrels.

In 1870, when the fisheries were short and irregular, the yield went down as low as 80,000 barrels in the northern district, whilst at *Söndmöre* it probably amounted to 25,000 barrels. The superintendent says in his report for 1870: "The meteorological conditions were on the whole more favorable than is generally the case, and the almost total failure of the fisheries must therefore be ascribed to the small number of herring which had approached the coast, although sea birds and whales, which are considered sure indicators of the occurrence of herring, showed themselves in the same numbers as during previous years."

A change was also noticed in the quality of the herring. At *Söndfiord* the herring seem not to have been of such even and good quality as at *Nordfiord* and *Söndmöre*. I gather these facts partly from the reports of the superintendents and partly from other sources to which I had access. It is a significant fact that the mingling of different kinds of herring took its beginning in the southern part of the district.

In 1871 it was reported that the herring were of the least even quality near *Bueland*, the southernmost of our more important fishing stations. In the northern part of the district and near *Söndmöre* the herring were of the usual good quality. In the northern district 61,000 barrels of fish were caught, and at *Söndmöre* 8,000. The yield, however, was smaller than it would otherwise have been, on account of storms, the severe cold of winter which set in exceptionally early, and other unfavorable circumstances.

What had been already indicated by the uneven size of the herring during the preceding years took place in 1872. There were hardly any fisheries in the whole southern portion of the northern district as far as Bremanger, on the very coast where formerly there had been the best fishing in the whole district. It also appears that the number of herring caught near Froe Island, southwest of Bremanger, was remarkably small, and that the fish were nearly all of small size. In 1871 the average number of herring caught near Froe Island was 504 per "standard barrel," whilst in 1872 it was 522. In the other portion of the northern district the yield was 62,000 barrels, and near *Söndmöre* 115,000, an unusually good yield for these northern latitudes, principally owing to the exceptionally favorable weather. These facts show that great masses of herring still come to these coasts. In spite, however, of the approach of such masses of herring, there seemed to be some indications that the same fate awaited these fisheries as the southern ones, the average number of herring per "standard barrel" being 540, whilst in 1871 it was 530. This was first observed at *Söndfiord*, therefore at the southernmost point of the district. Herring of the same size as those caught in former years could only be counted on with any degree of certainty in the northernmost portion of this coast, viz, at *Söndmöre*.

In 1873 the average number of herring per standard barrel near *Fröi Island* was 540. But few herring were caught near that station, and no school of any consequence seemed to have approached the coast. The prospects south of *Bremanger*, which during the preceding year had been tolerably good, seem certainly to have been far less favorable. At *Nordfiord* the yield was only about 24,000 barrels, although it must be taken into consideration that the conditions were particulary unfavorable; no decided decrease in the number of herring could, however, be observed. The indications seemed to be that the herring would be smaller in size. At *Söndmöre* no change in the size of the herring could be noticed; the yield at this last-mentioned place was only 6,000 barrels, owing exclusively, however, to the stormy weather.

In 1874 there was no fishing south of *Bremanger* or near this island, except at *Nordfiord*. The yield at the latter place was very insignificant, viz: only 5,000 barrels. There was a very marked decrease in the number of herring, and their size was very uneven, but on the whole smaller than in former years. Now, at last, there were likewise indications that the fisheries would come to an end near *Söndmöre*. In spite of the most favorable weather only 8,000 barrels of fish were caught at this station, and the herring were decidedly smaller, the average number per "standard barrel" being 570 to 580 (against 532 in 1872).

In 1875 there was no fishing whatever north of *Bremanger* in the *Nordfiord*. Near *Söndmöre* it was reported that 3,000 to 4,000 barrels were caught to the northwest of *Stat*. This year must be considered as the closing year of the spring-herring fisheries.

The above brief review of the decline of the spring-herring fisheries shows conclusively that also in the northern district and near *Söndmöre* the herring disappeared gradually in the direction from south to north, the schools decreasing in size from year to year. In the southern district the herring went in a northerly direction, even before the schools began to decrease in size.

The same regular and gradual decrease could be observed not only in each individual fishing-district, but all along the coast where the spring-herring fisheries were going on. The herring first disappeared in the southern district, then in the northern, and finally at *Söndmöre*. After the decrease in the size of the schools had set in, it was slower in the northern district and at *Söndmöre*. For a considerable time large numbers of herring continued to come near these coasts, and disappeared all of a sudden. The average size of the herring also continued to be larger,* and their quality was on the whole better. These phenomenon

* The fact that the herring in the northern district and at *Söndmöre* were larger than those of the southern district, not only during the period when they decreased in numbers, but as a general rule, is—according to *Löberg*—caused by the circumstance that in the first mentioned districts nets with larger meshes are used (See LÖBERG: *Norges Fiskerier*, 1864, p. 47). This assertion, however, needs further examination.

must of course be in some way connected with each other, and doubtless depend on the circumstance that the herring go farther north.

As to time, the spring herring came—as has been said above—later and later towards the end of the period; and this phenomenon was the same in both districts. Another circumstance, relative to the spring fisheries along our entire coast, likewise deserves to be mentioned here, when the spring herring commenced to come later and later in the season, they were first seen in the southern district, then in the northern, and finally, somewhat later at *Söndmöre*, which order of time probably depends on the geographical location of the different districts, and corresponds to the order of place which the spring herring observed when gradually disappearing from our coasts.

With regard to the *great herring fisheries* we can, to some extent at least, observe the same regularity as in the spring-herring fisheries.* It is a well known fact that the great herring commenced to appear near our coasts in 1861, when large schools of them were observed off the northern and western coasts of the Lofoden Islands and *Vesteraalen*. In the beginning, however, they kept at a distance of several miles from the coast, and only approached it in rare cases to within a distance, which enabled the fishermen to catch some. Gradually they were moving farther south. In 1863 they appeared north of *Helgeland*, near *Thænen* on the Island of *Lurö*, and to some extent also near the *Myk* Islands and near *Rödö*. In 1864 they were observed south of *Helgeland*, near the outer islands of *Herö* and *Vegö*, and also—according to reports from merchants and fishermen of *Christiansund*—still farther south near *Sulen*, *Halten* and *Hitteren*, and at *Nordmöre*, near *Smælen*, *Talgsö*, *Grip*, and *Stemmet*.† At *Nordmöre* there was excellent seine fishing, and large hauls were made; but unfortunately many of these fish were lost again during a most violent storm, which actually resembled a hurricane. The great herring during the following years continued to make their appearance far south, which fact is also mentioned in the reports on the fisheries of Norway, published by the Department of the Interior. During these years the whole coast of Norway from *Karmö* to Finmark was literally surrounded by herring. South of *Helgeland*, however, no great herring fisheries of any importance were carried on. According to the reports published by the Department of the Interior, which speak of the occurrence of great herring near *Vigten*, in the district of *Namdalen*, they seem to have disappeared from those localities at the same time when they moved farther north into the great-herring district proper. During the years 1868 and 1869 there were fisheries as far north

* My success of information for the following review of the great herring-fisheries have been the reports published every year and every fifth year by the governors, and by the Department of the Interior.

† See also the report for the five years 1861 to 1865, by the governor of *Romsdalen*, according to which the herring in 1864 and 1865 appeared near *Nordmöre* and near *Romsdalen*. Nothing is said, however, in this report among what class these herring should be counted (with regard to the size of the herring, see *Boeck's* report for 1873, p. 8).

as Finmark, but their yield was only about 2,000 barrels per year. Later than 1869 there were no fisheries in these high latitudes. The great herring-fisheries proper were carried on near the coasts of the districts of *Nordland* and *Tromsö* where the largest number of great herrings approach the coast. After having reached the coast about the same time near *Senjen* in *Tromsö* and near *Vesteralen*, the great schools of herring passed the southern point of the Lofoden Islands, going in a southerly direction to the *Skibbaads* Reefs in Southern *Helgeland*. Smaller schools went further east to the *Gildeskaal* Reefs near *Sydsalten*. One year after the other the great herring returned to exactly the same localities, and the time of their arrival was exceedingly regular. Later the herring went farther north; the *Helgeland* fisheries came to an end, and the great masses of herring turned farther north from the southern point of the Lofoden Islands in the direction of the *Vestfiord*, not a few of them going as far north as Finmark.

The more important data as to time and place of these remarkable migrations are as follows:

In 1868 and 1869 the hitherto insignificant *Gildeskaal* fisheries began to improve, especially at the fishing-stations of *Fuglövær* and *Fleinvær*. In 1869 an enormous mass of herring came to *Fleinvær*, and large numbers also came to *Fuglövær*.

In 1870 herring not only came in large masses to *Fuglövær*, where the fisheries were very good, but also farther north to the *Hellig* Reefs in the district of *Bodö*, where formerly no great herring had been caught. Owing to various unfortunate circumstances not many fish, however, were caught, the yield being only about 2,000 barrels. Even during that year (1870), therefore, a change could be noticed in the migrations of the great schools of herring, many of them going as far north as the *Vestfiord*.

In 1871 enormous masses of herring came near the *Gildeskaal* coast, so that in some places the sounds were absolutely filled with herring. Herring also came to the *Hellig* Reefs, and to *Blixvær* and *Landegade*, and other places in the same district; the yield was 56,000 barrels.

In 1872 large numbers of herring again came to the *Gildeskaal* coast, and to many places on the coast of the *Bodö* district. Near the *Helgeland* Reefs, however, where there had been the most extensive fisheries, but few fish were caught; this applied especially to the three southernmost reefs viz: *Skibbaadsveer*, *Aasvær*, and *Lovunden*. The total yield was only 24,450 barrels, against 294,200 in 1871, when, it is true, the fisheries were exceptionally productive. Farther north, near *Rödö*, in the *Helgeland* district, the yield was 10,500 barrels.

In 1873 but few herring came to the coast of *Helgeland*, excepting, however, the northernmost portion near *Melö*, and the fisheries proved an almost total failure at *Skibbaadsveer*, *Aasvoær*, and *Lovunden* (total yield 4,600 barrels), and at *Rödö* (yield 1,000 barrels). At *Melö* the herring approached the coast several times, but even here a decrease could be noticed (9,850 barrels, against 17,275 during the preceding year). At *Gildeskaal* and *Bodö* large masses of herring were yet found, but their arrival was somewhat irregular; and it seems that especially at *Gildeskaal* the herring sought other reefs than formerly. During this year the herring went farther north into the *Vestfiord*, and an unusually large number was found along the entire coast of *Salten* and far in the *Tysfiord*.

In 1874, the last year when great-herring fisheries were carried on, only a few small schools made their appearance near *Helgeland*. Near *Melö* only 1,220 barrels of fish were caught. Also at *Gildeskaal* in *Salten* the herring failed to put in an appearance, and but very few came to the *Bodö* district, whilst towards the *Vestfiord*, in the *Stegen* and *Hammerö* districts, large numbers came near the coast.

As regards the more northerly localities, large numbers of herring had regularly approached the coast near *Vesteraalen*. In 1871 and the following years they came also to the Lofoden Islands, in particularly large numbers during 1871 and 1872, without, however, making the fisheries in these localities specially productive.

In the *Tromsö* district large numbers of herring likewise approached the coast, but one year they came quite near the coast, and the next they kept at a considerable distance from it, which of course made the the fisheries very irregular.

In Finmark there were no fisheries since 1869. Prof. G. O. Sars furnishes the interesting item of information, that considerable numbers of herring were seen in 1873, even near the coast of East Finmark.

It is not known with any degree of certainty how much the herring decreased in number in the northern portions of the great herring district proper (the districts of *Nordland* and *Tromsö*) during the last year of their occurrence in those parts. At *Salten* a much larger number of herring was caught in 1874 than in 1873; but this circumstance was caused partly by the exceptionally favorable weather, and partly by the fact that the fishermen in 1874 were not as well prepared for fishing on a large scale as in 1873. At *Vesteraalen* about the same number of fish was caught in 1874 as in 1875, and the fisheries of both years were considered good. In the *Tromsö* district the fisheries of 1873 were more productive than in any previous year, the yield being 168,000 barrels. In 1874 the yield was much smaller, viz; 70,000 barrels; but even this fact does not furnish any absolutely satisfactory evidence of a decrease in the number of herring.

In 1875 the fisheries were a total failure everywhere, and there was hardly any indication at all of any great herring having approached the coast. The rumors which were current during the year that the herring showed themselves in the *Nordland* district proved to be unfounded, or at any rate grossly exaggerated. In the *Tromsö* district birds were noticed to hover over the sea, and "it is therefore probable," says the governor in his report, "that there were great herring near the coast," but in no case did they approach it very closely.

In 1876 no great herring were found in any portion of the *Nordland* coast. Farther north, in the district of *Tromsö*, it is said that a small percentage of great herring were found among the fat herring.

The great herring fisheries, therefore, came to an end, after *a gradual disappearance of the great masses of herring in a direction from north to south*, in a similar manner as the spring-herring fisheries.

It is peculiar that the great herring did not, like the spring herring, confine themselves to the northermost of their old accustomed landing-places, but sought new places, going north towards the *Vestfiord*. In the occurrence of great herring near the coast of Finmark in 1873, we probably find a phenomenon of a similar character. One would think that the great herring also, particularly in 1875, after having left the coasts of *Nordland* and *Tromsö*, would have appeared later in larger numbers near the coast of Finmark, but it is expressly reported (see *Norges Statistik*) that in 1875 and the following years no herring came near the coast of Finmark.

In 1871, and also later, the great herring went farther up the inland fiords than they had ever done before, and this must be considered as a very marked and remarkable change in the occurrence of the herring, which hitherto had been extremely regular. I will here only note the fact that during the following year, 1872, the *Helgeland* fisheries commenced to decline. The migration of the herring in the direction of the *Vestfiord*, taken in connection with the circumstance that the herring went higher up the inland fiords seems to point to a changed condition of the coast waters towards the close of the great herring fisheries.

With regard to the quality of the herring, it was reported that the great herring caught near *Helgeland* in 1873 were *mixed with smaller kinds of herring* resembling spring herring, which was considered as an indication that the masses of great herring were disappearing. I have no exact information as to the degree to which the herring were mixed. In the northern districts, where the herring did not decrease so much in number, the size of the great herring seems not to have undergone any considerable change. Altogether there was less change both as to number and size in the great herring, till they disappeared entirely, than in the spring herring.

From information found in the reports of the governors regarding the time when the great herring *arrived* at the different fishing stations, it appears that the time of arrival did not undergo any considerable change, and there is no indication whatever that towards the end of the fishing period it took place later in the year. In this respect, therefore, the great herring differs from the spring herring. The conditions under which the great herring lived certainly differed from those of the spring herring, which, as well as in other ways, is shown by the fact that they arrived on the coast much sooner; on the coast of *Tromsö* and *Vesteraalen* as early as October and September, and at *Salten* and *Helgeland* in November and the first half of December. The exact cause of the difference above referred to is unknown, and it is impossible to decide whether any special significance is to be attributed to it.

There is another circumstance, relating to the time when the great herring fisheries were carried on, which I must mention, although I do not consider it as of primary importance.

The great herring which began to appear on the coast in 1861 came therefore towards the end of the spring-herring period 1807, 1875, and they disappeared about the same time as the spring herring. As regards the former spring-herring period, 1698–1787, I am unable to tell when the great herring disappeared from the coast; but according to reports from the *Nordland* district in the royal Danish archives, it appears that there were great-herring fisheries during the latter half of the century, especially during the years 1760–1770, therefore likewise during the latter part of the herring period.*

It is possible that this appearance of the great herring far north and towards the end of the herring periods is a regular occurrence. The striking phenomenon that both spring herring and great herring disappeared from the coast at the same time also encourages the supposition that their occurrence is subject to common laws of nature. During the last herring period, regarding which we possess fuller and more definite data, the disappearance of the great herring not only took place at the same time as that of the spring herring, but the time of their first appearance in 1861, towards the end of October and therefore *comparatively early*, coincided with a decisive turning point in the history of the spring-herring fisheries; for about that time the spring herring commenced to come to the coast later and later in the season. This may be an accidental coincidence, but perhaps it has some deeper significance. During the latter portion of the spring-herring period, counting in about the last 20 years, a remarkable change was observed in the quality of the spring herring. They decreased in size, and at the same time they are said to have approached the coast in a more mature condition.† It seems as if the spring herring about this time approached the coast under less favorable conditions, since they could not reach their former size. The great herring, which thereupon came very unexpectedly (it was thought in *Nordland* that the great herring did not properly belong to these waters, but had only accidentally found their way there), altogether resembled the spring herring (*Boeck's* report, 1873). The only difference was that they were somewhat larger and less mature when they arrived near the coast. They therefore dis-

* See the report of Governor *Vorsö* for the five years 1866–1870. It would be very desirable to get some further information regarding these old great-herring fisheries; but, so far, I have had no opportunity to obtain such information.

† The decrease in the size of the herring I have often heard spoken of. See, also, "*L'industrie de la pêche en Norwége*," par H. B., 1876.

tinguished themselves in those very respects in which the spring herring underwent a change. The great herring, moreover, were much fatter than the spring herring. They evidently lived under more favorable conditions. Should this be an indication of a more intimate connection between the occurrence of the spring herring and that of the great herring? We are justified in asking this question; but we cannot enter further upon this subject, because we still lack more reliable information. The changes through which the spring herring passed need much more accurate investigation. That the great herring only showed themselves several years after these changes had taken place forms no serious objection to the supposition that there is an intimate connection between the two kinds of herring. All that can be said is that the great herring did not show themselves near the *coast* till that time

After this brief review of the great-herring fisheries we will return to the first year when there were indications that the spring-herring fisheries would come to an end with a view of describing a very remarkable occurrence of herring about that time, in connection with the spring-herring fisheries which have now again begun to spring up on our coasts.

In 1869, as in the preceding year, the spring-herring fisheries commenced very late, we may say not till the 3d of February. But according to the reports of the superintendents a few spring herring mixed with fat herring were caught near *Udsire* as early as the 9th of January. The reports give no further details as to the quality of the herring. In a newspaper article, published about that time, we read as follows: "It seems now to be absolutely certain, that the birds which have recently been seen in the *Udsirefiord* have accompanied large shoals of small herring (probably young spring herring) of the same size as the 'Christiania herring,' mixed with fat herring, some of which contained roe and milt like other spring herring." These herring also showed themselves in other places besides *Udsire*. Thus the superintendents report that herring of different kinds were noticed near the southwestern point of *Karmö*, and the newspaper article above referred to also contains the following: "Such small herring, mixed with fat herring, have also appeared about New Year in large numbers in several places, especially in the *Skjoldsfiord* and *Förresfiord*, in which latter inlet a great many were caught."

Both the fact that the herring were mixed and the time when they appeared, seem to indicate that these herring were "mixed herring" or "new herring," which began to appear in 1869, at the very time when the changes in the occurrence of the spring herring above referred to began to show themselves. The description of the herring suits the "new herring" in every particular. Nobody, however, thought it worth his while to examine further into this matter. During the following year these herring appeared in enormous numbers.

A considerable time prior to the beginning of the spring-herring fisheries people were surprised to see large masses of the so-called "new herring" or "mixed herring." Some were caught as early as the middle of December; towards the middle of January, they again began to disappear; some, however, remained till the end of January or the beginning of February, and, even under date of the 11th of February, it was reported in the *Karmesundsposten* (a paper) that small quantities of "new herring" had been seen in the bays, both north and south of *Karmö*. The "new herring" like the spring herring immediately came in near the coast from the high sea in large schools, and were principally caught in seines. They came simultaneously in many places along a considerable extent of coast. They were found everywhere, in the southern, northern, and central spring-herring districts. They even showed themselves as far south as *Egersund*, but especially on the heights of *Bergen*, the largest masses being noticed a little to the west and southwest of that city, on the west coast of the *Sartor* Island. The yield during that year amounted to about 150,000 barrels, which was very little when compared with the large masses of herring off the coast.

The "new herring" differed greatly in size and quality, and they were therefore called "mixed herring." I prefer, however, to call them "new herring," as the name "mixed herring" is apt to confuse, since those spring herring and small herring which are often caught together *towards the close* of the year's spring-herring fisheries, are frequently called "mixed herring."

When the "new herring" came near the shore, their schools were found to consist of "blood herring," some spring herring, herring of the size of the *Nordland* great herring, and finally some summer or fat herring. The occurrence of summer herring is, to a great extent at least, caused by the circumstance that the schools had fallen in with them near the coast and in the mouths of the fiords and had mingled with them. Whenever there were any considerable fisheries near the mouths of the fiords the superintendents' reports say that there were large numbers of "fat herring" mixed with the other herring. Only in exceptional cases spring herring were noticed in the schools, and had probably found their way there from the great masses of spring herring. They were not fully matured, but the same is said to have been the case during this year with most of the spring herring.* It must be supposed that those herring which in size resemble the *Nordland* great herring, and which also were not fully matured, were nothing but spring herring, many of which reach the same size as the great herring. During the following year, however, still larger herring were caught; and it is not impossible that these herring which arrived off the coast very early in the season, together with the great mass of "new herring," came from farther north, where such large herring have their home. But even these must under all circumstances have been mixed.

The largest and most important portion of the schools of "new her-

* BOECK: *Om Silden og Sildefiskerierne*, p. 111.

ring" was doubtless composed of so-called "ray herring" or "blood herring." As to this fact most fishermen agree in their reports, and quite frequently they call the "new herring" simply "ray herring" or "blood herring."

By "ray herring" or "blood herring" we mean smaller herring which, in small numbers, make their appearance every year, just prior to the arrival of the spring herring. *Boeck** says that the "blood herring" are very lean; that they have hardly any trace of sexual organs, and no fat whatever. He supposes that "possibly they are stragglers from the spring-herring schools of the previous year, which on account of not having ready access to food have not been able to feed enough to have their sexual organs fully developed." Sars, referring to Boeck's statement, considers them as barren herring. In the Bergen Museum we now have several (12) specimens of herring, labeled "ray herring" or "blood herring," caught during the years 1864 and 1865. It was of course exceedingly interesting to me to examine these specimens. Not one of them could be said to "have hardly any trace of sexual organs," and none were without these organs; both the roe and the milt were distinctly seen and in course of development, though not yet fully matured. With most of the small specimens, measuring 27.5 to 28 centimeters in length, the roe and milt were still in a very early stage of development, in the transition period from stage II to stage III, as *Heinke* terms them;† the largest breadth of the ovary was 6 to 9 millimeters; in some of the other specimens the sexual organs had been further developed; thus in one fish, measuring 27.5 centimeters in length, the greatest breadth of the milt was 17 to 18 millimeters; and in another one, measuring 26.5 centimeters in length, the greatest breadth of the ovary was 16 millimeters, corresponding to *Heinke's* stage III. In larger specimens the roe and milt were still farther developed. All these herring were doubtless what are called "ray-herring" or "blood herring."‡ Most of these specimens came from the Bergen Fishery Exposition of 1865. They were labeled "ray-herring," &c., by experienced men, and were placed on exhibition as representatives of these kinds of herring. From this I am led to suppose, that as far as the roe and milt are concerned, the "ray-herring" differ from the common mature spring herring by a more or less unfinished development of these organs; and this opinion is confirmed by many fishermen whom I consulted on the subject. To mention one case: Regarding those "ray-herring" which formed part of the schools of "new herring," a report from *Stavanger*, under date of January 9, 1873, says that specimens of the "new-her-

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* BOECK: *Om Silden og Sildefiskerierne*, p. 23.

† *Die Varietäten des Herings*, 1877, p. 69.

‡ These names are given to the herring according to the greater or less development of the roe and milt, and according to the leanness or fatness of the herring. By "blood herring" the fishermen understand the leanest herring whose roe and milt are in a very early stage of their development. They are called "ray-herring" after they have gone to sea.

ring" caught at *Hisken*, when brought to *Stavanger*, were found to be "ray-herring," and had both roe and milt, though not fully matured. When fishermen, as is often the case, tell you that the "ray-herring" have *no* roe or milt, such expressions are caused by the circumstance that the roe and milt, as a general rule, are but little developed, and do not strike the eye when the herring are opened. As far as Boeck's description is concerned, it is not certain whether it is based on accurate *personal* observations.

In saying that in the "ray-herring" the roe and milt are not fully developed, we do not imply that these organs never reach maturity, but we only desire to convey the idea that these fish are not yet ready for spawning when they approach the coast.

The size of the herring in the schools of "new herring" varies, according to the reports of the superintendents, from that of the *Nordland* great herring to a very small herring. According to the unanimous testimony of the fishermen, the smallest specimens measured 6 to 7 inches in length. Occasionally some were found which only measured 5 inches. By far the greater number did not reach the size of spring herring, or were, at most, of the size of small spring herring.

The "new herring," and among them especially the "ray-herring," were, during the season 1869-'70, very lean and thin, with a comparatively large head, and seemed (probably only on account of their leanness) to have coarser bones than the spring herring. Some of the "ray-herring" were excessively lean, and had on each side a row of dark stripes running upwards from the belly.

The size and quality of the "new herring" varied greatly from time to time. At first it seemed as if a continuous improvement could be seen in them, but later—about the middle of January—it is again reported that the herring were again small, and varied very much in size. The "new herring" were very different in different places. It is thus specially reported that near the northern fishing stations (particularly near *Florö*) they were larger and of a better quality than farther south. This applied especially to those herring which were caught early in the season, and which by experienced fishermen were considered to be as large as the *Nordland* great herring.

I have no data as to how the "new herring" compared with those small herring which in 1869 began to appear among the schools of spring herring, and I am therefore not prepared to pass an opinion on this subject. Their occurrence is probably connected with that of the "new herring, and possibly it resembled that of the "new herring." A remarkable difference was noticed in the time of arrival. As has already been remarked, the new herring kept near the coast till the end of January, and even far into February, 1870. During the following years it was very generally reported that "new herring" arrived during the spring-herring fisheries, and it seems as if no distinction was made between them and the small herring. Some of the "new herring" have during these years doubtless been taken for small herring mixed with the spring herring.

Professor Sars has advanced an opinion regarding the cause of the unexpected and numerous occurrence of the "new herring" which corresponds with his well-known theory as to the cause of the disappearance and reappearance of the herrings on our coast during the so-called "herring periods." Professor Sars's theory is certainly ingenious and contains ideas which well deserve to be further examined; but as regards the "new herring" Sars does not seem to have been so fortunate. It must be remembered, however, that it is only the experience gained during the last few years which has enabled us to form more correct opinions regarding this whole question, and that there are still questions of the most vital importance which have not yet been satisfactorily answered.

In accordance with his theory Sars explains the occurrence of the "new herring" in a similar manner, as in former timesg *Löberg* and Boeck have explained the arrival of the ray-herring prior to the beginning of the spring-herring fisheries. Sars is of opinion that the "new herring" are principally "ray-herring," *i. e.*, barren herring and partly young, and therefore not fully matured fish, both of which come nearer the coast than the spring herring. When the enormous schools of spring herring arrive, they drive the "new herring" towards the coast, and this would easily explain the early arrival of the "new herring." The fact that the "new herring" appeared in such large numbers and were mixed with other herring, finds—according to Sars—its natural explanation in the fact that the great mass of the spring herring during this time have been compelled by meteorological causes to keep at an unusually great distance from the spawning places, and had therefore to pass over a much greater distance than otherwise would have been the case. The scattered schools of herring have thereupon been forced to give way by the irresistible advance of the great masses of spring herring, and have by them been driven towards the shore.

When Sars examined the herring fisheries the season of the year prevented him from personally observing the "new herring," and he had to rely on the information furnished by other persons. He supposes that only a comparatively small portion of the "new herring" were fully matured. For this very reason, and because the so-called "herring food"—small crustaceans, &c., is very scarce at the time when the "new herring" come near the coast, Sars is compelled to look for some external cause which would force the herring to go near the coast. This theory of Sars's is, as we have seen, not correct. By far the larger number of the "new herring" were "ray-herring," which were not barren, but had both roe and milt in different stages of development. It may be important to keep these facts in mind in endeavoring to explain the arrival of the "new herring." It will not do to ignore the reproductive instinct, because the "new herring" doubtless contained roe and milt, and the generative organs in some of the fish were developed to a considerable degree; nor is the occurrence of the "new herrings" in our coast waters exceptional, as similar herring also approach other coasts, where there are no spring-herring fisheries, and where there are no enormous masses of herring to drive them towards the coast.

I therefore considered Sars's theory somewhat doubtful. Ljungman has raised another, and very weighty, objection to this theory, by remarking that Sars has not explained by his theory why such a driving towards the coast of enormous masses of "new herring" has not also taken place during the preceding "herring period."

Some explanation of this, however, is found in Sars's report for 1872, where he says: "Formerly no attention was paid to the new herring, because they were very much mixed with older herring, whilst during the last few years they have been less mixed, because the great mass of older herring coming from the sea spawned in the outermost spawning places." But this explanation pre-supposes, as the fishermen state, that the "new herring" were fatter than the spring herring, but somewhat smaller, and had spawned much earlier. These statements, however, are—as will be seen from Sars's next report—rather unreliable, and are, as far as the time of spawning is concerned, based on a mistake. Sars's theory cannot, therefore, be maintained. The genuine "new herring" which principally made their appearance during the season 1869–'70, could, according to the unanimous testimony of the fishermen, be easily recognized both by their leanness and by their small size, as well as by the circumstance that with most of them the roe and milt were but little developed. Later, the "new herring" began to change their size, appearance, &c., finally ceased to be "new herring," and to all intents and purposes assumed the nature of our spring herring. Only a very small number of the original "new herring" were observed, and their appearance was so striking that they could immediately be recognized. Fishermen are very quick in detecting any difference in fish, and it is hardly probable that they would have entirely overlooked the inferior kind of herring, such as the "new herring" then really were. According to Sars's theory one would expect that the schools of spring herring which arrived first, would be particularly mixed with the smaller "new herring," but in these very schools the spring herring were unusually large and little mixed with other herring.

Ljungman's objection, therefore, is still valid. Especially from 1860 on, the "new herring" should have been very numerous and mixed, prior to the commencement of the spring-herring fisheries, as from that year the herring began to approach the coast later in the season, and therefore, according to Sars's theory, probably stayed at a considerable distance from the coast. But even then no unusually large masses of "new herring" were noticed. After they had appeared sporadically in 1869, they suddenly appeared in enormous masses in 1869–'70.

On the other hand, the spring herring have, during the last few years, arrived earlier in the season, and some mixed herring have been noticed, which was more unexpected now than during the years preceding 1870. Nor has there been any indication during the last few years of large masses of herring, or so-called "herring-mountains," such as were observed in olden times.

Altogether it does not seem probable that, after 1869, any unusually large masses of spring herring came near the coast. It has always been an open question whether the spring herring, during those years when they did not visit their usual spawning places, had actually left our waters entirely, or whether these same masses of spring herring spawned at a greater distance from the coast, hoping to return to their former spawning places when the conditions should again become favorable. The history of the last decade is of great importance for the final solution of this problem. In the beginning of the decade the prospects were very bright; large layers of roe were said to have been noticed on the bottom of the sea, and it was reported that there were large masses of herring far out in the deep waters. These reports were afterwards acknowledged to have been exaggerated. (See superintendent's report for 1872.) These favorable indications, however, soon began to disappear, and even at the outermost fishing station of *Udsire* there were, after 1873, no indications whatever of the presence of large masses of herring. On the other hand, there was a significant indication of a decrease in the masses of herring, viz, the mixing of small herring among the schools, which became apparent as early as 1869, when the fisheries began to decline, and increased from year to year until the fisheries came to an end. In the enormous masses of herring, or the so-called "herring-mountains," the herring are generally of the same size. When the fisheries again began to flourish, after 1876, it was not the former masses of great spring herring which returned, but comparatively small schools of herring which, as a general rule, were small, and which have gradually increased both in number and size, but have so far not formed regular "herring-mountains." (These herring must be supposed to be descended from the "new herring"; concerning this see farther on.) No one can deny that the former masses of spring herring have disappeared. It cannot be supposed that they were driven away by smaller herring; but they would have disappeared, even if these smaller herring had never shown themselves.

For these reasons I cannot agree with Sars in his theory regarding the "new herring."

I shall now continue my review of the history of the "new herring" after the season of 1869–1870, the principal events of which are as follows:

As I have mentioned before, the "new herring" in 1869–1870, visited a considerable extent of coast, and this continued to be the case during the following seasons. In 1870–1871 they spread still farther, especially towards the south, where they appeared on the entire coast from *Tananger* (west of *Stavanger*) as far as Cape *Lindesnæs* and remained there, although at a considerable distance from the coast, for several weeks. During the following years they were very generally observed in the south near *Egersund*, *Soggendal* and *Flekkefiord;* they were also seen along the Bergen coast as well as in the northern district. This scattering and the irregularity which these herring exhibited in their visits to different points on the coast, are highly characteristic of the "new herring." On the whole they made their appearance in a manner entirely different from that of the spring herring, and it actually seemed as if they did not feel at home anywhere.

With regard to the number of the "new herring" there was a sudden change after the season of 1869–1870. The approach of great masses of "new herring" about New Year, 1870 (which year is termed the "new herring year" by the fishermen) was certainly brought about by extraordinary causes (strange to say, unusual masses of herring also made their appearance during that year in *Bohus-län*). During the season of 1870–1871 only small numbers of herring approached the coast, and this was also more or less the case during the following years. The numbers of "new herring," however, were somewhat larger than appears from the reports, for they were near the coast earlier, during the spring-herring fisheries proper and far into February, all of which has been passed by in silence in the reports.

The most remarkable change, however, was noticed in the quality of the "new herring." During the following years they became larger and of a more even size, and the number of fish with more fully developed roe and milt had increased considerably. The roe, however, was invariably fine grained—not fit for spawning. During this time new but smaller schools of the original new herring seem to have approached the coast; for quite a number of herring of that king were caught. Thus during the season of 1872–'73, the "new herring" caught west and north of Bergen were again mixed, as had been the case in 1869–'70. The average number per standard barrel was, according to the reports of the superintendents, about 730. Later the "new herring" in these schools have probably developed in a similar manner as the other "new herring."

Through this development the "new herring" became spring herring and are the very same fish which, during the last few years, have approached our coasts and have become an object for the fisheries.

The fishermen very generally maintain that the spring herring which are caught in our days, are a different kind from the former spring herring, and mention several features in which they are said to differ. Their eggs are said to be smaller than those of the former spring herring; they are certainly fatter, have finer meat, and thinner bones. Some fishermen also say that the shape of the body is comparatively higher and shorter, that the head is smaller, and that the eggs are of a lighter color, whilst those of the former spring herring had a more brownish hue. Finally, it is sometimes said that the present spring herring have smaller scales* and that they adhere more firmly to the body of the fish.

Most of these features are actually of very little significance, and, in distinguishing one kind of herring from the other, they have no scientific value whatever. But as they are mentioned so frequently, I shall refer to them at greater length.

The smaller size of the eggs means, as will be seen at a glance, nothing more nor less than that they are not yet fully developed; in other words, that the present spring herring do not arrive on our coasts in as advanced a stage of maturity as the former ones. Quite frequently it is positively asserted that even the eggs of the mature herring, which arrive later, in February, have not the same size as those of the old spring herring. But this is simply a mistake. In comparing the eggs of old spring herring—preserved in spirits of wine—with those of the present spring herring, I have been unable to discover the slightest difference in size. In his well-known work, *Om Silden og Sildefiskerierne*, Boeck says that the fully matured eggs of the spring herring measure 1.50 millimeters in diameter; and this is found, if observed with the naked eye, to be the exact measure of the eggs of the present spring herring. In small specimens of the present spring herring, measuring only 28 centimeters in length, I have found the diameter of the eggs to vary from 1.31 to 1.48 millimeters. When eggs, however, measure only 1.31 millimeters in diameter, the difference is so small that it can hardly be observed without a manifying glass, and, therefore, by no means agrees with the statements of the fishermen.

The greater quantity of fat in the present herring of course depends to a great extent, or almost exclusively, on the fact that these fish are not yet ready for spawning; and the fatness again explains in a most natural manner the circumstance that in the present herring the bones are thinner than in the old ones. In a fat herring the bones are not so distinctly felt as in a lean one, when cut with a knife, and they consequently appear to be thinner and finer. That there is much chance for making mistakes through this very cause is shown by the fact that the fatness of the great herring gave rise to the assertion that they *did not have* a certain row of fine bones along the sides, the so-called "side-ribs," and that thereby they were distinguished from the spring herrings. (*Boeck's report*, 1873.)

The fine quality of the meat in our present spring herring must likewise be ascribed to the circumstance that these fish are not yet ready to spawn, and that, as is always the case prior to the spawning period, the meat is firm and solid. During and after the spawning period the meat becomes looser and of an inferior quality.

* See the reports on the old *Bohus-län* herrings (A. LJUNGMAN: *Preliminær Berättelse för* 1873–1874).

I have measured the length of body, length of head, and the distance between the fins, in some specimens of the former spring herring preserved in the Bergen Museum, and I have also examined the number of rays in the fins, and compared all these data with those of our present mature spring herring. As regards the height of the body, if compared with its length, it is difficult to arrive at an absolutely correct result if the only specimens of which measurements can be taken are preserved in spirits of wine. These measurements prove this, however, that no such change has taken place as is maintained by the fishermen. I am inclined to suppose that a difference can only be noticed between the former spring herring and those of our present spring herring which are not yet ready to spawn, and this difference is only caused by their greater fatness, which makes the body appear comparatively higher and shorter. As soon as the spring herring of the present season spawned they were, as many fishermen were compelled to acknowledge, just as long and lean as the former spring herring. It is well known that in fat herring the head seems smaller than in lean ones, but in our present spring herring it was by no means smaller than in the old spring herring. As regards the distance between the fins and the number of rays in each fin, I could not discover any regular difference. A comparative table, which will be of special interest with regard to the location of the fins, will be published at some future time. The number of rays, both in the present and in the former spring herring, does not correspond entirely with Nilsson's (and Boeck's) statement, and, as might be expected, it varies greatly in the different fish. The dorsal fin does not have 18, but generally 19 rays, and their number even varies from 17 to 20. The anal fin had generally 18 to 19 rays, and in one 20, whilst in another case it had as low as 14, which, of course, was an exceptional case. The pectoral fins had 16 to 17 rays, and the ventral fins had generally 9 bunches of rays, which is the usual number in all herring. When the Danish naturalist *Kröyer* wrote his description of the herring he had before him a specimen of the former Norwegian spring herring, and in counting the bunches of rays doubtless had reference to this kind of herring, and he likewise counted 9 bunches of rays in the ventral fins. The circumstance that Nilsson counted 10 bunches of rays in a former Norwegian spring herring was doubtless caused by his having before him specimens which accidentally had that number. In only one specimen of the former spring herring did I find 10 bunches of rays. One specimen of our present spring herring showed a strange anomaly, the right ventral fin having 9 and the left 8 bunches of rays. One specimen of the great herring had 8 bunches of rays in each ventral fin.

As regards the difference in the color of the eggs (in fish which are ready to spawn), it is impossible at the present time to draw any comparison, as the eggs of the former spring herring have of course lost their original color by being kept in spirits of wine; and as, so far as

I know, we possess no picture of these eggs. The statements of the fishermen relative to the color of the eggs seem but little credible. But the color of the eggs has, under any circumstances, very little to do with the answering of the question, whether the present spring herring are the same kind of spring herring as the former ones. I may as well say here that the color of the eggs, which is produced by the outer shell, differs considerably in the different mature individuals of the present kind of spring herring, without any reference to the size of the fish. The color is generally light brown, sometimes darker, sometimes lighter, and occasionally so light that the brown color can hardly be distinguished. The color of the eggs doubtless varied in the same manner in the former spring herring. In other localities a difference of color has likewise been observed in the eggs of one and the same kind of herring.

But few fishermen knew anything of a difference in the character of the scales. Some of the specimens of the former spring herring which have been preserved in spirits of wine have a more or less well-preserved coat of scales; one specimen, especially, which through the kindness of Professor *Esmark* was loaned to me from the University Museum, showed all its scales in a fine state of preservation. In order, however, to make this comparison really valuable, I ought to have had specimens of our present spring herring of the same size as the old ones, and also a larger number of these last-mentioned fish. The statements of the fishermen relative to the size of the scales seem very doubtful.

Of all the differences mentioned by the fishermen, only one remains to be accounted for, viz: The difference in the development of the roe and milt. In our present spring herring the roe and milt are not as fully developed, when the fish arrive in our coast waters, as in the former ones. The difference, however, is not very great. When our present spring herring first became an object of the fisheries (in 1876) their roe and milt were, according to the statements of the fishermen, still less developed than they are now.

In the "new herring" the roe and milt were not fully developed either, or at any rate there was a great difference between the different individuals as regards their degree of development. In some other respects the present herring resemble the "new herring." Like these they arrive on the coast very early in the season—differing in this respect very much from the old spring herring—so that fishing commences already in the beginning of January. Our present spring herring also show the same tendency to spread as the "new herring," and finally they were, when the fisheries first commenced, of very different size, and, on the whole, somewhat smaller than they are now. Our present spring herring are, doubtless, the descendants of the "new herring." In this way all the points of resemblance between the two can easily be explained.

During the season 1869–1870 the "new herring" were, as a general rule, not as large as our present spring herring at the time when they first made their appearance, and their roe and milt were not as fully developed. All the reports from the season 1870–1871 say that the "new herring" were somewhat larger than during the preceding season. From the season 1871–1872 it is reported that they were of a more even size. During the season 1873–1874 the number of spawners and milters, or fish with more fully developed milt and roe, was considerably larger; the same observation was, by the way, also made during the season 1871–1872 regarding the small number of "new herring" which were caught during that season. The quality of the fish began to be better, and they are now spoken of as "fat and fine new herring." Many reports of the same nature come to us from the following years. "Such a new herring," it was said, "can hardly be distinguished from a spring herring." Finally, people did not know whether to call them "new herring" or spring herring. Just as the "new herring" had developed gradually, thus the present spring herring have done the same till this year. The present spring herring seem to be nothing else but a continuation of the "new herring," and there is no doubt in my mind that they are the descendants of the latter. After 1870 "new herring" were but rarely found in our coast waters. The same was also the case with our present spring herring, when they first made their appearance, and only gradually they became more numerous. "New herring" of an inferior quality were caught, as has been said above, together with more fully developed "new herring," and they probably have since passed through the same stages of development, and at the proper time turned into our present spring herring.

If you ask the fishermen when the present spring herring first began to show themselves, they generally say that this took place about four or five years ago. Some maintain that it took place as early as 1874, and others even say that they saw such herring in 1870. From what has been said, this difference in the statements is easily explained by the very gradual development of our present spring herring. Some of the so-called "blood herring" which formed part of the "new herring," were, during the season 1869–'70, already so fully developed that they strongly resembled our present spring herring. The opinion, very prevalent among fishermen, that the present spring herring came to our coast waters four to five years ago is evidently based on the fact that they were not till then (1876) recognized as spring herring, and that the fisheries proper cannot be said to have commenced till that year.

In a very interesting treatise on the herring in the Sound and the Belts, *Georg Winther** speaks of a similar development of the herring as that observed in our waters. He says that towards the close of a "herring period" a smaller kind of herring make their appearance at the time when the former herring disappear, and that these small herring soon reach the size of the former herring. Their number increases very

* "*Tidsskrift for Fiskeri,*" new series, iii.

rapidly, just as has been the case with us during the last few years. According to *Winther* the new herring simply take the places occupied by the former herring, and their rapid growth is owing to the favorable conditions under which they live. This does not altogether apply to our "new herring," as they arrived in our coast waters much sooner than the spring herring, which, according to Sars, indicates that they lived nearer the coast than the great masses of spring herring, most of which had, at that time, already left our coasts. Even our present spring herring come much earlier than the former ones.

The important question, therefore, arises: "Where do the new herring come from, which during the season 1869-'70 suddenly appeared in large masses?" It might be supposed that the smaller "new herring" were only the younger generations of spring herring, which, after the masses of old spring herring had disappeared, from some unknown cause occupied their spawning-places, and in a few years grew into new masses of old spring herring. This supposition is, to some extent, justified, but it is doubtful whether its principle is applicable in all cases. In solving this question, a more thorough examination of the so-called "ray-herring," which come to our coasts every year, might prove useful. In making a preliminary comparison between several specimens of the same size of the "ray herring" and those herring which, according to Sars, must be considered as fish in the earlier stages of the former spring herring, I could discover no difference except in the varying degree of leanness and fatness.

Our present schools of spring herring are composed of "new herring" and of remnants of the former masses of spring herring. These were mixed with quite a large number of small herring. If these small herring bear more of the character of the "new herring," it will come to almost the same thing to say that our present herring are descended from the "new herring," or from small herring mixed with the spring herring.

It has already been mentioned that our present spring herring have gone through *further* stages of devêlopment.

After the new herring had developed in the manner above described, the present spring herring may be said to have begun their existence as such; but still they did not come up to the old spring herring in size or maturity, and moreover they only occurred in small numbers.

As regards their size, it still varied somewhat, like that of the "new herring;" and it must also be taken into consideration that they were still mixed with remnants of the former masses of spring herring.

During the last few years the herring have become larger and of a more even size; but even the year before last they are said to have been smaller than the old spring herring. From all the reports, it appears that this year the herring which arrived first were exceptionally large and of even size. I measured numerous herring caught in the seines. The smallest measured about 27 centimeters in length, large specimens even measured 34, but these were not very frequent. As a general rule the spring herring measured 31 to 33 centimeters, which must be considered a very good length. It must, however, be remembered, that these measurements apply to herring caught in nets, on the size of the meshes of which the size of the herring caught in them will more or less depend. In order to determine the exact size of the herring, we would have to measure herring caught in seines, but during my stay in the fishing district no fish were so caught. I am therefore not yet prepared to say to what extent the present herring have *in general* reached the size of the former spring herring.

According to the statements of the fishermen, both the roe and the milt had also become further developed. I possess, however, no reliable information on this point. It is certain that our present spring herring at the time of their arrival near our coasts are not as fully prepared for spawning as the old spring herring; they are not ready to spawn till the latter portion of their stay near the coast; this has particularly been observed during the season of 1879–'80, when most of the herring spawned in February. Herring which I examined on the 11th and 12th February of the present year had loose roe and milt. During these very days, and possibly somewhat earlier, the herring had begun to spawn.

Later in the season there were constant indications of spawning; the nets were full of roe, the water was colored by the milt, and herring, when caught, emitted roe or milt upon the slightest pressure. On the 20th of February herring were caught which had almost done spawning.

Whilst but few herring showed themselves near the coast during the first years after 1870, when the transition from "new herring" to spring herring commenced, they gradually began to increase in number from that time. So far, however, no herring mountains, like those which were common in olden times, have been observed. The yield per annum of the fisheries has been as follows during the period 1876, 1880: in 1876 it was 9,500 barrels, in 1877 about 25,000, in 1878 about 32,000, in 1879 about 63,400,* and in 1880 only 30,000, this last low figure being caused, not by any decrease in the number of fish, but principally by the long-continued stormy weather, which prevented the fishermen from going to sea.

Only in the southern districts have the fisheries been of any account. Near *Skudesæs* there was considerable seine fishing, and it will be interesting to see whether the herring will again visit this southern point, which, in their northward migration, they left during the last "herring period."

It is a characteristic peculiarity of our present spring herring caused,

*According to *J. M. Nymann's* report made to the government of the *Stavanger* district. From the newspaper reports it appears that of this number 8,000 barrels were caught near *Söndmöre.*

of course, by their not yet being ready to spawn, that for a long time after their arrival in our waters they will stay near the surface of the sea. They sport about in the coast waters in a similiar manner (as Sars supposes) to the spring herring in the open sea, outside of the spawning season.

Whilst the herring thus swim about on the surface, they are eagerly pursued by whales, which divide the large masses of herring into smaller schools, and scatter them in every direction. The occurrence of these whales is a phenomenon peculiar to our present spring-herring fisheries.* They come in large numbers, so that in the beginning the fishermen would not venture out for fear of these immense animals. During the old spring-herring fisheries but little was seen of these whales. On the other hand the large herring whales, which were quite common during the old spring-herring fisheries, are not so frequent now, probably because of the circumstance that these two kinds of whales are bitter enemies. Our present whales, the so-called *stourhval*, will attack the large herring whale and tear large pieces of fat from its sides, for which reason it is frequently called whale hound (*hvalhund*), or fat biter (*spækhugger*). While the so-called *stour* whales follow the schools of herring and feed on them, the herring whales have but little to fear; still they seem to avoid them, and I have often heard the fishermen remark that the great herring whales act as if they were afraid of the *stour*, or great whales, and keep at some distance from them.

As soon as the masses of spring herring, which has especially been the case during the last two years, are ready to spawn, that is in February, all this is very much changed. The herring then go deeper and seek the bottom for the purpose of spawning; and the great whales disappear from the scene. The cause of this repeated disappearance must be found in the fact that it is too difficult for the great whales to follow the herring into deeper waters, or at least that, when the herring go deep, these whales do not find it so easy to satisfy their greedy appetite. The fishermen corroborate this fact, and say that they have had occasion to observe that the great whales are very unsuccessful in their chase of the herring when these have gone into deep water. While the great whales are gone the herring whales have again made their appearance in as large numbers as during the old great-herring fisheries.

The spring herring present in the month of January were pursued by a large number of great whales, which is precisely what happened during the great-herring fisheries in *Nordland;* neither was the great herring ready to spawn. It must, however, also be recollected that great

*It is not certain to what species these whales belong. Two kinds are probably designated by this name (*stourhval*): *Orca gladiator*, la Cep., and *Orca Eschrichtii*, *Stp.* In January, 1876, a large number of whales were caught near *Udsire*, one of which *Mr. Collet* (from the description given by Light-house Keeper *Eyde*) supposes to have been the *Orca Eschrichtii*, and not the *Orca gladiator*. (See *Nyt Magazin for Naturvidenskaberne*, 1877, vol. xxii, p. 139.)

whales are certainly more numerous northward. On the other hand, during the previous spring-herring fishing, scarcely any great whales were seen, because the earlier spring herring were gravid the whole time and followed the same course as the spring herring at the present time, in the month of February.

Another peculiarity of the present spring herring which is not yet prepared to spawn is this, that they stay farther out without making any attempt to come near the coast. This year, for instance, there was hardly any seine fishing until the herring had become ready for spawning, and fishing commenced with nets which were set during the night. The same was the case last year and the year before last, when fishing was carried on with floating nets ½ to 2 (Norwegian) miles from the coast.

It has been supposed that by chasing the herring the great whales would prevent them from coming near the coast, as it has several times been observed that these whales keep nearer the land than the "herring whales." This is easily explained, however, by the well-known fact that the "herring whales" are afraid of the great whales, and therefore keep at a greater distance from the coast. It is, of course, not impossible for the great whales to drive the schools of herring away from the coast; but, in chasing the herring about without any particular aim, one would suppose that they would occasionally also drive them towards the coast. This does not therefore appear to be a satisfactory cause of this phenomenon.

It is likewise an open question whether the immature condition can be adduced as a satisfactory reason for the fact that the herring keep at some distance from the coast.

During the last two years even the mature spring herring have not shown any special inclination to come near the coast, and the fisheries have been almost exclusively confined to the little island of *Udsire*, two (Norwegian) miles out at sea, west of *Karmö*. Here the persecutions by the great whales cannot come into consideration, for only very few of these were seen in the *Udsire* waters, and their presence could not possibly have disturbed the herring. Last year we had frost during the fishing season, and, judging from the experience of former years, it was supposed that the low temperature was the reason why the herring would not come near the coast. This year we had very mild weather, and still the herring did not come near the coast. It is well known now, however, that it is not absolutely necessary for the herring to come near the coast for the purpose of spawning. The *spring herring*, it is true, have, as a rule, sought the coast when they wanted to spawn. But, as the spring herring now come in smaller numbers, and as only those fish are ready to spawn which arrive late in the season, it may, of course, easily happen that the spring herring stay in the outer spawning places. If, during the coming years, the spring herring gradually reach their maturity earlier in the season and increase in number, the schools which arrive first will, as usual, come to the coast of *Udsire*, whilst the schools which follow later will seek other spawning places nearer the mainland.*

In going through various stages of development our present spring herring have evidently come to resemble the former spring herring very strongly. As to size, there is hardly any difference. This, taken in connection with the steady character of the development, which gives cause for the hope that it may continue, seems to augur well for the future and justifies the expectation that we shall again have as large spring-herring fisheries as in olden times.

After having given the above brief sketch of the spring-herring fisheries during the last few years, we must cast a retrospective glance at certain prominent features in this history, and institute a comparison between them and certain features of the old spring-herring fisheries at the time when they, too, after having been on the decline for a number of years, again began to flourish.

The decline of our fisheries extended from 1869–1875, when the num- of herring was smallest and the fisheries were at their lowest ebb. But after 1875 the fisheries gradually began to recover, as there was a steady increase in the number of herring. There has, therefore, not been any very considerable interval between the former "herring period" and the one which—to judge from all appearances—is about to begin, but one "herring period" has been closely followed by another. Yea, more. Those herring which during the last few years have come near our coasts as new spring herring, had already come once before, near New Year, 1870, and probably they had also come in 1869, therefore before the former "herring period" had come to a close.

Here there seems to be a difference from olden times, when there was an interval of years between the end of one "herring period" and the beginning of another (twenty years between the last two "herring periods").

Our present spring herring, moreover, come early in the year, having been caught as early as the first part of January, whilst in the beginning of the last "herring period" fishing commenced very late, which—according to Boeck's observations—seems to be the rule at the beginning of a new "herring period."

This difference, however, is probably a difference only in appearance, but not in reality. In former times fishing in the open sea with floating nets was unknown, as it has only come into use during the last few years. No exertions were made to seek the herring in distant parts of the coast. To go to *Udsire*, to catch herring, seemed too much of a venture. If matters in this respect were now as they were then, our

* The great whales will then disappear. Any attempt to exterminate them (even if successful) would result only in a very doubtful advantage. The fishermen themselves, as a general rule, are of opinion that the so-called "*Aater*," *i. e.*, schools of herring which, chased by the great whales, come near the surface of the sea, are easily discovered, and are therefore easily caught, must be considered as a decided benefit to the fisheries.

present fisheries would not be of any great importance, and at any rate, there would have been a much longer interval between the last and the present "herring period." *Ljungman* already remarks, that a glance at the fishing-apparatus in use, which is only suitable for our rocky and broken coast, will explain the fact that our "herring periods" are so well defined, whilst in other countries, such as Scotland and in North America, where fishing is carried on with purse-nets or floating nets, their beginning and their end can hardly be noticed. It is also a well-known fact, that during the long interval (1787–1807) between the two preceding "herring periods," herring were found near our coast. Thus Boeck reports that in 1803 they showed themselves in large numbers near the coast of Bergen; but few, if any were caught, as they came so unexpectedly. The *Udsire* fishermen say that the year 1808 was by no means the first year when herring came to their coast, but that they were noticed out at sea during several of the preceding years; but people at that time did not think of going to sea even that short distance, to catch herring.

As regards the time of arrival, there has so far at least, been an actual and marked difference between the present and the former spring-herring fisheries.

It must also be borne in mind that the time during which the present fisheries have been going on, very probably does not correspond with the time which is designated as the beginning of the former herring period, but rather with certain years of the interval, when there was no fishing.*

Below I have given a list of different degrees of temperature of the water near the surface and at different depths. As I only had occasion to make observations of the temperature towards the end of the fishing season, and as the fisheries were unfortunately disturbed a great deal by stormy weather, it was impossible for me, this year, to observe the influence of the temperature on the daily course of the herring. These observations, however, will prove of interest even as they are.

Boeck took the following observations of the temperature during the spring-herring fisheries: While at the surface the temperature varied from 0°.5 to 5° C., according to the state of the wind, the difference at a depth of 10 fathoms (almost 19 meters) was only 1° C., that is, the temperature varied from 3° to 4° C., and at a depth of 30 fathoms (56½ meters) the temperature remained stationary at 4° C., no matter how much the meteorological conditions varied.

* The fisheries even now do not commence till February, about the same time when they commenced in the beginning of the former "herring period." I am not at present prepared to say whether this circumstance has any weight in explaining the difference in the time of arrival of the herring. (See BOECK, *Om Silden og Sildefiskerierne*, p. 109; it is certain that in the beginning of the former "herring period" the herring arrived near the coast some time before the *fisheries* commenced. Thus Boeck says that in 1814, 1815, and 1816 the whales arrived on the 23d January, which, however, is a late date.)

This year the temperature at the surface varied from 2°.5 to 6° C., while the temperature at the surface varied from 3°.5 to 6° C. The temperature at a greater depth varied as follows: At a depth of 38 to 42 meters, from 4°.2 to 6°.9 C.; at 51 to 53 meters from 4°.8 to 7°.3 C.; at 62 to 66 meters, from 4°.7 to 5°.5 C.; at 76 meters, from 5°.1 to 6° C.; and at 119 to 123 meters, from 6°.3 to 6°.7 C. At a depth of 132 meters the temperature was found to be 6°.9 C., and at 189 meters 7°.1 C.—(See table of temperature.)

In the first place, therefore, the temperature has varied much more than Boeck reported, viz, 2½° C., at a depth of 51 to 53 meters, and, in the second place, it has this year been higher than any which Boeck has given.

In his work "*Om Silden og Sildefiskerierne*," Boeck speaks of a peculiar phenomenon observed in the sea between *Hangesund* and *Udsire*, viz, that the water near *Röværr*, at a certain depth, about 20 fathoms, seemed to be so cold that its temperature was only about 3° C., whilst farther out, not far from *Udsire*, where there was a pretty strong current from south to north, it was much warmer, viz, over 4° C. Boeck was prevented by sickness from making further observations of this strange phenomenon. If further observations should show this statement to be correct, Boeck thinks that this warm current must be a branch of the Gulf Stream, and he inclines to the opinion that in these waters the herring follow such a branch of the Gulf Stream towards the coast, particularly as the herring always approach the coast between *Udsire* and *Röværr*, where the warm current, mentioned by him, is found. Near *Röværr*, Boeck found the so-called "whale food" (*Clione limacina* Phipps), an animal generally occurring much farther north, near *Finmark*, and which was once discovered by Prof. G. O. Sars, near the Lofoden Islands (at *Skroven*). In the polar seas it is found in enormous masses. Boeck supposes that this clione was carried south by a cold polar current flowing nearer the coast than the Gulf Stream.

During my visit to the fishing stations, I one day—the 9th March—when the weather was calm, carefully examined the temperature of the water from *Udsire* to *Röværr* (and on the 11th of March, as far as *Hangesund*), both at the depths given by Boeck, in other depths, and near the surface. The result of these observations is given in a list below. At a depth of about 20 fathoms (38 meters), between *Udsire* and *Urter*, the temperature varied from 4°.3 to 4°.5 C.; on the side of *Urter* towards *Röværr*, the temperature was 4°.4 C., at a depth of 32 meters (bottom); a little (one-eighth Norwegian mile) farther out, towards *Röværr*, it was 4°.2 at a depth of 38 meters; one-fourth Norwegian mile distant from *Urter*, in the direction of *Roværr*, it was, at the same depth, 4°.5 C.; and from there to *Röværr* and *Hangesund* it varied from 4°.5 C. to 4°.4 C.

I must say that, in my opinion, my observations have not corroborated Boeck's statement, not even as to the temperature taken at the same depths as his observations, and much less with regard to temperature observed at different depths.

As the above report may also be of interest to foreign readers, I shall give below the latitude of most of the places mentioned in it:

Southern spring-herring district: *Latitude*, 58° 55′ to 60°.

Northern spring-herring district: *Latitude*, 60° 47′ to 62° (*Stat*).

The more important subdivisions of the northern district: *Söndfiord: Latitude*, 61° 15′ to 61° 55′; and *Nordfiord: Latitude*, 61° 55′ to 62°13′.

North of *Stat*, in the southern part of *Söndmöre*, the so-called *Söndmöre* fisheries are carried on.

	Latitude, °
Aasvær	66 14
Bergen	60 24
Blixvær	67 17
Bodö	67 17
Brandesund	59 54
Bremanger	61 51
Bueland	61 17
Egersund	58 27
Fleinvær	67 10
Florö	61 35½
Flekkefiord	58 10
Fröyöen	61 47
Fruglövær	67 4
Gildeskaal	67 5
Grip	63 14
Halten	64 10
Hammerö (see Stegen and Hammerö)	
Haugesund	59 25
Helligvær	67 24
Herö	66
Hisken	59 44
Hitteren	63 30
Hvitingsöerne	59 4
Karmö	59 8 — 59 25
Landegode	67 24
Lindesnæs	57 59
Loffoden and Vesteraalen	67 20 — 69 19
Lovunden	66 22
Melö	66 50
Mykóerne	66 45
Rödö	66 40
Rövær	59 26
Sartorö	60 20
Senjen	69 20
Skibaadsvær	66 7

	Latitude, ° ′
Skudesnæs	59 9
Smölen	63 25
Soggendal	58 19
Stavanger	58 58
Stegen and Hammerö	67 40 — 68 15
Stemmet	63
Sulen	61
Trænen	66 30
Tysfiord, mouth of	68 15
Udsire	59 19
Vegö	65 40
Vesteraalen	68 35 — 69 19
Vigten	64 55

Table of deep-water temperature. Observations taken with Negretti and Zambra thermometer, No. 43233.

1880.		Location.	Scale of temperature.				Wind.			
Day.	Hour.		Depth in meters.	Thermometrical reading.	Correction.	Corrected temperature.	Direction.	Force 0—6.	Weather.	Sea 0—9.
Feb. 23	10-11 a. m.	Udsire (north side)	0	3.5	—0.4	3.1	W. SW.	2	7	3
23	do	do	28½	4	—0.4	3.6		2	7	3
23	do	do	42	4.5	—0.3	4.2		2	7	3
25	10 a. m.	do	0	6	—0.3	5.7	W. NW.	3	5	4
25	do	do	42	6.9	—0.3	6.6		3	5	4
25	do	do	51	7.3	—0.2	7.1		3	5	4
28	9-10 a. m.	do	0	4	—0.4	3.6		5	*4	6
28	do	do	23	4.2	—0.3	3.9		5	4	6
Mar. 3	2-3 p. m	½ mile north of Udsire	0	4.4	—0.3	4.1	SW.	2	†4	4
3	do	do	62	5.5	—0.3	5.2		2	4	4
3	do	do	119	6.7	—0.3	6.4		2	4	4
3	do	do	132	6.9	—0.3	6.6		2	4	4
5	10-12 a. m.	1 mile north of Udsire (Klækken fishing station).	0	4.5	—0.3	4.2	S.	2	1	3
5	do	1 mile north of Udsire (Klækken fishing station).	189	7.1	—0.2	6.9		2	1	3
9	9-9.30 a. m	Udsire (north side)	0	4.4	—0.3	4.1	SW.	2	4	3
9	do	do	38	4.5	—0.3	4.2		2	4	3
9	do	do	76	5.4	—0.3	5.1		2	4	3
9	10.30 a. m	¼ mile NW. of Udsire	0	4.4	—0.3	4.1		2	4	3
9	do	do	38	4.4	—0.3	4.1		2	4	3
9	do	do	76	5.1	—0.3	4.8		2	4	3
9	do	do	123	6.6	—0.3	6.3		2	4	3
9	11 a. m.	⅜ mile NW. of Udsire	0	4.4	—0.3	4.1		2	4	3
9	do	do	38	4.3	—0.3	4		2	4	3
9	11 a. m.	do	76	5.1	—0.3	4.8		2	4	3
9	do	do	123	6.3	—0.3	6		2	4	3
9	12 a. m.	½ mile SE. of Urter	0	4.4	—0.3	4.1		2	4	3
9	do	do	38	4.3	—0.3	4		2	4	3
9	do	do	76	5.2	—0.3	4.9		2	4	3
9	1 p. m	Urter (southwest side)	0	4.4	—0.3	4.1		2	4	3
9	do	do	23	4.5	—0.3	4.2		2	4	3
9	3.30 p. m.	Urter (northwest side)	32	4.4	—0.3	4.1		2	4	3
9	4-4.30 p. m.	½ mile NW. of Urter	0	4.3	—0.3	4		2	4	3
9	do	do	38	4.2	—0.3	3.9		2	4	3

* Hail storms. † Rain.

Table of deep-water temperature, &c—Continued.

1880.		Location.	Scale of temperature.				Wind.		Weather.	Sea 0—9.
Day.	Hour.		Depth in meters.	Thermometrical reading.	Correction.	Corrected temperature.	Direction.	Force 0—6.		
Mar. 9	4–4.30 p. m.	¼ mile NW. of Urter	0	4.4	—0.3	4.1	....	2	4	3
9	do	do	88	4.5	—0.3	4.2	....	2	4	3
9	do	do	66	4.7	—0.3	4.4	....	2	4	3
9	do	⅝ mile NW. of Urter	0	4.4	—0.3	4.1	....	2	4	3
9	do	do	88	4.5	—0.3	4.2	....	2	4	3
9	do	do	76	5.8	—0.3	5.5	....	2	4	3
9	5 p. m.	⅛ mile SW. of Rövær	0	4.4	—0.3	4.1	....	2	4	3
9	do	do	38	4.4	—0.3	4.1	....	2	4	3
9	do	do	76	6	—0.3	5.7	....	2	4	3
9	5.30 p. m.	Rövær Harbor	0	4.3	—0.3	4	....	2	4	3
9	do	do	78	4.2	—0.3	3.9	....	2	4	3
11	9–10 a. m.	Rövær (east side)	0	4.3	—0.3	4	SE.	1	0	2
11	do	do	88	4.4	—0.3	4.1	....	1	0	2
11	do	do	63	4.8	—0.3	4.5	....	1	0	2
11	do	do	76	5.7	—0.3	5.4	....	1	0	2
11	11 a. m.	¼ mile W. of Haugesund	0	4.5	—0.3	4.2	....	1	0	2
11	do	do	38	4.4	—0.3	4.1	....	1	0	2
11	12 a. m.	Near Haugesund	0	4.3	—0.3	4	....	1	0	2
11	do	do	66	4.4	—0.3	4.1	....	1	0	2
11	do	do	55	4.6	—0.3	4.3	....	1	0	2

VIII.—THE SARDINE FISHERIES.

There will be but few of our readers who do not know the fish called "*Sardine*," or at least but few who have never seen a sardine-box. Empty sardine-boxes are met everywhere, even among people who have never tasted a sardine. These small boxes, made of thin tin, are used in many different ways, and people will keep them for various purposes. For the benefit of those of our readers who do not know the sardine or sardel, we would state that they are a kind of herring which somewhat resembles our common sprat, and which in large numbers is caught in the Mediterranean and on the west coast of France. Frenchmen first commenced to put up these small herring in oil and to export them to other countries as a great delicacy, thereby deriving a considerable revenue from their sardine fisheries. It may interest our readers to learn something respecting these fisheries, and we therefore give the following information, principally derived from a French journal.

The importance of the sardine fisheries will become evident from the fact that they employ 25,000 to 30,000 fishermen during seven months in the year; the number of boats employed in these fisheries is also very large, as a boat's crew is composed of 4 men and 1 boy. The preparation of the sardines requires a similar number of persons. In 1875 a single fishing village prepared 2,650,000 pounds sardines in oil and as many pounds of salt sardines, called in the interior of France fresh sardines.

The fishing-boats are 20 feet long, with square sterns, and sharp sheer forward, which makes them fast sailers, but crank. They have two masts leaning slightly backward, and two square lugger-sails of considerable size, so that the slightest breeze carries them through the waves.

The nets have no weights below. They are 30 to 45 yards long and 9 to 12 yards deep, are made of very fine twine, and have such narrow meshes that the sardines can get their heads in and be caught by the gills. The buoy-line has cork floats, which keep the net near the surface of the water. Every net has its own peculiar nickname, "Fool them," "Greedy-guts," &c., by which names they are invariably known among the fishermen.

In the sardine fisheries the bait is of much greater importance than

Sardinfisket in *Fiskeri Tidende,* No. 11, March 14, 1882.—Translated from the Danish by Herman Jacobson.

the net. As bait codfish roe is used, which mostly comes from Norway, and is salted down in barrels. Norway annually exports about 35,000 tons of codfish roe, at an average price of 36 crowns ($9.64) per ton. When the roe is to be used as bait it is soaked and stirred in water and mixed with sand, so as to make it sink quicker when thrown into the sea.

Various signs indicate the approach of the sardines. Floating bunches of algæ are a good indication. The experienced fishermen can also recognize the approach of the sardines by the peculiar odor caused by the oil flowing from the sardines when they are devoured by fish of prey. But birds are a particularly certain indication of the approach of the sardines. When the cormorant scarcely touches the water with its bill it is a sign that the sardines are near the surface of the water, and when the terns descend straight, with their wings close to the body, the sardines are deeper in the water.

The sails are now taken in and the nets are set, whilst the roe is thrown into the sea by the first mate. If he is successful in making the sardines rise (move from the deep water toward the surface), a greenish shimmer is noticed in the furrows of the waves. The roe is then cast out more plentifully, and numberless schools of fish may be seen near the nets. The sardines move rapidly backwards and forwards and make a rush at the bait, fighting for it among themselves, and are thus caught by the treacherous net, which gradually grows heavy from the weight of the fish. The nets are now hauled in, the fish are taken out of the meshes and thrown into the hold, and the boat returns to the shore.

In former times it was no rare occurrence for a boat to catch in a single trip 12, 15, and even 20,000 sardines. Nowadays they rarely catch more than 5,000 to 6,000 sardines in a single trip. The yield of the fisheries varies not only from one year to the other, but also between different points of the coast, even if close together. No special reason can be assigned for this. People have endeavored to explain this phenomenon by accidental changes in the current of warm water which comes from the equator and runs all along the northwest coast of France. Migratory fish like this warm current and follow it in all its changes of direction. It is not astonishing that the fish do not approach the coast in large numbers when strong winds continue to blow from one direction for any length of time and force the current to assume another course, thus making the water near the coast cold instead of warm.

The sardine-fishers generally return between six and ten o'clock in the morning. The scene at that time is very animated. When the time approaches for the fishermen's return, people hasten towards the coast from all directions, and whilst the crowd gathers on the shore the sardine fleet appears on the horizon like a swarm of giant birds, whose white and brown wings glide along the surface of the waters.

The boats come as near the shore as the depth of the water will allow. At the moment when they are about to cast anchor the scene is particularly lively. Hundreds of boats containing fish-dealers of both sexes and agents of the factories are engaged in an eager race to reach the fishing boats. Some people roll up their pants or gather up their dresses and boldly step into the water, whilst others take a complete bath.

After the price has been fixed the fish are gathered in baskets which hold about 500 fish each. The bearers generally dip the baskets a few times in the water so as to make the fish look fresh, and carry them up to the shore, where they are salted if destined to be eaten immediately. During the fishing season sardines take the place of money and are not refused by any one. Carriers and other laborers are paid in sardines, and it is said to be a common sight to see a child go into a store, buy some candy, and pay for it with two or three sardines.

Some factories have their own fishing-vessels, others have a contract with some fishermen to supply them regularly with sardines, whilst some only buy their fish whenever they need them. These factories only take sardines which are very fresh, and which have not been salted in the least. As soon as the fish are received at the factory they are immediately prepared; women cut off the heads of the fish, clean them, and lay them side by side on flat stones, which are thinly covered with salt. This is called the "first drying." Whilst the fish lie on these stones for some time, enormous boilers with the finest olive-oil are placed over the fire, and as soon as the oil boils the sardines are put, by layers, in wire baskets. These baskets are dipped into the boiling oil, and are then placed on frames to let the oil drip off. When the fish have become tolerably dry, they are taken into the drying-rooms, where they are exposed to the sea air, and where they remain a longer or shorter time, according to the condition of the atmosphere. They are thereupon sorted, the largest being used for select sardines.

The packing is done very carefully; after the sardines are put in the boxes, they are placed under an oil tank where fresh oil is constantly filled in. At last the lid is closed. This must be done very carefully, as the slightest break or hole, invisible to the naked eye, is apt to spoil the contents of a box. To ascertain that the boxes are properly closed, they are for a few seconds put in boiling water. Those boxes which are not well closed will bulge out; and in that case they are cut open, the fish are taken out and placed in another box. After the boxes have received the factory mark they are ready for the market.

IX.—REPORT SUBMITTED TO THE DEPARTMENT OF THE INTERIOR ON THE PRACTICAL AND SCIENTIFIC INVESTIGATIONS OF THE FINMARK CAPELAN-FISHERIES, MADE DURING THE SPRING OF THE YEAR 1879.*

By Professor G. O. Sars.

In accordance with a plan made some time ago, it was my intention this year to give special attention to the so-called capelan-fisheries, which I had not yet investigated, and which on account of their varying character, seemed to deserve a closer examination. The loud complaints raised during the last few years regarding the injurious influence on the capelan-fisheries of Mr. Foyn's whale fisheries, especially in the Varanger-fiord, compelled me to some extent to change my original plan. Instead of traveling over the entire capelan-district, as had been my original intention, the above-mentioned cause induced me to confine my investigations for this year to the Varanger-fiord, which has been, and is still, the principal scene of the whale-fisheries.

In order to be present at the beginning of the capelan-fisheries, I went north as early as the 28th of March, and arrived at Vadsoe on the 11th of April. At that date there had not yet been any fisheries of importance, and no capelan had entered the Varanger-fiord. Considerable masses of capelan, however, had approached the coast of Western Finmark and the fishing-stations near the North Cape, where the fisheries were already in full operation. Capelan had also been noticed near the eastern fishing-stations as far as Vardoe. On the 15th of April the first capelan entered the Vadsoe sound, and a few boat-loads were captured. But on the following day most of the capelan had disappeared, and after this only approached the coast in small numbers. I, nevertheless, succeeded during these days in making a number of important observations of the capelan, and expected at a later period to have ample opportunity to complete these observations. This expectation, however, was doomed to disappointment. The great mass of capelan did not go any nearer this coast this year than Kiberg, from which place they seemed to have taken their course across the mouth of the fiord towards the Fisher Island on the coast of Russia, whilst only a few scattered schools entered the Varanger-fiord. Those who had previously expressed the

* "*Indberetning | til | Departementet for det Indre | fra | Professor, Dr. G. O. Sars | om de af ham i Vaaren* 1879, *anstillede praktisk-videnskabelige | Undersögelser over | Loddefisket | ved Finmarken.*" | Christiania, 1879.—Translated by Herman Jacobson.

opinion that Foyn's whale-fisheries had injured the capelan-fisheries, saw in this circumstance a further corroboration of their views, whether justly or not I shall endeavor to explain below.

As no capelan schools of any importance entered the Varanger-fiord, I intended to change my place of observation to one of the outer fishing stations, either Kiberg or Vardoe. But, unfortunately, I contracted a severe cold, accompanied by acute bronchitis, soon after my arrival at Vadsoe, probably owing to the severity of this northern climate. I was therefore compelled to stay where I was, and was prevented from making any further observations during the first half of my stay. After I had recovered from my indisposition, I visited two other points on the Varanger-fiord, viz, Bugönæs and Mortensnæs. In both of these places I made observations and gathered information relative to the capelan-fisheries during this and the preceding years. Complaints were heard everywhere about the scarcity of bait; but whenever bait was obtained there was good fishing, and even exceptionably good fishing, until the 24th of June.

Foyn's whale-fisheries did not commence till May (those of the Iarfiord Company had commenced somewhat sooner), and were principally carried on in the outer portion of the fiord, off the coast of Kiberg and Vardoe and off the coast of Russia. The whales which were brought in were carefully examined, and information was obtained regarding the circumstances under which they were caught.

On the 9th of July I left Vadsoe for the south, and arrived at Christiania on the 20th of the same month.

I shall in the following state in detail the results of my observations, both as regards the capelan-fisheries in general, and the supposed influence on them of the whale fisheries; but I must at the very outset direct attention to the fact that I do not consider my observations on this subject as completed. Many and complicated conditions have to be examined, and even, under the most favorable circumstances, a year's time would hardly be sufficient to complete this investigation. A beginning has at any rate been made this year, and, although there are a number of gaps in my investigation, I think that even now I am prepared to speak, with a tolerable degree of certainty, on several important and hitherto neglected conditions of the capelan-fisheries, as well as on the much discussed whale question.

A.

ON THE CAPELAN-FISHERIES IN GENERAL.

It is well known that the name "capelan fisheries" is the technical term employed by the fishermen to designate the codfisheries, carried on during the spring months (April–June) on the coast of Finmark, and which are dependent on the occurrence of a smaller kind of fish, the capelan (*Osmerus arcticus*), which approaches these coasts in large numbers for the purpose of spawning. At this season the capelan constitutes the food of the cod, and is therefore almost exclusively employed as bait. The cod-fisheries therefore essentially depend on a regular and numerous approach of the capelan to the different fishing-stations. I have already had occasion to make a brief statement regarding the capelan, and the so-called capelan-cod, in my report on the practical and scientific investigations made during the last polar expedition; and the investigations of the capelan-fisheries made by me during the present year have not caused me to change any of the opinions expressed in said report.

As I have said in that report, I have reason to suppose—and I base this supposition on the extensive physical and biological investigations made in the Polar Sea—that the proper home of the capelan is the sea between Spitzbergen, Greenland, Iceland, and Jan Mayens, especially that portion of it, which forms the immediate boundary of the polar current. This, however, does not imply that the capelan is not likewise found in other parts of the Polar Sea. Here it seems, for the greater part of the year, to lead a roving (pelagian) life, like the herring, which it resembles closely, not only as to its form, but also in its propagation and mode of life, although it belongs to an entirely different family. Towards spring the mature individuals gather in large schools and go south towards the northern coasts of Europe and America, in order to spawn. During this time it is pursued by whales and different fish of prey, the principal one of which is the cod. It is so well known that the capelan is found near Greenland and Iceland, that I did not deem it necessary to mention this fact in my report. On the other hand I thought that it was not generally known that large schools of capelan visit the coast of Labrador and the northern and eastern coasts of Newfoundland, where they cause codfisheries of exactly the same character as those of Finmark to spring into existence. I have therefore deemed it proper to direct attention to this interesting fact in my report above referred to, after having obtained not only satisfactory information regarding these fisheries, but also specimens of capelan from Newfoundland.

The only place on our coast where the capelan come in large numbers is the coast of Finmark. Farther south only small and scattered schools or stragglers, which seem to have lost their way, have been observed; even as far south, however, as the Christiania fiord. As the capelan-district proper we must designate the portion of the sea extending from the Lapland Sea in the west to the Varanger-fiord and Vardoe in the east, more particularly the northern coast of Russia from the Varanger-fiord to the fishing-stations near the mouth of the White Sea (the so-called Murman coast). The capelan, as a general rule, make their appearance simultaneously at the different fishing-stations on the north coast of Finmark. In the Varanger-fiord, and on the coast of Russia, however, they invariably come somewhat later. The capelan do not always appear in the same number along this entire extent of coast, but it has often been observed that when they appear in exceptionally large numbers in one place their number was smaller in other places, or they even staid away altogether from some places. With regard to this matter, a comparison between the capelan-fisheries of East and West Finmark will be found interesting, as showing that during some years their character has been entirely reversed. With the view of further illustrating this fact, I shall give below some statistics showing the quantities of fish captured in the two districts above referred to during a period of twenty-one years:

Statistics of the Finmark capelan-fisheries, 1856–1876.*

Year.	According to the governors' reports the fisheries were in—		Entire yield of the Finmark capelan-fisheries.
	West Finmark.	East Finmark.	
1856	Good	Remarkably good	?
1857	Good	Tolerably good	?
1858	Almost a failure	Good at Vardoe; otherwise poor	?
1859	Good	Rather poor	?
1860	Exceptionally good	Rather poor	?
1861	Excellent	Inconsiderable	6 millions.
1862	Good	Good	9 millions.
1863	Poor	Good	5 millions.
1864	Very poor	Exceptionally good	10 millions.
1865	Very poor	Exceptionally good	11 millions.
1866	2.5 millions	10.5 millions	13 millions.
1867	2.2 millions	11.4 millions	13.6 millions.
1868	0.5 million	11.18 millions	12.5 millions.
1869	2.03 millions	7.45 millions	9.48 millions.
1870	3.12 millions	9.05 millions	12.17 millions.
1871	5.07 millions	6.45 millions	11.52 millions.
1872	3.42 millions	6.05 millions	9.47 millions.
1873	6.83 millions	9.36 millions	16.19 millions.
1874	6.95 millions	10.61 millions	17.56 millions.
1875	3.93 millions	15.79 millions	19.72 millions.
1876	4.13 millions	1.12 millions	5.25 millions.

* For the years prior to 1866 no exact figures were given by the governors. The data given for those years were furnished by the Statistical Bureau, and are sufficient to show the difference between the fisheries of the two districts. From 1867 on, the figures are taken from the governors' fish reports published in "*Norges Officielle Statistik*," and are entirely reliable.

From the following data, kindly furnished by Mr. *Nordvie*, from a Russian work, by *Danilewsky* on the fisheries of the Murman coast, it will be seen that the capelan-fisheries have also on the coast of Russia been very changeable:

1828 was a good fishing year.

1829 was not so good.

1830, poor (good in Norway).

1831, very poor.

1832–1836, not very good.

1837, good.

1839, poor in the west, good in the east.

1840, an excellent fishing year.

1841, poor.

1842–1843, good.

1844, poor.

1845, good halibut, but poor cod-fisheries.

1846, good fishing west of Tsypnavolok.
1847–1848, average fisheries.
1849, poor.
1850, poor.
1851–1857, exceptionally good.
1858–1859, not as good as formerly.
1860, good in the beginning; afterwards poor.
1867, the best fisheries within man's memory.
1868, the same.

I shall below give a number of statistical data regarding the capelan-fisheries in the Varanger-fiord, showing that there, too, the capelan-fisheries have varied considerably from year to year. The approach of the capelan is noticed at a considerable distance from the shore by the columns of steam rising from the pursuing whales, and by enormous numbers of birds, mostly kitti-wakes (*Larus tridactylus*). At the same time, or somewhat later, the so-called capelan cod begins to appear in large numbers, voraciously devouring the capelan. These codfish differ from the common winter codfish by their brighter color, their larger livers, and their sexual organs, which are but little developed. Their size varies a good deal, much more so than is the case with the common cod (*Gadus morrhua*). The schools of capelan evidently consist of individuals of very different age, from the so-called "*smaagjed*" (small pike) to old codfish. The enormous numbers in which they appear exclude the idea that these schools are only those fish which live near the coast or in the waters immediately outside the respective coast. They evidently contain fish which have gathered from a wide extent of sea, and the opinion seems very plausible that they have gathered by degrees during the migrations of the capelan schools towards the coast. The important discovery, made during our last expedition, of the widely extended Polar Sea barrier, taken in connection with the direct observations of the frequent occurrence of cod near the Bear Island, has led me to the opinion—mentioned in my report above referred to, and further corroborated in this report—that both the Loffoden-cod and the capelan-cod have their home near said barrier; and up to the present time I have seen no reason to change this opinion. By direct comparison I have convinced myself that the Finmark capelan-cod is the same fish as the cod found near the Bear Island and Spitzbergen; and I have already, in the report referred to, mentioned an interesting observation which seems directly to prove the identity of the two fish.

The spawning-season of the capelan, like that of other fish, extends over a tolerably long period, the schools which arrive first spawning much earlier than those which arrive later. The earliest date when I noticed spawning this year was during the first days in May. Among a number of specimens captured in the *Busse* sound, near Vardoe, on the 5th of May, and sent to me for examination, were several which had almost done spawning, and in the stomach of a few I found recently-emitted roe. At the fishing-station north of Vardoe spawning probably commenced even earlier. In the Varanger-fiord and on the coast of Russia the fish seem to spawn latest. As late as the last days of June I obtained at Vadsoe, from the stomachs of coal-fish, capelan with fully-matured roe, which, however, was not yet ready for spawning. As a general rule the spawning-process occurs on sandy bottom, at a depth of 4 to 20 fathoms. It is probable, however, that it can also proceed on rocky bottom, and at a greater depth; but we are still without reliable data on this question. As soon as the roe has been emitted, and has become impregnated, the capelan again go out to sea, and the schools of cod disappear in proportion as the capelan leave the coast in order to seek their accustomed hunting grounds. It happens quite frequently, however, that some schools of capelan stay at the bottom of the deep fiords till autumn and winter, just as the spring herring are sometimes known to do. This seems to have happened with tolerable regularity in the innermost and most sheltered portion of the Varanger-fiord, the so-called *Mæskefiord*, where, during certain years, the capelan have been observed to remain under the ice in considerable numbers. These so-called winter-capelan, which must be considered as stragglers which have lost their way out to sea, are very lean and lank, but are nevertheless greedily pursued by cod and other fish of prey, in the stomachs of which they are frequently found. These are probably the capelan, which, on going out to sea, are occasionally seen near Vardoe as early as January.

It is hardly probable that the capelan schools, after having spawned, take exactly the same route when they leave the coast as when they came. There are many indications that the capelan when they leave the coast, at any rate near East Finmark, go out to sea in an easterly direction. On the coast of Russia the route of the capelan can be traced in an easterly direction as far as the fishing-stations near the mouth of the White Sea. Farther east there are no capelan fisheries. But the occurrence of capelan observed later in summer on the west coast of Nova Zembla makes it probable that at any rate a portion of the capelan schools take this route, afterwards following the boundary of the Polar current in a westerly direction, past the Bear Island, and thus reaching their proper home, the sea between Greenland and Spitzbergen.

B.

ZOOLOGICAL, ANATOMICAL, ANL EMBRYOLOGICAL OBSERVATIONS RELATIVE TO THE CAPELAN.

Of the investigations made in this direction I shall, in this report, only give those points which relate to the spawning and mode of life of the capelan while near the coast.

According to its whole build the capelan is a genuine pelagian fish, and both in its internal and external organization shows a great similarity with the herring; although it is generally in accordance with certain zoölogical characteristics, especially the so-called "fat-fin" on the back—classed with the salmonoids. It is a peculiarity of the capelan that there is a very sharply marked external difference between the sexes, which has caused the adoption of separate designations for the male and female. In these northern latitudes the female is generally called "herring-capelan" or "roe-capelan," and the male "*faxe*"-capelan. Both generally come near the coast at the same time, but sometimes the number of "herring-capelan" is larger, and at other times smaller than that of the "*faxe*"-capelan. On opening individuals caught in the beginning of the fishing-season, one will, without exception, find the sexual organs completely developed. The greater portion of the abdominal cavity of the "herring-capelan" is filled with rather coarse-grained reddish-yellow roe, which, on closer examination, appears to be inclosed in a single thin-skinned bag, lying to the left of the intestinal duct. The right roe-bag, on the other hand, is never fully developed, the capelan in this respect differing from other fish. In the "*faxe*"-capelan both the ribbon-shaped milt-bags are found, but the right one is invariably smaller (hardly half the size of the left). By exercising a gentle pressure on the abdomen, both milt and roe are easily extracted, and can then be more closely examined. As soon as the roe is emitted it sinks to the ground, and by means of a peculiar slime, which coagulates in the water, it adheres to any object on the bottom of the sea with such a tenacity that it requires some force to tear it off. Sometimes the roe gathers in large lumps or cakes, one grain of roe adhering to the other. The milt also sinks to the bottom and is absorbed by the roe, which thereby becomes impregnated. Soon after the roe has been emitted, the first preparatory process of development begins, as a portion of the yolk (the germ) becomes separated from the other portion (the food portion), and, differing in this from the roe of the cod, collects near the upper end of the egg. This is followed by the first "furrowing process," whereupon the fetus begins to develop in the usual manner. I have not yet had an opportunity of ascertaining how long it takes the fetus to reach its full development, but it is probable that the time varies according to the temperature of the water.

The young fry of the capelan was first observed near Vadsoe on the 17th of June after a fresh breeze from the east, with a strong landward current. These small fish had evidently been recently hatched, as none of those which were captured measured more than 8 to 10 millimeters in length; but it is certain that the hatching-places were at some distance east of the coast, as this year no roe was observed on the bottom, neither at Vadsoe nor at two other points on the Varanger-fiord which I had occasion to visit. The fry at this stage of their development are as transparent as clear water, and have a very thin body encased in a single clear skin, and a shapeless, broad head with two large eyes glittering like silver. They were observed in large numbers swimming about near the surface of the water, and were easily caught with a fine muslin net. At this period of its life the capelan is extremely tender, and even when treated in the most careful manner dies soon after it has been taken out of the water. Later in the season the young fish were repeatedly observed as far up the fiord as *Morteusnæs*. Towards the end of my stay in these parts the capelan formed the principal bait for codfish, and were found in enormous numbers, together with small crustaceus and other pelagian animals. The codfish which were captured had the stomach almost invariably full of a jelly-like substance, which, on closer examination, proved to be young capelan, with but few other fish among them. The largest specimens caught with the fine net had at that time reached the length of 23 millimeters, and all the fins were completely developed, so that with absolute certainty they could be recognized as genuine young capelan.

An examination of the contents of the stomach and intestines of the grown capelan showed that it feeds exclusively on pelagian animals. At the furthest end of the intestinal duct remnants of *themists* and other characteristic animal forms of the arctic seas could be distinguished. In the stomach itself there were found various copepods of the species *Calanidæ*, some pelagian worms (*sagitta*), and occasionally *Thysanopoda;* therefore only such animals as had been observed in the fiord at the same time as the capelan.

C.

THE APPROACH OF THE CAPELAN TO THE COAST AND THE CONDITIONS WHICH SEEM TO EXERCISE AN INFLUENCE ON THE SAME.

The capelan approach the coast in dense schools, and often seem to move with great rapidity, swiftly passing islands and capes, and rushing into bays and sounds and out again. When the roe and milt are ready for spawning this process commences in the first suitable place, and seems to go on very fast. If the capelan does not immediately find a suitable place it roams about, sometimes near the coast and at other times farther from it, until it finds such a place.

It is a fact well known among fishermen that the weather has a considerable influence on the approach of the capelan. When there is a high sea and a strong wind blowing landward the capelan do not seek the sandy bays, but keep in deep water, where they probably spawn. When the wind, however, blows from the land, and the sea is calm, this is considered favorable to the approach of the capelan. The temperature of the sea is likewise important. Like most other fish, the capelan is very sensitive in the matter of sudden changes of temperature, and therefore endeavors, as much as possible, to keep in water of a tolerably uniform temperature. As long as the schools keep in the open sea they will not, during their migrations, be exposed to any very sudden changes, but when they come nearer the coast this will be different. Here they often meet with different currents of greatly varying temperature, and this cannot but have a considerable influence on their approach to the coast. The water of the deep Finmark fiord is generally very cool in spring, owing to the severe cold of the winter, and near the surface its temperature is often several degrees lower than in the open sea immediately outside the fiords. This difference of temperature, traces of which are found for a long time in the deep portions of the water, gradually disappears with the increasing warmth of summer. But as the heat of summer comes early one year and late another, the period when the temperature of the surface is the same in the fiords as in the open sea varies considerably from year to year, and this circumstance cannot fail to influence the character and location of the capelan-fisheries. It will therefore easily be understood why unusually cold weather during the early part of summer is considered as very unfavorable for the entrance of the capelan into the fiords.

Although the capelan are, during their approach to the coast, pursued by numerous enemies, both whales, fish, and birds of prey, this seems to have much less influence on the course of the capelan schools than the above-mentioned physical conditions. The capelan, on the whole, seems to be rather a lazy fish, and, especially when gathered in large schools, by no means shy. On this point I have made several observations; the first on my way north in the Sanfiord near Nordkyn. While the steamer stopped to unload goods a number of capelan were observed quietly swimming by the side of the steamer. When the machinery again began to work and the steamer resumed its motion, it did not seem to affect them in the least, some of them even kept close to the stern without changing their course in the slightest, in consequence of which some were struck by the propeller and were thrown upward in a half-dead condition. It is well known that the method formerly employed for obtaining bait was very simple, and consisted in dipping the capelan out of the water with a sort of purse net. Although of late years small seines have been used for this purpose, the above-mentioned primitive method is still successfully employed in many places, and I have once seen how two boat-loads of capelan were obtained at Vadsoe in this manner, although the schools were by no means large. This shows that the capelan is not at all shy. Its worst enemy is the coal-fish. This greedy fish of prey, by its peculiar method of chasing the capelan, often succeeds in scattering the schools, and in disturbing the approach of the capelan to the coast. Neither the so-called "capelan cod," nor whales, nor birds seem to produce this effect.

D.

THE CAPELAN-FISHERIES IN THE VARANGER-FIORD.

As has already been mentioned, the capelan-fisheries are as a general rule not very steady, the principal fisheries being one year in West Finmark and another year in East Finmark. The Varanger-fiord capelan-fisheries seem to be still more uncertain. In going over the different fish-reports, and examining the condition of the fisheries in previous years, I found ample proof of this assertion, and there have even been years when the Varanger-fiord fisheries proved an entire failure, the capelan either staying away altogether or not advancing beyond *Kibergnæs*, where the Varanger-fiord proper commences. According to the official reports this has been the case during the years 1869, 1871, and 1876, and the present year must also be classed among the years when the capelan only enter the Varanger-fiord in small and scattered schools. Old fishermen say that in former times there were also years when no capelan came near the coast. Even if such is the case, however, some fishing is going on, as the "capelan-cod," before leaving the coast, likes to follow the raised portion of the bottom as far as possible. I had occasion during the present year to observe this circumstance. Although the great mass of capelan which, after passing Vardoe, approached the coast, evidently took their course from Kiberg across the mouth of the fiord towards the coast of Russia (where they were observed soon afterwards), a considerable number nevertheless entered the Varanger-fiord at Vadsoe, but more especially at Bugönæs, where on certain days, when bait (herring) could be obtained, there was very good fishing (about 1½ tons of liver per boat). But the lack of bait brought the fisheries to a stand-still, and it is probable that a large number of cod would during this year have been caught in the Varanger district if there had been a sufficient quantity of bait. It is greatly to be deplored that, after the experience of former years, no measures were taken to supply this urgent want. A swift steamer, which could have supplied the fisheries in the fiord with bait from Vardoe or the nearest fishing-stations having plenty of capelan, would doubtless have proved an inestimable advantage. I have no doubt that even with preserved capelan or herring (packed in ice or slightly salted) large numbers of cod might have been caught. It is stated that attempts made in this direction in former years have proved unsuccessful, but in making these statements no regard seems to have been had for the peculiar circumstances under which these attempts were made. When the sea is full of capelan, it is quite natural that the cod prefers the fresh capelan to preserved fish. In years like the present, however, when but few, if any, capelan are found near the fishing-stations, the cod will doubtless take to the bait, even if it is not fresh fish.* I myself have seen a large quantity of cod caught near Bugönæs with herring which were so old and soft that they could hardly be fastened to the hooks, which shows that the cod was not over nice in the matter of food. As lines are almost exclusively used in the Varanger-fiord cod-fisheries (not hand-lines as at most of the other fishing-stations), it cannot be considered a misfortune, but rather the contrary, that there are so few capelan during the fishing-season, as it

*It is well known that in the Loffoden fisheries salt herring are almost exclusively used for line fishing.

would be much more difficult to catch the cod with lines when the sea was full of capelan.

As a peculiarity of this year's fisheries in the Varanger-fiord it must be mentioned that during the whole season the cod went very deep, so that the first good hauls were made near the edge of the outer bottom-elevation. I think that I can explain this by purely physical and meteorological causes, of which more below.

In answer to the question what caused the capelan this year to stay away from its usual spawning places in the Varanger-fiord most fishermen will say that the whale-fisheries were the only cause of this. No facts, however, are given on which to build this opinion, and I believe, and expect to show in the following, that I am able to mention a much more plausible cause, which will also explain the failures of former years, when there were no whale-fisheries.

I give below some statistical data, taken from the fish-reports reprinted in "*Norges Officielle Statistik*," relative to the capelan-fisheries in the Varanger-fiord during the last few years, from which it will be seen that there has not been a uniform decrease of the capelan-fisheries since the begining of the whale-fisheries, as is maintained by some persons, but that the fisheries have varied considerably from year to year.

Statistics showing the number of fish caught in the Varanger-district during the period 1868–1878.

1868	3,160,000
1869	446,000
1870	1,192,000
1871	797,900
1872	431,200
1873	900,000
*1874	1,187,000
1875	961,000
1876	476,000
1877	1,120,000
1878	569,000

E.

ON THE SUPPOSED INFLUENCE OF THE WHALE-FISHERIES ON THE CAPELAN-FISHERIES IN THE VARANGER-FIORD.

As this question is for the time being of vital importance to the inhabitants of the coast, I have given special attention to it, and have, after the best of my ability, during my stay at Vadsoe sought to examine all the points which seem to have any bearing on this question. It is the general opinion in these parts, as is well known, that the whale-fisheries exercise an exceedingly hurtful influence on the capelan-fisher-

* The figures for the last two years have been kindly furnished by the Statistical Bureau.

ies, and that the failure of the Varanger-fiord fisheries during the last few years is principally owing to the growing development of the whale-fisheries. No satisfactory proof of this opinion, however, has as yet been given, and the bill introduced in the *Folkething* (Norwegian Parliament) during its last session to limit the whale-fisheries, did not, therefore, pass. My private opinion has always been that no such hurtful influence can be ascribed to the whale-fisheries, and I have freely stated this opinion to the department on former occasions. But, as at that time I had not yet personally observed the capelan-fisheries, and as the whale-fisheries were carried on in a somewhat different manner from what they are now, I thought it desirable to make another thorough investigation of the whole matter, in which I could engage with entire impartiality, as I did not consider myself bound to abide by any opinion previously expressed by me, and was not hampered by any considerations of a personal nature.

In examining this matter the following points seem to me to be of special importance; and from my present experience I shall endeavor to answer each one of them as best I can:

(1.) What justifies the supposition that the whales chase the capelan from the sea towards the coast?

(2.) Does the whale, during good capelan-fishing, cause the capelan to stay for a considerable time in shallow bays and sounds?

(3.) Which kinds of whales come near the coast during the capelan-fisheries, and which of these must be considered as the capelan-whale proper?

(4.) Can any considerable decrease be noticed in the number of whales at the present time, and can it be supposed that, as these fisheries are carried on at present, the whales will be exterminated in the near future?

(5.) Will an actual decrease or the extermination of the whales have any influence on the character of the capelan-fisheries?

(6.) Do the whale-steamers, while cruising near the coast, scare away the capelan schools, and disturb their approach to the coast?

(7.) In how far can there be any direct conflict between the whale and other fisheries?

(8.) Is it probable that the refuse from the captured whales fills the sea with impure matter to such a degree as to drive the capelan away from places where whales are slaughtered?

(9.) Does impure matter from the same source gather at the bottom of the sea and make it unfit for the development of the roe of the capelan?

(10.) What physical and meteorological causes can be supposed to have an influence on the entering of the capelan into the Varanger-fiord?

In the following I shall endeavor to answer each one of these questions under its respective number:

(1.) It is a very old opinion, as is well known, that the approach to the coast of the capelan and herring is solely caused by the whales, and that nature had appointed these gigantic animals to gather the scattered schools of herring and capelan from the different parts of the ocean and chase them towards certain portions of the coast in order that man might get his share of the wealth of the sea. For this reason a sort of veneration was, in olden times, shown for whales, which were considered the special servants of Providence. Our time is less fanciful in its interpretation of natural phenomena, and we hesitate somewhat to assign to the whale the part of a disinterested benefactor of mankind. It has been shown with a sufficient degree of certainty that both the spring herring and the capelan approach the coast at certain seasons of the year from a natural instinct, in order to spawn in suitable places, and that the whales simply follow the schools of herring and capelan, because they supply them with food. Although it might be supposed that no educated person could any longer entertain the antiquated notion above referred to, the opinion seems still to be very generally spread among fishermen that the presence of the whale during the capelan-fisheries is of great significance and benefit. Though the more enlightened fishermen will grant that, even if the whales staid away, the capelan must come near the coast for the purpose of spawning, they still think that it is owing to the whales that the capelan spawn so near to the coast, and that there are successful fisheries. Experience, however, does by no means bear out this opinion. There have been years when large whales were seen out at sea and no capelan approached the coast, and at other times there have been instances (as in the Varanger-fiord) when the capelan came quite near the coast without a single whale making its appearance outside.

(2.) It has been maintained that during the rich Varanger-fiord capelan-fisheries the whales formed a sort of cordon outside the bays and sounds, thus forcing the capelan towards the coast against their will, and preventing them from returning to the deep waters. In all such cases, however, it has been ascertained that the capelan spawned in the above-mentioned bays and sounds, and also, that, after the spawning-process was finished, the capelan went out to sea again, without any regard to the whales. It is evident, therefore, that we should consider this matter in a somewhat different light, viz, that the schools of capelan have chosen their spawning-places from their own instinct and entirely independent of the whales, and that the whales have simply followed the schools, as is their wont, and that when the capelan schools stopped in certain places the whales likewise stopped somewhere in the neighborhood, so as to be able to take their meals regularly. In rejecting the last-mentioned and entirely natural explanation and showing a preference for the old idea, that the whales bring the capelan to the coast and distribute them among the different fishing-stations, people only furnish another proof of how difficult it is to tear loose from old and deeply-rooted prejudices. This idea, as has been said above, is evidently based on a complete misunderstanding of the mutual relations between the capelan and the whale. There are no reliable facts to show that the approach of the capelan schools is influenced to any great degree either by the pursuing whales or by the cod, or by flocks of birds; but there is every reason to suppose that only physical and meteorological conditions determine the course of the capelan while near the shore.

(3.) The species of whales which follows the schools of capelan seems to be almost exclusively the so-called "Fin-whale," which I have found to be identical with the *Balænoptera musculus*, the same which generally makes its appearance during the spring-herring fisheries. The so-called "blue-whale," on the other hand, makes its appearance later, hardly before the middle of May, and does not live on capelan, but on pelagian animals of a lower class, particularly small crustaceans. I have already had occasion to show that this species of whales, which forms the principal object of Foyn's fisheries, has absolutely nothing to do with the capelan, and the investigations made by me during the present year fully corroborate this statement. Of other whales, the *Megaptera bœops* occasionally makes its appearance, but only later in spring. Shortly before setting out on my return journey I had occasion to examine a specimen of this kind which had been captured by Foyn's men. A thorough examination of the contents of its stomach showed that this species of whale, like the "blue-whale," lives exclusively on lower pelagian animals, especially small crustaceans. Finally, a fourth species of whales is known in these regions, the so-called "coal-fish-whale," which takes its name from the circumstance that it does not appear in any considerable number until the approach of the coal-fish. As this whale only reaches a comparatively small size, it is not caught. I have, however, obtained a tolerably close view of it at sea, which convinced me that it is the so-called "*Vaäge-whale*," well known on our western coast. It lives principally on small herring, but it must be supposed that in these northern latitudes it also, to some extent, feeds on capelan. The three last-mentioned species of whales are seen near the coast, and in the Varanger-fiord, long after the capelan have disappeared. The "Fin-whale," on the other hand, leaves the coast with the capelan, and also arrives with it. It must, therefore, be considered as the "capelan-whale" proper. Although, as has been said above, the "blue-whale" forms the principal object of Foyn's fisheries, several "Fin-whales" have been caught during the last few years, as the whale-fisheries commence before the "blue-whale" comes near the coast. During the present year, as far as known, 15 "Fin-whales" have been caught by Foyn's men. The stomachs of those which I examined were completely filled with capelan, and some were even found in the mouth, the whale evidently not having had time to swallow them.

(4.) To the question, "Can a considerable decrease in the number of whales be noticed on the coast of Finmark?" my experience compels me to return a negative answer. The schools of capelan are still followed by numerous whales, and the reports on the capelan-fisheries, year after year, speak of the large number of whales and birds, just as in former times. As regards the complaint that there has been a decrease in the number of whales in the Varanger-fiord, we must take into consideration the circumstance that the whale only visits those places where it can obtain sufficient food. As it is a fact that of late years the capelan have not entered the Varanger-fiord in any considerable number, it is but a natural consequence of this fact that the whales in this fiord are not as numerous as in former years. If any species of whales may be supposed to have decreased on account of the present whale-fisheries this would be the "blue-whale," but the rich hauls made during the last few years do not seem to indicate any such decrease. As the whale-fisheries are carried on at present, it is hardly probable that there will be any noticeable decrease in the number of whales in the near future. If the whale-fisheries, however, should be further developed, and new whaling-stations be established on this coast, such an occurrence is within the range of possibility. In this case it would be advisable to take suitable measures for preserving a source of income, which doubtless in the future will yield a still greater gain, in proportion as the preparation and improvement of the raw material becomes more perfect and better apparatus is employed.

(5.) There are instances on record, unfortunately, which show that it is possible for man to exterminate an entire species of animals. Although it seems hardly possible that this should ever be the case with the whales, whose home and place of refuge is the whole vast ocean, it is quite possible that, by being too eagerly pursued for a long number of years, their number may decrease, and that finally they may be more or less driven away from certain coasts. It is not easy to say what would be the consequences of such an occurrence. It is my opinion, however, that as far as the fisheries are concerned these consequences would not be as serious as some people are inclined to think. Whilst it is certainly doubtful whether the whales to any great extent chase the capelan and herring towards the shore, it is absolutely certain that enormous quantities of these fish are destroyed by the whales. The "Fin-whales" must actually be considered as hurtful animals. The "blue-whale," on the other hand, lives almost exclusively on small crustaceans, which are of considerable importance to the fisheries, as they form the principal bait for the cod. The probable consequence of the disappearance of the whales would be an increase in the number of capelan, and an improvement in the cod-fisheries, on account of the larger number of small crustaceans; in other words, there is reason to suppose that instead of being injured, the fisheries would be benefited. It would, however, be wrong to encourage, from this point of view, a war of extermination against the whales. Although these animals do not play the peculiar part which the superstition of former years has assigned them, they doubtless have their place in the great household of nature by contributing their share towards maintaining that equilibrium which is necessary for the fauna of the sea, if it is to preserve its present character. Any violent disturbance of this equilibrium will, under all circumstances, be fraught with danger, as we do not know what further consequences it may produce. The desire to preserve the whale-fisheries for our descendants ought likewise to prevent people from engaging in a useless war of extermination against these animals.

(6.) As during the last few years the whale-fisheries have been carried on at a time when capelan-fishing was in full activity, the question arises whether the whaling-ships are liable during their cruises to scare the schools of capelan. Some people think that the noise made by the propeller of a steamer is capable, even at a considerable distance, of frightening capelan and herring and driving them away from the coast. This, however, is merely a supposition, and has never been proved by facts. Various observations (see also those mentioned by me above), on the contrary, seem to show that at any rate the capelan is in no wise affected by this kind of noise. It is another question, whether the noise of the cannon, which are fired off by the whaling-vessels, can frighten the capelan. It cannot be denied that the capelan, like all fish, is strangely affected by any sudden noises of this kind. One can easily convince himself by actual experiment that even a slight noise, such as the falling down of an oar in the boat, &c., is noticed by the schools of capelan which are in the immediate neighborhood, and that, on hearing the noise, they make a sudden movement, which causes their shining sides to appear in the water. One may, however, at the same time, convince himself that this movement is purely temporary, and that, as soon as the noise has subsided, the schools of capelan quietly pursue their course. As the cannon shots which are fired by the whaling-vessels are by no means of the character of a continuous cannonade, but are only fired at long intervals, it cannot be supposed that the course of the capelan is in any way influenced thereby, especially when these shots, as is mostly the case, are fired at a considerable distance from the coast. It cannot be denied, however, that if these shots should be fired close to the shore, and right among the schools of capelan whilst they are engaged in spawning, the spawning-process might be endangered, and the capelan frightened to such a degree as to make their capture much more difficult. It would be still worse if a wounded whale should in its agony rush among the schools of capelan, dragging the steamer after it. Such cases will probably be of rare occurrence, but are said to have happened, and must under any circumstances be considered as extremely unfavorable to the capelan-fisheries. Some complaints on this point have been raised during the present year, and I have had occasion during my stay at Vadsoe to become acquainted with the nature of these complaints, and I must say that, although they were doubtless exaggerated, there was certainly some foundation for them. I am, therefore, prepared to grant that it will be a benefit to confine the whale-fisheries within certain limits.

(7.) The greatest danger which, in my opinion, threatens the capelan-fisheries from the whale-fisheries is that there may possibly be a conflict between these two interests. If this should really ever be the case it will be time enough to take measures for assigning certain limits to each fishery, so as to preclude the possibility of a collision. But, strange to say, very few complaints have been raised relative to this (in my opinion) very important point, and from what I heard during my stay at the fishing-stations, there has so far been very little cause for such complaints. There seem to have been a few cases where the lines of the capelan-fishers have been disturbed by the whale-fisheries, but in such cases Mr. Foyn has invariably reimbursed the fishermen for their loss in such a liberal manner as to make their gain exceed their loss. It is, however, within the range of possibility that, if the whale-fisheries should be further developed, the conflict between the two interests might become more serious. Another point should be taken into consideration —the possible danger to the lives of the fishermen, if the whale-fisheries should be prosecuted on a more extensive scale in the usual fishing-places, which are crowded with boats and implements. When a whale, which has been shot but is not yet dead, rushes furiously along with the steamer in tow, it cannot possibly make way for the boats which accidentally cross its path; nor will it be possible for the crews of such boats who are engaged in hauling in their lines and nets to escape the approaching danger. It is evident that accidents could thus easily happen, and in such cases neither Mr. Foyn nor any one else could make up for the losses sustained. For these reasons I would be inclined to favor a reasonable limitation of the whale-fisheries, promising greater safety to apparatus and human life; and it is my idea that this could best be done by drawing a certain line at some distance from the coast, within which no whale could be shot during the fishing-season. If this line were drawn one half mile (Norwegian) from the coast the whale-fisheries would not be inconvenienced, and the other fisheries could be carried on with greater safety, and the danger, to some extent well founded, that under certain circumstances the whale-fisheries might drive away the schools of capelan, would be removed.

There are a few more points regarding the whale-fisheries which have attracted attention during the last few years, and to which I will refer, because during my stay at the fishing-stations I have made them the subject of special investigations.

(8.) The fear has been expressed that the refuse from the captured whales might fill the sea with fatty and impure substances to such an extent as to prevent the capelan entering the Varanger-fiord, since the capelan seemed to avoid the places where whaling-establishments are located. As regards this last-mentioned point, I must say that experience does not prove its correctness. Whenever capelan have visited the Varanger-fiord, and this has more or less always been the case, they have gone to their accustomed places, and the Vadsoe Sound has always been one of the best points for the capelan-fisheries; it has even been noticed that the schools of capelan seemed to prefer that portion of the sound which bordered on Mr. Foyn's establishment. On the south side of the fiord the bay into which the Jacobs River empties has always been the best place for the capelan-fisheries, and is still considered so, although the whaling-establishment of the Iarfiord Company is quite near. As regards the refuse, it is true that the Iarfiord Company only uses the oil and the whalebone, while Foyn's establishment utilizes everything except the entrails. These are taken outside of the fiord and thrown into the water to be carried away by wind and waves; they continue to float near the surface until they are either scattered or sink to the bottom after the fatty substances have disappeared. During my excursions I have several times had occasion to see such refuse. These half-decayed substances do not emit the most pleasant odor, and it is anything but agreeable for the inhabitants of Vadsoe to have the current, as will sometimes happen, carry such matter into the immediate neighborhood of the town. But the poisoning of the water of the Varanger-fiord is entirely out of the question. Another disagreeable consequence is this, that during the slaughtering of the whales at Foyn's establishment a quantity of oil and fat is carried across the sound to Vadsoe by wind and current, and adheres to the piers, which suffer much from this cause, and are destroyed in a comparatively short time. One can easily convince himself of the presence of these oily substances, which are of course confined to the surface of the water whenever there is a fresh sea-breeze. It can then be noticed that the water in the immediate neighborhood of Foyn's establishment does not show the slightest ripple, but remains as smooth as a mirror, just as if there was no wind, and at the same time boats may be seen passing by at a short distance, their sails filled by the breeze. It must, however, be said that this phenomenon is only noticed in the Vadsoe Sound, and that the sea outside of the sound preserves its usual appearance. It is hardly probable that the fatty substances floating about on the surface of the water should drive the capelan away, and experience has shown that the capelan have entered the Vadsoe Sound in spite of the existence of this fatty matter. In slaughtering the captured whales a large quantity of blood likewise flows into the sea, but as it is heavier than the sea-water it is not carried as far as the oil; and I have never seen blood in the water except in the immediate neighborhood of Foyn's establishment, where the sea certainly at times resembles a pool of blood. The question has also been asked whether the close proximity of Foyn's establishment to the town of Vadsoe could in any way affect its sanitary condition. Although this question, properly speaking, did not belong to the subject which I intended to investigate, I nevertheless thought that it might be useful to gather some information on this point from the resident physician, Dr. Hartman, who has assured me that there had not been any change for the worse in the sanitary condition of the town since the beginning of the whale-fisheries.

(9.) The idea has also been advanced that the refuse from the captured whales might fill the bottom of the sea with impurities to such an extent as to make it unfit for the development of the roe of the capelan. This idea, however, does not rest on any actual observation, but is merely a supposition. I have made this the subject of most careful and thorough investigation, the result of which by no means corroborates that supposition. Immediately on my arrival at Vadsoe, therefore, prior to the beginning of this year's whale-fisheries, I made a careful examination of the sound, both near the town and near Foyn's establishment. I found nothing of a peculiar character, except that close to the above-mentioned establishment there was an unusual quantity of those small green algæ which are used a good deal to keep the water in aquaria in a fresh condition. In the deep cavities between the stones there was a thin layer of fine mud; otherwise the bottom everywhere consisted of pure white sand, which in some places was coarser than in others. After the whale-fisheries had been going on for some time I again examined the sound on different occasions. Near Foyn's establishment stinking mud had, in some places, accumulated on the sand, and this mud was evidently composed of refuse-matter from the slaughtered whales; but at a very short distance from the shore this mud began to disappear, and farther out in the sound the bottom was exactly of the same character as when I first examined it, and I could not discover the slightest impurities. I even go so far as to say that, in spite of the whale-fisheries, the harbor of Vadsoe has a cleaner bottom than most other harbors on the coast of Finmark. Both at Vardoe and at Hammerfest and many other places I have on former occasions examined the nature of the bottom, and have invariably found a more or less extensive layer of dark mud covering the sand, composed principally of fish-refuse and other decayed organic matter. The Vadsoe harbor, however, is remarkably free from this mud. This seems to be owing to the steady and often very strong current which flows through the sound, and which does not allow any organic substances floating in the water to sink to the bottom. Farther out not the slightest trace of impurity can be discovered on the bottom of the fiord. As a general rule the upper layer is sand, then comes rock with a rich algæ-vegetation, and below this a clay bottom. Nothing anomalous could be observed in the composition of this clay; and both it and the sandy and rocky bottom were swarming with different aquatic animals which seemed to thrive remarkably well. Although I am not able to report any direct observations on the development of the capelan-roe in these regions, for the simple reason that this year the capelan did not spawn in the Varanger-fiord, I feel convinced that the nature of the bottom will not prevent the capelan from spawning either here or anywhere else. It is true that the entrails of the whales, after having floated in the water for some time, finally sink to the bottom;

but when this takes place the organic substances have for the greater part been destroyed, and the numerous aquatic animals living on the bottom do the rest of the work. I once had occasion to examine some of the remnants of the entrails of a whale which were accidentally brought up by the bottom-scraper in the fiord near Vadsoe. It looked like a mass of wool rolled together, as only the thin and tough sinews had been left, all the flesh and fat having disappeared. There was no unusual odor from these remnants. It is my opinion that but very little time is required to reduce the entrails to this condition. It is a well-known fact that in the arctic regions large animals, the walrus or polar bear for instance, are completely skeletonized by sinking them to the bottom and letting them lie there for a few days. There are a number of small marine animals, especially amphipods, which make their appearance in enormous masses, and do the work of skeletonizing very thoroughly, and which are everywhere to be considered as diligent sanitary police, clearing off from the bottom all decaying organic matter. In the Varanger-fiord these small animals are found in enormous masses. In the Vadsoe Sound alone I discovered 20 different kinds of amphipods, and these have on the whole been found to be identical with those usually found in the arctic seas.

(10.) In conclusion, if I am asked what I suppose to be the cause of the last years' poor fisheries in the Varanger-fiord, I must—referring to my investigations of this matter, and to what I have said regarding it above—express it as my conviction that the principal causes are of a physical and meteorological nature, and that the whale-fisheries have much less to do with it than is generally supposed. Although it cannot be denied that under certain circumstances these fisheries may disturb the course of the capelan and their distribution over the different fishing-stations, there is nothing to justify the supposition that the capelan have ever been driven away from the coast thereby, or have been prevented from reaching their accustomed spawning places.* During the present year the capelan-fisheries in the Varanger-fiord were not very successful, as hardly any capelan entered the fiord, and public opinion very generally ascribed this to the whale-fisheries, no one ever thinking of other possible causes. As such a cause I have mentioned meteorological conditions, and my experience in this respect is fully borne out by that of the fishermen. If we inquire into the meteorological conditions of the present year we find that the whole spring and early summer till the 24th of June were unusually cold and raw. The temperature of the sea-

*One of the complaints raised during my stay at Vadsoe was that a single cannon shot fired near *Great Ekkero* from the steamer of the Iarfiord Company caused the schools of capelan and the whales to leave this neighborhood, not to return again; but it may well be asked why the same was not the case at Vardoe and Kiberg, in the immediate neighborhood of which shots were fired repeatedly. It was evidently a mere accident that the capelan disappeared at the same, or nearly the same, time when the above-mentioned shot was fired; and there is every reason to suppose that the same would have happened if no shot had been fired.

water in the Varanger-fiord was consequently very low, and remained in the neighborhood of +2° C. till the end of the fisheries. During the nights the temperature was often several degrees lower, and the surface water at times consequently still colder. I have not the slightest doubt that thereby the schools of capelan were to a great extent prevented from entering the Varanger-fiord. I also think that this unusually low temperature of the upper portion of the water is the reason why the capelan-cod went into such deep waters, and did not visit the banks as is their wont, and also why there was such a scarcity of small crustaceans. Even if one should not be inclined to ascribe so decided an influence on the course of the capelan to the meteorological conditions as I do, I nevertheless believe that every one will agree with me that it will not do to be led by an old prejudice, and make the whale-fisheries solely responsible for the poor fisheries in the Varanger-fiord, without taking into consideration meteorological and other conditions, which very probably have had a good deal to do with it.

I have in the above given a plain review of the opinions to which the investigations made by me during the present year have led me. If these opinions differ somewhat from those generally entertained in these regions, I can honestly confess that this is not caused by any pre-conceived prejudice on my part. On the contrary, it has been my desire as much as possible to meet the views of the inhabitants of these parts half-way; and I have therefore investigated all the complaints made against the whale-fisheries as conscientiously as possible. As a scientist I am obliged to confine myself strictly to the facts in the case, and I have found that these facts do not favor the popular opinion. If, in spite of this, I have declared my willingness to favor a reasonable limitation of the whale-fisheries, this has principally been done from reasons entirely different from those which have generally been advanced; my idea as to this proposed limitation, and the manner in which it had best be carried out, also differs greatly from that proposed in former years.

X.—THE HALIBUT FISHERY.—DAVIS' STRAIT.*

By Newton P. Scudder, A. M.

ANALYSIS.

* The following article is the result of a trip taken, in 1879, upon a Gloucester fishing vessel. Professor Baird, convinced that it would be one of the best methods of collecting information respecting the sea-fisheries, sent representatives of the United States Fish Commission upon some of the regular fishing trips of the Gloucester vessels, to note and report everything of interest. With this object in view, the writer was sent on the fishing vessel Bunker Hill, Capt. John McDonald, bound to Davis' Strait for halibut.

It was decided that, since the Davis' Strait fishery formed a fishery by itself, it would be better to write its history up to the present time than to confine this report to the trip of the Bunker Hill.

The writer acknowledges with pleasure his indebtedness to Mr. R. E. Earll, then in charge of the Fish Commission station at Gloucester, for his kindness in arranging for comfortable quarters and outfit; to Mr. A. Howard Clark, for notes of statements of fishermen and others relating to this fishery, and to Capt. J. W. Collins for many valuable suggestions. Nor would he forget to mention with gratitude the kindness and aid of the fishermen with whom he was brought into so intimate contact. The captain offered every advantage in his power, consistent with the interest of the fishery, and the rest were equally generous. There is probably no class of men more generous and self-denying than the Gloucester fishermen, and recent events only confirm this statement.

A.—GENERAL DISCUSSION OF THE FISHERY.

1.—OUTLINE HISTORY.

Reports of the abundance of halibut off the west coast of Greenland were first brought to Massachusetts by Provincetown whalers. The first trip to Greenland after these fish was made in 1866 by the schooner John Atwood. She sailed June 29 and returned October 14, stocking $5,500. Capt. G. P. Pomeroy, of New London, went as navigator, and Capt. Averill L. York, of Gloucester, as fishing master. Though she failed to fill her hold, only because of her late arrival upon the fishing banks, no enthusiasm was excited in this fishery until Capt. John McQuinn, in 1870, brought from Greenland a trip of flitched halibut, worth over $19,000. Each of the two or three succeeding years, five or six vessels, with hopes of having like success, were fitted out for the same place. But, for some reason or other, the fish were not caught in very extravagant quantities, and a fall in the price of the fish rendered such a long trip financially rather uncertain. Besides, as there was no reliable chart of Davis' Strait and the coast of Greenland, the fishermen hesitated considerably before undertaking a voyage to such a precipitous and barren coast; and no one can blame them. Once give them a good chart of the coast and harbors of Western Greenland, and their greatest difficulty will be removed. No reliable survey and chart of Greenland have been made.

Notwithstanding the need of large and accurate charts and the immense distance of two thousand miles, so great are the probabilities of making a profitable catch, that thirty-one trips have been made from Gloucester to Davis' Strait after halibut. The following is a tabular view of the vessels and captains engaged in the Greenland fishery from its beginning to the present time, showing the year and weight of flitches for each trip. This gives a total of 3,283,765 pounds of salt halibut brought to Gloucester from Greenland, or an average of 113,233 pounds for the vessels that returned in safety.

Year.	Vessel.	Captain.	Pounds of fish.
1866	John Atwood	George Pomeroy	60,000
1869	Caleb Eaton	John McQuinn	134,400
1870	Caleb Eaton	John McQuinn	177,800
1871	Membrino Chief	John McQuinn	
1871	Caleb Eaton	Jeremiah Hopkins	429,200
1871	River Queen (lost)	George Robinson	
1871	Thorwaldsen	James Hamilton	
1871	William S. Baker	Albion Pearse	156,800
1871	Mary E	Rasmus Madsen	30,000
1872	Aaron Burnham	Charles J. Lawson	112,000
1872	Thorwaldsen	Henry Hamilton	145,000
1872	William S. Baker	Albion Pearse	145,000
1872	Membrino Chief	John McQuinn	134,400
1872	Carrie Jones	John Gaskill	112,000
1872	Caleb Eaton	Jeremiah Hopkins	134,400
1873	Aaron Burnham	Charles J. Lawson	91,000
1873	William S. Baker	Albion Pearse	75,700

Year.	Vessel.	Captain.	Pounds of fish.
1873	Caleb Eaton	Jeremiah Hopkins	62,500
1873	Albert Clarence	John Gaskill	51,000
1874	Nulli Secundus	Charles J. Lawson	163,000
1877	Henry Wilson	James Jamisen	91,000
1878	Grace L. Fears	Randall McDonald	60,000
1878	Cunard (lost)	Garrett Galvin	....
1878	Bellerophon	Thomas Scott	60,000
1879	Herman Babson	Charles J. Lawson	140,000
1879	Bunker Hill	John McDonald	140,000
1879	Mary E	Rasmus Madson	75,000
1880	Mary E	Rasmus Madsen	70,000
1881	Herman Babson	Charles J. Lawson	168,400
1881	Mary E	Rasmus Madson	84,890
1881	Bunker Hill	John McDonald	179,575
	Total		3,283,765
	Average for vessels returning		113,233

Two vessels were lost, but one of these, the Cunard, after starting for home, went to the Grand Banks and was lost there, leaving only one lost in the Greenland fishery. The River Queen probably failed to reach home because too little care had been taken in properly arranging the salted fish, thus throwing the vessel considerably out of trim. The last seen of her she was rather low in the bow, and sailing before a northeast gale, on her way home.

2.—GENERAL SUMMARY.

If one compares this fishery with that of the Grand Banks there is much in its favor. The water is not so deep, and fogs are not so frequent as on the Grand Banks. Good harbors are available in case of storms, which are not common. The climate is excellent, neither very cold nor very warm. The continual light permits fishing at all times of the day, and does away with much of the risk of the dories losing sight of the vessels. One great objection is the long distance from home, and lack of opportunities of hearing from the outside world. The fish, however, are plentiful, and, if the fishermen only had accurate charts of the banks of the west coast of Greenland and of the harbors of Sukkertoppen and Holsteinborg, the long distance would be little thought of, as they would then be quite sure of a profitable catch. The harbor of Holsteinborg is usually open by the middle of May and perhaps fishing could be commenced by the 1st of June, but the ice, brought by the current down the east coast of Greenland, besides blocking up the more southern harbors, will probably render the passage north too dangerous before the middle of June. On this account and because of the change in the weather about the 20th of August, the fishing here will have to be done in July and August.

Besides the halibut, the common cod is also caught on the trawls of the fishermen, but not in sufficient numbers to warrant their being salted. The proportion of cod to halibut is about 1 to 15. The Eskimo fish for both in the bays and harbors, and the cod may be more plentiful there, but they are likewise smaller.

The fine salmon of the coast might afford profitable fishing. This opinion is founded upon the quantity of these fish the natives catch with their rude appliances, and sell for $4 to $8 a barrel to the Danish trade agents. If the American fishermen were acquainted with the deep fiords, and should engage in this fishery with all the modern improvements for seine fishing, they would probably meet with great success. There is, however, this probable limit: the fish are caught mostly in June and July when they visit the mouths of the fresh-water creeks. After this they become scarce, but, if the fishermen do not succeed in securing a cargo of salmon, they have at least a month, after the salmon season is over, during which they can set their trawls for halibut.

The average of 113,233 pounds of salt halibut for a trip is a good average, but does not represent fully what the fishery may become in the future. For, several of the trips were made the conclusion of cod-fishing trips to the Grand Banks, and the vessels were already partly filled with cod, leaving not enough room for a *full* cargo of halibut. Thus the Mary E., in 1871, '79, '80, and '81, fished first on Flemish Cap, and from *there* went to Greenland. In 1871 she did not reach the Davis Strait fishing-ground until August 20, and left off fishing August 28, but during these eight days she secured 30,000 pounds of halibut. In 1879 the Herman Babson had on board 60,000 pounds of codfish, which she brought from the Grand Banks. If we omit from our calculations the Mary E., which is comparatively a small vessel, the above average will be increased to nearly 121,000 pounds for each trip.

Again, since the fishermen first visited Davis' Strait, the methods of fishing in that region have altered considerably, principally because the first fishermen were unacquainted with the fishing banks, and were afraid to remain on them whenever the wind showed signs of increasing to a gale. Because of this, visits to the harbor were frequent, and much time was lost in regaining the banks after the blow was over. The custom now is to remain on the banks as much as possible, and to fish at every opportunity, and, had this method been employed from the start, the average would have been considerably larger.

The success of the Bunker Hill, in 1881, proves this beyond a doubt. This vessel, though not arriving upon the banks until July 11, commenced fishing before going into the harbor, and by persistent effort, in spite of unfavorable weather, secured the largest fare of any vessel since the beginning of the fishery.

In the future, competition among the fishermen will become greater, knowledge of harbors and fishing banks more definite and wide-spread, improved methods of fishing will be introduced, and, as the demand for the fish and the confidence of the fishermen increase, the Greenland halibut fishery will grow until it may even rival in importance the summer fishery of the Grand Banks.

B.—FISHING GROUNDS.

3.—LOCATION AND CHARACTER.

The fishing banks are fifteen to forty miles from the coast and, if we can rely upon the Danish charts, extend from Disko Bay to within 3° of Cape Farewell; for these charts give soundings all along the coast between these two points. Extensive as the banks may be, only a small part of them, the part about Holsteinborg and Cape Amalia, has been tried by American fishermen. That the fish are to be found throughout their whole extent is more than probable; for the species is identical with that taken on the Grand Banks, and we would naturally infer it would be found in all favorable situations within the limits of its distribution. It is also reported that Capt. Rasmus Madson, commonly known as "Captain Hamilton," who has been to Greenland several times, set his trawls for these fish farther to the south (probably off of Godthaab) and found them very abundant, but was unable to secure many on account of the numerous ground-sharks playing the mischief with his trawls.

At Cape Amalia are the favorite fishing-grounds of the natives, and a few of the Gloucester vessels have visited them, but, as the fishing there is mostly by anchoring in the harbor and sending the dories a distance of two or three miles, this place does not offer many inducements to our fishermen. The best luck has attended the vessels fishing off and to the south of Holsteinborg.

Previous to 1872 the fishing-grounds were 4 or 5 miles off Holsteinborg. That year, however, some of the fleet went 30 miles off this settlement, and since that time most of the fishing has been done on this latter ground.

In 1879, the fishing in July was on this ground, but in August better fishing was secured on a new ground 20 miles south of this. In 1881 the best fishing was found in the vicinity of Victori Island, some 15 miles from shore, in water from 14 to 28 fathoms deep.

Between the old ground off Holsteinborg and Victori ground there is a gully over 150 fathoms deep and 15 or 20 miles wide, and there is probably another gully south of Victori ground.

The depth of water on the banks is from 15 to 90 fathoms and, on this account, the fishing is much easier than in the deep water of the Grand Banks. At the inner edge the banks have a sudden slope, leaving a long submarine valley, the depth of which I did not ascertain, between them and the mainland. The surface of the banks is varied, though generally rocky, with here and there sandy and clayey spots.

The character of the fauna varies considerably and often abruptly in places a little distance apart, as the following extract from my diary of the 25th of July will show: "The fish caught to-day and two preceding days have not been taken on all sides of the vessel, but in one particular spot, where the bottom is more attractive than elsewhere. This spot is covered by *tunicata* called 'sea-lemons' and 'sea-pumpkins.' The moment the trawls strike the bottom covered by the stems of *hydrozoa*, by the crew called 'trees,' the fish are no longer found in any quantity."*

It will readily be seen from the preceding remarks that a careful survey of the banks, with the view of dertermining their limits, character, and fauna, could not fail of being of great use to the fishing interest, to say nothing of its immense importance, from a natural history and geoligical point of view.

4.—CLIMATE.

The climate on the banks for July and August is, on the whole, very favorable for fishing. In the tables that follow I have omitted observations made in the harbor, in order to avoid confusing the two climates together, for there is considerable difference. The climate on the banks is more constant in temperature and absence of rain, but more variable in respect to wind.

The temperature is very constant. The lowest observed was 36° Fahr. and the highest 52° Fahr. The extremes of surface temperatures were 38¾° and 43¼° Fahr. There were no sudden changes, as the tables will show. The temperature was thus very favorable for work, though perhaps a little chilly in foggy weather, but nevertheless much better than the sweltering heat of summer in our own latitude. The men even found, on sunny days, a temperature of 48° Fahr. uncomfortably warm for work. On chilly days a fire was kept in the cabin, so that all could keep comfortable when not working.

A reference to the tables of the condition of the sky will show that we had very little rain on the banks. Clouds were common and fogs not rare, but it only rained four or five times, and then mostly in the shape of fine, misty rain, lasting at the longest only four or five hours.

The tables of the wind need explanation. The directions expressed are those of the compass, which here varies about 70°; for not knowing the exact variation, I thought this the best way of expressing them. The estimations of the velocity is much of it guess-work, founded on remembrance of former estimates and comparisons of the wind's velocity made by myself, and, on this account, not much reliance can be placed on them except for the relative velocities of the winds observed. The hardest blow was August 14, on which day I have put the velocity down as between forty-five and fifty-five miles, and am well satisfied it could not have been any greater. Between this and a perfect calm I have used six numbers to designate as many different velocities: 2 for air just perceptible; 5 for a breeze of three to ten miles an hour; 13 for a breeze of ten to fifteen miles an hour; 20 for a breeze of fifteen to twenty-five miles an hour; 30

*I regard the occurrance of the *tunicata* and *hydrozoa* as not immediately, if at all, casual, but rather concomitant, for I failed to find traces of either in the stomachs of the fish.

for a breeze of twenty-five to thirty-five miles an hour; 40 for a breeze of thirty-five to forty-five miles an hour; and 50 for a breeze of forty-five to fifty-five miles an hour.

The temperature, sky, and winds were quite different in the harbor. The land on all but the sea side of the harbor rises abruptly and not only protects it from the winds, but also permits the sun to warm the surface of land and water more than in an exposed place. The thermometer is, therefore, more variable than in the strait, and the wind is seldom felt. The mountains, by causing the condensation of the vapors of the sea breezes, make fogs and showers frequent.

I have also given tables of the height of the barometer, made from an aneroid belonging to the captain. This was hung up in the cabin and I noticed considerable variation in the instrument whenever a fire was built there. When this variation was very marked, I have indicated the same in the tables by an asterisk.

The season of 1879 was, however, uncommonly mild for Davis' Strait, and the weather that summer more favorable for fishing than it has been since. In 1880 the Herman Babson was started for Greenland, but was turned back in 52° N. lat. by immense quantities of icebergs and field ice. The Mary E. succeeded in getting through by going farther to the eastward.

In 1881 the three vessels that went to Davis' Strait skirted the ice 200 to 300 miles before succeeding in getting through, and, even after reaching the fishing-grounds, they were obliged several times during the summer to change their positions on account of drifting bergs.

This ice is carried by the currents down the east coast of Greenland, and thence across to the Strait of Belle Isle, and the fishermen will probably encounter more or less of it every year.

TABLE OF THE TEMPERATURE FOR JULY.

[Expressed by the Fahrenheit scale—all positive.]

	Midnight.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
July 1																								
2								37½	37¾	38	37¼	38	38¼	38½	39	39	39	38¾	38¼	37½				
3																38¾	39							
4													38	38	38½	38	37	37						
5	39							41	42	45	44	43	44	43½	42½				41½		40			
6														37¼		38			36¼	36¼				
7	36											39	39¼	39¼	41½	41	40½		39½	39½				38½
8											45½	41¾			41	40½	39½	38½	38½	38½				
9												38¼	40				41½		40½					
10																								
11								45	44						46									
12																		46¼						
13													49	48¼	48	46½		44¼	41		39	38		
14										42½											39¼			
15													39¾	39¾	39	39¼		39	39		38½			
16																43				42				
17																								
18																								
19							40	40½	41		41		42											
20																								
21																								
22																								
23												40	40½			40½				48				
24											42⅓	42¾	42¼	44	44¼	45¼								
25									45¼	45	45	46		46¼		44	44	42½	42		41			
26									39¾	40		40	40		41	41	41	40½						
27								40	40¼	41½	42¼			43			41¼							
28								41¼	40½	42½		43¾	42¾	44½	43½				41½					
29								42½	42¼		42¾	43			43	44	44							
30											40¼		43		44	44		44¼						
31																								

No observations made in harbor.

TABLE OF THE TEMPERATURE FOR AUGUST.

[Expressed in the Fahrenheit scale—all positive.]

	Midnight.	1 a.m.	2 a.m.	3 a.m.	4 a.m.	5 a.m.	6 a.m.	7 a.m.	8 a.m.	9 a.m.	10 a.m.	11 a.m.	Noon.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.	6 p.m.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Aug. 1																								
2										45	45	45		45½	45½	45½	45¼	45¼	45¼	44½	44			
3								43		44	44½		46	46½	46½	45½	45	43½	44¾	44½				
4							44	44	44¼	45¼	46¾	47¼				*50	*52	46						
5								46½			46½	46½	46¾	46	46	46			46		45			
6						46	46	47		47	*50	47½	47½	48½			47		47¼					
7							45		45¼		45¼		47			*48½				46				
8									45¼	46¼	46½	47	47						45½					
9										46	46½		46		45½		44½		43					
10										44¾			45						44½					
11								44					44¼						44					
12								45					47						46					
13									42				42											
14							40						41						39					
15							42		43															
16†																								
17†																								
18							38						39						42					
19																								
20													43						47					
21								42					42						42					
22‡																								
23‡																								
24													40½						40½					
25							39¾						40						39½					
26							40						41						41½					
27							41																	
28																								
29									42															
30							40½						40						38¾					
31							40						41½											

*Affected by reflection of sun's rays. †Barrels lashed in front of thermometer so it could not be seen on the 16th and 17th. ‡Thermometer wet with spray.

No observations made in harbor.

TABLE SHOWING THE CONDITION OF THE SKY FOR JULY.

	Midnight.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
July 1																								
2											b., m.	m.	m.	m.	c.	c.	c.	c.	c.	c.				
3																o.	o.							
4													m.	f.	f.	o., m.	o., m.	o., m.						
5	o., m.							b.	m.	b.	m.	m.	m.	m.	m.			c.			c.			
6														c.		m.			c.					
7	o., m.											o.	f.	k.	b., o.	b.	c.		m.	c.				b., c.
8											c.	c.			m.	f.	r.	r.	o.	r.		r.		
9	o.											k.	b.				c.	r.	c., r.					
10																								
11								c.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	f.	f.
12	f.	f.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	b.	f.
13	f.	b.	b.	b.									b.	b.	b.	b.	b.	f.	f.	f.	o.	o.		
14										o.											f.			
15													f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.
16	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	k.	b.				b.	b.			
17																								
18												k.												
19							o.	o.			o.		o.						o.					
20																								
21																								
22																								
23												o.	o.	o.	o.	o.	o.	o.	o.	o.				
24											o.	o.	o.	o.	o.	f.	f.							
25									o.			c.		k.			c.	c.	c.	c.				
26									m.	m.		o.	o.		o.	o.	o.	o.						
27								o.	o.	o.	o.	o.	o.	o.			o., m.							
28								b., f.	b.	b.		b.	b.	b., f.	b., f.				f.					
29								r.	r.	r.	o.	o.	o.	o.	o.	o.	o.							
30											o.	o.	o.	o.	o.	o.	o.	k.						
31																								

b. Blue sky. f. Foggy. m. Hazy, misty. r. Rain. c. Clouds, detached. g. Gloomy. o. Overcast. k. Clearing off.

No observations made in harbor.

TABLE SHOWING THE CONDITION OF THE SKY FOR AUGUST.

	Midnight.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
Aug. 1																								
2													o.	o.	o., r.	o.	o.	o., r.	o., r.	o., r.	o., r.			
3								c., k.		b., c.	m.	c.	c.	c.	c.	c., r.	o., f.	c., f.	c.	c.	o., f.			
4							o.	o.	o.	o.	c.	c.		b., c.		b.	b.	b.	b.					
5								c.			c.	c.	c.	c., b.	b., c.	b., c.			c.		c.			
6						b.	b.	b., c.		c.	c.	b., c.	b., c.	c.	c.		o.		b., c.					
7							o., f.		o., m.		o., m.		o., m.		c.	c.				b., c.				
8									o.	o., c.	c.	c.							r.	r.				
9										c.	b., c.		c., b., m.		m.		F.		f.					
10										o.			o.						f., m.					
11								o., m.					o.						o.					
12								o.					c.					b.	b.					
13									m.				c.											
14					o.		c.						o.						o.					
15							o.		o.				c.						b., m.					
16								b.					b.						b.					
17							o.						o.						o.					
18							o.						o.						o.			r.		
19							o., r.																	
20													b.						b.					
21								b.					o., f.						o.					
22								b.					b.						b.					
23								b.					b.						o., f.					
24								c., f.					c.						g.					
25							b.	b.					b.						b.					
26							b.			b.			b.						b.					
27							c.																	
28							b.						b.						b.					
29									b.		c.								c.					
30		r.		r.	r.	c.	c.	c.			b	b.	m.											
31							c.						c.						m.					

b. Blue sky. f. Foggy. F. Thick fog. m. Hazy. r. Rain. c. Clouds, detached. g. Gloomy. o. Overcast. k. Clearing off.

No observations made in harbor.

TABLE SHOWING THE DIRECTIONS AND RELA

		Midnight.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.
July	1	......	......	......	...	...	...	......	......	......	......	E. by N. 20	E. by N. 20
	2	......	......	......	...	...	...	......	......	......	......		
	3	......	......	......	...	...	...	......	......	......	......	......	......
	4	......	......	......	...	...	...	......	......	......	......	......	......
	5	......	......	......	...	...	...	......	SE. 2	SSE. 2	SSE. 2	SW. 5	SW. 5
	6	......	......	......	...	...	...	......	......	......	......	......	......
	7	0	......	......	...	...	...	......	......	......	......	......	0
	8	......	......	......	...	...	...	......	......	......	......	SE. 5	E. 5
	9	WSW. 20	......	......	...	...	...	......	......	......	......	......	WNW. 20
	10	......	......	......	...	...	...	......	0	0	......	......	......
	11	......	......	......	...	...	...	......	......	......	......	......	......
	12	......	......	......	...	...	...	......	......	......	......	......	......
	13	0	0	NE. 5	...	...	...	......	......	......	......	......	......
	14	......	......	......	...	...	...	......	......	......	W. by S. 5	......	......
	15	......	......	......	...	...	...	......	......	......	......	......	......
	16	......	ENE. 5	......	...	...	...	......	......	......	......	......	......
	17	......	......	......	...	...	...	......	......	......	......	......	......
	18	......	......	......	...	...	...	......	......	......	......	......	......
	19	......	......	......	...	...	...	SW. 20	WSW. 20	......	......	SW. 13	......
	20	......	......	......	...	...	...	......	......	......	......	......	......
	21	......	......	......	...	...	...	......	......	......	......	......	......
	22	......	......	......	...	...	...	......	......	......	......	......	......
	23	......	......	......	...	...	...	......	......	......	......	......	0
	24	......	......	......	...	...	...	......	......	......	......	0	0
	25	......	......	......	...	...	...	......	......	0	0	......	NE. 5
	26	......	......	......	...	...	...	......	......	N. 13	NNW. 13	NNW. 13	NNW. 13
	27	......	......	......	...	...	...	......	0	0	NW. 2	NW. 2	NW. 2
	28	......	......	......	...	...	...	......	NE. 5	NE. 13	NE. 13	......	ENE. 5
	29	......	......	......	...	...	...	......	S. by W. 5	S. by W. 5	......	......	S. by W. 5
	30	......	......	......	...	...	...	......	......	......	......	0	0
	31	......	......	......	...	...	...	......	......	......	......	......	......

Calm by 0. Just perceptible, by 2. 3 to 10 miles, by 5.
No observations

TIVE VELOCITIES OF THE WIND FOR JULY.

Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
....	....	....	....	....	....	....	....	....	....	....	....
E. by N. 20	NE. 20	NE. 20	NE. 20	NE. 20	NE. 20	NE. 20	}......	....	....	....	....
....	....	......{	ENE. 5	ENE. 2	}......	....	....	....	....	....	....
NNE. 13	NNE. 13	NNE. 13	NNE. 20	ENE. 20	ENE. 20	}......	....	....	....	....	....
SW. 5	SW. 5	SW. 5	SW. 5	SW. 5	SW. 5	SW. 2	}....{	WNW. 20	}......	....	....
......{	NE. 13	}....{	NE. 5	}......	......{	NNE. 5	....	....	....	....	....
0	SW. 5	SW. 5	SW. 5	SW. 5	}......	0	0	....	....	......{	ENE. 5
}......	......{	NE. 13	NE. 13	NNE. 13	NNE. 13	NE. 13	} 0	......{	SW. 13	}......	....
WNW. 13	}......	....	....	0 {	ESE. 13	}......	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....
WNW. 5	WNW. 5	WNW. 5	WNW. 5	W. 13	W. 13	W. by S. 13	W. 20	W. 20	}......	....	....
....	....	....	....	....	....	....	......{	NE. 13	}......	....	....
NE. 13	NE. 5	NB. 5	NE. 5	NE. 5	NE. 5	NE. 13	}....{	NE. 5	}....{	ENE. 5	}......
....	....	......{	NE. 13	}......	....	......{	NE. 13	NE. 13	}......	....	....
....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	......{	WSW. 30	}......	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....
0	0	......{	SW. 2	}......	....	....	0	....	....	....	....
0	0	0	0	0	....	....	....	....	....	....	....
NE. 5	NE. 5	}......	......{	NE. 5	N. 13	N. 13	NNE. 13	}......	....	....	....
NNW. 13	NNW. 5	NNW. 5	NW. 5	NW. 5	}......	....	....	....	....	....	....
}......{	N. 5	}......	......{	ENE. 5	}......	....	....	....	....	....	....
ENE. 5	NE. 2	NE. 2	}......	....	....	0	....	....	....	....	....
}......	....	0	0	0	....	....	....	....	....	....	....
0	0	0	0	......{	SW. 5	}......	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....

10 to 15 miles, by 13. 15 to 25 miles, by 20. 25 to 35 miles, by 30.

made in harbor.

TABLE SHOWING THE DIRECTIONS AND RELA

	Midnight.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.
Aug. 1												
2											SW. 13	SW. 13
3								SW. 20		WSW. 20	WSW. 20	WSW. 13
4							0	SE. 2	SSE. 5	S. 5	SSW. 5	SW. 2
5								0			0	NNW. 5
6						E. 2	E. 2	S. 2		SW. 2	0	0
7							WNW. 2		0		0	
8									WSW. 5	W. 5	W. 5	W. 5
9										W by S. 5	W by S. 5	
10										SW. 30		
11								SW. 20				
12								SW. 5				
13									NE. 30			
14					NE. 50		NE. 50					
15							WNW. 30					
16								NE. 13				
17							NNE. 30					
18							ENE. 5					
19							WSW. 20					
20												
21							NE. 20					
22							NE. 30					
23							NE. 30					
24							NE. 20					
25							NE. 30					
26							NE. 20					
27												
28												
29									SW. 13			
30				0	NE. 5							
31					NE. 30							

Calm, by 0. Just perceptible, by 2. 8 to 10 miles, by 5. 10 to 15 miles, by 13. No observations

TIVE VELOCITIES OF THE WIND FOR AUGUST.

Noon.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.	6 p.m.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.
......	......	......	......	......	......	......	......	......	......	......	......
SW. 13	SW. 13	SW. 5	SW. 5	SW. 2	SW. 2	SW. 2	SW. 2	S. 2	......	......	......
WSW. 13	W. 13	W. 5	0	0	0	0	0	......	......	......	......
......	0	......	E. 2	E. 5	E. 5	E. 5	......	......	......	......	......
NNW. 13	N. 13	N. 13	N. 13	......	......	0	......	NE. 2	......	......	......
NW. 2	0	0	......	0	......	0	......	......	......	......	......
0	......	......	0	......	......	......	NE. 13	......	......	......	......
0	......	......	......	......	......	0	......	......	......	......	......
W. 5	......	W. 5	......	WbyN. 5	......	W. 5	......	......	......	......	......
SW. 30	......	......	......	......	......	W. 30	......	......	......	......	......
W. 13	......	......	......	......	......	W. 13	......	......	......	......	......
ENE. 5	......	......	......	......	ENE.	NE. 13	......	......	NE. 30	......	......
NE. 40	......	......	......	......	......	......	......	......	......	......	......
NE. 50	......	......	......	......	......	NE. 13	......	......	......	......	......
NW. 20	......	......	......	......	......	0	......	......	......	......	......
NNE. 13	......	......	......	......	......	NNE. 30	......	......	......	......	......
NNE. 30	......	......	......	......	......	NE. 13	......	......	......	......	......
0	......	......	......	......	......	WSW. 20	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......
NE. 13	......	......	......	......	......	ENE. 5	......	......	......	......	......
NE. 20	......	......	......	......	......	NE. 20	......	......	......	......	......
NE. 30	......	......	......	......	......	NE. 30	......	......	......	......	......
NE. 30	......	......	......	......	......	NE. 30	......	......	......	......	......
NE. 20	......	......	......	......	......	NE. 20	......	......	......	......	......
NE. 30	......	......	......	......	......	NE. 30	......	......	......	......	......
NE. 20	......	......	......	......	......	NE. 13	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	NNE. 13	......	......	......	......	......
SW. 30	......	......	......	......	......	SW. 20	......	......	......	......	......
NNE. 20	......	......	......	......	......	NE. 20	......	......	......	......	......
NE. 30	......	......	......	......	......	NE. 20	......	......	......	......	......

15 to 25 miles, by 20. 25 to 35 miles, by 80. 35 to 45 miles, by 40. 45 to 55 miles, by 50.
made in harbor.

TABLE SHOWING THE HEIGHT OF THE BAROMETER FOR JULY.

	Midnight.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
July 1																								
2								30. 23	30. 23	30. 22	30. 22	30. 21	30. 21	30. 20	30. 20	30. 19	30. 16	30. 16		30. 15				
3																29. 92	29. 93							
4													29. 78	29. 78	29. 76	29. 75	29. 72	29. 70	29. 68					
5								29. 73	29. 75	29. 75	29. 76	29. 76	29. 76	29. 77	29. 78			29. 80			29. 80	29. 82		
6																30. 05			30. 11	30. 11				
7												30. 28	30. 28	30 29	30. 30	30. 30			30. 29	30. 27				30. 20
8											30. 19	30. 18					30. 13	30. 08	30. 07	30. 08		30. 08		
9	30. 05											30. 37	30. 39				30. 41		30. 40					
10																								
11								30. 41	30. 40															
12																								
13				30. 46									30. 30	30. 30	30. 30	30. 32		30. 40	30. 50		30. 52	30. 50		
14										30. 60										30. 53	35. 53			
15												30. 43	30. 43	30. 43	30. 40	30. 43		30. 42	30. 38		30. 36	30. 38		
16	30. 37	30. 37														30. 24				30. 26	30. 24			
17																								
18																								
19							30. 25	*30 36			30. 36		30. 38			30. 33			30. 26					
20																								
21																								
22																								
23												30. 46	30. 44	30. 43		30. 48				30. 48				
24											30. 54	30. 56	30. 57	30. 56	30. 56	30. 54	30. 56							
25									30. 50		30. 44	30. 42		30. 37	30. 36		30. 46	30. 42	30. 43		30. 40			
26									30. 32	30. 34		30. 32			30. 28	30. 28	30. 26	*30. 38						
27								30. 36	30. 36		30. 36	30. 35		30. 35			30. 33							
28								30. 24	30. 26	30. 24		30. 24	30. 20	30. 20	30. 20				30. 26					
29								30. 18	*30. 30	30. 28	30. 26					30. 25	30. 26							
30											30. 12		30. 12		30. 12	30. 10		30. 06						
31																								

*Due to building of fire in cabin.

TABLE SHOWING THE HEIGHT OF THE BAROMETER FOR AUGUST.

	Midnight.	1 a.m.	2 a.m.	3 a.m.	4 a.m.	5 a.m.	6 a.m.	7 a.m.	8 a.m.	9 a.m.	10 a.m.	11 a.m.	Noon.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.	6 p.m.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.
Aug. 1																								
2										30.02	30.04	30.04	30.05	30.04	30.04	30.04	30.06	30.14	30.15		30.17			
3								30.24		30.24	30.26	30.28	30.28	30.28	30.28	30.30	30.30	30.33	30.33	30.32				
4							30.37	30.36	30.34	30.34	30.36	30.28		30.40		30.40	30.36	30.40	30.32					
5								30.30			30.26	30.24	30.22	30.22	30.22	30.20			*30.26		30.26			
6						30.24	30.26	30.24		30.27	30.26	30.24	30.24	30.26	30.28		30.32		30.28					
7							30.30		30.28		30.27					30.20				30.16				
8									30.26	30.27	30.30	30.33							30.30					
9										30.37	30.37		30.38		30.36		30.32		30.40					
10										30.26			30.20						30.18					
11								30.06					30.04						30.07					
12								30.11					30.11						30.04					
13									29.92				29.90											
14					29.80		29.74						29.74						29.80					
15							29.89		29.93				30.06						30.00					
16								29.78					29.84						29.84					
17							29.90						29.94						29.96					
18							30.00						30.06						29.95					
19							29.86																	
20													30.12						30.12					
21								30.18					30.12						30.12					
22								29.92																
23																								
24													30.09						30.14					
25							30.12						30.12						30.11					
26							30.00						*30.06						30.08					
27							30.02																	
28													30.22						30.22		30.23			
29									30.18				30.30						30.16					
30							30.06				30.28		30.22						30.22					
31							30.12						30.08						30.10					

*Due to fire in the cabin.

5.—TIDES AND CURRENTS.

I had hoped to construct tables that would give definite figures regarding the tides, but, on account of the frequent changes of position and the remarkable complexity of the currents, near the edge of the banks, this was impossible. The first peculiarity one would be likely to notice, is that the tide runs up the strait much longer and with greater velocity than in the opposite direction. In fact, some days there was no tide at all down the strait, but corresponding to it would be nearly slack water for seven or eight hours. The tide also, instead of changing every six hours, would only do so twice a day. The observations made August 4, will show this. The velocity is expressed in the number of feet a chip floated in a minute, and the directions are those of the compass. As this varies about 70° toward the west, it will be seen that all the directions given are up rather than down, the strait.

TIDE AUGUST 4.

6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	12 m.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.
NE. Slight.	NE. Gentle.	NE. Moderate.	NE.xE. 160 feet.	ENE. 179 feet.	E. 246 feet.	....	E. x S. 168 feet.	....	SSE. 185 feet.	SE.xS. 96 feet.	SE.xS. 90 feet.	SE. 60 feet.

The greater velocity of the tide running north compared with that going south, is probably due to the existence of a current on the east side of the strait running up the coast of Greenland. The slack water, of six or seven hours at a time, would then be when the current and tide just balanced each other. The few icebergs we saw while fishing came from the south. The harbors of Holsteinborg and Sukkertoppen are open much earlier than the more southern ones, owing to the ice that is brought round Cape Farewell, blocking up these latter. The existence of this southern ice will be a great barrier to the utilization of the southern fishing banks, making those about Sukkertoppen and Holsteinborg the ones most accessible.

The combining of the tide and current often renders fishing impossible five or six hours at a time, but, as the slack water is usually correspondingly long, the loss of time need not be very great, for, by careful observation, the fishermen can time themselves so as to sleep while the tide is strong and fish when it is slack water. It must be remembered, that in this latitude it is light enough in July to work all night without inconvenience.

The tides and currents are not, however, as simple as the preceding remarks would seem to imply. Often a changing of our position a few miles would bring us into a different combination of currents. The banks occasion variations in currents a few miles apart. The whole coast of Greenland is indented by deep fiords, three or more miles broad, and fifty to a hundred miles long; and the tides running out of these with great force have an influence miles from their mouths.

Temperature of the water, at every ten fathoms, on the Fishing Banks, off the west coast of Greenland, latitude 66° +. Time, July and August.

July 6. Latitude 66° 25′. Taken between 3 and 4 p. m., during the slack, after the tide had been running north.

	° Fahr.
Temperature of air	38
Temperature of surface	38¾
Temperature of 10 fathoms	37¾
Temperature of 20 fathoms	36¾
Temperature of 30 fathoms	35¾
Temperature of 40 fathoms, bottom	35¼

July 7. Same place and time of day.

	° Fahr.
Temperature of air	40¼
Temperature of surface	38¾
Temperature of 10 fathoms	37½
Temperature of 20 fathoms	36½
Temperature of 30 fathoms	35¾
Temperature of 40 fathoms, bottom	35¼

August 2. Taken between 7.30 and 8 p. m.

	° Fahr.
Temperature of air	44
Temperature of surface	42½
Temperature of 10 fathoms	39¾
Temperature of 20 fathoms	38¾
Temperature of 30 fathoms	38
Temperature of 37 fathoms, bottom	37¾

August 5. Taken between 7 and 7.30 a. m. Tide very slack.

	° Fahr.
Temperature of air	46¼
Temperature of surface	41½
Temperature of 10 fathoms	38½
Temperature of 20 fathoms	38¼
Temperature of 30 fathoms	38
Temperature of 35 fathoms, bottom	37

August 8. Taken 6 p. m. The time of slack different in places a few miles apart; likewise the force and direction of the current.

	° Fahr.
Temperature of air	45¼
Temperature of surface	43½
Temperature of 10 fathoms	41
Temperature of 20 fathoms	38½
Temperature of 24 fathoms, bottom	37¾

August 20. Taken between 8 and 8.30 p. m. Slight surface tide. About 40 miles W.S.W. from Holsteinborg.

	° Fahr.
Temperature of air	44
Temperature of surface	43
Temperature of 10 fathoms	41¾
Temperature of 20 fathoms	39¼
Temperature of 25 fathoms, bottom	38¾

The preceding observations, though few, will show very well the temperature of the water on the banks at various depths.

6.—HARBORS.

The harbors of greatest use to the fishermen will be those of Holsteinborg and Sukkertoppen. Of the latter I can say nothing, except that it is reported, by those who have been there, as a good harbor. Holsteinborg, surrounded on three sides by the mainland and on the other by several islands, is completely protected from the rough water, and is only exposed to the wind on the side towards the strait, from which quarter there is scarcely ever a violent blow. The harbor is large, and has a depth of 10 to 25 fathoms. The harbors mentioned are ninety miles apart, and as the best fishing we had was about half way between the two, we could easily have run into one of them, whichever way the wind might have been.

Previous to the summer of 1879, which was considered very mild, the fishing vessels went into harbor at least, three times a month. This was due to the S. W. and N. E. winds, which, combined with the strong tides and comparatively shallow water, would soon raise a "nasty sea." These blows, though perhaps not extremely dangerous, would frequently occasion loss if an attempt was made to ride them out, either by the breaking of some part of the rigging, or, if the deck was filled with fish when the wind came, by the loss of a part or all of these.

Nor are winds and waves the only things causing the vessels to seek the harbor. It is frequently very convenient to leave some things on shore, so as to have more room in the vessel. Thus the Bunker Hill left barrels of pickled *fins* on shore, and Captain Lawson left there, until ready to return home, quite a cargo of codfish he had brought from the Grand Banks, but which was in his way while fishing. New supplies of water must also be secured. The harbor of Holsteinborg usually is open by the middle of May, and perhaps fishing could be commenced by the first of June, but the ice that is brought down the east coast of Greenland, besides blocking up the more southern harbors, will probably render the passage north too dangerous before the middle of June. On this account, and because the change in the weather about the 20th of August, the fishing here will have to be done in July and August.

C.—FISHING.

7.—TIME OF YEAR FOR FISHING.

The time for fishing in these waters is July and August. There is no doubt but that the fish will bite both earlier and later than this, but these are the best months, and August is better than July. Besides abundance of fish, other considerations, such as climate and the passage to the strait and home again, tend to limit the time to these months. The fish caught in August were in much better condition, and had a much larger proportion of females than those caught in July. This may, however, have been due to the fact that the fishing was done on an entirely different part of the bank in August than the preceding month, and also to a difference in the food of the fish.

8.—APPARATUS AND METHODS.

The fishing is done by means of trawls. A trawl is composed of several parts. First, there is the "ground line," which is anchored at each end, and lies on the bottom. The hooks are attached to lines 5 feet long, called gangings, which are in turn fastened to the ground line at every 2 fathoms, sometimes at every 2½. To mark the position of each end of the trawl, a line extends from the anchor at the end of the ground line to a buoy on the surface of the water.

The main or ground line is about a quarter of an inch in diameter, and is made up of parts, 50 fathoms long. Each of these parts has one end fastened, so that it will not unravel, while the other has a loop spliced in it. The end not spliced is tied by a knot, that is both strong and secure, but still easily untied, to the loop end of the next part. The trawls can thus, by using more or less of these 50-fathom pieces, be made of any desired length, but, when not in use, six of these parts are usually kept fastened together, and are then called a tub or skate of trawl, according to the manner of keeping them. In fishing for cod and haddock, and formerly in the halibut fishery also, they were kept coiled up in tubs; whence the name "tub of trawl," meaning 300 fathoms of trawl. But now, in the latter industry, they are kept in what are called skates.

A skate is a piece of canvas about a foot and a half square, having two pieces of rope, 6 feet or so in length, so fastened across it that an end projects from each corner. Upon this canvas the 300 fathoms of trawl are coiled and firmly secured by the ropes, tied together above.

The phrases "tub of trawl" and "skate of trawl" are often synonymous. Thus on the Bunker Hill, though no tubs were used to keep the trawls in, it was quite common to hear the fishermen speak of setting two or more "tubs of trawl."

The buoys used on this trip were of two kinds: the "boat buoys" and "keg buoys." The boat buoys were blocks of wood, three feet long, cut in the shape of a round-bottomed row-boat, and coated with tar. The buoy line is attached by means of a swivel to the under part of the buoy, just in front of the middle. Back of the middle is bored a hole from top to bottom, through which passes the flag-pole. This pole fits in loosely so that it turns freely and can be taken out for easy packing in the dory. In order that it may not slip too far through the hole, a piece of leather is nailed round the pole above the hole, and, to keep it upright, a weight is attached to its lower end. The flag is a small canvas painted black. These buoys are not, however, so serviceable as the keg buoys, which are small water-tight kegs, holding a little over a quarter of a barrel. Through the keg runs the flag-pole, tightly wedged in to prevent leakage and strongly fastened by stout lines to prevent its coming out. To this is fastened the flag above, and the buoy line below. The great advantage of these last over the other kind of buoy is their greater buoyancy; for the boat buoys were continually being carried under by the force of the tide, so much so that it was frequently necessary to use two of them in place of one. On the other hand, the keg buoys were liable to burst, an accident rendering them fit only for the fire. Unfortunately only ten keg buoys were brought on this trip; not enough for each dory to have one at each end of its trawl. The matter was settled by using one of these for the outer end of the trawl, while one or two of the boat buoys were used at the inner end.

The typical manner of setting a trawl is in a straight line, across the direction of the tide; for if the fish swim, either with or against the current, a greater number will cross the ground line lying in this direction than in any other. Two men are necessary for the operation. One man sits in the bow of the boat, rowing slowly in the required direction, while the other, in the stern, sets the trawl, by first throwing out the inner buoy, with its attached buoy line, to be followed by the inner anchor. This, in turn, is succeeded by the ground line, outside anchor, buoy line, and keg buoy. The length of a trawl varies, according to circumstances, from one to four skates, *i. e.*, from 300 to 1,200 fathoms.

As already stated, two men in a dory were necessary for setting a trawl, and, as there were six dories, three for each side of the vessel, twelve of the crew were required for the fishing, while the captain and cook made the whole number fourteen. Each dory had by lot a particular position assigned to it, and according to this was its relative place of setting the trawl. The vessel at anchor would naturally have her bow toward the tide, and thus the middle dory, on each side, by setting in a line perpendicular to the length of the vessel, would set exactly across the tide, the most favorable direction. In order not to be too close together, the dories in front of the middle ones would set in lines running a little forward, while the stern dories would set in lines running a little backward. This, the typical manner of setting, is varied, of course, by many circumstances, as winds, tides, position of vessel, or the narrow spots to which the fish may be confined.

Before speaking of the hauling of the trawls, it will be best to consider the arrangements about the dories and the baiting. Before starting, the crew, according as the disposition of the men inclined them, had become divided up into pairs for dory mates, but not until we were well on our way were lots drawn to decide upon their respective dories. Previous to the drawing of these lots, the dories, which were entirely without internal arrangements, such as seats, &c., were kept amidships, three on each side of the vessel, firmly lashed, upside down, one within the other, to the deck. The dories were numbered from one to six, and six slips of paper were prepared, each having one of these numbers on it. These, being thrown into a hat, were drawn by one from each pair of dory mates, each having the dory with the number corresponding to the one on his slip. Boards had been brought for making seats, and, as might have been expected, different degrees of proficiency were displayed by the men in working them up. The men in each dory are expected to do everything pertaining to their own boat, such as taking care of dory, baiting, setting, hauling and keeping the trawls in good condition.

Two barrels of pickled menhaden were taken to use for the first baiting, or until enough fresh bait had been caught for this purpose. Afterward the cod and smaller halibut were employed, and, when these were not enough, the napes of the larger halibut were used. The bait is cut up into strips about six inches long and an inch square at the end. The cutting of this is done mainly on the roof of the cabin, by large heavy knives. Thick planks had been nailed on top of the cabin for this purpose, and the men of each dory had their places for chopping (for the cutting is more of a chopping than anything else) chosen by lot. There not being room on the cabin for all the men, those of the forward dories used boards laid across the large flitching tubs, for cutting their bait.

After enough bait is cut, the skate of trawl is placed on the cabin, and, being untied, the skate is taken away from the coil and spread out on the deck below. The fisherman then commences at the top of the trawl and, baiting the hooks as he proceeds, recoils it again on the skate below. The baited hooks are thrown into the center of the coil. Both the chopping of bait and the baiting are lively times, and wonderful stories are told about the speed with which some fishermen can perform these operations. There is however, a limit to the speed with which these can be done well, and those who boast most of their quickness are, ten to one, not the best fishermen.

The skates, baited and tied up, are ready for the water, and, if the set is to be made immediately, they are placed in the stern of the dories. When the weather is favorable, it takes about fifty minutes to set four skates to a dory, but, when either tide or wind is strong, more time is necessary. Two to four hours are allowed from the time of setting to the time of hauling.

This last is usually commenced from the outer end, so that the men may work toward the vessel and have less distance to row should they be so fortunate, as to secure a load of fish. When the buoy is reached, the oars are taken in and laid one side, where they will be the least in the way; a roller, whose wheel is four to six inches in diameter, with two or three grooves on its rim, is fastened to the side of the dory near the bow; the buoy is taken in, unfastened from the line, and placed in the stern of the boat, and the hauling commences. The roller is almost indispensable. The line is hauled over this by the man in the bow, who does the hauling, and is then passed on to the man in the stern, to be by him coiled up and put with the buoy in the stern. (The stern is separated from the rest of the boat by a cross-partition of boards.)

After the buoy line and anchor have been taken into the boat, comes the fishy part of the haul. The hooks, whether with or without fish, are not hauled into the dory by the man in the bow, but are kept over the side until they, as they are carried along by the ground line, reach the other end of the boat, and are there freed either of poor bait or of fish. The bait is easily shaken off by striking the hook against the gunwale of the boat, but the fish are not as easily managed. The large size of the fish necessitates the use of something besides the fishing hooks for pulling them into the dory. Accordingly, large iron barbless hooks, with a loop on the end away from the hook for the hand to grasp, are used for this purpose.

But the fish must also be killed or stunned before taken into the boat, or otherwise considerable inconvenience, to say nothing of danger, might be occasioned by their lively flapping. For this reason killers are used. The "killer," which is also employed for unhooking the fish, is a hardwood club, about 2½ feet long. The larger or striking end is round, while the other, or handle part, is flattened a little and has a notched end.

When the fish comes to the stern of the dory, the fisherman hooks him in the eye, or some firm part of the head, with the large iron hook, and, after stunning him by hitting him several heavy blows over the snout with the killer, hauls him into the boat. Frequently the fish has swallowed the hook, and its extraction, were it not for the killer, would be a problem involving much cutting and loss of time. The flattened and notched end of this instrument is run down the gullet of the fish and, after the line is secured to the other end so as to prevent slipping, the club is turned until, by the coiling of the line, the hollow of the hook fits into the notched end. Then, by a sudden push downward and a jerk upward, the hook is loosened and hauled out.

The work continues on in this manner, the man in the bow doing the hauling, while his mate attends to the coiling of the line, shaking off old bait, and taking the fish into the boat, until either the boat is full, or else all the trawl is hauled. In the latter case a return is made to the vessel. Should, however, the boat be filled before the hauling is completed, and any of the fishermen be through with the hauling of their trawls, an oar is raised as a signal for a dory to come and take the fish already caught, that the hauling may be interrupted as little as possible. If, on the other hand, all of the fishermen are busy when the boat-load is secured, the ground line is buoyed at the end of one of the 50-fathom pieces, while the load is carried to the vessel. Relieved of their load, the men return to the buoy they have just left and continue the hauling.

Sometimes the trawl is caught in the rocks, so that it is necessary to break it and commence at the inside buoy for the hauling of the remainder. Should it be caught and broken the second time, there is great danger of losing the part that is still in the water, unless it can be caught by the grapple. The grapple is a chain with an iron bar at one end and having, at several places along its length, circles of iron points, three or four inches long, directed away from the end to which the bar is attached. It is used in the following manner: Three men go in the dory, two to row and one to attend to the grapple. This, fastened to a line by the end toward which the iron points are directed, is let down until the iron bar drags upon the bottom, but not so low as to permit the whole chain to drag. The men row back and forth over the spot where they think the trawl is, and, if they are right in their calculations, it is hard to see how they can fail to grapple it.

The fish are taken from the dories by the large iron hooks, already mentioned as being used in the small boats. When a load of fish is brought to the side of the vessel, one of the fishermen holds the stern and another the bow painter, while the man in the stern hooks the fish and hands them up to his dory mate, standing on deck ready to haul them on board.

The last set was made August 27, and was done while the vessel was under sail. Comparatively little fishing had been done since the 20th, for the wind had prevented the setting of the trawls, though the hand line showed that the fish had not departed. The captain accordingly decided to run into harbor and prepare for going home, but, finding the wind near the shore rather gentle and the water smooth, thought best to see how the fish would bite near the mouth of the harbor. As this was the first time we had set under sail, I was curious to see how it was managed.

The dories set in turns. First one is towed astern, while the outside buoy and buoy line are being thrown overboard, then it is set adrift and the rest of the trawl set at right angles to the direction the vessel is sailing. The rest of the dories go through with the same operation in succession, by which time the first dory has finished setting and is taken in tow by the vessel. Some of the dories are left fastened to the buoy line to mark the place of the trawls while the vessel sails back and forth an hour or two, until the time of hauling comes. The hauling is done in the usual manner. This manner of setting is used quite frequently on the banks of Newfoundland to find out whether the fish are abundant. If the fish are found in considerable numbers, the anchor is dropped, and the trawls run out again in the regular way. Only eighteen fish were caught this haul, so we turned the bow towards the harbor.

9.—DRESSING AND SALTING.

After all the trawls have been hauled, the men usually attend to the dressing of the fish. For this operation, the men had prepared four legless tables, about 6 feet long and 3 feet wide, which, in use, were inclined against the side of the vessel in such a manner that one end rested upon the gunwale while the other remained on deck. Two men worked at a table, one on each side.

The knives employed were of different shapes and sizes, but the one seemingly the most in favor has the blade about 8 inches long, an inch and a half wide, and not so thick but that it had a good spring to it. All were sharp pointed and most of them of good material.

Iron hooks similar to, but smaller than, those used for taking the fish out of the dories into the vessel, are used for fastening the fish upon the table. To the loop end of the hook a short rope, having a cross-piece of wood, is fastened. The fish is hooked in the small of the tail, and, being drawn up on the inclined table, is secured there, head downwards, by placing the rope in a notch cut in the top edge of the table, the cross-piece of wood preventing its slipping back.

It will be remembered that the halibut is shaped somewhat like our common flounder, or flat fish. The backbone, with its spines lying in the same plane with the body, leaves, on each side, a thick layer of boneless flesh. These layers, called *flitches*, are what the men are after. After the flaps of the dorsal and ventral fins have been cut off close to the body, a cut, deep enough to reach the plane of the backbone and extending from the head to the tail, is made, about 2 inches from and parallel to the dorsal line of the body, followed by a similar cut from the gills to the tail, but on the ventral edge of the body. These two are then connected at the head by a cut parallel to a gill plate and at the tail end by a straight cross-cut. For the better handling of the flitch, a slit, large enough to admit the hand, is made at each end. The flitch is then grasped at the posterior part with one hand, and, as it is raised by this hand, is cut free from the backbone with the other. The fish is then turned over and the other flitch taken off in the same manner.

The cuts made parallel to the dorsal and ventral edges of the body, being 2 inches or more from these, leave strips of flesh and fat attached to the inner bones of the fins, which, when pickled, bring a good price under the name of halibut fins. Accordingly, after the flitches, these strips are cut off and pickled. The rest of the fish, consisting of the bones, head, and viscera, is then thrown overboard and another one is placed on the table.

After the flitches are cut from the fish, they are thrown into large tubs called flitching-tubs, to be there rinsed free from blood and dirt, previous to being salted in the hold. It is one man's duty to attend to the washing of the flitches and to the passing them below, while three men are salting. The hold is divided up by plank partitions into six large bins, three on a side, in some of which the salt is kept until used by the salting of the fish in the others. One man carefully places the flitches in layers, one above the other; a second man, with a scoop like the grocers use for flour and sugar, covers them with the salt, while a third shovels the salt within reach of the second. The Bunker Hill left Gloucester with 270 hogsheads of salt, and out of this salted 9,000 fish, amounting to 140,000 pounds of flitches, having used a little over nine-tenths of the whole quantity. This salt came from Cadiz, Spain, and cost $1.50 per hogshead, or $405 for the whole.

10.—TABULAR VIEW OF SUMMER WORK.

The following tables represent in a concise form the times of setting and hauling of the trawls, the number of fish caught at each haul, together with the depth of water, tides, weather, &c., while the trawls were in the water. I have taken the time when the men left the vessel for setting and hauling to represent the time of these operations. To set four skates of trawl usually took a little less than one hour, while for hauling the same, especially if there were many fish, required three, and often four hours.

Since the outer end of the trawl was set last and hauled first, this would remain in the water less time than that represented by the tables, while the inner end, set first but hauled last, would be in the water much longer. Yet, as a rule, more fish were caught on the outer than on the inner end. Many things are unfavorable for the trawls remaining long in the water. In the first place, if the fish are present they will soon hook themselves, and more time than is necessary for this is, of course, wasted. Then, again, the tide, fish, or both combined, are apt to entangle the trawls in the rocks, if these are left too long in the water. Besides, the voracity of the little shrimp would soon leave nothing but the bones of the halibut for the disappointed fishermen, were they allowed many hours to satisfy their appetites. So plentiful are these little creatures in some places that they could be scraped off the fish by the handfuls, and, when the trawls had remained in the water two or three hours, they had left the branchiostegals hanging loosely, besides making a general assault on the whole body.

There were three days of fishing before the 5th of July (the date first mentioned in the table) of which I have no minute notes, and have therefore omitted mentioning them in the table. The fish caught during these days, together with those caught on the hand-line from the side of the vessel, would certainly make the whole number taken during the trip over nine thousand. Sixty-six hauls are recorded in the table, by which 8,616 fish were taken, averaging 139 for each haul. The smallest number taken at a single set was four, the depth being 27 fathoms, and the largest number was 497, the depth being between 25 to 30 fathoms. The depths expressed, owing to the irregularities of the banks and the extent of surface covered by the trawls, are, of course, only approximate, but whenever this was measured, I have used the depth where the vessel was anchored in preference to the rough calculations of the fishermen, for I have found them, in this respect, a little inclined to overestimate. It will be observed that the depth in August was less than in July.

Table for July and August, representing the times of setting and hauling trawls, fish taken, depth of water and remarks on weather, tides, &c.

Date.	Set.	Hauled.	Fish.	Depth.	Remarks.
				Fath.	
July 5	2.30 p. m...	4.05 p. m...	48	40	Wind S.W. Cloudy, with slight mist. Tide slackening from running N. Shifted position.
5	8.15 p. m...	11.40 p. m..	96	40	Wind W.N.W. and increasing. Cloudy.
6	2.50 p. m...	5.25 p. m...	144	40	Wind N.E. Hazy. Tide slackening from running N.
6	7.45 p. m...	10.05 p. m..	24	40	
7	8.15 p. m...	0.55 p. m...	90	40	Wind S.W. and nearly calm toward the end. Partly cloudy. Tide slackening. Shifted position.

Table for July and August, representing the times of setting and hauling trawls, &c.—Cont'd.

Date.	Set.	Hauled.	Fish.	Depth.	Remarks.
				Fath.	
July 8	4.05 p. m...	6.45 p. m...	56	50	Wind N.E. Rain. Tide slackening from running N. Fish small. Shifted position.
9	3.45 p. m...	6.30 p. m...	352	50	Calm at first, wind rising from E.S.E. Cloudy. Tide quite strong, but slackening from running N.N.E.
10	5.50 p. m...	8.45 p. m...	95	50	Wind W.S.W. Raining. Tide slackening from running N. Shifted position.
11	7.30 a. m...	10.20 a. m..	66	(?)	Calm. Sky clear. Tide slack.
11	2.50 p. m...	6 p. m......	48	(?)	Calm. Sky clear. Tide running slight toward the S.S.W. Shifted position.
12	6 a. m......	10 a. m.....	158	50–60	Calm. Sky clear. Tide not strong; running N.
12	3.45 p. m...	6.30 p. m...	282	50–60	Wind slight, S.W. Sky clear. Tide slackening.
13	8.30 a. m...	11.45 a. m..	157	50–60	Wind slight, W.N.W. Sky clear. Tide running W.
14	6.40 a. m...	(?)	12	50–60	
14	4 p. m......	7 p. m......	37	(?)	Wind gentle, N.E. Foggy.
15	1.20 p. m...	4.15 p. m...	93	55–60	Wind N.E. Foggy.
15	7.55 p. m...	1 a. m......	65	55–60	Wind N.E. and E.N.E. Foggy.
16	2.30 p. m...	6 p. m......	14	55–60	Wind N.E. Sky clear. Shifted position.
18	11.35 a. m..	2.10 p. m...	4	27	Wind S.W. Clearing from fog. Tide quite strong. Shifted position. Three skates to a dory.
19	12.55 p. m..	2.15 p. m...	54	40	Wind S.W. Cloudy. After hauling ran into Holsteinborg Harbor.
23	7.15 a. m...	10.45 a. m..	148	35–40	Calm. Cloudy. Tide running strong toward N. Two skates to a dory.
23	2.50 p. m...	5.40 p. m...	380	35–40	Calm. Cloudy. Tide slackening from running N. Four skates to a dory.
24	8.30 a. m...	12.25 p. m..	328	35–40	Calm. Cloudy. Tide running strong to the N.E. Four skates to a dory.
24	4.15 p. m...	9 p. m......	127	35–40	Calm. Cloudy. Threatening fog from the W. Tide strong toward the W. Two skates.
25	6 a. m......	9.20 a. m...	305	35–40	Calm. Cloudy. Tide moderate at setting, strong at hauling. Four skates to a dory.
25	4.05 p. m...	7.45 p. m...	257	35–40	Wind gentle, N.E. and N. Cloudy. Tide strong. Four skates to a dory.
26	6.45 a. m...	10.45 a. m..	162	35–40	Wind gentle, N. Misting. Tide running strong to N.E. Shifted position.
27	6 a. m......	9.30 a. m...	24	55–60	Calm. Cloudy. Tide running northward. Four skates to a dory. On edge of bank.
27	12.45 p. m..	3.40 p. m...	25	55–60	Calm. Cloudy and misting. Tide slackening. Two skates to a dory. On edge of bank. Shifted position.
28	5.30 a. m...	8.40 a. m...	7	(?)	Wind slight, N.E. Low fog; clear above. Tide moderate. Two skates to a dory. Shifted position.
31	5.10 a. m...	8 a. m......	76	40–45	Wind moderate, S.W. Cloudy, with rain. Tide strong, running N.E. Two skates to a dory.
Aug. 1	Noon	2.30 p. m...	138	40	Two skates to a dory.
1	5.30 p. m...	7.15 p. m...	61	40	Two skates to a dory.
2	5.15 a. m...	7.15 a. m...	39	40	Wind S.W. Raining. Tide strong. Two skates to a dory. Shifted position.
2	1.15 p. m...	4.15 p. m...	113	40	Wind slight, S.W. Raining. Tide slackening. Two skates to a dory.
2	5.45 p. m...	8.45 p. m...	48	40	Wind slight, S.W. Raining. Tide commencing to run. Two skates to a dory. Shifted position.
3	1.45 p. m...	4.45 p. m...	305	40	Wind moderating, W. Cloudy. Tide strong, but slackening. Four skates to a dory.
4	1.15 p. m...	4.30 p. m...	289	40	Calm. Sky clear. Tide slackening, running E. Four skates to a dory.
4	7.15 p. m ..	11 p. m.....	18	40	Shifted position.
5	2.30 p. m...	6 p. m......	274	35	Wind gentle, N. Clear, with few clouds. Tide slackening. Four skates to a dory.
6	3 a. m......	5.45 a. m...	84	35	Wind very slight, E. Sky clear. Tide nearly slack when hauled. Two skates to a dory.
6	3.20 p. m...	(?)	172	(?)	Calm. Cloudy. Tide slackening. Four skates to a dory.
7	7.15 a. m...	10 a. m.....	251	25–30	Calm. Cloudy. Tide commencing to run strong. Two skates to a dory.
7	2.15 p. m...	6 p. m......	407	25–30	Calm. Nearly clear. Tide slackening. Four skates to a dory.
8	2.15 p. m...	5 p. m......	497	25–30	Calm. Cloudy.
9	2.40 p. m...	5.30 p. m...	420	25–30	Wind slight from the W. Hazy, followed by fog.
10	3 p. m......	(?)	234	25–30	Wind moderate, W.S.W. Cloudy. Tide slackening. Four skates to a dory.
11	4.15 a. m...	7 a. m......	61	25–30	Wind moderate, S.W. Two skates to a dory.
11	1.10 p. m...	5 p. m......	53	25–30	Wind W., moderating. Cloudy. Shifted position.

Table for July and August, representing the times of setting and hauling trawls, &c.—Cont'd.

Date.	Set.	Hauled.	Fish.	Depth.	Remarks.
				Fath.	
Aug. 12	4.50 p. m.	7.30 p. m.	254	35	Wind gentle, E.N.E. Clear. Tide slack. Two skates to a dory.
15	4 a. m.	6.45 a. m.	60	35	Wind N.W., freshening. Cloudy. One skate to a dory.
15	4.45 a. m.	7 p. m.	63	35	Calm. Clearing, followed by blue sky. Two skates to a dory.
16	6.30 a. m.	8.10 a. m.	102	35	Wind gentle, N.E. Sky clear. Tide strong, running to windward. Two skates to a dory. Shifted position.
16	2.30 p. m.	4.45 p. m.	112	30	Wind gentle, N.E. Hazy. Tide moderate, running to the east. One skate to a dory. Fish large.
16	6 p. m.	8.30 p. m.	111	30	Wind moderate, N.E. Clear. Tide running to windward. Two skates to a dory.
17	6 p. m.	8.10 p. m.	112	30	Wind moderate, N.E. Cloudy. Tide slack. Three skates to a dory. Shifted position.
18	7.10 a. m.	Noon	200	30	Wind light, E.N.E., becoming calm. Cloudy. Tide strong. Three skates to a dory. Fish excellent. Holsteinborg.
20	4.35 a. m.	7.45 p. m.	68	25	Wind gentle, N.E. by E. Clear. Tide running strong, S.S.W. Three skates to a dory.
21	5.30 a. m.	10 a. m.	74	25	Wind moderate, N.E. Clear, followed by fog. Tide strong to windward. Three skates to a dory.
21	4.30 p. m.	7.30 p. m.	81	25	Wind moderate, N.E. Foggy. Tide slackening. Shifted position.
24	11 a. m.	2.40 p. m.	123	30	Wind moderating, N.E. Clouds broken. Tide running to windward. Shifted position.
27	7.15 a. m.	(?)	18	....	Set under sail on the inner ground, near the mouth of Holsteinborg Harbor.
	Total	....	8, 616		

Average time between setting and hauling in July, 3 hours.
Average time between setting and hauling in August, 2 hours, 53 minutes.
Average depth of water in July, 45.5 fathoms.
Average depth of water in August, 33 fathoms.

Number of fish caught in July	3, 764 +
Number of fish caught in August	4, 852
Total	8, 616 +

11.—Natural history of the halibut so far as it affects the fishing.

In the preceding tables, under the head of "remarks," quite frequently occurs the phrase "Shifted position," which signifies, in this connection, a little more than mere changing of the position of the vessel; it implies that the fish, for some reason, are no longer to be caught where they may have been, up to that time, quite abundant. Are the fish of a roving disposition, or do the individuals remain within restricted limits? I shall not attempt to decide, but will merely mention some facts which may have a bearing on the question.

The fishermen seldom expect to catch many fish near the vessel after the first flitching. If you ask for an explanation of this, they will tell you that the "gurry" drives the halibut away. By "gurry," they mean the refuse of the fish, that is thrown overboard at the time of flitching. There is only a single case, that I know of, which would seem opposed to this explanation. It is that of a large halibut which had eaten the head, backbone, and viscera of a fish that had been flitched. It cannot be that the flesh of their own species is distasteful to the halibut, for this is what the fishermen use for bait, nor can it be that they mistake the white gleam of the flesh for sharks, for the sharks caught here were of a very dark color. Whether we know the cause or not, it is none the less true that the fish cease to bite near the vessel, after the first flitching, whereas, if this operation is delayed, or the tide, at the time of it, is strong enough to carry the "gurry" away a considerable distance, the fish continue to bite freely. Considering, then, that the "gurry" has this effect, what is the result of remaining in one spot several days? Evidently the mass of "gurry" will increase, and, being drifted by the tides, will cause the vessel to be the center of an ever-increasing spot, where the halibut will not bite. It is thus necessary, either to set the trawls at a greater distance from the vessel, or else to move this to a new spot. The latter method, of course, is the easier.

On the 23d, 24th, and 25th of July, over 1,500 fish were taken from a limited spot, at some distance from the vessel, where the gurry did not reach, because the tide ran in the opposite direction, but there appeared little if any decrease in the numbers. The spot could be easily distinguished from the rest of the bottom, by the absence of the tree-like stems of Hydrozoa. On the 26th, only two of the dories succeeded in setting on this spot, and these two got fish while the others failed. The attempt to bring the vessel nearer failed so utterly that the trawls did not touch the spot again; 1,700 fish had been caught in four days, on a spot not a mile square. I am inclined to think that as fast as some were caught their places were filled by new arrivals, and were it not for the gurry, a vessel once anchored in a favorable position would not have to move until a load had been secured.

But, it will be asked, will this gurry permanently injure the fishing? Probably not. There are many carnivorous animals, besides the little shrimp already spoken of, which would soon eat up everything except the bones of the fish, and it is hard to see what harm these can do. Nevertheless, there does seem to be some effect produced by the fishing of one year upon the abundance of the fish in the same place the succeeding years; for the fishermen complain that the halibut off the coasts of New England, Nova Scotia, and New Foundland must be sought in deeper and deeper water year after year. If this be so, it is hard of explanation. For if we consider the halibut as of a roving disposition, why should they shun their former haunts because they have been fished on, or if, on the other hand, they are not rovers, how can they, considering this great fecundity, be so easily exterminated, as their disappearance from these haunts would imply?

This fecundity must be very great. In a fish about six feet in length I calculated the ovary had 2,782,425 eggs. This was done by counting how many eggs there were in a straight row an inch long and from this finding how many there were in a cubic inch. The number of cubic inches in one of the boxes in which the codfish hooks came was calculated and the box filled with eggs. These eggs were then weighed.

The whole mass of eggs was next put on the scales and their weight divided by the weight of one cubic inch, to ascertain the number of cubic inches of eggs. This result, multiplied by the number of eggs in one cubic inch, would give the number of eggs in the whole ovary. Considering that the number given is some too large, I cannot conceive how any error so great, as to make the number less than two millions, could have crept in. I do not know whether all these eggs would have been laid at one time, or not, but, as they appeared to be nearly of the same size, I judge that such would probably have been the case.

There was no way of determining accurately at what stage of the tide the fish were the most voracious, but they appeared to take the bait best the latter part of the stronger tide, for it was then that the hand-line was most successful, and the men expected the best luck with the trawls.

Though the fish are of the same species as those caught on the Grand Banks, nothing was found in them, in the shape of hooks or food, indicative of a migration from any other place.

August 5 I made several observations upon the temperature of the rectum of the halibut, when they were first taken by the hand-line, and found, with one exception, the temperature to be 39° Fahr. These observations were made within an hour or two of the time the temperature of the bottom was taken. The exception referred to was where one halibut showed a temperature of 39½° Fahr., half a degree higher than the others.

The food of the fish was different for different places and times. Where we first fished it was composed of crabs and other crustacea, with now and then a fish of the genus *Cyclopterus*. But, when we shifted to a spot twenty miles or so south of this, we found some of the species of crustacea had disappeared, and the principal source of food was a small fish called "lant." There was also a great difference in the condition of the fish in these two places; those of the last place being far better and more vigorous. The males were above 6 to 1 female in the first place, whereas the females in the latter place predominated greatly over the males. I take the following from my diary of August 8 to show the difference in the two places:

"The fish on this bank have none of the large shrimp in their stomachs that were found in the stomachs of the halibut on the other bank. Here they have mostly lant, there mostly shrimp. None of the common cod have as yet been caught." A few were caught after this. "Sharks and cat-fish are likewise very few. There are no walruses or seals, few whales, and many birds. The birds are not as hungry as on the other bank, and it is harder to shoot them, for they do not fly very near."

N.W. mag. from Holsteinborg, July.	W. S.W. mag. from Holsteinborg, Aug.
Food, principally crustacea.	Food, principally lant.
6 males to 1 female.	1 male to 7 females.
Fish poor.	Fish fat and vigorous.
Fish in spots.	Fish more evenly distributed.

The halibut do not always swim near the bottom. I saw one leap out of the water where the depth was 40 fathoms, and have caught them on the hand-line when this was only half-way down. Several have followed the bait to the surface, and one even followed the thermometer up twice in succession. Feathers were pulled out of the mouth of one, and the skeleton of a gull, *Larus tridactylus*, was found in the stomach of another.

D.—FISHERMEN.

In the proceding pages I have considered the halibut from a fisherman's standpoint, and have attempted to give a clear idea of the methods of capture, and will, in the rest of this report, pay particular attention to the fishermen themselves.

12.—GENERAL CHARACTER OF VESSEL, CREW, AND FINANCIAL ARRANGEMENT.

The Bunker Hill is a two-masted schooner, of 100 tons burden. This is large for a fishing vessel, as the majority of the Gloucester vessels are less than 75 tons burden, and I believe there are only a few fishing vessels in that place as large as the Bunker Hill. The crew, including the captain and cook, consisted of fourteen men, and was considered one of the best that ever sailed from Gloucester. They certainly were well acquainted with their business, and, as for disposition, there was no sign of a quarrel during the whole summer. This last is especially remarkable, because of the absence on board of the fishing vessels of the traditionally severe ship discipline. The captain, unless the cook can be so called, was the only officer on board. The cabin was open alike to all, and as the bunks, with the exception of the captain's and my own, were chosen by lot, each one of the crew, providing he was sober when the lots were drawn, had as good a chance as his neighbor of securing sleeping quarters there.

The explanation of this general freedom is probably to be found in the co-operative nature of the trip, the financial plan of which was about as follows: The owners of the vessel were to receive 46 per cent. of the net stock and furnished, besides the vessel, food, salt, and fishing tackle, while 50 per cent. of the net stock, after deducting the cost of tarring the rigging, refilling medicine chest, pilotage, etc., was to be divided into fourteen equal parts, according to the number of the crew, one part going to each. The captain was to receive, besides one of the fourteen parts, the remaining 4 per cent.* The arrangement was thus, in some sense, a partnership, the owners furnishing the capital and the fishermen the labor, the profits to be shared in certain proportions. This general arrangement is not universal; for on some fishing vessels the men are paid a stipulated sum for the trip, the owners running the risk

* The captain's share is usually four cent. of the net stock, but it may vary either one way or the other.

of profit or loss, while on others the crews are composed of both hired men and shares-men.

13.—EVERY-DAY LIFE, SUPERSTITIONS, ETC.

At a quarter past six, Monday evening, the 9th of June, the steam-tug, Sarah E. Wetherell, pulled the Bunker Hill off from the wharf, so that her sails might catch the wind favorably. We had expected to start several hours earlier, but the little unexpected delays common to such occasions had prevented. Even as it was, on counting up hands, two were found missing; so that, while we tacked back and forth at the mouth of the harbor, waiting, a dory was sent to find the delinquents. Two hours passed before the return of the dory, and our number was complete; but during this time the wind had died out, rendering it doubtful whether we would succeed in leaving the harbor that evening. Nine o'clock, however, saw us outside of the harbor, headed in the direction of Nova Scotia.

A general feeling of excitement prevailed, strengthened in part by indulgence in the strong stuff; but as only a quart of the fiend was brought on board, outside of the crew and the Fish Commission tanks, all were soon sober and ready for work.

The captain had his berth, and one had been assigned to me, but the rest of the crew had as yet no settled sleeping place. The bunks to be chosen were in the cabin and forecastle. The cabin had two double-berths on each side, but as the starboard (right hand) ones were reserved for the captain and myself, only two of the berths were vacant. As the berths were large there was room in the two larboard (left hand) ones for four, making six to sleep in the cabin. The forecastle was arranged with berths on each side, and a table in the center, in front of the foremast, where we took our meals. One of the men was too much overcome, by something he had taken, to choose his sleeping-quarters at the same time the rest did, and naturally the worst bunk in the vessel fell to him. This was more, or rather less, than he could endure; so he took up his quarters back of the cabin, under the wheel, and, with the exception of the dampness of the place, had quite a comfortable bunk. This added one more to the occupants of the cabin, leaving eight to sleep in the forecastle. Each man furnished his own bed and bedding.

This evening we had our first meal on board. The crew took their meals in two sets, the first of seven, and the second of eight, and this division was made in such a manner as the least to interfere with the fishing arrangements. As already seen, the dorymates had to attend to the fishing arrangements of their own dory. Now, many of these things, such as renewing hooks, baiting, &c., could be attended to by one man at a time, and less time would be lost if only one went to meals while the other kept on working, than if both went together. On this account, the division of the men at meals was made, with one exception, caused by my presence, in such a manner that only one man to a dory would eat at a time. As for the captain and cook, who were exempted from fishing, the captain ate with the first set, while the cook waited until the second.

Another important matter attended to this evening was the setting of the watches. On leaving the wharf at Gloucester, the captain had taken the helm and kept it until we were well out of the harbor and on our course, when the watches were divided. Two men stand on watch at a time. Each watch is two hours long, and each man is at the wheel half of this time and forward the other half. The captain and cook, having no watching to do, this falls upon the other twelve of the crew, who each have, out of the twenty-four, four hours of watching, two of which are spent at the wheel. In order to prevent each man's watch coming the same hour each succeeding day, one man, each day, omits his watch. and by this means all the watches are pushed backward every twenty-four hours. The man who omits his watch is the one who, otherwise, would have his wheel between six and seven in the evening.

12–1 p. m.	*a*	*b*	*c*
1–2 p. m.	*b*	*c*	*d*
2–3 p. m.	*c*	*d*	*e*
3–4 p. m.	*d*	*e*	*f*
4–5 p. m.	*e*	*f*	*g*
5–6 p. m.	*f*	*g*	*h*
6–7 p. m.	*h*	*i*	*j*
7–8 p. m.	*i*	*j*	*k*
8–9 p. m.	*j*	*k*	*l*
9–10 p. m.	*k*	*l*	*a*
10–11 p. m.	*l*	*a*	*b*
11–12 p. m.	*a*	*b*	*c*

Thus, for instance, in the table just given, if *f*'s wheel was between 5 and 6 p. m., *g*'s wheel would naturally come between 6 and 7, but *g* omits his watch and *h*, taking his place, has the wheel an hour earlier than the preceding day. The next day *g* has the wheel, between 5 and 6, and *h* omitting, *i* takes the wheel from 6 to 7.

The watches were arranged so that dorymates watched together every other day. Thus in the table, suppose that *e* and *f* are dorymates. The first day *e* and *f* watch together, the second day *f* and *g*, while the third day *e* and *f* are together again. Each watch called the next watch. The order of the watches was decided in the following manner: A hat was held crown down, one man from each dory putting a finger upon the border of the opening, while one of the others, commencing at random, counted the fingers in succession, until he reached the number nine. Finger number nine being withdrawn, the counting commenced again with one and continued to nine, which was also withdrawn. This continued until no fingers were in the hat. The owner of the first finger withdrawn, together with his dorymate, had the first watch, the owner of second finger withdrawn, with his dorymate, the second watch, and so on through the whole.

I have said that the watches were two hours long, and this was true while we were on the passage out and back, but not so the intervening time; for, while we were anchored in the strait no watch was kept, because there was little or no danger. When, however, we shifted position and were expecting to anchor in a very few hours, the time would be divided into twelve equal parts, each man taking one part at the wheel. Thus once or twice the wheels were only ten or fifteen minutes long.

The passage from Gloucester to Holsteinborg lasted twenty days and was along the coast of Nova Scotia through the Gut of Canso, northward in the Gulf of Saint Lawrence, within sight of the western coasts of Cape Breton and Newfoundland, and thence by means of the Strait of Belle Isle, into the Atlantic and Davis Strait. The pleasanter days were occupied by the crew in fixing the dories and fishing tackle. I am not able to give a minute account of the events on the way up, because prolonged seasickness prevented the taking of many notes, but will give some extracts from my diary that may throw light upon the work and character of the men.

Friday, June 20, '79.—"The crew act very much like bees. Yesterday, a warm, pleasant, sunny day, they were all activity; to-day, cold and rainy, they were in their bunks most of the time from breakfast until dinner, and during the rest of the time, with few exceptions, have done little or nothing."

Though this was true, it was not on account of any disposition to shirk work, but rather because of there being only enough to do to occupy them on pleasant days; for, after the fishing commenced, they showed themselves to be good steady workers.

The duties devolving upon them, while on the way north, were the sailing of the vessel, fixing the dories, and rigging the trawls. The first was of course attended to principally by the different watches, leaving much time for the others. The fixing of the dories did not take very much time, as it only consisted in making thole-pins, three seats, and two vertical partitions for each boat and winding the oars with oakum to prevent them from wearing out. The vertical partitions, like the seats, were movable and were used to divide the dory into three parts. Typically, the stern apartment held the trawls, the central one the fish, while the bow was reserved for the anchors, but whenever the fish were numerous they were put wherever room could be found for them.

The rigging of the trawls, however, kept the men busy much longer than fixing the dories. Four skates had to be rigged for each dory, and all of these were of new material, excepting a large part of the lines to which the hooks are fastened. These short lines, called gangings, had been for two years kept in bundles, with the hooks protected from moisture by a canvas or rubber covering. These must, of course, be examined, in order to test the strength of each ganging, and to free the hooks from rust. Besides this, most of the hooks had to be taken from the line and refastened. This last operation is called "ganging the hooks."

The gangings finished, the ground-line next occupies the fisherman's attention. This being composed, as already stated, of fifty-fathom pieces requires, that each of these pieces should have a loop spliced in one end, while the other is fastened by what the sailors call a "wall," so that it will not untwist. The loops and walls finished and six of the fifty-fathom pieces tied together, the ground-line is ready for the attachment of the gangings, which are then fastened to it at every two fathoms. Besides the ground-lines and gangings, the buoys, buoy-lines, and anchors had to be made ready, but as these have already been mentioned, they will need no further notice here. In doing these things, the men would sometimes be in the cabin, forecastle, or on deck, just as convenience and fancy inclined them.

June 19.—I have the following short note: "The men are very kind and obliging, and although they may be very rough in their language toward each other, they are ready to help one another out of trouble." I, at no time during the trip, felt in the least like altering the above.

Saturday, June 14.—"I would like to put down some of the conversation of the crew, but there is too much profanity and vileness mixed with it to allow of its appearing on paper." This, I am sorry to say, was true to the end of the trip, but it did not appear that they meant all that they said, but spoke from habit. Such expressions as "A d——n nice thing" were common, where the objectional word increased the emphasis of the word nice. A few words upon the peculiarities of their oaths would be interesting but not proper. Leaving out the profanity, the conversation consisted principally of stories of past experiences on land and water. Some of the men had been regular sailors, and, having visited many parts of the earth, their opinions were interesting if not always correct. For instance, one of them, among other sage remarks, asserted that guano is not composed largely of bird excrement, but is nothing but foul air.

The only difference between Sunday and any other day in the week was that no nail must be driven on that day, for they said that would "nail the trip." Their superstitions are a little curious. The old notion that any enterprise commenced on Friday would be unlucky has, in a great measure, disappeared, on account of the fishermen having read in the papers a long list of great events that had happened on Friday. The objection to hammering on Sunday was so strong that the captain delayed fixing a part of the rigging from Sunday until Monday on this account.

There is one superstition about which they are exceedingly particular. They will never leave a hatch upside down. I was in the cabin fixing the fire, and had taken up the hatch in the floor to get at the coal, which was kept in the bottom of the vessel, beneath the cabin floor. The hatch I had placed in such a manner against the side of the cabin, that, if it had fallen down, it would have been bottom side up. One of the fishermen, whom I had always regarded as very sensible, seeing the hatch in that position, said to me, "Mr. Scudder, don't leave the hatch that way," and when I asked him why, he explained, that if it should slip down it would be upside down, which would bring ill luck upon the whole trip. I replied, "Let's try it," and knocked the hatch down on the floor bottom up. I do not remember of ever having been more surprised than I was to see him jump to turn the hatch over. He then said, "I don't know what the captain would say if he saw that." One of the fishermen told of a captain he was with who swore terribly at him because he pushed a dory off from the vessel with the bow of the dory toward the sun. I found, however, some difficulty in getting the men to acknowledge their belief in many superstitions, and I should not have found out those I have mentioned, had not the incidents spoken of called them into action. I think, as a whole, they were, for sea-going men, remarkably free from superstition.

The food during the trip was excellent of its kind. Fresh meat and vegetables were, from the nature of the case, out of the question, but the salt meat could not have been better, and fresh halibut and cod, while the fishing continued, were ever available. There was no milk of any kind, and no canned vegetables. Only enough potatoes were taken to last a few days. A little variety was noticed in the meals on Sunday, for on this day the cook added baked beans and brown bread to the bill of fare. Pea soup was common. Tea was prepared for each meal, and coffee for breakfast, and occasionally also for dinner, but both of these had to be taken without milk. Rice pudding and the famous dish of "duff" appeared occasionally. Neither were we without our mince pies, for the cook made some very fair ones out of dried apples and salt meat. Sugar, butter, and molasses were only wanting the last two weeks. The water of Greenland was excellent, as well as that taken from Gloucester. The food was nicely cooked, and many a housekeeper would be proud could she make such bread and cook such dishes as we had, with similar materials. Though the food was good and healthy, condensed milk and canned vegetables would have been a great addition.

The most regular meal was dinner, which came about noon. The other meals were more or less interfered with by the fishing, but while we were on the passage out and back breakfast came about 6 a. m. and supper about 5 p. m.

With the exception of the captain, all the fishermen used tobacco, both by chewing and smoking, and when, toward the end of the trip, tobacco became scarce, some would save their quids for smoking, after drying. Smoking must come before and after every important operation.

There was no severe sickness during the trip. One of the crew had what appeared to be the quinsy sore throat, which prevented him taking an active part in the fishing for several days. The captain seemed threatened with consumption and was confined to his bunk a day or two. All were more or less troubled with running sores on hands and wrists, which soon healed after the fishing was over. These were probably caused by the fish slime, as several of the men showed me scars of similar sores they had had on former trips. I had two such sores, caused by fish slime getting into slight cuts, and lasting over two months, but which healed rapidly while coming home.

The course taken coming home was the reverse of that going. Those who have been to Greenland after halibut several years, say that after August 20 the weather will permit of but little fishing. Our captain, however, having some salt left, decided to remain a little longer, so we did not start for home until the 28th of August. Then followed the active preparations for going home. The first thing was the bringing on board the barrels of fins, and the careful heading up of these. Next came the repacking of the flitches. After flitches have been packed ten or twelve days, for the first time, they are usually repacked in a more compact form and a little more salt added. During the fishing the packing had been mostly forward of midships, so that the bow of the vessel was low down in the water, and to trim the vessel better the flitches were repacked farther back. The trawls were also unrigged and packed away in the hold, but the cleaning of the vessel was left until we were south of the Strait of Belle Isle.

The decks being cleared, and the dories lashed in their places amidships, we started for home August 28. For the first few days the wind favored us, but before reachimg Belle Isle died out, and most of the time after that was unfavorable in direction or a dead calm.

Getting south of the Strait of Belle Isle we found the climate much different from that in Davis' Strait. The captain had brought a bushel or so of very fine black sand from Holsteinborg, and this was now used to scrub the vessel clean of fish slime, that had been collecting ever since the fishing commenced. The crew likewise took a general wash, many of them having their hair cut by one of the crew, who was quite proficient in that way. Vessel and crew both seemed transformed.

The passage home was uneventful, the crew being unemployed the greater part of the time. Some read, others walked the deck smoked if they could get tobacco, and lay in their bunks. Most of the food gave out, until toward the last nothing but salt meat and bread were left. We reached Gloucester the 17th of September.

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APPENDIX D.

ECONOMIC RESEARCH.

XI.—REPORT OF PROGRESS OF AN INVESTIGATION OF THE CHEMICAL COMPOSITION AND ECONOMIC VALUES OF FISH AND INVERTEBRATES USED FOR FOOD.

UNDERTAKEN FOR THE UNITED STATES FISH COMMISSION.

By W. O. ATWATER, PH. D.,

Professor of Chemistry, Wesleyan University, Middletown, Conn.

SIR: Herewith I have the honor to transmit a report of progress of the investigation of the chemical composition and economic values of fish and marine invertebrates used for food, which has been in process for some time past in this laboratory, under the auspices of the Smithsonian Institution and the United States Fish Commission.

This report includes analyses of fifty-one samples of fish and twenty-five of oysters, lobsters, and other invertebrates. It is divided into three parts.

Part I gives account of analyses of fish, including description of samples, tabular statements of results, and methods of analyses.

Part II gives similar data regarding invertebrates. The investigation it describes was undertaken at my suggestion by my assistants, Messrs. Woods and Beamer, who have also shared in the investigations of fish, and who report those upon invertebrates.

Part III summarizes the more immediately practical results of the work, especially in its relations to the nutritive values of the samples analyzed, the detailed account of the more abstract investigations being reserved for another occasion.

Permit me to say that I regard this as only the beginning of a much needed research. Work in this line, rightly conducted, may, unquestionably grow into an inquiry of the greatest value.

To obtain the best results the investigation should, it seems to me, be pushed in two directions, namely, toward the study of—

1. The chemical constitution of the tissues and fluids of the bodies of the animals.

2. Their economic values, especially for food.

The more abstract study of the chemical composition of the substances is of less immediate interest to any except the chemist and physiologist; but, if successfully carried out, its results will have most important bearings upon the more practical questions referred to. We must know more of the chemical constitution of the compounds that occur in our foods and of their functions in nutrition before we can, with satisfactory accuracy, estimate their values and proper uses for food. At the same time, an approximate estimate of the nutritive values, and one commensurate with our present knowledge of the ingredients of foods and their functions, can be based upon analyses somewhat less detailed, even, than most of those here given. The analyses already made, though insufficient to permit as reliable generalizations as are to be desired, do, nevertheless, help toward an estimate of the composition and values of a number of our more common species of edible fish and invertebrates.

Some of the results herewith reported are striking and unexpected. Among the different sorts of fish which the New York and Middletown markets furnished for my table, a sample of flounder contained only 5 per cent. of dry edible solids, actual nutrients, the rest being water and refuse; while one of salmon yielded 33 per cent. of nutritive substance. The proportion of nutrients in salmon was nearly one-third larger than it would be in an ordinary slice of beef-steak; that in flounder not one-fourth as large.

Taking the fish at retail prices in Middletown markets, the total nutrients in striped bass came to about $2.30 per pound; while in Connecticut River shad, whose price, thanks to our fish commissions, was very low, we bought the same nutrients at 44 cents per pound. In good beef they were costing about $1 per pound.

It makes very little difference to the man with five thousand dollars a year whether he pays fifty cents or five dollars a pound for the albuminoids in his food; but it does make a difference to the man who must pay his rent and support his family on five hundred dollars a year. The economical housewife who hesitates in the dry-goods store before taking a piece of calico at eleven cents a yard when she can get another that may do as good service for ten, goes to the market and unknowingly pays, perhaps, a dollar for a given amount of food, when she might have got the same materials in forms equally nutritious and wholesome, for fifty cents.

The large amount of attention devoted to this kind of investigation in Europe has brought results capable of being successfully popularized. In Germany, tables giving the chemical composition and nutritive valuations of foods are becoming current among even the common people. An attempt toward a similar application of the results of the present work is given in tabular form in Part III.

The details of the analytical work herewith reported have been performed for the most part by my friends and assistants, Messrs. W. H. Jordan, B. S., G. P. Merrill, B. S., C. D. Woods, B. S., and M. Beamer, C. E., for whose skillful aid I desire to express my thanks.

I wish also to acknowledge the generous contribution by Mr. A. R. Crittenden, of the firm of Wilcox, Crittenden & Co., of this city, of $100 towards the expenses of the analysis of fish.

Further and especial thanks are due to Mr. E. G. Blackford, Fish Commissioner of the State of New York, for a gift of the same amount ($100) towards defraying the expenses of the investigation of the invertebrates, as well as for the furnishing of samples and valuable information.

In conclusion, permit me to express my appreciation of the pecuniary and other aid which has been courteously afforded by yourself, and which has rendered the investigation possible.

Very respectfully, your obedient servant,

W. O. ATWATER,

Chemical Laboratory, Wesleyan University,
Middletown, Conn., July 1, 1881.

Prof. SPENCER F. BAIRD,
Secretary of the Smithsonian Institution,
and United States Commissioner of Fish and Fisheries.

PART I.

ANALYSES OF FISH.

DESCRIPTION OF SAMPLES OF FISH ANALYZED.

Nos. I, XIII, XV, and XVI were purchased at fish markets in Middletown, in the months of March, April, May, and June, 1879; the other samples were procured as stated below.

No. I. Halibut (*Hippoglossus americanus*).

The sample was from the posterior half of the body. The price was 15 cents per pound. The proportions of flesh, edible portion, refuse, and loss in cleaning (see "Methods of Analysis") were as given in Table I.

No. II. Flounder (*Pleuronectes americanus*).

The entrails of the fish had been removed. Price 10 cents per pound. The following figures show the proportions of edible portion, waste, &c., in each sample and in both together. The figures for the two together are also given in Table I.

	A.	B.	Both.
	Grams.	*Grams.*	*Grams.*
Weight of edible portion, flesh	239	715	954
Weight of refuse, head, bones, skin, &c	355	961	1,316
Loss in preparing for analysis	19	19	38
Total weight of sample in grams	613	1,695	2,308
Total weight of sample in pounds and ounces	1 lb. 5.6 oz.	3 lbs. 11.8 oz.	5 lbs. 1.4 oz.

No. III. Cod (*Gadus morrhua*).

The head and entrails of the fish had been removed. Price 10 cents per pound. Proportions of flesh, refuse, &c., as per Table I. Total weight of one dressed fish, 2,780 grams=6 pounds 2.1 ounces.

No. IV. Eels (salt water) (*Anguilla rostrata*).

Dressed, *i. e.* skin, head, and entrails removed. Price 15 cents per pound. The proportions of flesh, refuse, &c., in Table I are those of eleven fish, which were not weighed separately. The total weight was 1,368 grams=3 pounds 0.3 ounces.

No. V. Alewives (*Pomolobus vernalis*).

Caught in the Connecticut River. Price 12 cents per dozen. Twelve whole fish weighed 2,566 grams=5 pounds 1.5 ounces. The cost per pound was thus 2⅓ cents. The proportions of flesh and refuse in four of the fish were as per figures in Table I, in which table are given corresponding data for samples which follow.

No. VI. Shad (*Alosa sapidissima*).

From the Hudson River. Price 20 cents per pound. Two whole fish weighed 1,925 grams=4 pounds 3.9 ounces.

No. VII. Striped Bass (*Roccus lineatus*).

From Connecticut River. Price 20 cents per pound. One whole fish weighed 2,055 grams=4 pounds 8.5 ounces.

No. VIII. Mackerel (*Scomber scombrus*).

Price 15 cents each. Four whole fish weighed 1,280 grams=2 pounds 13.1 ounces, which would make the price about 20 cents per pound.

No. IX. Halibut (*Hippoglossus americanus*).

Section of fatter portion of body. Price 15 cents per pound.

No. X. Shad (*Alosa sapidissima*).

From Connecticut River. Price 8 cents per pound. One whole fish weighed 1,595 grams=3 pounds 8.3 ounces.

No. XI. Cod (*Gadus morrhua*).

Price, 8 cents per pound. One fish, dressed, *i. e.*, with head and entrails removed, weighed 2,532 grams=5 pounds 9.3 ounces.

No. XII. Blue Fish (*Pomatomus saltatrix*).

Price 10 cents per pound. One fish, entrails removed, weighed 1,400 grams=3 pounds 1.3 ounces.

No. XIII. Mackerel (*Scomber scombrus*).

Price 18 cents per pound. Two whole fish weighed 8,982 grams=19 pounds 12.1 ounces.

No. XIV. Salmon (*Salmo salar*).

Sample furnished by Mr. E. G. Blackford, 74, 75, 76, and 80 Fulton Market, 134 Beekman street, and 223 Front street, New York City. From Maine. One fish, entrails removed, weighed 4,764.3 grams=10 pounds 8 ounces.

No. XV. Porgy (*Stenotomus argyrops*).

Four whole fish weighed 1,290.5 grams=2 pounds 13.5 ounces.

No. XVI. Haddock (*Melanogrammus aeglefinus*).

Price 8 cents per pound. One fish, with entrails removed, weighed 1,900 grams=4 pounds 3 ounces.

No. XVII. Salmon Trout, called also "Mackinaw Trout" (*Salvelinus namaycush*).

Received November 7, 1879, from Mr. Blackford, Fulton Market, New York. In letter of November 6, Mr. Blackford describes the samples as follows: "Salmon trout (*Christivomer namaycush*) weighs 8 pounds 3 ounces. Caught in Lake Ontario November 5. This is very plenty in market at this season of the year. You will probably find spawn in it." The sample, a whole fish, weighed on receipt 3,630.4 grams=8 pounds, and had evidently shrunk slightly by loss of water and otherwise in coming. It contained considerable spawn, which, as in other cases, was rejected, with entrails, bone, skin, &c., in preparing for analysis.

No. XVIII. White Fish (*Coregonus clupeiformis*).

Received November 7, 1879, from Mr. Blackford, who says in accompanying letter: "White fish (*Coregonus clupeiformis*) weighs 2 pounds 15 ounces, caught at Alburgh Springs, Vt., from Lake Champlain. Is the great food fish of the lakes, and is in its finest condition at the present season." Total weight of one whole fish as received, 1,313 grams =2 pounds 14.3 ounces, showing, as usual, slight shrinkage in transport and handling.

No. XIX. Striped Bass (*Roccus lineatus*).

Received November 7, 1879, from Mr. Blackford, who described it as "Striped bass; weighs 2 pounds 9 ounces; caught at Bridgehampton, Long Island, November 5. They are very plenty at this season and in their best condition." Total weight of one whole fish, 1,098.5 grams=2 pounds 6.7 ounces.

No. XX. Red Snapper (*Lutjanus Blackfordii*).

Sample received from Mr. Blackford November 28, 1879, "caught in Fernandina, Fla." Total weight of one whole fish, 3,507.5 grams=7 pounds 15 ounces.

No. XXI. Haddock (*Melanogrammus æglefinus*).

Sample received from Mr. Blackford November 28, 1879, "caught off Rockaway, Long Island." Total weight of one fish from which entrails had been removed, 2,402 grams=5 pounds 4.7 ounces.

No. XXII. Flounder (*Paralichthys dentatus.*)

Sample received from Mr. Blackford March 9, 1880. "The fish was caught at Amagansett, Long Island." The sample was rather old, and the flesh very soft. It emitted some odor and assumed a pasty appearance in drying. It is worthy of note in this connection that the percentage of "gelatin" in this sample is large. Total weight of one whole fish, 1,257.5 grams=2 pounds 12 ounces.

No. XXIII. Smelt (*Osmerus mordax*).

Received March 9, 1880, from Mr. Blackford, from Hackensack River, New Jersey. Seventy-three whole fish weighed 1,023 grams. = 2 pounds 4 ounces.

No. XXIV. Spotted Brook Trout (*Salvelinus fontinalis*).

Sample received from Mr. Blackford, March 16, 1880, "Cultivated Trout." Six whole fish weighed 1,295 grams = 2 pounds 13.7 ounces.

No. XXV. Boned Codfish.

Per label on box, "Packed and warranted by Henry Meigs & Co., Boston, Mass.," "Snow flake" brand. Purchased April 8, 1880, in Middletown, in 5 pound packages; price 50 cents each, or 10 cents per pound. The following statements were printed on the box: "This package contains pure codfish, and that the best that could be cured. Great care is taken in the selection, curing, and packing, and the fish is recommended to the consumer for its economy, convenience, cleanliness, and quality. In the fall of 1876 we introduced boned codfish in small boxes. We have been experimenting with paper, and we have now to offer a paper box that is in every way water and air tight. The package is thus always neat, the contents clean, and there no longer escapes the fish odor, that to many is so offensive."

No. XXVI. Red Snapper (*Lutjanus Blackfordii*).

From the eastern coast of Florida. Sample received from Mr. Blackford April 20, 1880. Entrails removed. Weight of sample, 5,499 grams = 12 pounds 1.9 ounces.

No. XXVII. California Salmon (*Oncorhynchcus chouicha*).

From Sacramento River, California. Received from Mr. Blackford, April 20, 1880. Edible portion of the anterior part of body. The fish was evidently not very fresh. It emitted some odor, and in drying swelled a great deal, and became pasty.

No. XXVIII. Smoked Halibut.

Purchased in Middletown, Conn., April 29, 1880. Part of one side of fish, including skin and a few small bones. Total weight of sample, 1,616 grams. = 3 pounds 9 ounces.

No. XXIX. Canned Salmon (*Oncorhynchcus chouicha*, probably).

Put up by G. W. Hume & Co., San Francisco, Cal. One can, said to contain 2 pounds, cost 45 cents. Weight of entire sample, 8,700 grams = 1 pound 14.7 ounces, which would make actual cost of the contents of can about 20 cents per pound. The sample had a good deal of oil. Solids and oil were crushed together in a mortar; the oil was readily absorbed, so that the sample was easily worked.

No. XXX. Fresh Mackerel (*Scomber scombrus*).

Caught off Cape May, N. J. Received from Mr. Blackford, May 11, 1880. Total weight of four whole fish, 2,594 grams = 5 pounds 11.5 ounces.

No. XXXI. Porgies (*Stenotomus argyrops*).

From Rhode Island. Received from Mr. Blackford, May 11, 1880. The fish were whole. Total weight, 2,847 grams = 6 pounds 4.4 ounces.

No. XXXII. Shad (*Alosa sapidissima*).

From Connecticut River. Purchased May 19, in Middletown, Conn. Price 10 cents per pound. Total weight of one whole fish, 1,750 grams = 3 pounds 14 ounces.

No. XXXIII. Smoked Herring (*Clupea harengus*).

Purchased May 19, 1880, in Middletown, Conn. Total weight of six whole fish, 4,547 grams = 10 pounds 0.4 ounces.

No. XXXIV. Salt Codfish.

Sample purchased in Middletown, Conn., November 16, 1880, of Mr. S. T. Camp, who states that the fish is the kind known to the trade as "channel fish," and were caught in the deep water near George's Banks. The fish as commonly sold (head and entrails removed, salted and dried) cost 7 cents per pound. One fish weighed 4,156 grams = 9 pounds 2.2 ounces.

Nos. XXXV *a* and XXXV *b*. Spent or foul salmon (*Salmo salar*), males.

Nos. XXXVI *a* and XXXVI *b*. Spent or foul salmon (*Salmo salar*), females.

Received November 18, 1880, from Government salmon breeding establishment, through the courtesy of Mr. Charles G. Atkins, Bucksport, Me. In accompanying letter Mr. Atkins suggests that though "spent" salmon [the eggs having been removed by stripping] they were in better condition than those that have spawned naturally. From measurements made by Mr. H. L. Osborn, assistant in natural history in Wesleyan University, I select the following as of interest in comparing the dimensions and weights of these with salmon in good condition:

	XXXV *a*	XXXV *b*	XXXVI *a*	XXXVI *b*
Greatest height of body........millimeters..	156	154	163	166
Least height of body........do	60	58	63	64
Greatest width of body........do	58	57	66	67
Girth at tip of pectoral fin........do......	360	355	380	400
Girth at anterior end of dorsal........do......	380	365	390	395
Girth over anus........do......	290	285	340	315
Girth at posterior end of adipose fin.....do......	200	190	200	210
Length to tip of middle caudal ray......do......	826	830	915	896
Length to base of middle caudal ray.....do	750	750	835	813

The proportions of flesh, refuse, &c., were:

	XXXV *a*.	XXXV *b*.	XXXVI *a*.	XXXVI *b*.
Edible portion........grams..	2,345.7	2,381.1	2,693.0	3,040.2
Waste, entrails, skin, bone, &c........do....	1,998.4	1,715.0	2,487.5	1,955.9
Loss in cleaning........do....	28.3	14.2	7.0	21.3
Total weight........do....	4,372.4	4,110.3	5,187.5	5,017.4
Total weight in pounds and ounces........	9 lbs. 10.2 oz.	9 lbs. 1 oz.	11 lbs. 7 oz.	11 lbs. 1 oz.

Portions of Nos. XXXV *a* and XXXV *b* were sampled together and analyzed as No. XXXV. The same was done with Nos. XXXVI *a* and *b*, which were analyzed as No. XXXVI.

No. XXXVII. Salt Codfish.

Sample purchased of Mr. S. T. Camp, Middletown, Conn., November 29, 1880, who states that the fish is of the kind known to the trade as "boat fish," and was caught near the shore, in the vicinity of Nantucket. Total weight of two whole fish, 2.813 grams = 6 pounds 3.2 ounces.

No. XXXVIII. Black Fish (*Tautoga onitis*).

From Stonington, Conn., received December 1, 1880, from Mr. Blackford. Weights of two whole fish as follows:

	a.	*b.*
Edible portion .... grams..	546.5	322.0
Waste .... do...	716.8	441.9
Loss in cleaning .... do...	23.7	11.1
Whole fish .... do...	1,287.0	775.0
Whole fish in pounds and ounces	2 lbs. 13.4 oz.	1 lb. 11.4 oz.

No. XXXIX. Mackerel (*Scomber scombrus*).

From Cape Cod, Mass., sample received from Mr. Blackford, Dec. 1, 1880. One whole fish weighed 337 grams = 11.9 ounces.

Nos. XL *a* and XL *b*. Land-locked Salmon (*Salmo salar*), var. *sebago*, males.

Nos. XLI *a* and XLI *b*. Land-locked Salmon (*Salmo salar*), var. *sebago*, females.

From Schoodic salmon-breeding establishment, Grand Lake Stream, Maine. Sample received December 1, 1880, from Charles G. Atkins, who says, in letter dated Grand Lake Stream, Maine, November 27, 1880, "I send * * * * four male land-locked salmon and four females, whose eggs have been taken from them by the artificial process. They are as near spent fish as we can get, but I think they are in better condition than those that have spawned naturally." The following measurements and weights indicate the size of the fish and proportions of flesh and refuse:

	XL *a.*	XL *b.*	XL *c.*	XL *d.*
Greatest length .... millimeters..	520	500	510	500
Girth at tip of pectoral fin .... do.......	285	250	265	260
Girth at anterior base of dorsal fin .... do	202	255	278	270
Girth at anus .... do.......	216	175	220	195
Edible portion .... grams..	745.1	623.8	754.3	761.8
Waste, entrails, &c .... do...	767.5	594.8	741.9	648.8
Loss in cleaning .... do...	17.4	11.6	10.4	8.9
Total weight .... do...	1,530.0	1,230.2	1,506.6	1,419.5
Total weight in pounds and ounces	3 lbs. 5.9 oz.	2 lbs. 11.4 oz.	3 lbs. 5.1 oz.	3 lbs. 2 oz.

	XLI *a.*	XLI *b.*	XLI *c.*	XLI *d.*
Greatest length .... millimeters..	480	460	450	450
Girth at tip of pectoral fin .... do	230	220	210	210
Girth at anterior base of dorsal fin .... do.......	240	225	210	200
Girth at anus .... do.......	177	175	168	160
Edible portion .... grams..	562.1	494.7	402.1	442.9
Waste, entrails, &c .... do...	471.8	401.7	391.1	409.4
Loss in cleaning .... do...	19.6	6.7	9.3	11.4
Total weight .... do...	1,053.0	903.1	802.5	863.7
Total weight in pounds and ounces	2 lbs. 5.1 oz.	1 lb. 15.8 oz.	1 lb. 12.3. oz.	1 lb. 14.5. oz.

Nos. XL *a*, XL *b*, XL *c*, XL *d*, were sampled together and analyzed as No. XL. The same was done with XLI *a*, *b*, *c*, and *d*, which were analyzed as XLI.

No. XLII. Salt Mackerel (*Scomber scombrus*).

Bought February 23, 1881, in Middletown, Conn., price 12½ cents per pound, described as "No. 1 mackerel". Caught probably in September or October, as the barrel from which sample was taken was marked as inspected at Chatham, Mass., in October. Weight of three fish at store a trifle short of 2 pounds; as received at laboratory, 857.8 grams = 1 pound 14.3 ounces. As the fish had considerable adhering salt and brine, they were rinsed in cold water and dried between folds of paper and with a linen towel. The weight of the three fish thus treated was 781.4 grams. Accordingly the three fish had (857.8—781.4 =) 76.4 grams or about 9 per cent. of adhering salt, brine, &c. Or, taking weight at store at 890 grams, the adhering brine, &c., would be 109 grams, or about one-eighth—12½ per cent. That is, one-eighth of the weight paid for at the store was brine, salt, &c., which would be rinsed off in preparing the fish for cooking. Such statements as this are of course of no importance except as data for calculating how much nutritive material is obtained in a given amount of the fish as bought.

XLIII. Spanish Mackerel (*Cybium maculatum*).

Sample received from Mr. Blackford, March 1, 1881. It was rather "soft", though entirely free from offensive odor. One whole fish weighed 1,513 grams=3 pounds 5.3 ounces.

XLIV. White Perch (*Morone americana*).

Sample received from Mr. Blackford, March 1, 1881. The fish contained considerable spawn. The proportions of flesh and refuse in two whole fish were:

	a.	*b.*
Edible portion .... grams..	128.7	142.7
Refuse .... do....	208.0	279.0
Loss in cleaning .... do....	6.7	5.0
Total weight .... do....	343.4	426.7
Total weight .... ounces..	12.1	15.0

XLV. Muskallonge (*Esox nobilior*).

From Saint Lawrence River. Received March 4, 1881, from Mr. Blackford, who says that it "is not often found in our markets." One whole fish weighed 4,118 grams=9 pounds 1.2 ounces.

XLVI. White Perch (*Morone americana*).

Received March 8, 1881, from Mr. Blackford. Proportions of flesh and refuse in four whole fish as follows:

	a.	*b.*	*c.*	*d.*
Edible portion .... grams..	78.7	110.6	78.0	71.9
Refuse .... do....	129.2	196.5	127.2	125.5
Loss in cleaning .... do....	7.1	4.6	3.3	3.3
Total weight .... do....	215.0	311.7	208.5	200.7
Total weight .... ounces..	7.6	11.0	7.4	7.0

XLVII. Herring (*Clupea harengus*).

Sample received from Mr. Blackford, March 8, 1881. Proportions of flesh and waste in four samples, as follows:

	a.	b.	c.	d.
Edible portion .... grams..	136.5	163.0	121.5	131.5
Refuse .... do....	142.0	129.0	83.0	143.2
Loss in cleaning .... do....	5.9	10.2	5.5	9.5
Total weight .... do....	284.4	302.2	210.0	284.2
Total weight .... ounces..	10.0	10.6	7.7	10.0

XLVIII. Sheeps-head (*Archosargus probatocephalus*).

From Florida. Received from Mr. Blackford, March 10, 1881. One fish, entrails removed, weighed 1,974 grams=4 pounds 5.6 ounces.

XLIX. Turbot (*Platysomatichthys hippoglossoides*).

From Newfoundland. Received from Mr. Blackford, March 10, 1881. The fish had been frozen and partly thawed. One whole fish weighed 2,497 grams=5 pounds 8 ounces.

LII. Yellow Pike-perch (*Stizostedium vitreum*).

Received from Mr. Blackford, March 17, 1881. The proportions of flesh and waste in two whole fish, of which the heavier had considerable immature spawn, were as follows:

	a.	b.
Edible portion .... grams..	232.5	230.2
Refuse .... do....	369.2	273.5
Loss in cleaning .... do....	9.8	7.5
Total weight .... do....	611.5	511.2
Total weight in pounds and ounces	1 lb. 5.6 oz.	1 lb. 2 oz.

LIII. Black Bass (*Micropterus salmoides?*).

Received March 17, 1881, from Mr. Blackford. One whole fish weighed 1,676 grams=3 pounds 11.1 ounces.

DESCRIPTION OF TABLES.

The main results of the investigation are expressed in the tables which follow.

Table I states the results of analyses of fifty-one samples of fish, in the terms commonly current in such investigations.

Table II recapitulates the analyses of Table I in such way as to set forth more fully the actual composition of the samples analyzed.

Table III recapitulates the composition of several samples on a somewhat different basis, the essential difference being in the method of estimating the amounts of albuminoids.

Table IV gives a brief résumé of the composition of the samples in forms more convenient for reference.

In Part III of this report is a table giving the nutritive valuations of the fish reported herewith and of the invertebrates, oysters, clams, lobsters, &c., reported beyond.

TABLE I.

Under "Kinds of fish and portions taken for analysis" are given the names and the localities, when the latter are known. The full details may be found under "Descriptions of Samples" above. The meaning of the figures in the first three columns will need no explanation; the rest are explained under "Methods of Analysis," beyond.

TABLE II.

Table II recapitulates the analyses of fish. The second column shows the percentages of flesh, edible portion, in each sample as actually received at the laboratory for analysis; some of these included the whole fish, others were dressed. As explained under "Methods of Analysis" these figures represent the proportions of edible material which we were able to separate from the skin, bones, &c., after the entrails had been removed. Thus the sample of halibut, No. IX, which was a section of the fatter part of the body, "halibut steak," gave 88¼ per cent. of flesh, the residual 11¾ per cent. being skin and bone; while a sample of flounder, No. XXII, yielded only 32 per cent. of edible substance, the remaining 68 per cent. consisting of entrails, skin, bone, and other waste. The proportion of waste in this flounder, which was whole, was naturally larger than in the other, No. II, from which the entrails had been removed, and which gave 41⅓ per cent. of flesh, and 58⅝ per cent. of refuse.

The remaining figures in Table II give the composition of the flesh computed first upon the dry substance, then upon the whole flesh including both dry substance and water. Explanations may be found under "Methods of Analysis." The albuminoids in this table are computed by multiplying the nitrogen by 6.25, as is generally customary, at present, in analyses of animal and vegetable food-products. As will be seen in the column "Albuminoids + Flats + Ash," under "Summary," the computation brings, generally, too large results; that is, a footing of over 100 per cent. In some cases, however, it falls short. The variations in the results at first led me to fear inaccuracy of the work, but the greatest possible pains has not availed to make them more uniform; they seem, therefore, to indicate wide variations in the nitrogen compounds themselves. I am inclined to think that one reason why the percentages of albuminoids here given are higher than have been obtained in many cases elsewhere, is to be found in the especial care that has been taken here in determining the nitrogen, which, when made by the soda-lime method, as is usually done, often came out too low.

The percentages of ingredients in both dry substance and flesh have been re-calculated to make the footings 100 per cent.; the original and the altered figures being given under "Summary."

Further explanations, with recapitulations of the figures in this and the following tables, may be found in Part III of this report.

TABLE III.

As is explained in "Methods of Analysis," some attempts have been made toward what might be called a complete analysis of the flesh. The figures are recapitulated in this table. The "Extractive matters" include, as stated, all the materials dissolved out by cold water, and not coagulated by boiling; "Albumen," the portion of the cold water extract coagulated by boiling; "Gelatin," the portion soluble in hot water; Fats, the portion soluble in ether; and "Insoluble protein," the residue insoluble in water and in ether. The footings generally exceed 100 per cent., perhaps from incomplete separation of water or fats from some of the ingredients, as stated under "Methods of Analysis," though care was taken to get them as pure as practicable.

TABLE IV.

This table gives a general résumé of such of the results as are most important for estimating the nutritive values of the samples. The figures, except those in the last column, "Total edible solids," are taken from Table II.

METHODS OF ANALYSIS.

PREPARATION OF SAMPLES FOR ANALYSIS.

Separation of edible portion (flesh) from refuse (bones, skin, entrails, spawn, &c.).—The sample, as received at the laboratory, was weighed; the edible portion, "flesh," was then separated from the refuse, and both were weighed. There was always a slight loss in cleaning, due evidently to evaporation and to slimy and fatty matters and small fragments of the tissue that adhered to the hands and to the utensils used in preparing the sample. Perfect separation of the flesh from the other tissues was difficult, but the loss resulting from this was small, so that, though the figures obtained for edible portion represent somewhat less than was actually in the sample, yet the amount thus wasted was doubtless scarcely more than would be left unconsumed at an ordinary table. The reasons for rejecting the skin, which generally has considerable nutritive value, were that its chemical constitution is different from that of the flesh, and that, so far as we have observed in this country, it is not ordinarily eaten. With the closer domestic economy that increased density of population must bring, people will doubtless become more careful hereafter to utilize such materials.

Sampling.—The whole edible portion was finely chopped and carefully mixed in a wooden tray.

Drying.—The drying was conducted in an ordinary bath at a temperature of nominally 100°, but actually about 96°, as is usual in drying-baths which consist of an air chamber with double walls inclosing boiling water. In each case two portions were dried, one, "A," in a current of hydrogen, and one, "B," in air.

Drying in hydrogen.—From 50 to 100 grams, in most cases preferably, 100 grams, of the freshly-chopped substance was weighed on a watch glass or small sauce-plate, dried in a current of hydrogen at 96° for 24 to 48 hours, cooled, allowed to stand in the open air for some 24 hours, weighed, ground, sifted through a sieve with circular holes of 1^{mm} diameter, bottled, and labeled "A." A few of the fattest samples, however, could not well be worked through so fine a sieve; for these, either a coarse sieve was used or the substance was crushed as finely as practicable, and bottled without sifting. For the complete drying, from 1 to 2 grams of "A" were weighed in small drying flasks, and dried in hydrogen three or four hours. It is extremely difficult to get an absolutely constant weight, though we find that the object is in most cases approximately attained in three hours. The total moisture and dry substance are computed from the two dryings.

Drying in air.—As the drying of large quantities in hydrogen was less convenient, and drying in air suffices perfectly well for certain determinations, particularly sulphur, phosphorus, and chlorine, a sufficient quantity of material for the work was insured by drying a portion in air. This was effected by weighing 200 grams or more of the freshly-chopped substance at the same time that the portion was taken for drying in hydrogen, drying in air, exposing to air of room, weighing, grinding, and bottling as above, this portion being labeled "B." The amount of water-free substance in "B" was calculated from the data obtained for "A."

Proximate ingredients by direct determination.—In a number of the samples, determinations were made of the ingredients soluble in cold and in hot water, and of the portion not dissolved by water, alcohol, or ether.

The objects of the determinations were to obtain data comparable with those of other investigations*, and to test the methods, as well as to learn the amounts of the ingredients. The methods have proved unsatisfactory in many respects, and we have felt it advisable to make no more determinations by them than are indicated in the tables, until the subject is worked up more thoroughly. For that matter, an at all satisfactory examination of the proximate constituents will naturally involve determinations of both the total amounts and the ultimate composition of the ingredients of the juices, as well as solids, of the flesh. Considering the complicated character of these compounds, the vagueness of our present knowledge regarding them, and the amount of preliminary work that is

* *E. g.*, Almen, *Analyse des Fleisches einiger Fische* (*Nova Acta Reg. Soc. Sc. Ups., Ser. III*), *Upsala*, 1877.

always necessary before such an investigation can be got into good running order, and adding to all this the importance of studying the mineral ingredients, it is clear that a great deal of labor will be necessary to reach the desired results.

Cold-water extract.—Of the freshly-chopped substance 33⅓ grams were digested for 18 to 24, generally about 20, hours, in 500^{cc} of cold water, and filtered.

The filtration was conducted at first through "coffee filter paper." Later Messrs. Woods and Beamer found it better to use fine linen cloth, which has the advantages of more rapid filtration and of allowing the liquid to be squeezed through with proper care. The solids do not pass through the cloth more than through the filter paper, and by laying on a glass plate, scraping, and subsequent rinsing, they are separated much more easily and completely than they can be from the filter paper.

Albumen.—The filtrate thus obtained was boiled and filtered through previously dried and weighed asbestos filters. After washing with ether, the filter, with its contents, was dried and weighed. That this method for determining the albumen is accurate, is by no means proven or even probable. But we find that treatment with acid, as acetic acid, in the ordinary way, instead of increasing the amount coagulated is very apt to hinder coagulation and sometimes to prevent it altogether, while boiling the extract alone invariably produces coagulation. Very likely precipitation by alcohol, ferric acetate, or otherwise, might insure more complete separation of the albumen.

Extractive matters.—The filtrate from the coagulated albumen was evaporated in platinum capsules and weighed. One sample was used for determination of the ash, which was done by charring at a low temperature, extracting with water, igniting the residue until it was well burned, adding the water solution, evaporating, igniting carefully at a low temperature, and weighing. The other sample was finely ground, dried in air to determine the percentage of water, and extracted with ether until free from fat, usually two or three hours. The crude extract, minus the water, fat, and ash, is reckoned as pure extract, and is designated in Tables I and II as "Extractive matters." It of course contains any albumen which may not have been coagulated, the other nitrogenous compounds, the carbohydrates, and whatever else, except fats and mineral matters, was taken from the flesh of the fish by the digestion in cold distilled water.

Hot-water extract—"gelatin."—The residue left after the extraction with cold water was treated for 18 to 24 hours, generally about 20 hours, with distilled water at 100° or slightly below. It was then filtered through weighed asbestos filters, and the filtrate evaporated to dryness in platinum, and weighed as crude gelatin. In this, fat and ash were determined, and the pure extract called in the tables "gelatin," estimated as in the cold-water extract. It should be stated that in both hot and cold water extracts the figures for total extract in the tables represent water-free substance, *i. e.*, crude extract minus water. I am inclined to think it would be better to determine both water and fat in the crude extracts in one operation by extracting with ether and noting the loss.

Insoluble protein.—The residue left after the extraction with hot water was treated with alcohol or ether, or both, dried and weighed. Water, ash, and fat were then determined (except, of course, that fat was not determined in the cases where it had been previously extracted). The ash was determined by direct burning, it being assumed that the previous treatment with cold and hot water had sufficed to remove the easily fusible and volatile salts. The removal of the last portions of fat is often extremely difficult, and it is not impossible that in some cases traces were left and weighed as insoluble protein. The figures for total insoluble protein in the table denote water-free substance.

Ether extract, fats.—From 0.3 to 1.0 gram of "A" (hydrogen dried) was extracted with ether until free from fat. The operation was conducted in an apparatus similar to that described by Johnson* (*Am. Jour. Sci.*, XIII, 1877, p. 190). The fat obtained was dried in a current of hydrogen before weighing.

Nitrogen was estimated by the soda-lime process. Some study has been made in this laboratory of the conditions under which this method gives accurate results, especially with materials rich in nitrogen, the outcome of which may be reported elsewhere. It will suffice here to say that we find it important to have the substance well ground and mixed with the soda-lime and to insure complete ammonification of the nitrogen in the, decomposition products. This last we attempt to secure by a sufficiently long anterior layer of soda-lime, preferably in coarse particles, high enough heat and rather slow burning.

The correctness of the determinations of nitrogen was tested by comparative trials by the absolute method. In this latter, two sources of error, often neglected, were taken into account, namely, the air which adheres to the interior of the tube and its contents even after long exhaustion with the Sprengel pump, and the vapor tension of the caustic potash solution over which the nitrogen is collected and measured in the eudiometer.

To determine the correction for residual air in the combustion tube, blank determinations were made with pure oxalic acid. The tube was well exhausted, the mercury being allowed to run three-quarters of an hour after the "click" was heard, before the combustion was begun. The amounts of gas obtained in four combustions were, when reduced to 0° and 760^{mm}, 0.3^{cc}, 0.6^{cc}, 0.5^{cc}, and 0.6^{cc}, averaging 0.5^{cc}, which amount was deducted from the volume of gas obtained in each determination.

It is common to disregard the vapor tension of the caustic potash solution, especially when the latter is nearly concentrated. In accurate work, however, this is hardly allowable. Even a 50 per cent.

* The same as that described by Tollens, *Fres. Zeit. Anal. Chem.*, 17, 1878, s. 320.

solution gives an appreciable vapor tension, as has been shown by Wüllner (Pogg. Annalen 110, S. 570). Wüllner's statements are not perfectly clear at first reading, but the facts appear from his formula for the tension, $V = .0032T - .00000432T^2$, where V is the decrease of tension for every part of "pentahydrate of potash" to 100 of water (0.51 K_2O to 100 H_2O.) and T the vapor tension of pure water. Several determinations of the vapor tensions of the solutions actually used were made by my friend and assistant, Dr. J. H. Long, who has devoted considerable attention to these subjects, and who conducted the investigation here referred to. The results were in harmony with Wüllner's formula.

Applying both corrections for residual air, Dr. Long obtained, in determinations of nitrogen in several samples of fish, results agreeing very closely with those obtained with the soda-lime method by Messrs. Woods and Beamer, as appear from the following figures:

	Soda-lime method.			Absolute method.
	a.	b.	Average.	
XLII. Per cent. N	5.82	5.88	5.85	5.95
XLIII. Per cent. N	10.77	10.75	10.76	10.76
XLV. Per cent. N	13.85	13.79	13.82	13.91
XLVII. Per cent. N	10.19	10.24	10.22	10.22
XLVIII. Per cent. N	11.91	11.89	11.90	11.05
L. Per cent. N	11.85	11.85	11.85	11.78
LI. Per cent. N	10.85	10.83	10.84	10.83
LIII. Per cent. N	14.84	14.86	14.85	14.87

It may be added that previous comparative trials with ammonium sulphate and oxalate had given closely concordant results. Thus, Dr. Long found by the absolute, and Mr. Woods by the soda-lime method, the following percentages of nitrogen*:

	Absolute method.					Soda-lime method.		
	a.	b.	c.	d.	Average.	a.	b.	Average.
Ammonium sulphate	21.24	21.16	21.29	21.25	21.23	21.18	21.17	21.18
Ammonium oxalate	19.84	19.75	19.71	....	19.77	19.68	......	19.68

Ash.—The ash was determined in the flesh in the same way as in the hot and cold water extracts, namely, by charring, extracting with water, burning the residue, adding the solution to the residue, evaporating and burning. The crude ash thus obtained was practically free from coal, and had, naturally, no sand. No determinations of carbonic acid in the ash were made. About 5 grams of substance were used for each deter-

*It may be worth while to add that direct determinations of ammonia by distillation with caustic alkali gave in the ammonium sulphate, 21.19, 21.21, and 21.22%, average 21.21%; with ammonium oxalate, 19,78 and 19,74%, average 19.76%, results midway between those by the two methods above.

mination. "B" (the air dried material) was employed for determination of ash, as well as for those of phosphorus, sulphur, and chlorine.

Phosphorus. (*Phosphoric Acid.*)—About 1 gram of substance was carefully burned in a platinum capsule, with some 10 grams of a mixture of equal parts of sodium nitrate and carbonate, previously proven free from phosphates. The white mass was dissolved in water, acidulated with nitric acid, evaporated, and treated with nitric acid again, the operation repeated when necessary to remove chlorine, and the phosphoric acid estimated with ammonium molybdate solution. A number of tests were made by Mr. Merrill to determine the circumstances in which phosphoric acid, in presence of large amounts of sodium nitrate, as here, is completely precipitated. The results will, I hope, be published hereafter. In brief, at the temperature of the trials, which in each case was not far from 20°, two precautions are necessary: use of a large excess of molybdate solution, and allowance of ample time for the precipitation. Neglect of these involves risk of loss of phosphoric acid, as is shown by the following brief recapitulation of results. The effect of higher temperature was not tested.

Time of precipitation and amount of molybdic solution used.	12–20 hours; 25cc.		36 hours; 25cc.		36 hours; 50cc.	
	a	*b*	*a*	*b*	*a*	*b*
10cc Na_2HPO_4 Solution with no $NaNO_3$ yielded P_2O_5, grms.	.0212	.0211				
10cc Na_2HPO_4 Solution with 5 grms. $NaNO_3$ yielded P_2O_5, grms.	.0211	.0212				
10cc Na_2HPO_4 Solution with 10 grms. $NaNO_3$ yielded P_2O_5, grms.	.0207	.0211	.0211	.0211	.0213	.0212
10cc Na_2PHO_4 Solution with 20 grms. $NaNO_3$ yielded P_2O_5, grms.	.0190	.0191	.0211	.0211	.0212	.0211

Practically we use 25cc of molybdic solution, and allow 36 to 48 hours for the precipitation.

Sulphur.—About 1 gram of substance is oxidized as for determination of phosphorus, the mass dissolved in hydrochloric acid, and the sulphuric acid determined with barium chloride. Quite an extended series of determinations were made to learn the effect of varying quantities of sodium chloride upon the precipitation of barium sulphate in solutions, hot and cold, concentrated and dilute. The details, which the limits of this article compel me to defer for subsequent publication, showed conclusively that, although when precipitated cold from concentrated solutions, the barium sulphate is apt to be too heavy, *i. e.*, to bring down sodium chloride; yet, when precipitated hot, or even precipitated cold from dilute solutions, it is pure. This is in accordance with the previous observations on which general practice is based. Our determinations served simply to show the limits of concentration and amount of sodium chloride within which it is safe to work. It should be noted, however, that the solutions contained in all cases a small, but only a small, amount of free hydrochloric acid, and that only a small excess of barium chloride was used in the precipitation. Practically, we find the ordinary method as recommended by Fresenius accurate for these determinations, even in presence of the large amounts of sodium chloride, provided the proper precautions are observed. But the solution must be sufficiently dilute, and excess of free acid and of barium chloride should be avoided.

Chlorine was determined by burning the substance in platinum evaporating dishes, as in the determinations of phosphorus and sulphur, and estimating the chlorine in the fused mass with ammonium sulphocyanate by Volhard's process. Dr. Long, by whom the determinations were made, has, at my request, made tests of the applicability of this method of determining chlorine in animal tissues.

Ten parts of a mixture of equal weights of sodium carbonate and potassium nitrate were used to each part of the substance for the oxidation. To test the conditions in which chlorine may be lost in the burning, experiments were made with sugar and sodium chloride intimately mixed. Allowing for the very small amounts of chlorine in the sugar, it was found that when the oxidation was conducted slowly and carefully the whole of the chlorine was, in each of four trials, recovered; but with rapid burning in four trials from 1.0 to 2.7 per cent. of the whole chlorine was lost. But while no appreciable amount of chlorine escapes in careful burning there is apt to be great loss of it if its determinations in the fused mass is attempted in the ordinary way by dissolving, precipitating with silver nitrate and weighing as silver chloride. Indeed, Dr. Long found that in some cases less than half as much chlorine was obtained by the gravimetric methods as by Volhard's process.

The method actually followed in the determinations was as follows:

1st. The substance was *slowly* fused with the mixed nitrate and carbonate so as to avoid any possible loss by spurting.

2d. The fused mass was dissolved in quite dilute nitric acid, since by using a stronger acid some chlorine could easily be driven off, as was found by experiment.

3d. To the solution thus obtained an excess of silver nitrate solution was added, and the whole boiled on the water bath for about two hours. This long boiling with excess of nitric acid, added after the silver nitrate, was necessary to expel nitrous acid coming from the reduction of the nitrate in the fusion.

4th. After the boiling, the solution was allowed to become quite cold before titrating.

PART II.

ANALYSES OF INVERTEBRATES,

BY C. D. WOODS, B. S., AND MILES BEAMER, C. E.

[The following analyses have been undertaken and reported, at my suggestion, by Messrs. Woods and Beamer, who have also shared in the analyses of fish above described.

Thanks are due to Mr. F. T. Lane, of New Haven, Conn., and Mr. J. F. Ely, of Baltimore, Md., and especially to Mr. E. G. Blackford,* Fish Commissioner of the State of New York, for samples furnished for analysis, and for valuable information.—W. O. A.]

DESCRIPTION OF SAMPLES.

In the descriptions as well as in the tables which follow the samples of each species are arranged in the order of locality, the most northern coming first.

OYSTERS (*Ostrea Virginiana*).

No. LXVIII. From *Buzzard's Bay, Mass.*

Received from Messrs. Bunting and Warren, Newton, Mass., May 5, 1881. They were of medium size. The relative amount of edible portion (flesh and liquids) as compared with shell was large, 20.01 per cent. Only one sample of all gave a larger percentage of edible material than this.

No. LXX. From *Providence River, Rhode Island.*

Received at the same time and from the same parties as No. LXVIII. They were larger than the average oyster even of our northern coast, but with this larger size of shell there was relatively less edible portion, 17.00 per cent.

No. LV. From *Stony Creek, Conn.*

Purchased, April 5, in Middletown, but originally obtained from the Stony Creek Oyster Company. These were very large, the length averaging not far from 6 inches. There were 39 in one peck.

No. LXXV. From *Stony Creek, Conn.*

Purchased in Middletown, May 24, 1881. The analysis of this second sample from the same locality as the previous one was suggested by the claim of the oystermen that the oysters at this time were much better than they had been earlier in the season. The analysis shows very little difference in composition, No. LXXV containing relatively less nitrogen and more fat. The percentages of water were: in No.

* A portion of the expense of the investigation was also borne by Mr. Blackford, as stated in the introduction to the present report.

LV, 90.04; No. LXXV, 90.89. Calculated on dry substance, the analysis of edible portion is as follows:

	Albuminoids.	Fat.	Ash.	Nitrogen.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
No. LV	34.76	3.55	48.50	5.57
No. LXXV	32.89	3.99	48.93	5.27

Of course the relation between composition and quality of oysters cannot be determined by two analyses. An extended series of observations might bring very interesting results.

No. LIV. *Fair Haven, Conn.*

Purchased, April 4, 1881, in Middletown. They were described as "natives," from H. C. Rowe & Co., Fair Haven, Conn., and had been dredged three days. There were thirty-three oysters in one-half peck.

No. LVI. *Blue Point*, from *Patchogue, L. I.*

Furnished, April 8, 1881, by Mr. E. G. Blackford, Fulton Market, New York City.

No. LVIII. From *Rockaway, L. I.*

Furnished, April 12, 1881, by Mr. Blackford.

No. LVII. *East River*, from *Cow Bay, L. I.*

Furnished April 8, 1881, by Mr. Blackford.

No. LX. "*Sounds*," from *Princes' Bay, Staten Island.*

Furnished by Mr. Blackford, April 20, 1881.

No. LXI. *Shrewsbury, N. J.*

Furnished, April 20, 1881, by Mr. Blackford.

No. LIX. *Virginias*, from *Norfolk, Va.*

Furnished, April 12, 1881, by Mr. Blackford.

No. LXXIII. *Virginias Transplanted* (to New Haven, Conn.).

Furnished by Mr. F. T. Lane, New Haven, Conn., May 16, 1881. In an accompanying letter, Mr. Lane says: "From James River, Virginia, and what we consider the best stock to plant, * * * have been planted here five weeks."

No. LXXII. *Virginias Transplanted* (to New Haven, Conn.).

Received as No. LXXIII. In an accompanying letter Mr. Lane says: "Are from Rappahannock River, Virginia, and are what we use mostly for winter and spring. They have been planted here three weeks, and taken up into a river where the water is quite fresh, and put into floats for forty-eight hours to fatten them."

No. LXXI. *Virginias Transplanted* (to New Haven).

Received as Nos. LXXIII and LXXII. Mr. Lane writes: "Are from the Potomac River, Virginia, and are the cheapest of anything that we get from the South. They have been planted here three weeks."

No. LXXIV. "*Cove*" or *Canned Oysters*.

Furnished by Mr. J. F. Ely, Baltimore, Md., May 24, 1881. In an accompanying letter, Mr. Ely says: "The oysters we *steamers* use are gathered from all points on the Chesapeake Bay and mouth of the Potomac River. There is no agency but heat applied in their preparation." We received as samples two cans, one half-pound and one pound can. The former conained 36, the latter 77 oysters.

SCALLOPS (*Pecten irradians*).

No. LI. *Shelter Island, N. Y.*

Furnished by Mr. Blackford, March 15, 1881. The sample consisted not of the whole scallop, but of the part usually eaten—the adductor muscle—and, of course, contained no refuse.

No. LXIII. *Shelter Island, N. Y.*

Furnished by Mr. Blackford, April 26, 1881.

LONG CLAMS (*Mya arenaria*).

No. LXVII. *Boston Harbor, Mass.*

Received from Messrs. Bunting & Warren, May 5, 1881.

No. LXV. *Napaug, L. I.*

Purchased in Middletown, April 28, 1881.

ROUND CLAMS (*Venus mercenaria*).

No. LXVI. *Little Neck, L. I.*

Purchased in Middletown, April 28, 1881.

LOBSTER (*Homarus americanus.*)

No. L. *Maine.*

Sample—two lobsters—furnished by Mr. Blackford, March 15, 1881. In separation of edible and refuse the weights of flesh, liquids, refuse, and loss in cleaning in the different parts of each animal were determined as follows:

	A.	B.
	Grams.	*Grams.*
Whole lobster	870.0	1,103.0
Flesh in claws	152.5	219.5
Flesh in tail	138.0	131.0
Flesh in body	118.5	127.5
Liquids in whole sample	54.4	94.8
Waste in whole sample	367.8	499.5
Loss in cleaning sample	38.8	30.7

The liquids in all the lobsters on being exposed to the air quickly gelatinized, and were put with the flesh for analysis.

No. LXII. *Maine.*

Furnished by Mr. Blackford, April 26, 1881.

No. LXIX. *Boston Bay, Mass.*

Received from Messrs. Bunting & Warren, May 5, 1881.

No. LXXVI. *Canned Lobster.*

Purchased in Middletown, May 26, 1881. The can was labelled "Thurber's Egmont Bay Fresh Lobster," H. K. & F. B. Thurber & Co., New York City. In a letter Messrs. Thurber & Co. say: "Sample was packed by Castine (Maine) Packing Company. The sample consisted of a pound can, the contents weighing 469.5 grams, or 1 pound 0.5 ounce.

CRAY FISH (*Cambarus*).

No. LXIV. *Potomac River, Virginia.*

Furnished by Mr. Blackford, April 26, 1881. The animals were whole, but only the tails were used for analysis, as this is the portion ordinarily eaten.

The weights of the different portions in the whole 21 samples were:

Cray fish, entire.	Grams.
Tails	170.6
Bodies	508.0
Loss in cleaning	10.4
Total	695.0
TAILS.	
Edible portion	85.5
Refuse	83.8
Loss in preparing for analysis	7.0
Total	170.0

Thus while the edible portion makes nearly 50 per cent. of the part taken for food, it is only 12.3 per cent. of the whole animal.

PREPARATION OF SAMPLES FOR ANALYSIS.

The oysters were, with the exception of the "cove" or canned oyster, all received in the shell. All adhering foreign matters—as mud, seaweed, hydroids, gasteropods, &c.—were removed by thorough washing. The oysters were then allowed to drain, wiped, and weighed. The weighed oysters were opened, the liquid thus escaping being caught in a large evaporating dish. The oysters after being opened were put upon a porcelain colander ("crystal drainer"), and allowed to drain into a beaker. In this way some very small particles of solid matter would probably be added to the filtrate. For the purposes of analysis we have called the part remaining upon the perforated dish "flesh," and the filtrate "liquids." The flesh and liquids in the cove oyster were separated in the same way. After this separation the flesh was chopped in an ordinary wooden tray till the sample was quite fine, and evenly and thoroughly mixed, as was done with the samples of fish reported by Professor Atwater.

In the scallops we have analyzed only the part usually eaten, viz, the muscle (*adductor*) that holds the shell together. They came from the market all ready for cooking, and were analyzed just as received, the flesh being chopped and sampled in the same way as that of the oyster.

The clams were prepared in the same way as the oysters, except that in the long clam the black "mantle" was added to the refuse. In the case of the lobsters and crayfish the flesh was carefully separated from the shell and prepared as above. For parts taken for analysis see "Description of Samples" above.

In all of the samples a portion, usually about 100 grams, of the chopped flesh was dried in hydrogen and prepared for analysis in the same manner as the hydrogen dried samples (A) of fish described by Professor Atwater in "Methods of Analysis."

The liquids were evaporated on a water bath and then dried in air, as the samples of fish designated as "B."

METHODS OF ANALYSIS.

The methods of analysis were the same that have been employed in this laboratory and described by Professor Atwater above. We are indebted to Dr. J. H. Long for the determinations of chlorine in all the samples.

DESCRIPTION OF TABLES.

In all the tables the arrangement of samples is the same, and in order of locality, the more northern coming first. The canned oysters and lobsters are not included in the averages.

TABLE V.

In the second column is given the date of receipt of each sample at the laboratory. In most cases they had been taken from the water two or three days before they were received by us. As will be seen in the third column, the number taken for analysis was always large in order to obtain a fair sample. In the fourth column are given the total weights of the samples taken for analysis, and in the fifth are the average weights of the animals. Details as to the proportions of shell, flesh, liquids, total edible portion, &c., in the several samples of oysters and of other invertebrates are given under the heading "In whole sample." Thus the 48 oysters in the sample from Norfolk, Va., weighed together 6,635.5 grams (14 pounds 9 ounces), and averaged 138.3 grams (4.9 ounces). Of the total weight, 11.2 per cent. consisted of "edible portion" (solid and liquid), the remaining 88.8 per cent. being reckoned as "refuse" (88.3 per cent. shell, and 0.5 per cent. matters lost in preparing for analysis), while of the total weight of the 33 oysters in the sample of Blue Points, 20.3 per cent. was edible portion, the rest being shell, &c.

In an article published in *Land and Water* and reprinted in *The Sea World* of November 10, 1880, Mr. Frank Buckland gives some determinations of the relative proportions of flesh and shell in different samples of oysters. But as he takes only three oysters for the basis of his percentages in each, and does not weigh nearer than one-fourth ounce, his estimates can be regarded as only approximate for the samples examined. We may also add that we have found as great differences in different oysters from the same sample as he finds in oysters from different localities. It was in order to obviate as far as possible this source of error that we have taken such a large number of oysters in each sample. The only American oyster Mr. Buckland notices is one from East River, New York, laid at Beaumarais, North Wales. In this he finds the proportion of flesh to shell one to ten.

The figures for "Flesh" denote the percentages of solids or "meat" those under "liquids" the liquid portion, "liquor" in the sample. The solids and liquids together are designated as "edible portion," which, with "refuse" and "loss in cleaning," make up the whole sample.

Under the heading "In Flesh" are given the percentages of water and dry substance in the flesh. After these follow the same percentages for liquids and for the whole edible portion.

Some explanation may be needed of the way in which these calculations have been made. For example, in obtaining the figures in the column headed "water" in total "edible portion", the percentages of flesh and of liquids in the total edible portion were multiplied each by its percentage of water as given in the table, the two products added and their sum divided by the sum of the percentages of flesh and liquids, the quotient being the percentage of water in the edible portion. The calculation for the Buzzard's Bay oyster is as follows:

$$\frac{(12.50 \times 84.21) + (7.51 \times 96.40)}{20.01} = 88.78.$$

The last three columns, "dry substance of flesh," "dry substance of liquids," and "dry substance of edible portion" are obtained by multiplying the percentage of each in the whole sample by its percentage of dry substance.

Table VI.

This table gives the figures for the dry substance in the flesh and in liquids. The only columns needing any explanation are those of albuminoids, phosphorus, and sulphur. The per cent. of "albuminoids" is obtained by multiplying the nitrogen by the factor 6.25. The phosphorus and sulphur are calculated as phosphoric and sulphuric anhydrides. The last division of the table "in flesh and liquids" is calculated as in Table V, already explained.

Table VII.

In the first section of Table VII the analyses of Table VI are calculated over to "fresh substance." By fresh substance are here meant the flesh and liquids as they were after the separation described under

"Preparation of Sample" above. The percentages in the column headed "extractives" are obtained by difference. That is, the albuminoids (as computed by multiplying nitrogen by 6.25), fats, and ash are added and their sum subtracted from the total dry substance. Though this method of computation is common in statements of the composition of animal and vegetable foods it is of course only a convenient and approximately accurate way of getting over the difficulty of determining and stating exactly the amounts of the several ingredients. It will be noticed that "extractives" as thus determined by difference are not the same as the "extractive matters" of the tables of analyses of fish.

The most important column from an economic point of view is the one headed "nutritive valuation." The calculations are based upon the standards assumed by König, and explained by Professor Atwater. Their valuations, though not absolute, are doubtless sufficiently accurate for purposes of comparison.

PREVIOUS ANALYSES OF INVERTEBRATES.

But very little work has been done hitherto in the way of analyses of invertebrates. In the very full compilation of analyses of this sort, given by König (*Nahrungsmittel* I. 17), one of a sample of oyster and one of the salt flesh (salted in brine) of a crustacean ("*Krebsfleisch, eingemacht*") are recorded, both analyses being by König and Kraut. The analyses are given below. Mr. R. H. Chittenden has reported analyses of two samples of American scallops (*Pecten irradians*) with results as appended, except that in the figures herewith the percentages of albuminoids have been, for reasons above stated (see Methods of Analysis), recalculated by multiplying the nitrogen by 6.25 instead of 6.4, the factor employed, perhaps more justly, by Mr. Chittenden. The extractives are estimated by difference, as explained above.

	Water.	Albuminoids.	Fats.	Extractives.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Oyster; European*	80.69	4.95	0.37	2.62	2.37
"*Krebsfleisch*," European	72.74	13.63	0.36	0.21	13.06†
Scallop, American	79.63	15.31	0.31	3.49	1.26
Scallop, American	80.25	14.69	0.28	3.55	1.23

* The analysis of the oyster included the total shell contents.
† "Of the ash of the *Krebsfleisch*" 11.98 per cent. was sodium chloride.

PART III.

GENERAL SUMMARY OF RESULTS OF ANALYSES OF FISH AND INVERTEBRATES.

The object of the present investigation has been to obtain information as to both the chemical constitution of the flesh of the animals investigated and their economic values especially for food.

The work thus far accomplished must be regarded as barely a beginning. I hope to be able to prosecute it further in both the directions named. Meanwhile it may be proper to consider some of the results already attained.

I do not yet feel prepared to enter upon the discussion of the chemical constitution of the flesh, and will therefore confine myself to the more practical question of the economic values of the samples analyzed, reserving the more abstract subject until satisfactory data shall have been obtained.

COMPARATIVE STATISTICS OF SAMPLES OF FISH.

It will facilitate a comparison of the composition of the different samples analyzed if we select some of the figures from the tables and place them in more convenient juxtaposition.

Considered from the standpoint of the food value, fish, as we buy them in the markets, consist of—

1. Flesh or edible portion.
2. Refuse—bones, skin, entrails, &c.

In Table I, under "Proportions of flesh and refuse" are given the percentages of flesh and refuse in the samples as received from the markets. As explained above, there was a slight but unimportant loss of flesh, owing to the difficulty of separating it from the skin, bones, &c. Below are some of the percentages of refuse:

Proportion of refuse—bone, skin, entrails, &c.

Kind of fish and portion taken for analysis.	Number of sample.	Per cent. of refuse, individual samples.	Averages of duplicate samples.
		Per cent.	*Per cent.*
Halibut, section of body	IX	11.72	17.90
Halibut, posterior part of body	I	24.08	
Salmon, entrails removed	XIV	23.84	
Cod, head and entrails removed	XI	31.87	33.65
Cod, head and entrails removed	III	35.43	
Mackerel, whole	XXXIX	35.35	
Mackerel, whole	VIII	39.45	
Mackerel, whole	XXX	49.69	44.69
Mackerel, whole	XIII	54.30	
Shad, whole	XXXII	47.20	
Shad, whole	X	47.65	48.85
Shad, whole	VI	51.60	
White perch, whole	XLIV	59.50	61.63
White perch, whole	XLVI	63.76	
Striped bass, whole	VII	57.01	58.20
Striped bass, whole	XIX	58.49	
Porgy, whole	XXXI	58.19	59.93
Porgy, whole	XV	61.66	
Flounder, entrails removed	II	58.07	
Flounder, whole	XXII	68.03	

Next to the halibut, the salmon had the least waste and most flesh. Then follow salt cod, salt mackerel, fresh cod dressed, &c.; while striped bass, porgy, and flounders end the list with the largest waste and least flesh of all. It is, of course, to be understood that the variations in individual samples of the same fish are so wide as to make a much larger number of determinations necessary to give us fair averages and allow satisfactory generalizations.

The proportions not only of flesh, but also of water and solids in the flesh differ widely in the different samples, as will be seen in the tables. Thus, in the third and fourth columns of Table II we find that the flesh in the samples of flounder contained from 83 per cent. to 85 per cent. of water, and only from 17 per cent. to 15 per cent. of dry substance, solids; while in the fat shad, mackerel, and salmon we have from 65 per cent. to 63 per cent. of water, and from 35 per cent. to 37 per cent. of dry substance. Below the samples of fish are arranged in the order of their percentages of dry substance in flesh.

Proportion of dry substance in flesh, edible portion.

	Number of sample.	Per cent. of dry substance in individual samples.	Averages of duplicate samples.
		Per cent.	*Per cent.*
Salmon (California), fat	XXVII	39.4	....
Salmon (eastern)	XIV	33.6	36.4
Canned salmon	XXIX	34.0	....
Salmon trout	XVII	33.2	....
Herring	XLVII	32.8	....
Spanish mackerel	XLIII	32.8	....
Shad	X	35.5	....
Shad	VI	30.7	....
Shad	XXXII	29.4	31.8
White fish	XVIII	29.9	....
Turbot	XLIX	29.9	....
Eels	IV	29.5	....
Sheep's-head	XLVII	28.5	....
Mackerel, very fat	XXXIX	37.3	....
Mackerel	XXX	26.3	....
Mackerel	XIII	25.8	....
Mackerel, lean	VIII	21.4	27.7
Halibut, very fat	IX	30.7	....
Halibut	I	20.7	25.7
Muskallonge	XLV	24.7	....
White perch	XLIV	24.9	....
White perch	XLVI	24.1	24.5
Alewives	V	24.2	....
Porgy	XXXI	23.1	....
Porgy	XV	23.3	24.2
Black fish	XXXVIII	23.8	....
Red snapper	XX	23.6	....
Red snapper	XXVI	23.0	23.3
Spent salmon, male	XXXV	24.7	....
Spent salmon, female	XXXVI	21.7	23.2
Brook trout	XXIV	22.9	....
Black bass	LIII	22.2	....
Blue fish	XII	21.8	....
Spent land-locked salmon, male	XL	21.6	....
Spent land-locked salmon, female	XLI	20.5	21.1
Striped bass	VII	21.4	....
Striped bass	XIX	20.9	21.2
Yellow pike-perch	LII	20.4	....
Smelt	XXIII	20.3	....
Haddock	XVI	19.4	....
Haddock	XXI	18.2	18.7
Cod	XI	17.5	....
Cod	III	17.0	17.3
Flounder	II	17.1	....
Flounder	XXII	15.2	16.2

Thus the flesh of flounder had 85 per cent. of water and only 15 per cent. of solids, while that of salmon contained 36½ per cent. of solids and 63½ per cent. of water, and the flesh of dried, smoked, and salt fish have still less water. Among the more watery kinds of fish are the flounder, cod, striped bass, and blue fish. Among those with less water and more solids are mackerel, shad, salmon, and salt and dried fish. The flesh of fish generally, though not always, contains more water than ordinary meats, as may be seen in Table VIII beyond.

Since neither the refuse, bones, entrails, &c., nor the water in the flesh have any food-value, the actual nutritive material of the fish is, of course, the dry substance of the flesh. To find the actual nutritive substance in a sample of fish we must first subtract the waste—the entrails, bones, skins, &c.—which leaves the flesh. We must then allow for the water in the flesh. What remains will be the total edible solids or actual nutrients in the sample. Thus, the sample of flounder No. II has 32 per cent. of flesh, of which only 15 per cent. is dry substance, so that the edible solids amount to only 15 per cent. of 32 per cent., or about 4.8 per cent. of the whole (as recalculated in Table IV, 4.85 per cent.). That is, 100 pounds of flounder like this sample would furnish only 4¾ pounds of nutrients, the rest being water and refuse. As explained in "Methods of analysis," however, the skin, which is nutritious and frequently eaten, is here reckoned as refuse. Considering, further, the small portions of flesh which could not be conveniently separated from the skin, bones, &c., the figures for the total edible solids are a trifle too small. Still the deficit is inconsiderable, and the figures are doubtless not far from a correct expression of the amounts of nutritive material which the samples would furnish in household use. Below the samples are arranged in the order of the percentages of edible solids.

Total edible solids, actual nutrients, in 100 pounds of samples as received from markets.

Kind of fish and portion taken for analyses.	Number of sample.	Percentages of nutrients, individual samples.	Averages of duplicate samples.
		Per cent.	*Per cent.*
California salmon, edible portion of anterior part	XXVII	39.39	....
Salmon, entrails removed	XIV	26.57	....
Smoked halibut	XXVIII	31.63	....
Salt mackerel	XLII	30.97	....
Boned cod, salt	XXV	30.01	....
Canned salmon	XXIX	29.95	....
Smoked herring	XXXIII	28.66	....
Eels, salt water; skin, head, and entrails removed	IV	22.50	....
Halibut, section of body, fat	IX	27.13	....
Halibut, posterior part of body, lean	I	15.67	21.40
Spanish mackerel, whole	XLIII	20.65	....
Salt cod, "boat fish"	XXXIV	20.99	....
Salt cod, "channel fish"	XXXVII	19.09	....

Total edible solids, actual nutrients, in 100 pounds of samples, &c.—Continued.

Kind of fish and portion taken for analyses.	Number of sample.	Percentages of nutrients, individual samples.	Averages of duplicate samples.
		Per cent.	*Per cent.*
Shad, whole	X	18.56	....
Shad, whole	XXXII	15.51	....
Shad, whole	VI	14.81	16.29
Turbot, whole	XLIX	15.61	....
Mackerel, whole	XXXIX	23.95	....
Mackerel, whole	XXX	13.24	....
Mackerel, whole	VIII	12.97	....
Mackerel, whole, lean	XIII	11.76	15.48
Salmon trout, whole, lean	XVII	14.38	....
Whitefish, whole	XVIII	13.69	....
Spent salmon, male, whole	XXXV	14.87	....
Spent salmon, female, whole	XXXVI	12.17	13.52
Muskallonge, whole	XLV	12.52	....
Smelt, whole	XXIII	12.51	....
Sheeps-head, entrails removed	XLVIII	11.99	....
Alewives, whole	V	11.95	....
Herring, whole	XLVII	11.52	....
Cod, head and entrails removed	XI	11.92	....
Cod, head and entrails removed	III	10.98	11.45
Bluefish, entrails removed	XII	10.96	....
Spent land-locked salmon, male, whole	XL	10.97	....
Spent land-locked salmon, female, whole	XLI	10.74	10.86
Brook trout, cultivated, whole	XXIV	10.77	....
Blackfish, whole	XXXVIII	10.72	....
Red snapper, entrails removed	XXVI	10.87	....
Red snapper, whole	XX	9.33	10.11
Porgy, whole	XXXI	11.73	....
Porgy, whole	XV	7.78	9.76
White perch, whole	XLIV	10.08	....
White perch, whole	XLVI	8.73	9.41
Black bass, whole	LIII	9.57	....
Striped bass, whole	VII	9.01	....
Striped bass, whole	XIX	8.87	8.94
Haddock, entrails removed	XVI	9.07	....
Haddock, entrails removed	XXI	8.68	8.88
Yellow pike-perch, whole	LII	8.46	....
Flounder, entrails removed	II	7.06	....
Flounder, whole	XXII	4.85	....

Before proceeding further with the discussion of the composition of the samples of fish we may note some of the figures for invertebrates.

STATISTICS OF THE SAMPLES OF OYSTERS.

The samples of oysters showed much wider variations than might have been anticipated, both in the proportions of edible substance, solid and liquids, to shell and in actual nutritive value.

In Table IV, under the heading "In whole sample," are given the percentages of flesh, liquids, and refuse (shell, &c.), in the samples analyzed. Below the samples are arranged in the order of the percentages of these constituents by weight, those with the largest proportion of each coming first in the category.

Proportions of flesh, of liquids, and of total shell contents (flesh and liquids) in samples of oysters.

Flesh in whole oysters.	Per ct.	Liquid in whole oysters.	Per ct.	Total shell contents in oysters.	Per ct.
Blue Point	13.39	Stony Creek	11.81	East River	20.28
Shrewsbury	12.64	Stony Creek	11.38	Buzzards Bay	20.01
Fair Haven	12.63	East River	10.01	Stony Creek	19.15
Buzzards Bay	12.50	Rockaway	7.72	Stony Creek	18.90
Providence River	10.88	Buzzards Bay	7.50	Blue Point	18.62
Rockaway	10.68	Rappahannock River	7.31	Rockaway	18.40
East River.	10.27	James River	7.29	Fair Haven	18.06
Staten Island	9.13	Staten Island	7.10	Shrewsbury	17.52
Rappahannock River	7.86	Norfolk	6.52	Providence River	17.00
Stony Creek	7.52	Providence River	6.12	Staten Island	16.23
Stony Creek	7.34	Potomac River	5.64	Rappahannock River	15.17
Potomac River	6.51	Fair Haven	5.43	James River	13.79
James River	6.50	Blue Point	5.23	Potomac River	12.15
Norfolk	4.66	Shrewsbury	4.88	Norfolk	11.18

Thus in the samples from East River, N. Y., and Buzzard's Bay, Mass., the contents of the shells, including both flesh and liquids, "meat" and "liquor," made respectively 20.2 and 20 per cent. of the whole weight, while of the samples from the James and the Potomac the shell contents constituted only 12.2 and 11.2 per cent. of the whole. The East River and Buzzards Bay were one fifth edible matter and four-fifths shell, while in the southern samples the shell contents made only one-eighth of the whole.

The ratios of flesh to liquids were still more variable. The sample of Blue Points had 13.4 per cent. of solids and 5.3 of liquids, while one from Stony Creek had 7.3 per cent. of meat and 11.8 of liquor. Taking the flesh and liquids separately the variation is even greater. The percentages of flesh range from 13.4 in the Blue Points to 4.7 in the Norfolks, the liquids from 11.8 in the Stony Creeks to 4.9 in the Shrewsburys.

None of the above figures, however, give a measure of the actual nutrients in the oysters, since both flesh and liquids consist mostly of water, and the proportions of dry substance which constitutes the actually nutritive portion are extremely variable.

Below the samples are arranged in the order of the percentages of dry substance in flesh, in liquids, and in total shell contents.

Proportion of dry substance, actually nutritive materials, in flesh, in liquids, and in total shell contents of oysters.

In flesh.	Per ct.	In liquid.	Per ct.	In total shell contents, flesh plus liquids.	Per ct.
Blue Point	23.76	Fair Haven	6.00	Blue Point	19.24
Potomac River	21.13	Blue Point	5.67	Providence River	15.21
Providence River	20.99	Providence River	4.95	Fair Haven	14.88
East River	20.08	Rockaway	4.94	Shrewsbury	14.68
Stony Creek	18.98	Shrewsbury	4.93	Potomac River	13.40
Rockaway	18.73	East River	4.56	Rockaway	13.02
Fair Haven	18.70	Potomac River	4.49	East River	12.43
Shrewsbury	18.35	James River	4.09	Buzzards Bay	11.20
Stony Creek	17.91	Stony Creek	3.88	Staten Island	10.42
Rappahannock River	17.30	Stony Creek	3.67	Rappahannock River	10.12
James River	16.51	Staten Island	3.65	Stony Creek	9.96
Norfolk	16.14	Buzzards Bay	3.60	James River	9.93
Buzzards Bay	15.79	Norfolk	3.17	Stony Creek	9.11
Staten Island	15.53	Rappahannock River	2.76	Norfolk	8.55

Thus in the flesh of the oysters the dry substance varies from 23¾ per cent. in the Blue Points to 15½ per cent. in the Staten Islands. The dry substance in the liquids varies from 5⅜ per cent. in the Blue Points to 2¾ per cent. in the Rappahannocks. The flesh of oysters is quite watery, more so than that of fish and much more than ordinary meats. The dry substance in the latter ranges from about 25 per cent. in lean beef to 50 per cent. in fat pork. In fish we find from 40 to 15 per cent., in the flesh of oysters from 24 to 15 per cent., and in the liquids, from 6 to as low as 2¾ per cent. The liquids contain but very little nutriment.

By comparing the proportions of flesh and liquids and the proportions of actual nutrients in them, we arrive at the figures for the actually nutritive substances in the oysters. Precisely this is done for the whole shell contents in the last of the above categories. The figures there represent the nutrients in the flesh and liquids together; that is, they show the proportions of actual nutrients in the total shell contents of the several samples. The range of variation of the nutrients is very wide, the Blue Points containing 19¼ per cent. and the Norfolks only 8⅓ per cent. In general, the Northern samples are the richest and the Southern the poorest in nutritive material. The mean of all the samples is not far from 14 per cent., a little above that of cow's milk, which averages about 12½ per cent. of dry substance.

If, however, we place the oysters in the order of the percentages of nutritive materials in the whole sample, including shell and contents, the arrangement will be as below. The other invertebrates are appended for comparison.

Percentages of nutritive materials in whole sample, including shell and shell contents.

	Per cent.		Per cent.
Oysters, Blue Point	3.37	Oysters, Staten Island	1.63
Oysters, Fair Haven	2.69	Oysters, Potomac River	1.68
Oysters, Providence River	2.58	Oysters, Rappahannock River	1.56
Oysters, Shrewsbury	2.55	Oysters, James River	1.37
Oysters, East River	2.53	Oysters, Norfolk	0.96
Oysters, Rockaway	2.38	Long clams	7.77
Oysters, Buzzards Bay	2.25	Round clams	3.38
Oysters, Stony Creek	1.87	Lobsters	6.80
Oysters, Stony Creek	1.76	Cray fish	2.31

These variations are the widest of all. The proportions of nutrients in the whole oyster, shell and all, are of course very small, the largest in the Blue Points, being only 3⅓ per cent. In 100 pounds of Norfolks we have less than one pound of nutritive material. Here again the samples from the New York and New England waters are the best, and those from Virginia the poorest.

THE NUTRITIVE VALUES OF FISH AND OTHER FOODS.

This subject has of late begun to attract very general attention. The chemico-physiological research of the past two decades has brought us where we can judge, with a considerable degree of accuracy, from the chemical composition of a food material what is its value as compared with other foods for nourishment. The bulk of the best investigation of this subject has been made in Germany, where chemists and physiologists have already got so far as to feel themselves warranted in computing the nutritive values of foods and arranging them in tables, which are coming into popular use.

As this may fall into the hands of some readers not entirely familiar with the latest developments of the chemistry of food and nutrition, I may be permitted to cite a few explanatory statements from a paper read before the American Fish Cultural Association.

THE NUTRIENTS OF FOODS.

We eat meat and fish, milk and bread, to build up our bodies, to repair their wastes, to supply heat, to keep ourselves warm, and strength with which to work. This is the common way of putting it. Speaking as chemists and physiologists, we should say that our food supplies, besides mineral substances and water, albuminoids, carbohydrates, and fats, whose functions are to be transformed into the tissues and fluids of the body, muscle and fat, blood and bone, and by their consumption to produce heat and force.

Albuminoids occur in plants, as in the gluten of wheat; and in the animal body, as in the fibrinogen and fibrinoplastic substances of blood, in the fibrin of muscle, in albumen (white) of eggs, and in the casein (curd) of milk.

The albuminoids are the most important of the nutrients of foods. Not only do they share in the formation of the fatty tissues and in the supply of material for the production of animal heat and muscular power, thus performing all of the functions of the other food ingredients in the body, but they also have a work of their own in the building up of the nitrogenous tissues, muscles, tendons, cartilage, &c., in which none of the other ingredients can share.

The carbohydrates, of which we have familiar examples in sugar, starch, and cellulose, differ from the albuminoids in that they have no nitrogen. They have, according to the best experimental evidence, no share in the formation of nitrogenous tissues in the body. It is hardly probable that they are transferred into fats to any considerable extent; their chief use in food seems to be to supply fuel for the production of animal heat, and very probably of muscular power. They are very important constituents of foods, but much less so than the albuminoids and fats. They occur in only minute proportion in meats, fish, and like animal foods.

The fats are familiar to us in the forms of vegetable fats and oils, like linseed and olive oils, in fat meat, tallow, and lard, and in butter. The fats, like the carbohydrates, are destitute of nitrogen. The fats of the food are stored in the body as fats, transformed into carbohydrates, and serve for fuel, but do not form nitrogenous tissue. They are more valuable than the carbohydrates, because richer in carbon and hydrogen, the elements which give value to fuel, and because they supply the body with fats.

In brief, the albuminoids, the nitrogenous constituents of foods (albumen, fibrin, &c.), which make the lean meat, the muscle, the connective tissues, skin, and so on, are the most important of the nutrients. Next in importance come the fats, and last the carbohydrates—sugar, starch, and the like. One reason of the inferior position of the carbohydrates is the fact that they have no nitrogen. The albuminoids can do their own work and all the work of the carbohydrates and the fats as well, while these latter can only do their own. With albuminoids alone we might make a shift to get on for a good while, but with carbohydrates and fats alone we should speedily starve.

See Reports of Am. Fish Cult. Ass'n., 1880 and 1881.

We might live on lean meat, but not on tallow and starch. Animal foods, meats, fish, and the like, consist mainly of albuminoids and fats, and contain very little of the carbohydrates. Vegetable foods, on the other hand, consist largely of carbohydrates, and contain less of the albuminoids and fats. Science and experience unite in testifying that a proper combination of all makes the most wholesome, as we know it gives the most agreeable, diet.

The table below is constructed to illustrate the composition and food values of the samples of fish, oysters, &c., analyzed, as compared with other animal foods and with each other. The figures for meat, game, milk, eggs, &c., as well as the basis of estimating the nutritive values, are from German sources.—(König, Nahrungsmittel, I, 206–210 and 223–226.) The analyses of fish (except the dried cod) and of invertebrates are taken from Tables I–VII of this report.

TABLE VIII.

Composition and valuations of animal foods.

[Valuation of medium beef assumed as 100.]

	Total edible solids, actual nutritive materials in whole sample. (1)	In flesh free from bone and other waste.					
			Solids—actual nutritive material.				
		Water.	Albuminoids, protein.	Fats.	Extractives. (2)	Mineral ingredients.	Nutritive valuation.
MEATS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Beef, lean	....	76.71	20.61	1.50	....	1.18	91.8
Beef, medium	....	72.25	21.30	5.19	....	1.17	100.0
Beef, fat	....	54.76	16.93	27.23	....	1.08	112.0
Veal, fat	....	72.31	18.88	7.41	0.07	1.83	92.4
Mutton, medium	....	75.99	18.11	5.77	....	1.83	86.6
Pork, fat	....	47.40	14.54	87.84	....	0.72	116.0
Smoked beef	....	47.68	27.10	15.85	....	10.59	146.0
Smoked ham	....	27.98	23.97	86.48	1.50	10.07	157.0
GAME, FOWL, &C.							
Venison	....	75 76	19.77	1.92	1.42	1.13	88.8
Hen, fat	....	70.06	18.49	9.34	1.20	0.91	93.9
Duck	....	70.82	22.65	8.11	2.83	1.09	104.0
MILK, EGGS, &C.							
Cow's milk	....	87.41	3.41	3.66	4.82	0.70	28.8
Cow's milk, skimmed	....	90.63	3.06	0.79	4.77	0.75	18.5
Cow's milk, cream	....	66.41	3.70	25.72	3.54	0.63	56.1
Butter	....	14.14	0.86	83.11	0.70	1.19	124.0
Cheese, skimmed milk	....	48.02	82.65	8.41	6.80	4.12	159.0
Cheese, whole milk	....	46.82	27.62	20.54	1.97	3.05	151.6
Cheese, very fat	....	35.75	27.16	80.43	2.53	4.13	163.0
Hens' eggs	....	73.67	12.55	12.11	0.55	1.12	72.2

(1.) The figures in the first column give the percentages of actual nutrients in the samples as actually found in the markets. Those for fish apply to either the whole or dressed samples, as stated in Tables I–IV of Part I of this report; those for oysters and clams to the shell contents; scallops, the muscle; lobsters and croy fish, the whole animal.

(2.) Essentially the carbohydrates, except in the European dried cod and in the invertebrates, in which the extractives are calculated as explained in Part II, "Methods of analysis," page 25.

Composition and valuations of animal foods—Continued.

	Total edible solids, actual nutritive materials in whole sample.	IN FLESH FREE FROM BONE AND OTHER WASTE.					
			Solids—actual nutritive material.				
		Water.	Albuminoids, protein.	Fats.	Extractives.	Mineral ingredients.	Nutritive valuation.
FISH (fresh).	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Perct.*
Halibut	21.40	74.31	18.23	6.33	....	1.14	87.9
Flounder	4.85	83.86	14.20	0.70	....	1.25	62.4
Cod	11.81	82.46	15.94	0.24	....	1.23	69.1
Haddock	8.86	81.22	17.26	0.16	....	1.36	74.9
Alewives	12.05	75.67	18.94	3.93	....	1.40	86.8
Eels (salt water)	22.50	70.48	18.85	9.77	....	0.90	95.6
Shad	16.30	68.17	18.80	11.66	....	1.36	98.2
Striped bass	8.94	78.86	17.86	2.15	....	1.14	80.4
Yellow pike-perch	8.42	79.61	18.55	0.47	....	1.37	80.9
Black bass	9.43	78.08	19.72	1.02	....	1.18	86.5
Mackerel	15.52	72.32	18.80	8.15	....	1.23	90.9
Blue fish	10.96	78.16	19.32	1.25	....	1.27	85.4
Salmon	32.09	63.52	19.73	15.67	....	1.08	107.9
Salmon trout	14.38	66.80	17.22	14.69	....	1.20	95.7
Brook trout	10.78	77.04	18.47	3.08	....	1.41	84.2
White fish	13.60	70.08	22.10	6.20	....	1.62	104.5
Porgy	9.66	75.84	18.15	4.65	....	1.36	85.2
Black fish	10.04	76.66	19.25	2.81	....	1.28	87.3
Red Snapper	10.10	76.74	20.53	1.81	....	1.42	90.7
Smelt	12.53	79.71	16.43	1.94	....	1.92	73.8
Spanish mackerel	20.03	67.77	21.34	9.39	....	1.50	105.9
White perch	8.74	75.43	19.[illegible]8	4.00	....	1.19	89.2
Muskallenge	12.47	75.33	20.24	2.87	....	1.56	91.8
Herring	11.48	67.77	19.43	11.32	....	1.48	100.4
Sheep's-head	11.97	71.54	20.68	6.68	....	1.10	96.9
Turbot	15.62	70.10	14.49	14.15	....	1.26	84.4
Spent salmon	12.96	76.84	18.41	3.60	....	1.14	84.8
CURED FISH.							
Salt cod	19.79	52.50	25.00	0.51	....	1.87	108.9
Boned cod	28.78	51.85	26.45	0.38	....	1.90	114.8
Dried cod (European)	....	16.16	78.91	0.78	2.59	1.56	846.0
Smoked halibut	32.45	50.85	18.43	15.57	....	1.64	102.2
Smoked herring	28.92	35.60	31.57	18.66	....	2.87	163.4
Canned salmon	29.91	66.00	21.10	11.04	....	1.86	107.2
Salt mackerel	33.14	42.66	21.87	22.84	....	1.63	125.4
INVERTEBRATES.							
Oysters, Stony Creek, Connecticut	9.54	90.47	4.42	0.62	1.84	2.66	21.6
Oysters, Fair Haven, Connecticut	14.88	85.12	7.53	1.44	3.41	2.50	37.6
Oysters, Blue Point, New York	19.24	80.76	8.20	1.72	7.30	2.02	44.3
Oysters, East River, New York	12.43	87.57	6.31	1.10	3.15	1.87	31.6
Oysters, Norfolk, Va	8.55	91.45	4.50	0.61	1.90	1.54	22.0
Oysters, Virginia (transplanted) (3)	5.04	88.84	5.09	1.02	2.99	2.06	26.1
Oysters, average of 14 samples	12.20	87.71	5.78	1.12	3.41	1.93	29.6
Oysters, "Cove" (canned)	13.86	86.14	7.89	2.04	2.51	1.42	39.2
Scallops, Shelter Island, New York	19.68	80.32	14.75	0.17	3.38	1.38	67.0
Long clams	13.92	86.08	7.97	0.94	2.54	2.47	38.0
Round clams	13.80	86.20	6.56	0.40	4.17	2.67	32.6
Lobsters	6.80	82.78	13.57	1.97	0.00	1.74	62.0
Lobsters (canned)	20.64	79.86	16.75	4.62	0.00	2.78	79.1
Cray fish	2.31	81.22	16.00	0.46	1.01	1.31	70.7

Three things should be said with reference to this table.

First. The figures represent simply the averages of analyses made up to the present time.

(3.) To New Haven, Conn.

Second. The figures of some of the kinds of food, indeed all except the fresh meats, milk and its products, and eggs, are based upon few analyses. More are needed to show the actual ranges of variation and the actual averages. Sometimes different samples of the same kind of flesh will show widely varying percentages of constituents. This is especially true of the fats, and to a less extent of the water. But the figures in the table are probably not very far from true representations of the average composition of the several kinds of foods.

Third. The nutritive valuations are made with only an imperfect knowledge of the digestibility of the foods and the influence of palatibility and other factors upon the nutritive value. They are, therefore, of necessity somewhat crude, and to be relied upon rather as approximations than as accurate quantitative statements. Much more chemical and physiological investigation is needed to make our knowledge of these as complete and satisfactory as it should be.

This table is, I think, worth studying. As above explained, after taking out the refuse, bones, skin, entrails, &c., of the sample we have left the edible portion, the flesh (or, in case of oysters, clams, &c., the flesh and liquids together). Multiplying the percentage of flesh by that of actual nutrients in each sample gives the actual nutrients in the sample, as is done in the first column. The composition of the edible portion is given in the four columns under "In flesh," the figures being taken from Tables IV and VII. As shown above, the proportions of flesh and of water and dry substance in the flesh differ greatly in the different samples.

PROPORTIONS OF NUTRIENTS.

The proportions of albuminoids, fats, &c., are, if anything, still more varied. The cod, haddock, and bass, have scarcely any fat, and the oysters, scallops, and clams, very little. But the eels, shad, mackerel, salmon, herring, and turbot are very fat. On the whole, fish average about the same percentages of albuminoids as the meats, but generally have less of fats.

It would be interesting to note in more detail the proportions of the constituents of the flesh, especially as illustrated in Tables II, III, and IV. The constituents soluble in cold and hot water, for instance, which so far as is known are analogous to those of meats, are of considerable interest, but demand much more investigation. Meat extract has become an important article of commerce. There is a fortune for somebody, I mistrust, in the extract from menhaden.

"FOUL" OR "SPENT" FISH *vs.* THE SAME IN GOOD CONDITION.

Some very interesting results are found in comparing the composition of the foul or spent fish with the same in good condition, as shown in Table II. As the fish becomes lean, it loses nutritive value in three ways; first, in total loss of weight; second, in relative increase of refuse and decrease of flesh; and, third, in the deterioration of the quality of the flesh which, in the lean fish, is more watery and considerably less valuable, pound for pound, than the flesh of the same fish in good condition. Thus the flesh of spent salmon is rated in the last column at 85, while that of fat salmon came up to 108. There is in this a strong argument in favor of legislation against the capture of fish out of season. In general the fatter fish are more valuable than the leaner, pound for pound, because they have more nutritive material and less water.

RELATIVE NUTRITIVE VALUES OF FISH AND OTHER FOODS.

The above table will help us to a very fair idea of the comparative composition of some of our more common animal foods.

Looking down the first column we see that while medium beef contains 72 per cent. of water, milk contains 87½ per cent. Roughly speaking, beefsteak is about three-fourths, and milk seven-eighths, water. A pound of beefsteak would thus contain four ounces of solids, and, if we assume a pint of milk to weigh a pound, a quart would contain four ounces of solids also; that is, a pound of steak and a quart of milk contain about the same weight of actual nutrients. But we know that for ordinary use the pound of beefsteak is worth more for food than the quart of milk. The reason is simple. The solids of the lean steak are nearly all albuminoid, while those of the milk consist largely of fats and of milk-sugar, a carbohydrate.

The figures in the last column are intended to show how the foods compare in nutritive value, "medium beef" being taken as a standard. They are computed by ascribing certain values to the albuminoids* and fats, and taking the sum in each case for the value of that particular food. The ratio here adopted, which assumes one pound of albuminoids to be equal to three pounds of fats and five pounds of carbohydrates, is that assumed by prominent German chemists.

Taking medium beef at 100, the same weight of milk comes to 23.8; mutton, medium, to 86.6; fat pork, 116, and so on. The samples of fish run from flounders, 65, to smoked herring, 163; while the European dried cod is rated at 346. Thus we have for example the following valuations for flesh, free from bone, skin, shell, and other refuse—

FISH.

Smoked herring	163.4	Shad	98.2
Salt mackerel	125.4	Mackerel	90.9
Boned cod	114.8	Red snapper	90.7
Salt cod	108.9	Blue fish	85.4
Salmon	107.9	Striped bass	80.4
Canned salmon	107.2	Haddock	74.9
Spanish mackerel	105.9	Cod	69.1
White fish	104.5	Flounder	62.4

INVERTEBRATES.

Oysters, Blue Point	44.3	Oysters, Norfolk	22.0
Oysters, "Cove" or "canned"	39.2	Scallops	67.0
Oysters, East River	31.6	Long clams	38.0
Oysters, Virginia (transplanted)	26.1	Round clams	32.6
		Lobsters	62.0

*E. g., *König, Zeitschrift für Biologie*, 1876, 497.

CHEAP *versus* DEAR FOOD.

These figures differ widely from the market values. But we pay for our foods according to, not their value for nourishing our bodies, but their abundance and their agreeableness to our palates.

As was stated in the introduction to this report, taking the samples of fish at their retail prices in the Middletown markets, the total edible solids in striped bass came to about $2.30 per pound, while in the Connecticut River shad, whose price was very low, we bought nutritive material at 44 cents per pound. The cost of the nutritive material in one sample of halibut was 57 cents, and in the other $1.45 per pound, though both were bought in the same place, at the same price, 15 cents per pound, gross weight.

As I have said, to the man whose income will permit him to eat what he likes regardless of cost, it makes very little difference how much he pays for the albuminoids and fats of his food, but it does make a difference to people of small means, and the knowledge that just study of these matters will bring, when obtained and diffused among the people, cannot fail to do great good.

The cook-books and newspapers have occasionally something to say upon these points, but their statements are apt to be as vague and far from the truth as in the lack of authoritative information they might be expected to be. Certain it is that we need to know more about these things, and that proper investigations may help us toward that knowledge.

FISH AS BRAIN FOOD.

Before closing I ought, perhaps, to refer briefly to the widespread notion that fish is particularly valuable for brain food. The percentages of phosphorus in the analyses above reported are not larger than are found, according to the best analyses, in the flesh of other animals used for food. The number of reliable determinations of flesh in the latter are, however, small, and it is, though very improbable, yet within the range of possibility that a more complete investigation of the subject might reveal a smaller proportion of phosphorus in meats than in fish.

But even if the fish be richer in phosphorus there is no proof that it would on that account be better for brain food. The question of the nourishment of the brain and the sources of intellectual energy are too indeterminate to allow decisive statements, and too abstruse for speedy solution in the present condition of our knowledge.

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TABLE I.

Laboratory number of sample.	Kinds of fish and portions taken for analysis	Number of fish in sample.	Cost per pound.	Proportions of flesh and refuse: Flesh, edible portion.	Refuse, bones, skin, entrails, etc.	Loss in preparing for analysis.	Total weight of sample.	Percentage of flesh in sample.	Analysis of flesh. In flesh: Water.	Dry substance, solids.
			Cts.	Grms.	Grms.	Grms.	Grms.	Pr. ct.	Pr. ct.	Pr. ct.
I	Halibut (*Hippoglossus americanus*). Posterior part of body, lean	...	15	1,438.0	438.0	18.0	1,894.0	75.92	79.15	20.85
II	Flounder (*Paralichthys dentatus*). Entrails removed	2	10	954.0	1,316.0	38.0	2,308.0	41.33	83.37	16.63
III	Cod (*Gadus morrhua*). Head and entrails removed	1	10	1,795.0	937.0	48.0	2,780.0	64.57	83.12	16.88
IV	Eels (*Anguilla rostrata*). Skin, head, and entrails removed	11	15	1,043.0	293.0	32.0	1,368.0	76.24	69.80	30.20
V	Alewives (*Pomolobus vernalis*). Whole. Connecticut River	12	15	425.0	434.0	...	859.0	49.48	75.92	24.08
VI	Shad (*Alosa sapidissima*). Whole. Hudson River	2	20	930.0	950.0	45.0	1,925.0	48.31	69.65	30.35
VII	Striped bass (*Roccus lineatus*). Whole. Connecticut River	1	20	865.0	1,165.0	25.0	2,055.0	42.09	79.18	20.82
VIII	Mackerel (*Scomber scombrus*). Whole	4	15	775.0	490.0	15.0	1,280.0	60.55	78.69	21.31
IX	Halibut (*Hippoglossus americanus*). Section of fatter portion of body	...	15	949.0	120.0	6.0	1,075.0	88.28	70.13	29.87
X	Shad (*Alosa sapidissima*). Whole. Connecticut River	1	08	835.0	740.0	20.0	1,595.0	52.35	65.25	34.75
XI	Cod (*Gadus morrhua*). Head and entrails removed	1	08	1,725.0	774.0	33.0	2,532.0	68.13	83.39	16.61
XII	Bluefish (*Pomatomus saltatrix*). Entrails removed	1	10	702.0	680.0	18.0	1,400.0	50.14	78.46	21.54
XIII	Mackerel (*Scomber scombrus*). Whole	2	18	411.0	465.0	22.2	898.2	45.70	74.26	25.74
XIV	Salmon (*Salmo salar*). Entrails removed. Maine	1	...	3,628.4	1,135.9	...	4,764.3	76.16	67.15	32.85
XV	Porgy (*Stenotomus argyrops*). Whole	4	...	494.8	775.8	19.9	1,290.5	38.34	79.68	20.32
XVI	Haddock (*Melanogrammus æglefinus*). Entrails removed	1	08	890.0	977.0	33.0	1,900.0	46.84	80.30	19.70
XVII	Salmon trout. "Mackinaw trout" (*Salvelinus namaycush*). Whole. Lake Ontario	1	...	1,559.2	2,028.0	13.2	3,600.4	43.31	68.78	31.22
XVIII	Whitefish (*Coregonus clupeiformis*). Whole. Lake Champlain	1	...	601.0	702.0	10.0	1,313.0	45.76	70.83	29.17
XIX	Striped bass (*Roccus lineatus*) Whole. Bridge Hampton, L. I	1	...	467.0	625.0	6.5	1,098.5	42.51	79.73	20.27
XX	Red snapper (*Lutjanus Blackfordii*). Whole. Fernandina, Fla	1	...	1,388.9	2,104.6	14.0	3,507.5	39.60	76.81	23.19
XXI	Haddock (*Melanogrammus æglefinus*). Entrails removed. Rockaway, L. I	1	...	1,140.9	1,240.1	21.2	2,402.2	47.50	82.03	17.97
XXII	Flounder (*Paralichthys dentatus*). Whole. Amagansett, L. I	1	...	402.0	840.0	15.5	1,257.5	31.97	85.04	14.96
XXIII	Smelt (*Osmerus mordax*). Whole. Hackensack River, N. J	73	...	632.0	356.2	34.8	1,023.0	61.78	80.16	19.84
XXIV	Brook trout (*Salvelinus fontinalis*). Whole. Cultivated	6	...	608.0	649.0	38.0	1,295.0	46.95	77.54	22.46
XXV	Boned cod (*Gadus morrhua*)	...	...	...	...	...	...	...	54.35	45.65
XXVI	Red snapper (*Lutjanus Blackfordii*). Entrails removed. Florida Coast	1	...	2,604.0	2,884.0	10.7	5,498.7	47.36	77.34	22.66
XXVII	California salmon (*Oncorhynchus chouicha*). Edible portions of anterior part. California	...	...	...	...	...	...	...	62.68	37.32
XXVIII	Smoked halibut (*Hippoglossus americanus*)	...	...	1,476.0	130.0	10.0	1,616.0	91.34	51.03	48.97
XXIX	Canned salmon (*Oncorhynchus chouicha*). California. (Oregon?)	...	...	765.5	101.5	8.0	870.0	87.99	65.86	34.14
XXX	Mackerel (*Scomber scombrus*). Whole. Cape May, N. J	4	...	1,305.0	1,267.0	22.0	2,594.0	50.29	74.14	25.86
XXXI	Porgy (*Stenotomus argyrops*). Whole. Rhode Island	4	...	1,190.0	1,638.0	19.0	2,847.0	41.80	71.98	28.02
XXXII	Shad (*Alosa sapidissima*). Whole. Connecticut River	1	...	925.0	804.0	23.0	1,752.0	52.80	70.78	29.22
XXXIII	Smoked herring (*Clupea harengus*)	6	...	250.0	202.0	2.7	454.7	54.98	33.14	66.86
XXXIV	Salt cod (*Gadus morrhua*). "Channel fish." George's Banks	1	...	3,068.6	1,055.9	21.2	4,145.7	74.02	53.62	46.38
XXXV	Spent salmon, male (*Salmo salar*). Whole. Penobscot River, Maine	2	...	4,726.8	3,718.4	42.5	8,488.7	55.73	75.27	24.73
XXXVI	Spent salmon, female (*Salmo salar*). Whole. Penobscot River, Maine	2	...	5,733.2	4,443.4	28.3	10,204.9	56.18	78.20	21.80
XXXVII	Salt cod (*Gadus morrhua*). "Boat fish." Vicinity of Nantucket, Mass	1	...	2,089.0	684.8	39.6	2,813.4	74.25	53.54	46.46
XXXVIII	Blackfish (*Tautoga onitis*). Whole. Stonington, Conn	2	...	868.5	1,158.7	34.8	2,060.0	42.16	76.95	23.05
XXXIX	Mackerel (*Scomber scombrus*). Whole. Cape Cod, Mass	1	...	337.3	176.4	8.4	522.1	64.60	64.01	35.99
XL	Spent land-locked salmon, male (*Salmo salar*, subsp., *sebago*)	4	...	2,885.0	2,753.0	48.3	5,686.3	50.74	77.88	22.12
XLI	Spent land-locked salmon, female (*Salmo salar*, subsp., *sebago*). Whole. Grand Lake Stream, Maine	4	...	1,901.8	1,673.5	47.0	3,622.3	52.50	79.20	20.80
XLII	Salt mackerel (*Scomber scombrus*). "No. 1 mackerel"	3	...	564.8	179.0	37.6	781.4	72.28	42.19	57.81
XLIII	Spanish mackerel (*Cybium maculatum*). Whole	1	...	968.0	523.5	20.9	1,512.4	64.02	68.10	31.90
XLIV	White perch (*Morone americana*)	2	...	271.4	487.0	11.7	770.1	35.24	75.64	24.36
XLV	Masquallonge (*Esox nobilior*). Whole. St. Lawrence River	1	...	2,082.6	2,027.4	8.0	4,118.0	50.57	76.26	23.74
XLVI	White perch (*Morone americana*). Whole	4	...	339.2	578.4	18.3	935.9	36.24	75.77	24.23
XLVII	Herring (*Clupea harengus*). Whole. Florida	4	...	552.5	497.2	31.1	1,080.8	51.13	69.03	30.97
XLVIII	Sheep's-head (*Archosargus probatocephalus*). Entrails removed. Florida	1	...	830.5	1,117.3	26.4	1,974.2	42.07	72.01	27.99
XLIX	Turbot (*Platysomatichthys hippoglossoides*). Whole. Newfoundland	1	...	1,305.0	1,149.3	42.2	2,496.5	52.27	71.30	28.61
LII	Yellow pike-perch (*Stizostedium vitreum*). Whole	2	...	462.7	642.7	17.3	1,122.7	41.27	79.74	20.26
LIII	Black bass (*Micropterus pallidus*). Whole. North Carolina	1	...	723.5	939.8	13.2	1,676.5	43.16	78.61	21.39

Analysis of flesh (continued). In dry substance, percentages calculated on basis of dry substance = 100.

Laboratory number of sample.	Cold-water extract: Albumen (coagulated by heating to 100°).	Not coagulated: Total.	Ash.	Fat.	Extractive matters.	Hot-water extract: Total.	Ash.	Fat.	Gelatin.	Insoluble: Crude residue.	Ash.	Fat.	Insoluble protein.	Fat, other extract.	Ash.	Nitrogen.	Albuminoids: Nitrogen × 6.25.	Albumen + gelatin + insoluble protein.	Phosphoric acid (total phosphorus calculated as P_2O_5).	Sulphuric acid (total sulphur calculated as SO_3).	Chlorine.	Laboratory number of sample.
	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	
I	...	...	...	...	...	...	...	...	...	...	...	...	...	10.26	5.48	13.45	84.06	...	2.11	2.11	...	I
II	...	...		...		...	...	...	...	...	...	...	...	3.72	7.76	14.76	92.25	...	1.86	2.23	...	II
III	...	...		...		...	...	...	...	...	...	...	...	1.66	7.46	14.68	91.75	...	2.19	...	...	III
IV	...	...		...		...	...	...	...	...	...	...	...	32.27	2.08	9.85	61.56	...	1.70	...	...	IV
V	...	...		...		...	...	...	...	...	...	...	...	16.35	6.08	12.61	78.81	...	2.06	...	...	V
VI	...	...		...		...	...	...	...	...	...	...	...	35.67	4.27	9.83	61.44	...	...	...	...	VI
VII	...	...		...		...	...	...	...	...	...	...	...	7.56	4.42	14.58	91.13	...	2.54	...	...	VII
VIII	...	...		...		...	...	...	...	...	...	...	...	10.31	4.46	13.72	85.75	...	2.26	...	...	VIII
IX	...	...		...		...	...	...	...	...	...	...	...	35.65	3.83	10.26	64.13	...	1.51	...	...	IX
X	6.33	...		...	...	5.35	.46	...	4.89	...	...	...	...	41.33	4.26	9.29	58.06	...	2.44	...	...	X
XI	10.17	...			...	14.81	.90	...	13.91	...	...	...	...	2.39	7.33	14.94	93.38	...	3.05	...	...	XI
XII	7.10	...			...	9.52	.70	...	8.82	...	...	...	...	5.79	5.91	14.42	90.13	...	2.93	...	...	XII
XIII	7.69	...			...	12.12	1.19	...	11.03	...	...	...	...	27.26	4.83	10.89	68.06	...	2.43	...	...	XIII
XIV	5.57	...			...	6.18	.61	...	5.57	...	...	...	...	39.29	3.35	9.72	60.75	...	1.79	...	...	XIV
XV	4.97	...		...	...	...	...		...	...	...	...	...	7.18	6.88	13.74	85.88	...	3.04	...	...	XV
XVI	...	...		...	...	...	...		...	...	...	...	...	.00	5.79	14.59	91.19	...	2.43	...	...	XVI
XVII	2.21	...		...	...	6.15	1.73	...	4.42	...	...	...	...	48.48	4.27	9.08	56.75	...	1.78	1.94	...	XVII
XVIII	5.31	...		...	...	6.58	.65	...	5.93	...	...	...	...	21.46	5.56	12.26	76.63	...	2.48	1.44	...	XVIII
XIX	8.88	...	...		...	14.50	.74	...	13.76	...	...	...	...	13.40	6.69	13.34	83.38	...	3.37	2.28	...	XIX
XX	6.85	11.17	3.32	...	7.85	16.47	.73	...	15.74	57.14	...	...	...	2.98	6.40	14.82	92.63	...	2.24	2.23	...	XX
XXI	7.96	9.96	3.78	...	6.18	17.25	.89	...	16.36	...	...	...	...	.78	8.72	14.77	92.31	...	2.54	2.23	...	XXI
XXII	6.56	18.18	5.41	...	12.77	25.67	1.60	...	24.07	...	...	...	...	5.18	8.16	14.14	88.38	...	2.73	3.05	...	XXII
XXIII	8.02	20.06	3.82	...	16.23	26.31	1.56	...	24.75	37.50	...	...	...	9.76	9.65	13.32	83.25	...	3.88	2.66	...	XXIII
XXIV	8.01	16.34	4.90	...	11.44	10.60	.72	...	9.88	...	...	...	...	13.82	6.33	13.25	82.81	...	2.72	2.13	...	XXIV
XXV	1.84	50.25	43.24	...	7.01	10.23	3.61	...	6.62	32.81	...	...	...	.88	50.82	9.81	61.31	...	.79	1.48	...	XXV
XXVI	8.12	12.80	4.64	...	8.16	13.50	.75	...	12.75	56.09	...	...	...	8.58	5.92	13.96	87.25	...	2.04	2.06	...	XXVI
XXVII	4.21	6.07	2.12	...	4.85	5.06	.32	...	4.74	32.02	...	...	...	51.59	2.90	8.76	54.75	...	1.91	1.14	...	XXVII
XXVIII	1.51	34.12	28.46	...	5.66	6.98	3.75	...	3.23	27.79	1.22	...	26.57	31.90	31.01	6.04	37.75	31.31	1.14	.98	...	XXVIII
XXIX	...	19.22	5.01	...	14.21	5.80	.53	...	5.27	43.09	.65	...	42.44	32.48	5.43	9.87	61.69	47.71	1.77	1.38	...	XXIX
XXX	7.27	13.26	3.72	.76	8.78	7.31	1.39	...	5.92	47.87	.50	...	47.37	27.04	5.02	11.25	70.31	60.56	2.16	1.68	...	XXX
XXXI	10.64	9.60	2.47	.56	6.57	8.77	1.20	.18	7.39	45.25	.85	...	44.40	28.04	4.81	10.77	67.31	62.43	1.98	1.84	...	XXXI
XXXII	6.57	10.75	3.51	.74	6.50	8.18	.97	.84	6.37	44.65	.55	...	43.60	34.37	4.51	9.90	61.88	56.54	1.77	1.78	0.74	XXXII
XXXIII	.48	30.89	17.47	.65	12.77	10.02	2.38	.28	7.36	33.35	.91	...	32.44	26.00	19.72	7.03	43.94	40.28	1.24	1.84	11.01	XXXIII
XXXIV	1.07	48.21	44.49	.40	3.32	13.45	3.10	.02	10.33	33.46	.79	...	32.67	.53	53.83	8.43	52.69	44.07	.53	1.58	25.66	XXXIV
XXXV	4.69	13.34	4.17	...	9.17	10.35	.61	.04	9.70	63.60	.40	10.10	53.10	17.66	4.51	12.39	77.44	67.49	1.01	1.58	0.74	XXXV
XXXVI	4.50	9.90	3.44	.23	6.23	15.00	1.09	.09	13.82	65.18	1.56	8.72	54.90	12.98	5.36	12.93	80.81	73.31	1.18	1.45	0.85	XXXVI
XXXVII	2.07	...	...	...	...	9.30	2.22	...	7.08	...	...	...	...	1.90	42.43	8.45	52.81	...	.48	1.61	25.71	XXXVII
XXXVIII	11.32	12.89	4.73	.61	7.55	16.80	.83	.28	15.79	56.32	5.85	...	50.07	12.20	5.54	13.42	83.88	78.08	2.24	1.07	1.03	XXXVIII
XXXIX	...	...	...	...	...	...	...	...	...	...	...	...	...	46.53	4.11	8.76	54.75	...	1.60	1.13	0.68	XXXIX
XL	2.94	14.46	5.29	...	9.17	9.67	.72	.05	8.90	...	...	...	...	18.12	5.76	11.70	73.13	...	2.31	1.77	0.95	XL
XLI	5.14	16.34	5.77	...	10.57	11.73	.77	.38	10.58	...	...	...	...	9.86	5.76	13.26	82.88	...	2.43	1.98	0.93	XLI
XLII	.50	27.12	22.15	.09	4.88	4.62	1.68	.03	2.91	...	...	...	...	30.08	22.47	5.85	36.58	...	.61	1.05	15.52	XLII
XLIII	3.92	11.06	3.98	.09	6.99	10.13	.91	.09	9.13	...	...	...	...	20.56	4.71	10.76	67.25	...	1.88	1.81	0.49	XLIII
XLIV	7.35	10.80	3.33	.25	6.72	14.40	.90	.04	13.46	...	...	...	...	23.07	4.56	12.03	75.10	...	1.46	2.54	0.66	XLIV
XLV	6.95	14.48	6.91	.17	7.40	11.20	1.01	...	10.19	58.88	.50	1.56	56.73	12.18	6.63	13.82	86.38	73.87	2.21	1.55	0.86	XLV
XLVI	9.78	13.95	7.22	.08	6.65	12.30	1.20	.04	11.06	...	...	...	...	9.96	5.27	13.42	83.88	...	2.13	2.80	0.83	XLVI
XLVII	5.23	6.78	2.00	.10	4.68	10.29	.61	.10	9.58	...	...	...	...	37.20	4.83	10.22	63.88	...	1.77	1.77	0.99	XLVII
XLVIII	7.11	10.71	4.32	1.25	5.14	13.50	1.50	...	12.00	...	...	...	...	24.02	3.93	11.90	74.38	...	1.62	1.71	0.72	XLVIII
XLIX	.42	10.67	3.22	.45	7.00	14.49	1.08	.49	12.92	43.09	.18	14.47	28.44	50.36	4.47	8.25	51.56	41.78	1.66	1.12	1.12	XLIX
LII	5.87	17.87	4.44	.30	13.13	18.16	1.09	.10	16.97	53.90	.64	1.09	52.17	2.81	6.75	14.67	91.69	75.01	2.24	4.43	0.77	LII
LIII	9.54	15.80	4.91	.42	10.47	15.84	1.03	.14	14.67	...	...	...	...	4.75	5.57	14.85	92.81	...	2.04	4.11	0.74	LIII

TABLE II.—*Recapitulation.*

[Albuminoids computed by multiplying nitrogen by 6.25.]

Laboratory number of sample.	Kind of fish and portion taken for analysis.	Percentage of flesh, edible portion, of sample.	In flesh: Water.	In flesh: Dry substance, solids.	In dry substance: Cold-water extract: Albumen, coagulated.	In dry substance: Cold-water extract: Extractive matters (not coagulated).	In dry substance: Gelatin, hot water extract.	In dry substance: Insoluble protein.	In dry substance: Phosphoric acid. Total phosphorus calculated as P_2O_5.	In dry substance: Sulphuric acid. Total sulphur calculated as SO_3.	In dry substance: Chlorine.	In dry substance: Nitrogen.	In dry substance: Summary: Per analyses: Albuminoids. Nitrogen × 6.25.	In dry substance: Summary: Per analyses: Fats.	In dry substance: Summary: Per analyses: Crude ash.	In dry substance: Summary: Per analyses: Albuminoids + fats + ash.	In dry substance: Summary: Calculated to basis of 100 per cent.: Albuminoids.	In dry substance: Summary: Calculated to basis of 100 per cent.: Fats.	In dry substance: Summary: Calculated to basis of 100 per cent.: Crude ash.	In flesh, dry substance plus water: Cold-water extract: Albumen, coagulated.	In flesh, dry substance plus water: Cold-water extract: Extractive matters (not coagulated).	In flesh, dry substance plus water: Gelatin.	In flesh, dry substance plus water: Insoluble protein.	In flesh, dry substance plus water: Phosphoric acid. Total phosphorus calculated as P_2O_5.	In flesh, dry substance plus water: Sulphuric acid. Total sulphur calculated as SO_3.	In flesh, dry substance plus water: Chlorine.	In flesh, dry substance plus water: Nitrogen.	In flesh, dry substance plus water: Summary: Per analyses: Water.	In flesh, dry substance plus water: Summary: Per analyses: Albuminoids.	In flesh, dry substance plus water: Summary: Per analyses: Fat.	In flesh, dry substance plus water: Summary: Per analyses: Crude ash.	In flesh, dry substance plus water: Summary: Per analyses: Water + albuminoids + fat + ash.	In flesh, dry substance plus water: Summary: Calculated to basis of 100 per cent.: Water.	In flesh, dry substance plus water: Summary: Calculated to basis of 100 per cent.: Albuminoids.	In flesh, dry substance plus water: Summary: Calculated to basis of 100 per cent.: Fats.	In flesh, dry substance plus water: Summary: Calculated to basis of 100 per cent.: Crude ash.	Laboratory number of sample.
	FRESH FISH.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	
I	Halibut (*Hippoglossus americanus*). Posterior part of body, lean	75.92	79.15	20.85	......	......	......	......	2.11	2.11	......	13.45	84.06	10.26	5.48	99.80	84.13	10.36	5.51	......	......	......	......	0.44	0.44	......	2.80	79.15	17.50	2.14	1.14	99.93	79.20	17.52	2.14	1.14	I
IX	Halibut (*Hippoglossus americanus*). Section of fatter portion of body	88.28	70.13	29.87	......	......	......	......	1.51	......	......	10.26	64.13	35.65	3.83	103.61	62.06	34.21	3.73	......	......	......	......	0.45	......	......	3.06	70.13	19.13	10.65	1.14	101.05	69.41	18.93	10.53	1.13	IX
II	Flounder (*Paralichthys dentatus*). Entrails removed	41.33	83.37	16.63	......	......	......	......	1.86	2.23	......	14.76	92.25	3.72	7.76	103.73	88.93	3.58	7.49	......	......	......	......	0.31	0.37	......	2.45	83.37	15.31	0.62	1.29	100.59	82.89	15.23	0.61	1.27	II
XXII	Flounder (*Paralichthys dentatus*). Whole. Amagansett, L. I	31.97	85.04	14.96	6.56	12.77	24.07	......	2.73	3.05	......	14.14	88.38	5.18	8.16	101.72	86.89	5.07	8.04	0.98	1.91	3.60	......	0.41	0.46	......	2.12	85.04	13.22	0.77	1.22	100.25	84.82	13.19	0.77	1.22	XXII
III	Cod (*Gadus morrhua*). Head and entrails removed	64.57	83.12	16.88	......	......	......	......	2.10	......	......	14.68	91.75	1.66	7.46	100.87	90.94	1.64	7.42	......	......	......	......	0.37	......	......	2.48	83.12	15.48	0.28	1.26	100.14	83.00	15.40	0.28	1.26	III
XI	Cod (*Gadus morrhua*). Head and entrails removed	68.13	83.39	16.61	10.17	......	13.91	......	3.05	......	......	14.94	93.38	2.39	7.33	103.10	90.64	2.23	7.13	1.69	......	2.31	......	0.51	......	......	2.67	83.39	16.69	0.40	1.22	101.70	81.99	16.42	0.39	1.20	XI
XVI	Haddock (*Melanogrammus æglefinus*). Entrails removed	46.84	80.30	19.70	......	......	......	......	2.43	......	......	14.59	91.19	0.90	5.79	97.88	93.16	0.93	5.91	......	......	......	......	0.48	......	......	2.87	80.30	17.96	0.18	1.14	99.58	80.64	18.04	0.18	1.14	XVI
XXI	Haddock (*Melanogrammus æglefinus*). Entrails removed. Rockaway, L. I	47.50	82.03	17.97	7.96	6.18	16.86	......	2.54	2.23	......	14.77	92.31	0.78	8.72	101.81	90.65	0.77	8.58	1.43	1.11	2.94	......	0.46	0.40	......	2.65	82.03	16.55	0.14	1.57	100.29	81.79	16.50	0.14	1.57	XXI
IV	Eels, salt-water (*Anguilla rostrata*). Skin, head, and entrails removed	76.24	69.80	30.20	......	......	......	......	1.70	......	......	9.85	61.56	32.27	2.98	96.81	63.65	33.28	3.07	......	......	......	......	0.51	......	......	2.97	69.80	18.60	9.72	0.90	99.02	70.48	18.85	9.77	0.90	IV
V	Alewives (*Pomolobus vernalis*). Whole. Connecticut River	49.48	75.92	24.08	......	......	......	......	2.06	......	......	12.61	78.81	16.35	6.08	101.24	77.85	16.15	6.00	......	......	......	......	0.50	......	......	3.04	75.92	19.00	3.94	1.46	100.32	75.67	18.94	3.93	1.46	V
VI	Shad (*Alosa sapidissima*). Whole. Hudson River, first of season	48.31	69.65	30.35	......	......	......	......	......	......	......	9.83	61.44	35.67	4.27	101.38	60.65	35.15	4.20	......	......	......	......	......	......	......	2.98	69.65	18.64	10.80	1.30	100.39	69.37	18.57	10.76	1.30	VI
X	Shad (*Alosa sapidissima*). Whole. Connecticut River, early in season	52.35	65.25	34.75	6.33	......	4.89	......	2.44	......	......	9.29	58.06	41.33	4.26	103.65	55.82	40.04	4.14	2.20	......	1.70	......	0.85	......	......	3.23	65.25	20.16	14.36	1.48	101.25	64.53	19.80	14.20	1.47	X
XXXII	Shad (*Alosa sapidissima*). Whole. Connecticut River	52.80	70.78	29.22	6.57	6.50	6.37	43.60	1.77	1.78	0.74	9.90	61.88	34.37	4.51	100.76	61.46	34.12	4.42	1.93	1.90	1.86	12.74	0.52	0.52	0.22	2.89	70.78	18.08	10.04	1.32	100.22	70.62	18.04	10.02	1.32	XXXII
VII	Striped bass (*Roccus lineatus*). Whole. Connecticut River	42.09	79.18	20.82	......	......	......	......	2.54	......	......	14.58	91.13	7.56	4.42	103.11	88.41	7.33	4.26	......	......	......	......	0.53	......	......	3.04	79.18	18.99	1.58	0.92	100.67	78.58	18.92	1.58	0.92	VII
XIX	Striped bass (*Roccus lineatus*). Whole. Bridge Hampton, L. I	42.51	79.73	20.27	8.88	......	13.76	......	3.37	2.28	......	13.34	83.38	13.40	6.69	103.47	80.53	13.00	6.47	1.80	......	2.79	......	0.68	0.46	......	2.71	79.73	16.90	2.71	1.36	100.70	79.13	16.80	2.71	1.36	XIX
VIII	Mackerel (*Scomber scombrus*). Whole	60.55	78.69	21.31	......	......	......	......	2.26	......	......	13.72	85.75	10.31	4.46	100.52	85.30	10.25	4.45	......	......	......	......	0.48	......	......	2.92	78.69	18.27	2.20	0.95	100.11	78.59	18.27	2.19	0.95	VIII
XIII	Mackerel (*Scomber scombrus*). Whole	45.76	74.26	25.74	7.69	......	11.03	......	2.43	......	......	10.89	68.06	27.26	4.83	100.15	67.93	27.25	4.82	1.98	......	2.84	......	0.62	......	......	2.80	74.26	17.51	7.02	1.24	100.03	74.23	17.51	7.02	1.24	XIII
XXX	Mackerel (*Scomber scombrus*). Whole. Cape May, N. J	50.29	74.14	25.86	7.27	8.78	5.92	47.37	2.16	1.68	......	11.25	70.31	27.04	5.02	102.37	68.68	26.41	4.91	1.88	2.27	1.53	12.25	0.56	0.43	......	2.91	74.14	18.18	6.99	1.30	100.61	73.69	18.07	6.95	1.29	XXX
XXXIX	Mackerel (*Scomber scombrus*). Whole. Cape Cod, Mass	64.60	64.01	35.99	......	......	......	......	1.60	1.18	0.68	8.76	54.75	46.53	4.11	105.39	51.93	44.16	3.91	......	......	......	......	0.58	0.41	0.24	3.15	64.01	19.71	16.75	1.48	101.95	62.75	19.34	16.45	1.46	XXXIX
XII	Bluefish (*Pomatomus saltatrix*). Entrails removed	50.14	78.46	21.54	7.10	......	8.82	......	2.93	......	......	14.42	90.13	5.79	5.91	101.83	88.51	5.68	5.81	1.53	......	1.90	......	0.63	......	......	3.11	78.46	19.41	1.25	1.27	100.39	78.16	19.32	1.25	1.27	XII
XIV	Salmon (*Salmo salar*). Entrails removed. Maine	76.16	67.15	32.85	5.57	......	5.57	......	1.79	......	......	9.72	60.75	39.29	3.35	103.39	58.63	38.12	3.25	1.83	......	1.83	......	0.59	......	......	3.21	67.15	20.06	12.91	1.10	101.22	66.33	19.81	12.77	1.09	XIV
XXVII	California salmon (*Oncorhynchus chouicha*). Edible portions of anterior part. California	......	62.68	37.32	4.21	4.85	4.74	32.02	1.91	1.14	......	8.76	54.75	51.59	2.99	109.33	50.08	47.19	2.73	1.57	1.81	1.77	11.95	0.71	0.43	......	3.27	62.68	20.43	19.25	1.12	103.48	60.57	19.75	18.60	1.08	XXVII
XVII	Salmon trout, "Mackinaw trout" (*Salvelinus namaycush*). Whole. Lake Ontario	43.31	68.78	31.22	2.21	......	4.42	......	1.78	1.04	......	9.08	56.75	48.48	4.27	109.50	51.80	44.23	3.97	0.69	......	1.38	......	0.55	0.60	......	2.83	68.78	17.71	15.13	1.33	102.95	66.80	17.22	14.69	1.29	XVII
XXIV	Brook trout (*Salvelinus fontinalis*). Whole. Cultivated	46.95	77.54	22.46	8.01	11.44	9.88	......	2.72	2.13	......	13.25	82.81	13.82	6.33	102.96	80.41	13.43	6.16	1.80	2.57	2.22	......	0.61	0.48	......	2.98	77.54	18.60	3.10	1.42	100.66	77.04	18.47	3.08	1.41	XXIV
XVIII	Whitefish (*Coregonus clupeiformis*). Whole. Lake Champlain	45.76	70.83	29.17	5.31	......	5.93	......	2.48	1.44	......	12.26	76.63	21.46	5.56	103.65	73.88	20.76	5.41	1.55	......	1.73	......	0.72	0.42	......	3.57	70.83	22.35	6.26	1.62	101.06	70.08	22.10	6.20	1.62	XVIII
XV	Porgy (*Stenotomus argyrops*). Whole	38.84	79.68	20.32	4.97	......	......	......	3.04	......	......	13.74	85.88	7.18	6.88	99.94	85.94	7.18	6.88	1.01	......	......	......	0.62	......	......	2.79	79.68	17.44	1.46	1.40	99.98	79.72	17.44	1.45	1.39	XV
XXXI	Porgy (*Stenotomus argyrops*). Whole. Rhode Island	41.80	71.98	28.02	10.64	6.57	7.39	44.40	1.98	1.84	......	10.77	67.31	28.04	4.81	100.16	67.21	27.99	4.80	2.98	1.84	2.07	12.44	0.56	0.52	......	3.02	71.98	18.86	7.86	1.35	100.05	71.94	18.85	7.86	1.35	XXXI
XXXVIII	Blackfish (*Tautoga onitis*). Whole. Stonington, Conn	42.16	76.95	23.05	11.32	7.55	15.79	50.97	2.24	1.97	1.03	13.42	83.88	12.20	5.54	101.62	82.56	12.00	5.44	2.61	1.75	3.64	11.75	0.52	0.46	0.24	3.09	76.95	19.33	2.81	1.28	100.37	76.60	19.25	2.81	1.28	XXXVIII
XX	Red snapper (*Lutjanus Blackfordii*). Whole. Fernandina, Fla	39.60	76.81	23.19	6.85	7.85	15.74	57.14	2.24	2.23	......	14.82	92.63	2.98	6.40	102.01	90.80	2.92	6.28	1.59	1.82	3.65	13.25	0.52	0.52	......	3.44	76.81	21.48	0.69	1.49	100.47	76.45	21.38	0.69	1.48	XX
XXVI	Red snapper (*Lutjanus Blackfordii*). Entrails removed. Florida coast	47.36	77.34	22.66	8.12	8.16	12.75	56.09	2.04	2.06	......	13.96	87.25	8.58	5.92	101.75	85.75	8.43	5.82	1.84	1.85	2.89	......	0.46	0.47	......	3.16	77.34	19.75	1.94	1.34	100.37	77.06	19.66	1.94	1.34	XXVI
XXIII	Smelt (*Osmerus mordax*). Whole. Hackensack River, New Jersey	61.78	80.16	19.84	3.02	16.23	24.75	37.50	3.88	2.66	......	13.32	83.25	9.76	9.65	102.66	81.09	9.51	9.40	0.60	3.22	4.91	7.44	0.77	0.53	......	2.64	80.16	16.52	1.94	1.91	100.53	79.71	16.43	1.94	1.92	XXIII
XLIII	Spanish mackerel (*Cybium maculatum*). Whole	64.02	68.10	31.90	3.92	6.99	9.13	......	1.88	1.81	0.40	10.76	67.25	29.56	4.71	101.52	66.24	29.12	4.64	1.25	2.23	2.91	......	0.60	0.58	0.16	3.43	68.10	21.45	9.43	1.50	100.48	67.77	21.34	9.30	1.50	XLIII
XLIV	White perch (*Morone americana*)	35.24	75.64	24.36	7.35	6.72	13.46	......	1.46	2.54	0.66	12.03	75.19	23.07	4.56	102.82	73.13	22.44	4.43	1.79	1.64	3.28	......	0.36	0.62	0.16	2.93	75.64	18.32	5.62	1.11	100.69	75.12	18.20	5.57	1.11	XLIV
XLVI	White perch (*Morone americana*). Whole	36.24	75.77	24.23	9.78	6.65	11.06	......	2.13	2.80	0.83	13.42	83.88	9.96	5.27	99.11	84.05	10.35	5.60	2.37	1.50	2.68	......	0.52	0.68	0.20	3.25	75.77	20.32	2.41	1.28	99.78	75.94	20.36	2.42	1.28	XLVI
XLV	Masquallonge (*Esox nobilior*). Whole. St. Lawrence River	50.57	76.26	23.74	6.95	7.40	10.19	56.78	2.21	1.55	0.86	13.82	86.38	12.18	6.63	105.19	82.04	11.59	6.37	1.65	1.76	2.42	13.48	0.52	0.37	0.20	3.28	76.26	20.51	2.89	1.57	101.23	75.33	20.24	2.87	1.56	XLV
XLVII	Herring (*Clupea harengus*). Whole. Florida	51.18	69.03	30.97	5.23	4.68	9.58	......	1.77	1.77	0.99	10.22	63.88	37.20	4.83	105.91	60.32	35.12	4.56	1.62	1.42	2.97	......	0.55	0.55	0.31	3.16	69.03	19.78	11.52	1.50	101.83	67.77	19.43	11.32	1.48	XLVII
XLVIII	Sheepshead (*Archosargus probatocephalus*). Entrails removed. Florida	42.07	72.01	27.99	7.11	5.14	12.00	......	1.62	1.71	0.72	11.90	74.38	24.02	3.93	102.33	72.69	23.47	3.84	1.99	1.44	3.36	......	0.45	0.48	0.20	3.33	72.01	20.82	6.72	1.10	100.65	71.54	20.68	6.69	1.09	XLVIII
XLIX	Turbot (*Platysomatichthys hippoglossoides*). Whole. Newfoundland	52.27	71.39	28.61	0.42	7.00	12.92	28.44	1.66	1.12	1.12	8.25	51.56	50.36	4.47	106.39	48.41	47.30	4.29	0.12	2.00	3.69	8.14	0.48	0.32	0.32	2.36	71.39	14.75	14.40	1.28	101.82	70.10	14.49	14.15	1.26	XLIX
LII	Yellow pike-perch (*Stizostedium vitreum*). Whole	41.27	79.74	20.26	5.87	13.13	16.97	52.17	2.24	4.43	0.77	14.67	91.69	2.31	6.75	100.75	91.03	2.29	6.68	1.19	2.66	3.44	10.60	0.45	0.90	0.16	2.97	79.74	18.58	0.47	1.37	100.16	79.61	18.55	0.47	1.37	LII
LIII	Black bass (*Micropterus pallidus*). Whole. North Carolina	43.16	78.61	21.39	9.54	10.47	14.67	......	2.04	4.11	0.74	14.85	92.81	4.75	5.57	103.13	89.99	4.61	5.40	2.04	2.24	3.10	......	0.44	0.88	0.16	3.18	78.61	19.85	1.02	1.19	100.67	78.08	19.72	1.02	1.18	LIII
XXXV	Spent salmon (*Salmo salar*), male. Whole. Penobscot River, Maine	55.78	75.27	24.73	4.69	9.17	9.70	53.10	1.01	1.58	0.74	12.39	77.44	17.66	4.51	99.61	77.75	17.72	4.53	1.16	2.27	2.39	13.13	0.25	0.39	0.18	3.06	75.27	19.15	4.37	1.12	99.91	75.34	19.17	4.37	1.12	XXXV
XXXVI	Spent salmon (*Salmo salar*), female. Whole. Penobscot River, Maine	56.18	78.20	21.80	4.60	6.23	13.82	54.90	1.18	1.45	0.85	12.93	80.81	12.98	5.36	99.15	81.35	13.12	5.53	1.00	1.36	3.03	11.98	0.26	0.32	0.19	2.82	78.20	17.62	2.83	1.17	99.82	78.34	17.65	2.84	1.17	XXXVI
XL	Spent land-locked salmon (*Salmo salar, subsp., sebago*), male. Whole. Grand Lake Stream, Maine	50.74	77.88	22.12	2.94	9.17	8.90	......	2.31	1.77	0.95	11.70	73.13	18.12	5.76	97.01	75.38	18.68	5.94	0.65	2.03	1.96	......	0.51	0.39	0.21	2.59	77.88	16.18	4.01	1.27	99.34	78.40	16.29	4.04	1.27	XL
XLI	Spent land-locked salmon (*Salmo salar, subsp., sebago*), female. Whole. Grand Lake Stream, Maine	52.50	79.20	20.80	5.14	10.57	10.58	......	2.43	1.98	0.93	13.26	82.88	9.36	5.76	98.00	84.52	9.54	5.94	1.07	2.20	2.20	......	0.51	0.41	0.19	2.76	79.20	17.24	1.95	1.20	99.59	79.53	17.31	1.96	1.20	XLI
	CURED FISH.																																				
XXV	Boned cod (*Gadus morrhua*)	......	54.35	45.65	1.84	7.01	6.62	32.81	0.79	1.48	......	9.81	61.31	0.88	50.82	113.01	54.06	0.78	45.16	0.84	3.20	3.02	14.98	0.36	0.68	......	4.48	54.35	28.00	0.40	23.20	105.95	51.35	26.45	0.38	21.82	XXV
XXXIV	Salt cod (*Gadus morrhua*), "Channel fish." George's Banks	74.02	53.62	46.38	1.07	3.32	10.33	32.67	0.53	1.56	25.66	8.43	52.69	0.53	53.82	107.04	49.24	0.50	50.26	0.50	1.54	4.79	15.15	0.25	0.72	11.90	3.91	53.62	24.44	0.25	24.96	103.27	51.92	23.67	0.24	24.17	XXXIV
XXXVII	Salt cod (*Gadus morrhua*), "Boat fish." Vicinity of Nantucket, Mass	74.25	53.54	46.46	2.07	......	7.08	......	0.48	1.61	25.71	8.45	52.81	1.90	42.43	97.14	54.86	1.93	43.21	0.96	1.16	3.29	......	0.22	0.75	11.94	3.93	53.54	24.50	0.90	19.72	98.72	54.24	24.87	0.91	19.98	XXXVII
XXVIII	Smoked halibut (*Hippoglossus americanus*)	91.34	51.03	48.97	1.51	5.66	3.23	26.57	1.14	0.98	......	6.04	37.75	31.90	31.01	100.66	37.50	31.69	30.81	0.74	2.77	1.58	13.01	0.56	0.48	......	2.96	51.03	18.49	15.62	15.20	100.34	50.85	18.43	15.57	15.15	XXVIII
XXXIII	Smoked herring (*Clupea harengus*)	54.98	33.14	66.86	0.48	12.77	7.36	32.44	1.24	1.84	11.01	7.03	43.94	26.00	19.72	89.66	49.01	29.00	21.99	0.32	8.54	4.92	21.69	0.83	1.23	7.36	4.70	33.14	29.38	17.39	13.20	93.11	35.60	31.57	18.60	14.17	XXXIII
XXIX	Canned salmon (*Oncorhynchus chouicha*). California. (Oregon)	87.99	65.86	34.14	......	14.21	5.27	42.44	1.77	1.38	......	9.87	61.69	32.48	5.43	99.60	61.94	32.61	5.45	......	4.85	1.80	14.49	0.60	0.47	......	3.37	65.86	21.06	11.09	1.85	99.86	66.00	21.10	11.04	1.86	XXIX
XLII	Salt mackerel (*Scomber scombrus*), "No. 1 mackerel"	72.28	42.19	57.81	0.50	4.88	2.91	......	0.61	1.05	15.52	5.85	36.56	39.08	22.47	98.11	37.27	39.83	22.90	0.29	3.57	1.68	......	0.35	0.61	8.97	3.38	42.19	21.14	22.59	12.99	98.91	42.66	21.37	22.84	13.13	XLII

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TABLE III.—*Recapitulation.*

[Albuminoids as directly determined.]

Laboratory number of sample.	Kind of fish and portion taken for analysis.	Per analyses. In dry substance. Extractive matters, cold-water extract, not coagulated.	Per analyses. In dry substance. Proteids, &c. Albumen, coagulated from cold-water extract.	Per analyses. In dry substance. Proteids, &c. Gelatin, hot-water extract.	Per analyses. In dry substance. Proteids, &c. Insoluble protein.	Per analyses. In dry substance. Fats.	Per analyses. In dry substance. Ash.	Per analyses. In dry substance. Total.	Per analyses. In flesh, dry substance plus water. Water.	Per analyses. In flesh, dry substance plus water. Extractive matters, cold-water extract, not coagulated.	Per analyses. In flesh, dry substance plus water. Proteids, &c. Albumen, coagulated from cold-water extract.	Per analyses. In flesh, dry substance plus water. Proteids, &c. Gelatin, hot-water extract.	Per analyses. In flesh, dry substance plus water. Proteids, &c. Insoluble protein.	Per analyses. In flesh, dry substance plus water. Fats.	Per analyses. In flesh, dry substance plus water. Ash.	Per analyses. In flesh, dry substance plus water. Total.
		Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
XXXII	Shad (*Alosa sapidissima*). Whole. Connecticut River	6.50	6.57	6.87	43.60	34.37	4.51	101.92	70.78	1.90	1.92	1.86	12.74	10.04	1.32	100.56
XXX	Mackerel (*Scomber scombrus*). Whole. Cape May, N. J	8.78	7.27	5.92	47.37	27.04	5.02	101.40	74.14	2.27	1.88	1.53	12.25	6.99	1.30	100.36
XXVII	California salmon (*Oncorhynchus chouicha*). Edible portion of anterior part. California	4.85	4.21	4.74	32.02	51.50	2.90	100.40	62.68	1.81	1.57	1.77	11.95	19.25	1.12	100.15
XXXI	Porgy (*Stenotomus argyrops*). Whole. Rhode Island	6.57	10.64	7.39	44.40	28.04	4.81	101.85	71.98	1.84	2.98	2.07	12.44	7.86	1.35	100.52
XXXVIII	Blackfish (*Tautoga onitis*). Whole. Stonington, Conn	7.55	11.32	15.79	50.97	12.20	5.54	103.37	76.95	1.75	2.61	3.64	11.75	2.81	1.28	100.79
XX	Red snapper (*Lutjanus Black ordii*). Whole. Fernandina, Fla	7.85	6.85	15.74	57.14	2.98	6.40	96.96	76.81	1.82	1.50	3.65	13.25	0.69	1.49	99.30
XXVI	Red snapper (*Lutjanus Blackfordii*). Entrails removed. Florida Coast	8.16	8.12	12.75	56.09	8.58	5.92	99.62	77.34	1.85	1.84	2.89	12.71	1.94	1.34	99.91
XXIII	Smelt (*Osmerus mordax*). Whole. Hackensack River, New Jersey	16.23	3.02	24.75	37.50	9.76	9.65	100.91	80.16	3.22	0.60	4.91	7.44	1.95	1.92	100.20
XLV	Masquallonge (*Esox nobilior*). Whole. St. Lawrence River	7.40	6.95	10.10	56.73	12.18	6.63	100.08	70.26	1.76	1.65	2.42	13.48	2.89	1.57	100.03
XLIX	Turbot (*Platysomatichthys hippoglossoides*). Whole. New Foundland	7.00	0.42	12.92	28.44	50.36	4.47	103.61	71.89	2.00	0.12	3.69	8.14	14.40	1.28	101.02
LII	Yellow pike-perch (*Stizostedium vitreum*). Whole	13.13	5.87	16.97	52.17	2.31	6.75	97.20	79.74	2.66	1.19	3.44	10.60	0.47	1.37	99.47
XXXV	Spent salmon (*Salmo salar*), male. Whole. Penobscot River, Maine	9.17	4.69	9.70	53.10	17.60	4.51	98.83	75.27	2.27	1.16	2.39	13.13	4.37	1.12	99.71
XXXVI	Spent salmon (*Salmo salar*), female. Whole. Penobscot River, Maine	6.23	4.59	13.82	54.90	12.98	5.36	97.88	78.20	1.36	1.00	3.03	11.98	2.83	1.17	99.57
XXV	Boned Cod (*Gadus morrhua*)	7.01	1.84	6.62	32.81	0.88	50.82	99.98	54.85	3.20	0.84	3.02	14.98	0.40	23.20	99.90
XXXIV	Salt Cod (*Gadus morrhua*), "channel fish." George's Banks	3.32	1.07	10.33	32.67	0.53	53.82	101.74	53.62	1.54	0.50	4.79	15.15	0.25	24.96	100.81
XXVIII	Smoked halibut (*Hippoglossus americanus*)	5.66	1.51	3.28	26.57	31.90	31.01	99.88	51.03	2.77	0.74	1.58	13.01	15.62	15.20	99.95
XXXIII	Smoked herring (*Clupea harengus*)	12.77	0.48	7.36	32.44	26.00	19.72	98.77	23.14	8.54	0.32	4.92	21.69	17.39	13.20	99.20
XXIX	Canned salmon (*Oncorhynchus chouicha*). California. (Oregon)	14.21	......	5.27	42.44	32.48	5.43	99.83	65.86	4.85	......	1.80	14.49	11.00	1.85	99.94

Calculated to basis of 100 per cent. In dry substance. Extractive matters, cold-water extract, not coagulated.	In dry substance. Proteids, &c. Albumen, coagulated from cold-water extract.	In dry substance. Proteids, &c. Gelatin, hot-water extract.	In dry substance. Proteids, &c. Insoluble protein.	In dry substance. Fats.	In dry substance. Ash.	In flesh, dry substance plus water. Water.	In flesh, dry substance plus water. Extractive matters, cold-water extract, not coagulated.	In flesh, dry substance plus water. Proteids, &c. Albumen, coagulated from cold-water extract.	In flesh, dry substance plus water. Proteids, &c. Gelatin, hot-water extract.	In flesh, dry substance plus water. Proteids, &c. Insoluble protein.	In flesh, dry substance plus water. Fats.	In flesh, dry substance plus water. Ash.	Laboratory number of sample.
Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	
6.38	6.45	6.25	42.80	33.69	4.43	70.42	1.90	1.92	1.86	12.64	9.94	1.32	XXXII
8.66	7.18	5.85	46.78	26.64	4.94	73.90	2.27	1.88	1.53	12.17	6.05	1.30	XXX
4.83	4.19	4.72	31.88	51.40	2.98	62.54	1.81	1.57	1.77	11.95	19.25	1.11	XXVII
6.45	10.45	7.25	43.60	27.52	4.73	71.58	1.84	2.98	2.07	12.88	7.80	1.35	XXXI
7.33	10.95	15.27	49.20	11.79	5.37	76.16	1.74	2.59	3.60	11.65	2.79	1.27	XXXVIII
8.08	7.07	16.24	58.96	3.07	6.58	77.36	1.83	1.60	3.68	13.85	0.69	1.49	XX
8.19	8.15	12.80	56.81	8.61	5.94	77.42	1.85	1.84	2.89	12.71	1.95	1.34	XXVI
16.07	8.04	24.51	37.15	9.67	9.56	79.96	3.22	0.60	4.91	7.44	1.95	1.92	XXIII
7.39	6.94	10.18	56.69	12.17	6.63	76.29	1.76	1.65	2.42	13.48	2.89	1.51	XLV
6.76	0.41	12.47	27.45	48.60	4.31	70.60	1.98	0.12	3.65	8.16	14.26	1.27	XLIX
13.00	6.04	17.44	53.62	2.37	6.93	80.14	2.68	1.20	3.47	10.65	0.48	1.38	LII
9.28	4.75	9.82	53.73	17.87	4.56	75.51	2.27	1.16	2.39	13.17	4.38	1.12	XXXV
6.36	4.69	14.12	56.09	13.26	5.48	78.57	1.36	1.00	3.04	12.02	2.84	1.17	XXXVI
7.01	1.84	6.62	32.82	0.88	50.83	54.86	3.20	0.84	3.02	14.98	0.40	23.20	XXV
3.27	1.05	10.16	32.11	0.52	52.89	53.10	1.53	0.50	4.75	15.03	0.25	24.75	XXXIV
5.66	1.51	3.23	26.61	31.94	31.05	51.11	2.27	0.74	1.54	13.01	15.63	15.20	XXVIII
12.91	0.48	7.46	32.84	26.33	19.98	33.44	8.60	0.82	4.95	21.87	17.61	3.21	XXXIII
14.21	......	5.27	42.53	32.56	5.43	65.92	4.85	......	1.80	14.49	11.09	1.85	XXIX

ANALYSES

TABLE IV.—*Gen*

Laboratory number of sample.	Kind of fish and portion taken for analysis.
	FRESH FISH.
I	Halibut (*Hippoglossus americanus*). Posterior part of body, lean
IX	Halibut (*Hippoglossus americanus*). Section of fatter portion of body
	Halibut, average of two samples
II	Flounder (*Paralichthys dentatus*). Entrails removed
XXII	Flounder (*Paralichthys dentatus*). Whole. Amagansett, L. I
	Flounder, average of two samples
III	Cod (*Gadus morrhua*). Head and entrails removed
XI	Cod (*Gadus morrhua*). Head and entrails removed
	Cod, average of two samples
XVI	Haddock (*Melanogrammus æglefinus*). Entrails removed
XXI	Haddock (*Melanogrammus æglefinus*). Entrails removed. Rockaway, L. I
	Haddock, average of two samples
IV	Eels, salt water (*Anguilla rostrata*). Skin, head, and entrails removed
V	Alewives (*Pomolobus vernalis*). Whole. Connecticut River
VI	Shad (*Alosa sapidissima*). Whole. Hudson River. First of season
X	Shad (*Alosa sapidissima*). Whole. Connecticut River. Early in season
XXXII	Shad (*Alosa sapidissima*). Whole. Connecticut River
	Shad, average of three samples
VII	Striped bass (*Roccus lineatus*). Whole. Connecticut River
XIX	Striped bass (*Roccus lineatus*). Whole. Bridgehampton, L. I
	Striped bass, average of two samples
VIII	Mackerel (*Scomber scombrus*). Whole
XIII	Mackerel (*Scomber scombrus*). Whole
XXX	Mackerel (*Scomber scombrus*). Whole. Cape May, N. J
XXXIX	Mackerel (*Scomber scombrus*). Whole. Cape Cod, Mass
	Mackerel, average of four samples
XII	Blue fish (*Pomatomus saltatrix*). Entrails removed
XIV	Salmon (*Salmo salar*). Entrails removed. Maine
XXVII	California salmon (*Oncorhynchus chouicha*.) Edible portion of anterior part. California
XVII	Salmon trout, Mackinaw trout (*Salvelinus namaycush*). Whole. Lake Ontario
XXIV	Brook trout (*Salvelinus fontinalis*). Whole. Cultivated
XVIII	White fish (*Coregonus clupeiformis*). Whole. Lake Champlain
XV	Porgy (*Stenotomus argyrops*). Whole
XXXI	Porgy (*Stenotomus argyrops*). Whole. Rhode Island
	Porgy, average of two samples
XXXVIII	Black fish (*Tautoga onitis*). Whole. Stonington, Conn
XX	Red snapper (*Lutjanus Blackfordii*). Whole. Fernandina, Fla
XXVI	Red snapper (*Lutjanus Blackfordii*). Entrails removed. Florida Coast
	Red snapper, average of two samples
XXXII	Smelt (*Osmerus mordax*). Whole. Hackensack River, New Jersey
XLIII	Spanish mackerel (*Cybium maculatum*). Whole
XLIV	White perch (*Morone americana*). Whole
XLVI	White perch (*Morone americana*). Whole
	White perch, average of two samples

OF FISH.

eral Résumé.

Flesh, edible portion.					Whole or dressed fish.						
		Ingredients of solids (nutrients).				Edible portion.					
Water.	Solids.	Albuminoids.	Fats.	Mineral matter.	Waste: bones, skin, entrails, &c.	Water.	Albuminoids.	Fats.	Mineral matter.	Total edible solids, actual nutritive substance.	Laboratory number of sample.
Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	
79.20	20.80	17.52	2.14	1.14	24.08	60.12	13.30	1.03	0.87	15.80	I
69.41	30.59	18.93	10.53	1.13	11.72	61.27	16.71	9.30	1.00	27.01	IX
74.81	25.69	18.23	6.33	1.14	....	....	....	....	....	....	
82.89	17.11	15.23	0.61	1.27	58.67	34.27	6.29	0.25	0.52	6.87	II
84.82	15.18	13.19	0.77	1.22	68.03	27.12	4.21	0.25	0.39	4.78	XXII
83.86	16.14	14.20	0.70	1.25	....	....	....	....	....	....	
83.00	17.00	15.46	0.28	1.26	35.43	53.59	9.98	0.18	0.82	10.98	III
81.91	18.09	16.42	0.39	1.20	31.87	55.61	11.43	0.27	0.82	12.54	XI
82.46	17.54	15.94	0.34	1.23	33.60	54.60	10.76	0.23	0.82	11.81	
80.64	19.36	18.04	0.18	1.14	53.16	37.77	8.45	0.08	0.54	9.07	XVI
81.79	18.27	16.50	0.14	1.57	52.50	38.85	7.84	0.07	0.74	8.65	XXI
81.22	18.78	17.26	0.16	1.36	52.83	38.31	8.15	0.07	0.64	8.86	
70.48	29.52	18.85	9.77	0.90	23.76	53.74	14.37	7.45	0.68	22.50	IV
75.67	24.33	18.94	3.93	1.46	50.52	37.43	9.37	1.95	0.73	12.05	V
69.37	30.63	18.57	10.76	1.30	51.69	33.51	8.97	5.20	0.63	14.80	VI
64.53	35.47	19.80	14.20	1.47	47.65	33.78	10.37	7.43	0.77	18.57	X
70.62	29.38	18.04	10.02	1.32	47.20	37.27	9.54	5.29	0.70	15.53	XXXII
68.17	31.83	18.80	11.66	1.36	47.43	34.85	9.63	5.97	0.70	16.30	
78.58	21.42	18.92	1.58	0.92	57.91	33.08	7.96	0.66	0.39	9.01	VII
79.13	20.87	16.80	2.71	1.36	57.40	33.64	7.14	1.15	0.58	8.87	XIX
78.86	21.14	17.86	2.15	1.14	57.70	33.36	7.55	0.90	0.49	8.94	
78.59	21.41	18.27	2.19	0.95	39.45	47.58	11.06	1.33	0.58	12.97	VIII
74.23	25.77	17.51	7.02	1.24	54.24	33.97	8.01	3.21	0.57	11.79	XIII
73.69	26.31	18.07	6.95	1.29	49.71	37.05	9.09	3.50	0.65	13.24	XXX
62.75	37.25	19.34	16.45	1.46	35.40	40.54	12.49	10.63	0.94	24.06	XXXIX
72.32	27.68	18.30	8.15	1.23	44.70	39.78	10.16	4.68	0.68	15.52	
78.16	21.84	19.32	1.25	1.27	49.86	39.18	9.69	0.63	0.64	10.96	XII
66.33	34.67	19.81	12.77	1.09	23.84	50.52	15.09	9.73	0.82	25.64	XIV
60.57	39.43	19.75	18.60	1.08	00.00	60.57	19.75	18.60	1.08	39.43	XXVII
66.80	33.20	17.22	14.69	1.29	56.69	28.93	7.46	6.36	0.56	14.38	XVII
77.04	22.96	18.47	3.08	1.41	53.05	36.17	8.67	1.45	0.66	10.78	XXIV
70.08	29.92	22.10	6.20	1.62	54.24	32.07	10.11	2.84	0.74	13.69	XVIII
79.72	20.28	17.44	1.45	1.39	61.66	30.56	6.69	0.56	0.53	7.78	XV
71.94	28.06	18.85	7.86	1.35	58.19	30.09	7.88	3.28	0.56	11.72	XXXI
75.84	24.16	18.15	4.65	1.36	59.92	30.33	7.29	1.82	0.55	9.66	
76.66	23.34	19.25	2.81	1.28	57.84	32.12	8.31	1.19	0.54	10.04	XXXVIII
76.45	23.55	21.88	0.69	1.48	60.40	30.27	8.47	0.27	0.59	9.33	XX
77.06	22.94	19.66	1.94	1.34	52.64	36.50	9.31	0.92	0.63	10.86	XXVI
76.74	23.26	20.52	1.31	1.42	....	....	....	....	....	....	
79.71	20.29	16.43	1.94	1.92	38.22	40.25	10.15	1.20	1.18	12.53	XXIII
67.77	32.23	21.34	9.39	1.50	35.98	43.39	13.66	6.01	0.96	20.63	XLIII
75.12	24.88	18.20	5.57	1.11	64.76	26.47	6.41	1.96	0.39	8.76	XLIV
75.94	24.06	20.36	2.42	1.28	63.76	27.51	7.38	0.88	0.47	8.73	XLVI
75.43	24.57	19.28	4.00	1.10	64.26	26.98	6.89	1.42	0.43	8.74	

ANALYSES

TABLE IV.—*General*

Laboratory number of sample.	Kind of fish and portion taken for analysis.	Salt.*
		Per ct.
	FRESH FISH—Continued.	
XLV	Masquallonge (*Esox nobilior*). Whole St. Lawrence River	
XLVII	Herring (*Clupea harengus*). Whole. Florida	
XLVIII	Sheepshead (*Archosargus probatocephalus*). Entrails removed. Florida	
XLIX	Turbot (*Platysomatichthys hippoglossoides*). Whole. Newfoundland	
LII	Yellow pike-perch (*Stizostedium vitreum.*) Whole	
LIII	Black bass (*Micropterus pallidus*). Whole. North Carolina	
XXXV	Spent salmon (*Salmo salar*), male. Whole. Penobscot River, Maine	
XXXVI	Spent salmon (*Salmo salar*), female. Whole. Penobscot River, Maine	
XL	Spent land-locked salmon (*Salmo salar*, subsp. *sebago*), male. Whole. Grand Lake Stream, Maine	
XLI	Spent land-locked salmon (*Salmo salar*, subsp., *sebago*), female. Whole. Grand Lake Stream, Maine	
	CURED FISH.	
XXIX	Canned salmon (*Oncorhynchus chouicha*). California. (Oregon)	
XXVIII	Smoked halibut (*Hippoglossus americanus*)	13.51
XXXIII	Smoked herring (*Clupea harengus*)	11.80
XXV	Boned cod (*Gadus morrhua*)	10.02
XXXIV	Salt cod (*Gadus morrhua*). "Channel fish." St. George's Banks	22.33
XXXVII	Salt cod (*Gadus morrhua*). "Boat fish." Vicinity of Nantucket, Mass	18.12
	Salt cod, average of three samples†	
XLII	Salt mackerel (*Scomber scombrus*). "No. 1 mackerel"	11.50

*In computing the mineral matter in the salted and smoked fish, it was assumed that the mineral as in the averages of the corresponding samples of fresh fish; the excess actually found is counted

OF FISH.

Résumé—Continued.

Flesh, edible portion.					Whole or dressed fish.						
		Ingredients of solids (nutrients).				Edible portion.					
Water.	Solids.	Albuminoids.	Fats.	Mineral matter.	Waste: bones, skin, entrails, &c.	Water.	Albuminoids.	Fats.	Mineral matter.	Total edible solids, actual nutritive substance.	Laboratory number of sample.
Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	
75.33	24.67	20.24	2.87	1.56	49.43	38.10	10.23	1.45	0.79	12.47	XLV
67.77	32.23	19.43	11.32	1.48	48.87	34.65	9.93	5.79	0.76	11.48	XLVII
71.54	28.46	20.68	6.69	1.00	57.93	30.10	8.70	2.81	0.46	11.97	XLVIII
70.10	29.90	14.49	14.15	1.26	47.73	36.65	7.57	7.30	0.66	15.62	XLIX
79.61	20.39	18.55	0 47	1.37	58.73	32.86	7.66	0.19	0.57	8.42	LII
78.08	21.92	19.72	1.02	1.18	56.84	33.73	8.51	0.44	0.48	9.43	LIII
75.34	24.66	19.17	4.37	1.12	44.27	41.99	10.68	2.44	0.62	13.74	XXXV
78.34	21.66	17.65	2.84	1.17	43.82	44.00	9.92	1.60	0.66	12.18	XXXVI
78.40	21.60	16.29	4.04	1.27	49.26	39.78	8.27	2.05	0.64	10.96	XL
79.53	20.47	17.31	1.96	1.20	47.50	41.75	9.09	1.03	0.63	10.75	XLI
66.00	34.00	21.10	11.04	1.86	12.01	58.08	18.56	9.71	1.64	29.91	XXIX
59.85	40.15	18.43	15.57	1.64	8.66	46.45	16.83	14.22	1.40	32.45	XXVIII
35.00	64.30	31.57	18.66	2.37	45.02	19.57	17.36	10.26	1.30	28.92	XXXIII
51.35	48.65	26.45	0.38	1.90	....	51.35	26.45	0.38	1.90	28.73	XXV
51.92	48.08	23.67	0.24	1.84	25.98	38.43	17.52	0.18	1.39	19.09	XXXIV
54.24	45.76	24.87	0.91	1.86	25.76	39.95	18.46	0.68	1.35	20.49	XXXVII
52.50	47.49	25.00	0.51	1.87	25.87	38.60	17.90	0.43	1.37	19.70	
42.66	57.34	21.37	22.84	1.63	27.72	30.83	15.45	16.51	1.18	33.14	XLII

matters properly belonging to the fish would bear the same ratio to the flesh (albuminoids plus fats), as "Salt." †Under "Whole or Dressed Fish," two samples.

ANALYSES OF

TABLE V.—*Statistics and propor*

Laboratory number of sample.	Name and locality of sample.	Sample received.	Number taken for analysis.	Total weight.	Average weight.	In whole sample. Flesh.	In whole sample. Liquids.
	OYSTERS (*Ostrea virginiana*).	1881.		*Grams.*	*Grams.*	*Pr. ct.*	*Pr. ct.*
LXVIII	Buzzard's Bay, Mass	May 5	29	2,764.0	95.3	12.50	7.50
LXX	Providence River, R. I	May 5	28	3,301.0	117.9	10.88	6.12
LV	Stony Creek, Conn	Apr. 5	39	6,685.0	171.4	7.52	11.38
LXXV	......do	May 24	30	3,448.0	114.9	7.34	11.81
LIV	Fair Haven, Conn	Apr. 4	33	3,784.5	114.7	12.63	5.43
LVI	Blue Point, N. Y	Apr. 8	47	3,725.5	79.3	13.39	5.23
LVIII	Rockaway, N. Y	Apr. 12	50	5,058.0	101.2	10.68	7.72
LVII	East River, N. Y	Apr. 8	51	5,433.7	106.5	10.27	10.01
LX	Staten Island, N. Y	Apr. 20	30	3,901.5	130.4	9.13	7.10
LXI	Shrewsbury, N. J	Apr. 20	28	3,904.0	139.4	12.64	4.88
LIX	Norfolk, Va	Apr. 12	48	6,635.5	138.3	4.66	6.52
LXXIII	Potomac River, Va. (Transplanted.)	May 16	55	3,501.4	63.7	6.51	5.64
LXXII	Rappahannock River, Va. (Transplanted.)	May 16	28	3,309.5	118.2	7.86	7.31
LXXI	James River, Va. (Transplanted.)	May 16	30	3,085.9	102.8	6.50	7.29
	Average of 14 samples	....	37.4	4,181.2	113.8	9.47	7.42
LXXIV	"Cove," Chesapeake Bay. (Canned.)	May 24	......	....	....	50.23	49.77
	SCALLOPS (*Pecten irradians.*)						
LI	Shelter Island, N. Y	Mar. 15	......	....	....	100.00	....
LXIII	......do	Apr. 26	......	....	....	100.00	....
	Average of 2 samples	....	......	....	....	100.00	....
	LONG CLAMS (*Mya arenaria*).						
LXVII	Boston, Mass	May 5	20	1,504.0	75.2	29.26	24.64
LXV	Long Island, N. Y	Apr. 28	20	1,378.5	68.9	36.49	21.15
	Average of 2 samples	....	20	1,441.3	72.1	32.87	22.90
	ROUND CLAMS (*Venus mercenaria*).						
LXVI	Little Neck, N. Y	Apr. 28	20	1,907.5	95.4	16.80	14.91
	LOBSTERS (*Homarus americanus*).						
L	Maine	Mar. 15	2	1,973.0	986.5	....	....
LXII	......do	Apr. 26	1	876.5	876.5	....	....
LXIX	Boston, Mass	May 5	1	1,335.0	1,335.0	....	....
	Average of 3 samples	....	......	....	1,065.7	....	....
LXXVI	Canned lobster. Maine	May 26	......	....	....	....	....
	CRAY-FISH.						
LXIV	Potomac River, Va	Apr. 26	21	695.0	33.1	12.80	....

INVERTEBRATES.

tions of water and dry substance.

In whole sample.			In flesh.		In liquids.		In edible portion.		In whole sample.			
Total edible portion.	Refuse (shell).	Loss in cleaning.	Water.	Dry substance.	Water.	Dry substance.	Water.	Dry substance.	Dry substance in flesh.	Dry substance in liquids.	Dry substance, in edible portion.	Laboratory number of sample.
Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	
20.01	79.77	0.22	84.21	15.79	96.40	3.60	88.80	11.20	1.98	0.27	2.25	LXVIII
17.00	82.41	0.59	79.01	20.99	95.05	4.95	84.79	15.21	2.28	0.30	2.58	LXX
18.90	79.74	1.36	81.02	18.98	96.12	3.88	90.04	9.96	1.43	0.44	1.87	LV
19.15	79.66	1.19	82.09	17.91	96.33	3.67	90.89	9.11	1.34	0.48	1.76	LXXV
18.06	79.92	2.02	81.30	18.70	94.00	6.00	85.12	14.88	2.36	0.33	2.69	LIV
18.62	80.16	1.22	76.24	23.76	94.33	5.67	80.76	19.24	3.18	0.19	3.37	LVI
18.40	81.18	0.42	81.27	18.73	95.06	4.94	86.98	13.02	2.00	0.38	2.38	LVIII
20.28	78.86	0.86	79.92	20.08	95.44	4.56	87.57	12.43	2.07	0.40	2.53	LVII
16.23	83.16	0.61	84.47	15.53	96.35	3.65	89.58	10.42	1.42	0.26	1.68	LX
17.52	81.76	0.72	81.65	18.35	95.07	4.93	85.37	14.63	2.31	0.24	2.55	LXI
11.18	88.31	0.51	83.86	16.14	96.83	3.17	91.45	8.55	0.75	0.21	0.96	LIX
12.15	87.10	0.75	78.87	21.13	95.51	4.49	86.60	13.40	1.38	0.25	1.63	LXXIII
15.17	84.02	0.81	82.64	17.36	97.24	2.76	89.88	10.12	1.36	0.20	1.56	LXXII
13.79	85.30	0.91	83.49	16.51	95.81	4.09	90.05	9.95	1.07	0.30	1.37	LXXI
16.89	82.23	0.88	81.43	18.57	95.69	4.31	87.71	12.29	1.85	0.30	2.08	
100.00	....	.....	78.73	21.27	93.57	6.43	86.14	13.88	10.68	3.20	13.88	LXXIV
100.00	....	.....	77.79	22.21	....	......	77.79	22.21	22.21	......	22.21	LI
100.00	....	.....	82.84	17.16	....	......	82.84	17.16	17.16	......	17.16	LXIII
100.00	....	.....	80.32	19.68	....	......	80.32	19.68	19.68	......	19.68	
53.90	44.28	1.82	77.98	22.04	95.73	4.27	86.11	13.89	6.45	1.05	7.50	LXVII
57.64	39.93	2.43	81.05	18.95	94.76	5.24	86.05	13.95	6.91	1.08	7.98	LXV
55.77	42.11	2.12	79.52	20.48	95.25	4.75	86.08	13.92	6.68	1.07	7.74	
31.71	67.50	0.79	78.24	21.76	95.22	4.88	86.20	13.80	3.66	0.73	4.39	LXVI
52.52	43.96	3.52	84.30	15.70	....	......	84.30	15.70	8.25	......	8.25	L
36.24	60.87	2.89	81.77	18.23	....	......	81.77	18.23	6.60	......	6.60	LXII
30.56	67.57	1.87	82.11	17.89	....	......	82.11	17.89	5.47	......	5.47	LXIX
39.77	57.47	2.76	82.73	17.27	....	......	82.73	17.27	6.77	......	6.77	
100.00	....	.....	79.36	20.64	....	......	79.36	20.64	20.64	......	20.64	LXXVI
12.30	85.15	2.55	81.22	18.78	....	......	81.22	18.78	2.31	......	2.31	LXIV

ANALYSES OF

TABLE VI.—*Analyses cal*

Laboratory number of sample.	Name and locality of sample.	In flesh.			
		Nitrogen.	Albuminoids (nitrogen × 6.25).	Fat.	Crude ash.
	OYSTERS (*Ostrea virginiana*).	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
LXVIII	Buzzard's Bay, Mass	7.85	49.06	9.95	9.39
LXX	Providence River, R. I	7.85	49.06	12.25	10.15
LV	Stony Creek, Conn	8.82	55.13	8.41	14.68
LXXV	......do	8.83	55.19	8.20	14.30
LIV	Fairhaven, Conn	8.46	52.88	10.92	11.77
LVI	Blue Point, N. Y	7.08	44.25	9.89	8.66
LVIII	Rockaway, N. Y	7.84	49.00	11.34	8.94
LVII	East River, N. Y	8.32	52.00	10.79	8.89
LX	Staten Island, N. Y	8.51	53.18	10.84	9.10
LXI	Shrewsbury, N. J	7.15	44.69	12.00	7.24
LIX	Norfolk, Va	9.24	57.75	9.01	11.27
LXXIII	Potomac River, Va. (Transplanted)	7.43	46.44	10.77	12.02
LXXII	Rappahannock River, Va. (Transplanted	7.83	48.94	10.96	9.12
LXXI	James River, Va. (Transplanted)	8.01	50.06	10.76	10.48
	Average of 14 samples	8.09	50.56	10.44	10.42
LXXIV	"Cove," Chesapeake Bay. (Canned)	10.50	65.62	17.76	7.51
	SCALLOPS (*Pecten irradians*).				
LI	Shelter Island, N. Y	10.84	67.75	0.13	6.68
LXIII	......do	13.46	84.13	1.76	7.51
	Average of 2 samples	12.15	75.94	0.95	7.10
	LONG CLAM (*Mya arenaria*).				
LXVII	Boston, Mass	10.56	66.00	8.13	12.51
LXV	Long Island, N. Y	10.57	66.06	8.03	8.23
	Average of 2 samples	10.57	66.03	8.08	10.37
	ROUND CLAM (*Venus mercenaria*).				
LXVI	Little Neck, N. Y	8.52	53.25	8.39	10.19
	LOBSTERS (*Homarus americanus*).				
L	Maine	11.85	74.06	11.62	10.38
LXII	......do	12.33	77.06	8.47	9.36
LXIX	Boston, Mass	13.44	84.00	14.19	10.43
	Average of 3 samples	12.54	78.37	11.43	10.06
LXXVI	Canned lobster, Maine	12.98	81.13	2.24	13.44
	CRAY-FISH.				
LXIV	Potomac River, Va	13.63	85.19	2.45	6.88

INVERTEBRATES.

culated on dry substance.

In flesh.			In liquids.				In flesh and liquids.				
Phosphorus (calculated as P_2O_5).	Sulphur (calculated as SO_3).	Chlorine.	Nitrogen.	Albuminoids (nitrogen × 6.25).	Fat.	Crude ash.	Nitrogen.	Albuminoids (nitrogen × 6.25).	Fat.	Crude ash.	Laboratory number of sample.
Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	
1.17	4.15	3.53	5.58	34.87	0.07	45.27	7.00	43.68	6.21	22.34	LXVIII
1.64	3.55	2.39	4.78	20.87	0.04	48.79	6.74	42.17	7.86	24.06	LXX
1.46	5.31	4.83	3.42	21.35	0.35	70.01	5.57	34.76	8.55	48.50	LV
1.77	3.65	3.70	3.06	19.12	1.31	70.46	5.27	32.89	8.99	48.93	LXXV
1.57	5.58	3.11	5.56	34.76	0.27	53.13	7.01	47.49	7.70	24.35	LIV
1.28	3.70	1.96	6.50	40.62	1.54	33.74	6.92	43.18	7.55	15.71	LVI
1.59	3.89	2.81	5.32	33.27	0.71	45.75	6.78	42.31	6.88	24.38	LVIII
1.02	9.01	2.94	5.85	36.57	0.45	34.45	7.10	44.31	5.69	21.51	LVII
1.98	3.19	1.98	5.71	35.68	2.55	23.15	7.29	45.42	7.21	15.25	LX
1.61	2.23	1.68	6.60	41.25	0.88	37.18	7.00	43.68	8.86	15.58	LXI
1.79	2.88	2.76	5.22	32.63	0.18	52.03	6.90	43.05	3.86	35.08	LIX
1.70	2.59	3.18	5.16	32.24	0.25	54.96	6.37	39.75	5.89	31.96	LXXIII
1.80	2.13	1.93	5.89	36.81	0.24	53.66	6.90	43.05	5.80	30.59	LXXII
1.79	2.78	3.24	4.64	29.00	0.27	62.64	6.23	38.88	5.21	38.06	LXXI
1.63	3.63	2.82	5.24	32.75	0.51	49.01	6.69	41.79	6.16	28.31	
1.62	0.94	2.56	4.41	27.56	4.14	19.32	7.47	46.61	10.98	13.89	LXXIV
2.17	2.23	1.70	....	....	....	....	10.84	67.75	0.13	6.68	LI
2.75	2.76	1.87	....	....	....	....	13.46	84.13	1.76	7.51	LXIII
2.46	2.55	1.81	....	....	....	....	12.15	75.94	0.95	7.10	
2.23	3.14	2.98	1.86	11.62	0.14	77.20	6.58	41.07	4.48	42.08	LXVII
2.48	2.35	1.84	3.92	24.50	0.55	56.00	8.14	50.79	5.29	25.75	LXV
2.36	2.75	2.41	2.89	18.06	0.35	66.60	7.36	45.93	4.89	33.97	
1.71	4.11	3.22	2.96	18.50	0.34	64.07	5.90	36.83	1.95	35.94	LXVI
2.13	2.30	4.35	....	....	....	....	11.85	74.06	11.62	10.38	L
2.24	1.97	3.23	....	....	....	....	12.33	77.06	8.47	9.36	LXII
2.35	3.06	2.81	....	....	....	....	13.44	84.00	14.19	10.43	LXIX
2.24	2.47	3.46	....	....	....	....	12.64	78.87	11.43	10.06	
1.14	2.34	5.05	....	....	....	....	12.98	81.13	2.24	13.44	LXXVI
2.35	1.39	1.44	....	....	....	....	13.63	85.19	2.45	6.98	LXIV

ANALYSES OF

TABLE VII.—*Recap*

Laboratory number of sample.	Name and locality of sample.	Calculated on — In flesh. Water.	Nitrogen.	Albuminoids (nitrogen × 6.25).	Fat.	Crude ash.	Phosphorus (calculated as P_2O_5).	Sulphur (calculated as SO_3).	Chlorine.
	OYSTERS (*Ostrea virginiana*).	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
LXVIII	Buzzard's Bay, Mass	84.21	1.24	7.75	1.57	1.48	0.16	0.66	0.56
LXX	Providence River, R. I	70.01	1.65	10.30	2.58	2.13	0.40	0.75	0.50
LV	Stony Creek, Conn	81.02	1.67	10.46	1.60	2.76	0.28	1.01	0.82
LXXV	......do	82.09	1.57	9.83	1.48	2.55	0.32	0.65	0.69
LIV	Fair Haven, Conn	81.30	1.58	0.89	2.05	2.20	0.29	1.04	0.58
LVI	Blue Point, N. Y	76.24	1.68	10.51	2.35	2.06	0.30	0.88	0.47
LVIII	Rockaway, N. Y	81.27	1.47	9.18	2.13	1.67	0.30	0.73	0.53
LVII	East River, N. Y	79.92	1.67	10.44	2.16	1.79	0.33	1.01	0.59
LX	Staten Island, N. Y	84.47	1.33	8.30	1.68	1.41	0.31	0.50	0.31
LXI	Shrewsbury, N. J	81.65	1.31	8.20	2.20	1.33	0.20	0.41	0.29
LIX	Norfolk, Va	83.86	1.49	9.32	1.45	1.82	0.29	0.46	0.45
LXXIII	Potomac River, Va. (Transplanted.)	78.87	1.57	9.81	2.27	2.54	0.38	0.55	0.67
LXXII	Rappahannock River, Va. (Transplanted.)	82.64	1.36	8.49	1.90	1.58	0.31	0.37	0.34
LXXI	James River, Va. (Transplanted.)	83.49	1.32	8.19	1.78	1.71	0.36	0.46	0.54
	Average of 14 samples	81.43	1.49	0.31	1.94	1.93	0.30	0.68	0.53
LXIV	Cove, Chesapeake Bay (Canned).	78.73	2.24	13.96	3.78	1.60	0.34	0.20	0.54
	SCALLOPS (*Pecten irradians*).								
LI	Shelter Island, N. Y	77.79	2.41	15.05	0.03	1.48	0.48	0.50	0.39
LXIII	......do	82.84	2.31	14.44	0.30	1.20	0.47	0.47	0.32
	Average of 2 samples	80.32	2.36	14.75	0.17	1.38	0.48	0.40	0.36
	LONG CLAM (*Mya arenaria*).								
LXVII	Boston, Mass	77.98	2.16	13.46	1.65	2.55	0.46	0.64	0.66
LXV	Long Island, N. Y	81.05	2.00	12.53	1.52	1.56	0.47	0.45	0.35
	Average of 2 samples	79.52	2.08	12.99	1.59	2.05	0.47	0.55	0.50
	ROUND CLAM (*Venus mercenaria*).								
LXVI	Little Neck, N. Y	78.24	1.86	11.50	0.74	2.22	0.37	0.89	0.70
	LOBSTER (*Homarus americanus*).								
L	Maine	84.30	1.86	11.65	1.82	1.63	0.33	0.38	0.68
LXII	......do	81.77	2.24	14.05	1.55	1.71	0.41	0.36	0.59
LXIX	Boston, Mass	82.11	2.41	15.03	2.54	1.87	0.42	0.55	0.50
	Average of 3 samples	82.73	2.17	13.57	1.97	1.74	0.39	0.43	0.59
LXVI	Canned lobster, Maine	79.86	2.68	16.75	4.62	2.78	0.24	0.48	1.05
	CRAY-FISH.								
LXIV	Potomac River	81.22	2.56	16.00	0.46	1.31	0.54	0.26	0.27

INVERTEBRATES.

itulation of analyses.

fresh substance.														
In liquids.					In edible portion = flesh and liquids.							Nutritive valuation (medium beef 100).	Total edible portion in whole sample (from Table V).	Laboratory number of sample.
							In dry substance.							
Water.	Nitrogen.	Albuminoids (nitrogen × 6.25).	Fat.	Crude ash.	Water.	Dry substance.	Albuminoids (nitrogen × 6.25).	Fat.	Crude ash.	Extractives.	Nitrogen.			
Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
96.40	0.20	1.23	0.03	1.63	88.80	11.20	5.30	0.99	1.54	3.87	0.85	28.00	20.01	LXVIII
95.05	0.24	1.48	0.00	2.41	84.79	15.21	7.12	1.65	2.23	4.21	1.14	36.83	17.00	LXX
96.12	0.13	0.80	0.01	2.72	90.04	9.96	4.64	0.64	2.73	1.95	0.74	22.68	18.90	LV
96.33	0.11	0.68	0.05	2.61	90.89	9.11	4.10	0.60	2.59	1.73	0.67	20.48	19.15	LXXV
94.00	0.33	2.03	0.02	3.19	85.12	14.88	7.53	1.44	2.50	3.41	1.20	37.60	18.06	LIV
94.33	0.37	2.26	0.09	1.01	80.76	19.24	8.20	1.72	2.02	7.30	1.31	44.26	18.62	LVI
95.06	0.26	1.60	0.04	2.26	86.98	13.02	6.00	1.25	1.92	3.85	0.96	31.09	18.40	LVIII
95.44	0.31	1.91	0.02	1.83	87.57	12.43	6.31	1.10	1.87	3.15	1.01	31.61	20.28	LVII
96.35	0.21	1.30	0.09	0.85	89.58	10.42	5.24	0.98	1.17	3.03	0.84	26.70	16.23	LX
95.07	0.33	2.03	0.04	1.83	85.37	14.63	6.48	1.00	1.47	5.08	1.04	34.72	17.52	LXI
96.83	0.17	1.05	0.01	1.64	91.45	8.55	4.50	0.61	1.54	1.90	0.72	21.99	11.18	LIX
95.51	0.23	1.42	0.01	2.47	86.60	13.40	5.92	1.22	2.51	3.75	0.95	30.61	12.15	LXXIII
97.24	0.16	0.99	0.01	1.48	89.88	10.12	4.68	0.99	1.52	2.73	0.78	24.90	15.17	LXXII
95.81	0.19	1.17	0.01	2.56	90.05	9.95	4.47	0.84	2.16	2.48	0.74	22.69	13.79	LXXI
95.69	0.23	1.42	0.03	2.10	87.71	12.29	5.78	1.12	1.98	3.41	0.93	29.58	16.89	
93.5	70.28	1.77	0.27	1.24	86.14	13.86	7.89	2.04	1.42	2.51	1.26	39.24	100.00	LXIV
......	......	......	......	......	77.79	22.21	15.05	0.03	1.48	5.65	2.41	70.03	100.00	LI
......	......	......	......	......	82.84	17.16	14.44	0.80	1.29	1.13	2.31	63.87	100.00	LXIII
......	......	......	......	......	80.82	19.68	14.75	0.17	1.38	3.38	2.36	66.95	100.00	
95.78	0.08	0.49	0.01	3.29	86.11	13.89	7.53	0.90	2.89	2.57	1.21	36.09	53.90	LXVII
94.76	0.21	1.30	0.03	2.93	86.05	13.95	8.40	0.97	2.06	2.52	1.34	39.91	57.64	LXV
95.25	0.15	0.89	0.02	3.11	86.08	13.92	7.97	0.94	2.47	2.54	1.27	38.00	55.77	
95.22	0.14	0.86	0.02	3.17	86.20	13.80	6.56	0.40	2.67	4.17	1.05	32.56	81.71	LXVI
......	......	......	......	......	84.30	15.70	11.63	1.82	1.63	0.62	1.86	53.47	52.52	L
......	......	......	......	......	81.77	18.23	14.05	1.55	1.71	0.92	2.24	63.78	86.24	LXII
......	......	......	......	......	82.11	17.89	15.03	2.54	1.87	0.00	2.41	68.08	30.56	LXIX
......	......	......	......	......	82.73	17.27	13.57	1.97	1.74	0.00	2.17	61.97	39.77	
......	......	......	......	......	79.36	20.64	16.75	4.62	2.78	0.00	2.68	79.11	100.00	LXVI
......	......	......	......	......	81.22	18.78	16.00	0.46	1.81	1.01	2.56	70.74	12.80	LXIV

APPENDIX E.

NATURAL HISTORY

XII.—MATERIALS FOR A HISTORY OF THE SWORD-FISH.

By G. BROWN GOODE.

ANALYTICAL SYNOPSIS.

A.—INTRODUCTORY NOTES.

1. Objects of the essay and sources of information.

This essay upon the Sword-fish and its uses makes no claim to be considered a contribution to knowledge. In the course of six summers' study of fish and fisheries on the coast of New England and as many winters of research into ichthyological literature, a considerable quantity of notes concerning the Sword-fish have accumulated in the writer's portfolio. These are printed below, arranged in systematic order, with the hope that they may stimulate inquiry by showing at a glance what is now known about the habits of this mysterious fish and what it is desirable should be learned. Such of the facts as have not previously been printed are for the most part drawn from the experience of fishermen either by the writer or by others who have kindly responded to letters asking for information by interviewing their local authorities. Mr. John H. Thomson, of New Bedford; Mr. Willard Nye, of New Bedford; Mr. E. G. Blackford and Mr. Barnet Phillips, of New York; and Mr. C. B. Fuller, of Portland, have aided thus. Capt. Benjamin Ashby, of Noank; Capts. R. H. Hurlbert, John Rowe, and George H. Martin, of Gloucester; and Capt. I. H. Michaux, of New Bedford, veteran swordfishermen, have been asked questions innumerable, and their words are frequently quoted. As far as possible, all statements have been confirmed by personal observation; but for this there has been little opportunity. Few fishes are so difficult to observe, and a student may pass summer after summer in the attempt to study them with few results other than the sight of a few dozen dorsal fins cutting through the water, a chance to measure and dissect a few specimens, a page or two of estimates of annual captures, and perhaps the experience of having the side of his boat pierced by one of the ugly swords.

This paper is the fourth of a series upon The Natural and Economical History of American Food-fishes, the first, on THE SCUPPAUG, and the second, on THE BLUEFISH, having been published by Professor Baird in the Report of the United States Fish Commission, Part I (1873); the third, on THE MENHADEN, in Part V (1879) of the same report. The HISTORY OF THE AMERICAN WHALE FISHERY, by Mr. Alexander Starbuck in Part IV of the same report, is also properly to be enumerated in this series.

B.—NAMES OF THE SWORD-FISH.

2.—POPULAR NAMES OF SWORD-FISH.

The names by which the fish under consideration is known all have reference to its most prominent feature, the prolonged snout. The "Sword-fish" of our own tongue, the "*Zwaard-fis*" of the Hollander, the Italian "*Sifio*" and "*Pesce-epada*", the Spaniard's "*Espada*", "*Espadarte*", and varied by "*Pez de epada*" in Cuba, and the French "*Espadon*", "*Dard*", and "*Épée de mer*" are simply variations of one theme, repetitions of the "*Gladius*" of ancient Italy and "*Xiphias*", the name by which Aristotle, the father of zoology, called the same fish twenty-three hundred years ago. The French "*Empereur*" and the "*Imperador*" and "Ocean King-fish" of the Spanish and French West Indies carry out the same idea; the Roman emperor was always represented holding a drawn sword in his hand. The Portuguese names are *Agulha* and *Agulhao*, meaning "needle" or "needle-fish".

3.—ZOOLOGICAL NAMES OF THE SWORD-FISH—WITH SYNONYMY.

Zoological names.

This species has been particularly fortunate in escaping the numerous redescriptions to which almost all widely distributed forms have been subjected. By the writers of antiquity it was spoken of under its Aristotelian name, and in the tenth edition of his Systema Naturæ, at the very inception of binomial nomenclature, Linnæus called it *Xiphias gladius*.* By this name it has been known ever since, and only one additional name is included in its synonymy, *Xiphias Rondeletii*, Leach. In the following table of synonyms, references are given to the principal descriptions and figures in the standard ichthyological works:

XIPHIAS GLADIUS, Linnæus.

Xiphias gladius, LINNÆUS, Systema Naturæ, 10th ed. 1758, i, p. 248; 12th ed. 1766, iii, p. 432 ("habitat in oceano Europæ").

BLOCH, Ichthyologie, iii, 1786, pl. lxxvi, p. 23 (habits from statements of Chevalier Hamilton).

GMELIN, Linn. Syst. Nat. 1788, p. 1149 (includes also under (β) the American *Histiophorus*).

WALBAUM, Artedi, Genera Piscium, 1792, p. 207.

LACÉPÈDE, Hist. Nat. Poiss. 2d ed. 8vo. 1819, i, p. 538, fig. 2, pl. 24 (grotesque figure).

SCHNEIDER, Bloch's Systema Ichthyologiæ, 1801, p. 93 (mentions occurrence in Baltic).

SHAW, Zoology, 1804.

RISSO, Ichthyologie de Nice, 1810, p. 99 (obs. on habits); Hist. Nat. Europe Méridionale, 1826–'27, iii, p. 208.

CUVIER, Règne Animal, 1st ed. 1817, p. 326; 2d ed. 1829, p. 200; Griffith's ed. 1834, p. 187, pl. xxvii, figs. 1, 2 (taken from CUV. & VAL. Hist. Nat. Poiss. q. v.); Suppl. p. 349.

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YARRELL, History of British Fishes, 1st ed. 1836, p. 143 (fig. of young); 2d ed. p. 164 (fig. of young).

RICHARDSON, Fauna Bor. Amer. 1836, pp. 78, 81 (denies its existence in the Western Atlantic).

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PARNELL, Fishes of the Firth of Forth, 1838, p. 55.

STORER, Report on the Fishes of Massachusetts, 1839, p. 51: Memoirs American Academy of Sciences, p. 36; 1853, p. 149: Synopsis of the Fishes of North America, 1846, p. 95: History of the Fishes of Massachusetts, 1867, p 71, pl. xiii, fig. 2.

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GILL, Cat. Fish. E. Coast N. A. 1861, p. 38: Canadian Naturalist, 1865, p. 250: Cat. Fish. E. Coast N. A. 1873, p. 24: and in Rep. U. S. C. F. i, 1873, p. 802.

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*Linné, Systema Naturæ, 10th ed. 1758.

XIPHIAS GLADIUS, Linnæus.

POEY, Syn. Piscium Cubensium, ii, 1868, p. 379 (*Xyphias gladius*).

STEINDACHNER, Sitzb. Ak. Wiss. Wien. 1868, p. 396 (measurement of a Spanish specimen).

HECTOR, Trans. New Zealand Institute, vii, 1873, p, 246 (occurring at Auckland) (*Ziphius gladius*).

HUTTON, Trans. New Zealand Inst., vii, 1874, p. 211 (second occurrence at Auckland).

CHEESEMAN, Trans. New Zealand Inst., viii, 1875, p. 219 (*Ziphias gladius*, measurements of specimens from Shelly Bay, Auckland).

GOODE, Cat. Fishes Bermudas, 1876, p. 45.

GOODE & BEAN, Cat. Fish. Mass. Bay, 1879, p. 14.

GIGLIOLI, Catalogo Esp. Internat. di Pesca. Berlin, 1880, p. 88.

LÜTKEN, Vid. Selsk. Skr. 5te Række, Naturv. og math. Afd. xii, 6 (*Spolia atlantica*), pp. 441, 592, figs. 1, 2, 3, pl. ii, fig. 10 (notes upon the young of *Xiphias gladius* and related species).

STEINDACHNER, Sitzb. Ak. Wiss. Wien, 1868, p. 396.

HUTTON, Trans. New Zealand Inst., viii, 1873, p. 211.

Xiphias Rondeletii, LEACH, Mem. Wernerian Nat. Hist. Society, ii, 1818, p. 58.

4.—POPULAR NAMES OF ALLIED AMERICAN SPECIES.

The Sword-fish has been so long and so well known that its right to its peculiar name has seldom been infringed upon. The various species of *Tetrapturus* have sometimes shared its title, and this is not to be wondered at, since they closely resemble *Xiphias gladius*, and the appellative has frequently been applied to the family *Xiphiidæ*—the Sword fish family—which includes them all.

The name Bill-fish, usually applied to the *Tetrapturus albidus*, a fish of the Sword-fish family often taken on our coast, and described below, is objectionable, since it is in many districts used for the various species of *Belonidæ*, the "Gar-fishes" or "Green-bones" (*Belone truncata* and others), which are members of the same fauna. Spear-fish is a much better name, and is recommended for adoption.

The "Sail-fish", *Histiophorus americanus*, is called by sailors in the south the "Boohoo" or "Woohoo". This is evidently a corrupted form of "Guebucu", a name, apparently of Indian origin, given to the same fish in Brazil. It is possible that the *Tetrapturus* is also called "Boohoo", since the two genera are not sufficiently unlike to impress sailors with their differences. Bleeker states that in Sumatra the Malays call the related species, *H. gladius*, by the name Joohoo (*Juhu*), a curious coincidence. The names may have been carried from the Malay Archipelago to South America, or vice versa, by navigators.

In Cuba the Spear-fishes are called *Aguja* and *Aguja de Paladas;* the Sail-fish, *Aguja prieta* or *Aguja voladora;* *Tetrapturus albidus* is specially known as the *Aguja blanca*, *T. albidus* as the *Aguja de Casta.*

In the West Indies and Florida the Scabbard-fish or Silvery Hair-tail (*Trichiurus lepturus*), a form allied to the *Xiphias*, though not resembling it closely in external appearance, is often called "Sword-fish". The body of this fish is shaped like the blade of a saber, and its skin has a bright metallic luster like that of polished steel; hence the name.

The various species of Sticklebacks, *Gasterosteus aculeatus*, *G. noveboracensis*, and *Pygosteus occidentalis*, are known as "Little Sword-fish" by the boys of Portland, Me., and vicinity. The spines, damaging in the extreme to small fingers of tyro fish-gatherers, give reason to the name.

Sail-fish appear to occur throughout the tropical and southern parts of the Atlantic and the Indian Ocean. Their names, wherever they are found, point to its most striking characters. In Marcgrave's time the Portuguese of Brazil called it *Bicuda*, referring to its snout, and Rochefort, in his History of the West Indies, calls it the *Bécasse de Mer*; a *bécasse* being a long-snouted bird like a woodcock or a snipe, while in the Malay Archipelago the Dutch call it *Zee-snip* or "Sea-snipe". The Malays of Amboyna called it the *Ikan-layer* or Fan-fish, in allusion to the fan-like movements of its dorsal fin, while those of Sumatra called it *Ikan-jegan* or Sail-fish. The French *Voilier* and the Dutch *Zeyl-fisch* and *Bezaan-fisch* mean the same; a *bezaan* being the sail upon the mizzen mast of a ship. The names "Boohoo" and "Woohoo" have already been referred to. The Tamil name used about Madras, South Hindoostan, is "*Myl-meen*", signifying "Peacock-fish".

C.—DESCRIPTIONS OF THE SWORD-FISH FAMILY, WITH ITS SUBFAMILIES AND GENERA, WITH NOTES UPON THE AMERICAN SPECIES.

5.—DESCRIPTION OF THE FAMILY XIPHIIDÆ.

Family XIPHIIDÆ, Agassiz.

Xiphioides, AGASSIZ, Recherches sur les Poissons Fossiles, v, 1843, p. 89.—BLEEKER, Enum. Sp. Pisc. 1859, p. 62.

Xiphiidæ, GÜNTHER, Catalogue of the Fishes in the British Museum, ii, 1860, p. 511; Fische der Südsee, i, 1873–5, p. 105; Study of Fishes, 1880, p. 431.—GILL, Arrangement of the Families of Fishes, 1872, p. 8 (name only).—DAY, Fishes of India, i, 1876, p. 198.

Diagnosis of Family.

Scombroid fishes, with elongate, compressed bodies, naked (*Xiphiinæ*) or covered with elongate scale-like scutes (*Tetrapturinæ*). Premaxillaries with nasal and vomerine bones, produced in a long spear-like snout, immovably articulated with the prenasal and maxillary. Teeth absent (*Xiphiinæ*) or rudimentary (*Tetrapturinæ*). Nasal bone cellular at its base. Ventrals absent (*Xiphiinæ*) or rudimentary (*Tetrapturinæ*). A single dorsal, extending nearly the whole length of the body in young, becoming with age subdivided into two short dorsals (*Xiphiinæ*), or persistent (*Histiophorus*) or subpersistent, divided in middle with age (*Tetrapturus*). A similar rudimentation of anal fin in both subfamilies. Preopercular spine present in young (*Xiphiinæ*) or parietal and preopercular spines (*Tetrapturinæ*), disappearing with age. Seven branchiostegals. Pseudobranchiæ present. Branchiæ cancellated or reticulated. Air-bladder present, simple (*Xiphiinæ*) or cellulated (*Tetrapturus* and *Histiophorus* (?). Intestine long, sinuous (*Xiphiinæ*), or short, not sinuous (*Tetrapturinæ*). Gall-bladder free, hanging at some distance from the liver. Articular processes developed from the parapophyses.

Synopsis of subfamilies.

Ventrals absent, skin scaleless, snout flat, caudal keel single...XIPHIINÆ, Swainson.
Ventrals present, skin with scutes, snout rounded, caudal keels double.
HISTIOPHORINÆ, Lütken.

6.—DESCRIPTION OF THE SUBFAMILY XIPHIINÆ AND THE GENUS XIPHIAS.

Subfamily XIPHIINÆ, Gill.

>*Xiphyinæ*, SWAINSON, Nat. Hist. Fish. Amphib. etc. 1839, p. 239.
>*Xipheini*, BONAPARTE, Cat. Metod. Pesci Europei, 1846, p. 80.
Xiphiinæ, GILL, Canadian Naturalist, 1867, p. 250.

Diagnosis of subfamily.

Xiphiid fishes, with bodies somewhat compressed, scaleless, or in young state covered with rough granulations. Sword flattened horizontally. Teeth absent. Pectorals sublateral. Pelvic arch and ventrals absent. A keel upon each side of the caudal peduncle. Air-bladder simple. Intestine long, sinuous. A single genus, XIPHIAS, L.

Genus *Xiphias*, Artedi.

Xiphias, ARTEDI, Genera Piscium, 1738, p. 29.
Xiphias, LINNÆUS, Syst. Nat. ed. x, 1758, p. 248; ed. xii, p. 432.
Xiphias, CUVIER, Règne Animal, 1817, p. 326, 1829, p. 200.
Xiphias, GÜNTHER, Cat. Fish. Brit. Mus ii, p. 511.

Diagnosis of genus.

Xiphiine fishes, with two dorsal fins in adult condition, the continuous dorsal of the young having become rudimentary in its median portion. Preoperculum spineless in adult, the large spine of the young disappearing at an early age. Teeth absent "except upon the pharyngeal bones, which are covered with a villosity of extremely fine and minute denticles" (*Owen*). Number of dorsal rays probably variable. Vertebræ 26 (*Steindachner*). Branchiostegals 7. Stomach siphonal, pyloric cæca very numerous. Gall-bladder large.

HABITAT.—Tropical and temperate parts of the Atlantic, Mediterranean, New Zealand, and South Pacific north to California.

A single species of this genus is now known, *Xiphias gladius*, L. The species recorded in GÜNTHER'S Catalogue of the Fishes in the British Museum, vol. ii, p. 512, under the name *Xiphias velifer*, if not mythical, is probably a *Histiophorus*. Lacépède's figure represents it with two caudal carinæ, and, what is stranger, without ventrals.

7.—DESCRIPTION OF THE SUBFAMILY HISTIOPHORINÆ AND THE GENERA TETRAPTURUS AND HISTIOPHORUS.

Subfamily HISTIOPHORINÆ, Lütken.

Tetrapturinæ, Gill in Rep. U. S. F. C. i, 1873, p. 787 (name only; no description).
Histiophorinæ, Lütken, Vid. Med. Nat. Forew., 1875, p. 18.

Diagnosis of subfamily.

Xiphiid fishes, with bodies much compressed, covered with elongate, scale-like scutes. Sword rounded at edges, spear-like. Tooth-like granulations upon the jaws. Pectorals lateral. Pelvic arch present. Ventrals present, slender, elongate. Dorsal fin single (*Histiophorus*) or in two portions, but little remote, separated by aborted section (*Tetrapturus*). Preopercular spine absent (but probably present in young). Two keels upon each side of caudal peduncle. Ultimate dorsal and anal rays suctorial. Air-bladder very large, sacculated, consisting of numerous separate divisions. Intestine short, straight.

Synopsis of genera.

Dorsal fin double, *Xiphias*-like, ventral rays anchylosed...... *Tetrapturus*, Rafinesque.
Dorsal fin single, high, sail-like, ventral rays separate........ *Histiophorus*, Lacépède.

Genus *Tetrapturus*, Rafinesque.

Tetrapturus, RAFINESQUE, Caratteri, etc. 1810, p. 54, pl. 1, fig. 7.
"*Tetrapterurus*, BONAPARTE."
Tetrapterus, AGASSIZ, Poiss. Foiss. v, 1843, p. 7.

Diagnosis of genus.

Xiphiid, tetrapturine fishes, with body much compressed. Two dorsal and two anal fins in adult state; single dorsal and anal in immature ages. Tooth-like asperities on palatines and lower jaw. Body covered with cultriform scale-like scutes, under epidermis. Dorsal rays much more numerous than in *Xiphias*, less so than in *Histiophorus*. Ventrals rudimentary, consisting of one pair of very elongate, flattened rays. Vertebræ 24 (*T. belone*). Pyloric cæca very numerous. Intestine short, nearly straight, making only about two foldings.

HABITAT.—Mediterranean; tropical and subtropical seas.

Genus *Histiophorus*, Lacépède.

< *Istiophorus*, LACÉPÈDE, Hist. Nat. Poiss. iii, 1803, p. 374.
< *Histiophorus*, CUVIER & VALENCIENNES, Hist. Nat. Poiss. viii, 1831, 291.
< *Histiophorus*, GÜNTHER, Cat. Fish. Brit. Mus. ii, 1860, p. 512.
"*Notistium*, HERMANN, Observ. Zool. 1804, p. 305."

Diagnosis of genus.

Xiphiid, tetrapturine fishes, with body slender and very much compressed. Dorsal single (though the last few rays are nearly abortive), retaining the character of extreme youth, which is lost in *Xiphias* and *Tetrapturus*, and very lofty. Vertebræ 24 (*H. indicus*). Anal fin double. Numerous tooth-like asperities on the jaws. Body covered with elongate scales. Dorsal rays, being unaborted, very numerous. Ventrals consisting each of two or three elongate rays. Intestine short, nearly straight, with two foldings.

HABITAT.—Tropical and subtropical seas.

8.—DESCRIPTIVE NOTES ON THE SWORD-FISH, XIPHIAS GLADIUS.

My notes fail to supply the necessary data for a full description of the species, and since the fish is not likely by any one to be confounded with any other, I do not think it necessary to defer publication until these data can be obtained. I append the following note upon a small specimen, and also partial measurement table for two others, the dimensions in one case in inches, in the other in millimeters.

A specimen taken off Seaconnet, July 23, 1875. Weight 113 pounds; extremity of sword gone. One of the smallest ever seen in this region. Dorsal fin in its median part nearly destroyed, but traces of the groove and spines remaining.

Color.—Above rich purplish blue, shading into whitish beneath the sides, and belly with a silvery luster. Fins bluish dark with silvery sheen, except dorsal. Top of the head rich purplish blue, the color extending upon the rostrum. Lower side of rostrum rich brownish purple. Eye deep blue. No trace of scales.

Viscera.—Liver greenish light brown. Stomach siphonal; pyloric cæca infinite in number; intestine spiral 10 inches long when in position, 90 when stretched out. Gall-bladder large, situated on the same line with the spleen, and at same distance from the liver, connected by a duct. Air-bladder simple, large. Spermaries large, 6 inches long. Stomach contained small, fish perhaps *Poronotus*, and jaw of *Loligo Pealii*. Fluke worms in cover of stomach and air-bladder.

Table of measurements.

Current number of specimen. Locality	A. Seaconnet, R. I., July 23, 1875.	B. Gloucester, Mass., 1878.
	Inches.	Millimeters.
Extreme length (tip of sword gone)	91.00	....
Length to end of middle caudal rays	81.50	2,040
Body:		
Greatest height	13.50	....
Greatest circumference	35.00	....
Least height of tail	....	80
Head:		
Greatest length	37.00+	....
Length to tip of lower jaw	16.50	490
Greatest width	6.75	....
Width of interorbital area	4.35	170
Length of snout	20.00+	....
Length of operculum	5.00	150
Length of mandible	11.00	310
Diameter of eye	2.75	80
Dorsal (*first*):		
Distance from tip of lower jaw	15.50	....
Length of base (including first and second)	37.00	470 (1st)
Greatest height	12.00	470

Table of measurements.—Continued.

Current number of specimen / Locality	A. Seaconnet, R. I., July 23, 1875.	B. Gloucester, Mass., 1878.
	Inches.	Millimeters.
Dorsal (*second*):		
Length of base	....	30
Height at longest ray	....	75
Height at last ray	2.25	....
Anal:		
Distance from snout	37.00	....
Length of base	12.25	250
Height at longest ray	8.25	300
Height at last ray	2.25	....
Caudal:		
Length of middle rays	3.50	160*
Length of external rays	16.50	550
Pectoral:		
Distance from tip of lower jaw	16.00	....
Length	14.25	390
Branchiostegals	8	....
Dorsal	20 (19), 2	....
Anal	11 (X), 3	....
Pectoral	20	....
Weight (pounds)	113	....

* From end of carina.

Table of measurements.

Locality	Portland, Me., Aug. 15.
	Millimeters.
Extreme length	3,900
Length to end of middle caudal rays	3,780
Body:	
Greatest height	633
Greatest width	470
Greatest circumference	1,705
Height at origin of anal	520
Least height of tail	120
Height under second dorsal	220
Length of caudal peduncle	238
Head:	
Greatest length	1,570
Greatest width	885
Width of interorbital area	223
Length of snout	1,085 (870)
Length of operculum	200
Length of mandible	485
Diameter of orbit	100
Dorsal (*spinous*):	
Distance from snout	1,530
Length of base	500
Greatest height	550
Dorsal (*soft*):	
Length of base	60
Distance from snout	3,175
Height	90
Distance between dorsals	1,208
Anal:	
Distance from snout	2,538
Length of base	330
Distance of second anal from snout	3,125
Height at longest ray	340
Caudal:	
Width at caudal carinæ	500
Length of external rays	730
Tip to lip of caudal	1,140
Pectoral:	
Distance from snout	1,508
Length	532
Weight, about (pounds)	600

Steindachner has given the following measurements of two specimens obtained by him on the coast of Spain, the largest 3 feet 7 inches in length, the smallest much younger and corresponding to the young specimen figured by Cuvier and Valenciennes in the *Histoire Naturelle des Poissons*, pl. 225.*

Table of measurements.

	A.	B.
	Inches.	Inches.
Total length	48.0	24.6
Length of head	20.7	9.7
Length of intermaxillary from anterior margin of eyes	15.6½	....
Length of mouth-opening from point of intermaxillary to posterior end of upper jaw	17.2	8.0
Breadth of forehead	1.9	1.1½
Length of under jaw	6.0	....
Height of body	4.0	2.8½
Length of pectoral	5.8	8.5½
Height of dorsal at first cleft rays	6.2	....
Greatest height of dorsal	....	8.1⅜
Length of base of dorsal	14.4	....
Height of anal	8.4	1.11
Length of base of anal	4.6	....

The following measurements were taken by T. F. Cheeseman, esq., F. L. S., from a specimen stranded in January, 1875, at Shelly Beach, Aukland, New Zealand:

	Feet.	Inches.
Total length from tip of snout to end of caudal fin	11	8
Length of snout from tip to center of eye	8	11½
Length of snout from tip to gape	4	1
Length of snout from tip to free edge of operculum	4	6
Length of snout from tip to nostrils	8	7
Length of lower jaw from point to gape	0	11
Projection of upper jaw over lower	8	2
Height of dorsal fin	1	8
From dorsal to caudal	4	0
Length of pectoral fins	1	5
Length of anal	0	8
Height of second dorsal	0	2½
From anal to caudal	1	8
Width across the tail	2	8
Girth just behind the eyes	2	11
Girth behind dorsal	4	8
Girth behind caudal	0	11
Diameter of eye	0	8

The extreme point of the snout was broken off, about three inches being wanting.†

9.—DESCRIPTIVE NOTES ON THE SPEAR-FISH, TETRAPTURUS ALBIDUS.

The following description was drawn up from a fine specimen of the Spear-fish taken at Block Island, R. I., in 1875:

A male fish of 2,150^{mm} (84.646 inches), ordinary size.

Body elongated, nape elevated, bringing the greatest height over the

* Sitzb. Ak. Wiss. Wien. 1868, p. 396.

† Transactions New Zealand Institute, viii, 1875, p. 219.

operculum (10.27 inches). At the point of the pectoral the height is nine-elevenths of that at the operculum (8.4 inches), and is contained about 10 times in total length.

The head from extremity of lower jaw is contained in the total length 4 times (21.161 inches). The eye is situated midway between operculum margin and tip of lower jaw. The length of the bill beyond lower jaw equals greatest height of head. Palatines with a narrow band of rough denticulations. Asperities on the lower jaw. Bill extremely hard, especially at its extremity; its form is depressed, its edges rounded, its height greater than half its width. Preoperculum situated far back; commences midway between the eye and the opercular margin. The other opercular bones are not visible in fresh specimen.

Lateral line marked by a series of minute apertures on a continuous band, connected at the top of operculum; continues backward in a straight line for a short distance, then bends downward and reaches the middle line of the body at the point of the pectoral. Scales bony, linear, absent from the head, except on the cheeks. Those of lateral line not pierced. All the scales covered by epidermis.

Br. 7; D. 3, 39-6; A. 2, 13-6; P. 19; V. 1, 4; C. 12.

All the rays osseous, not articulated; those indicated as osseous are only distinguished from the others by their terminating in a point, which is not free. The others are flattened towards the extremity and frayed at the ends. The two first anal and three first dorsal rays are ossified to each other and upon the ray behind them, so that they appear to sight and touch as if only a single ray. Dissection shows that the first dorsal is very small (20^{mm}); second, 2½ times as high (50^{mm}); third, 115^{mm}; the fourth twice as long. The same in anal. First, 30^{mm}; second, 70^{mm}; third like fourth dorsal in form. These fins are for the most part hidden in the furrows, and their last rays are extremely short, so that it is necessary to lay them bare by dissection.

First ray of second dorsal and second anal flat and striated; these fins are crenated. The fourth of first dorsal and third of first anal touch the summits of the fins, which are slightly rounded.

First ray of pectoral very strong and prolonged to the extremity; 8 last short, forming the subbrachial dilation.

Ventral appears at first sight a single ray, but dissection shows 5, the 3 first anchylosed. They are received in a furrow, which extends to the anus.

Caudal stiff; bifurcation making angle of 72° from middle of the two caudal crests to the point of the lobes, and, neglecting points, 80°.

Origin of first dorsal above preopercle, its height surpassing by one-sixth the height of the body beneath it.

Pectoral one-eighth length of body from point of lower jaw.

First anal lower than dorsal.

The two others are small and opposite. The second dorsal a little farther back, a little higher, and a little more "échancrée".

Color.—Pronounced deep blue above, a little lighter on the flanks, passing into white below. Fins intense blue; second anal and outside of pectoral lighter. First dorsal with rounded spots, more intense, of same color. Iris clear blue; cornea blackish.

Four gills of double structure and an accessory, reticulated as in *Xiphias*.

Pylorus attached high up and has great longitudinal folds; also the duodenum, which is swollen and receives, by two openings, the secretions of the compact and glandulous mass which covers it.

Intestine slender, with two short convolutions, embracing in its last the spleen.

Swim-bladder cellulous, showing great puffs, which extend far behind the anus.

A second specimen, the measurements of which are given below (B), suggested the following notes:

Top of head and body, upper lobe of caudal fin, and caudal cartilage bluish black. Belly and throat white. Cheeks and opercular blackish, covered with a pearly sheen. The black hue of the back shades into the white of the belly through an insensible gradation of lines, the most prominent of which are rich purplish brown and light smoky gray. The belly and the sides are pearly up to the lateral line. The boundary between the colors of the back and the belly is indicated by an indistinct line, which may be traced from the base of the rostrum over the top of the orbit and the operculum, then descending across the lateral line at a point above the middle of the pectoral fin; it then rises in the arc of a circle above the lateral line, which it meets again at the tail, the distance between them being the greatest over the anal fin. The lower lobe of the caudal is blackish, with a pearly sheen. The ventrals and second dorsal fins are blue-black. The anterior rays of the first dorsal are also blue-black, the membrane being light bluish purple, irregularly spotted with circular dots from one-quarter to one-half an inch in diameter. The first anal is deep bluish purple at its extremity, but on its basal half bright pearly white. The inner surface of the pectoral is bluish purple, brightest in the axil; its outer surface is blackish, though completely covered with a pearly sheen.

The ventrals, first dorsal, and first anal, when not erected, are completely hidden in grooves. The second dorsal and second anal are not so hidden. The pectorals are flat, closely clinging to the sides when not in motion; their base received into a depression in the side of the fish.

The lanceolate scales may be seen through the epidermis, giving a reticulated appearance to sides of the fish.

The second dorsal and the second anal have broad, flattened, ultimate rays, which adhere closely to the body of the fish.

Measurements.

Current number of specimen Locality	A. New Bedford, Mass., July, 25, 1875.	B. Wood's Holl, Mass., 1875.
	Inches.	Inches.
Extreme length	80.00	89.00*
Length to end of middle caudal rays	70.50	81.00
Body:		
Greatest height	9.00	11.50† 9.00‡
Height at ventrals	9.00	....
Head:		
Greatest length	27.00	28.75
Greatest width	5.00	....
Width of interorbital area	4.25	....
Length of snout	17.50	19.50
Length of bill	....	12.25§
Length of operculum	3.00	....
Length of upper jaw to commissure of jaws	....	22.75
Length of lower jaw to commissure of jaws	....	10.50
Distance from snout to orbit	17.50	....
Diameter of orbit	2.00	2.00
Dorsal:		
Distance from snout	26.00	28.00
Length of base	40.00	37.00
Greatest height	....	12.25
Height at first spine	11.50	....
Height at second spine	11.75	....
Height at third spine	11.00	....
Height at fourth spine	10.75	....
Height at fifth spine	10.50	....
Height at sixth spine	9.00	....
Height at seventh spine	7.25	....
Height at eighth spine	5.00	....
Height at ninth spine	5.75	....
Height at tenth spine	4.50	....
Height at eleventh spine	3.50	....
Height at twelfth spine	3.50	....
Height at thirteenth spine	3.00	....
Height at fourteenth spine	2.50	....
Anal:		
Distance from snout	49.00	54.00
Length of base	15.00	10.25‖
Height at first spine	7.50	....
Height at second spine	7.50	....
Height at third spine	6.75	....
Height at fourth spine	6.00	....
Height at fifth spine	5.50	....
Height at sixth spine	2.75	....
Height at seventh spine	.80	....
Height at eighth spine	.50	....
Heigth at ninth spine	.35	....
Height at tenth spine	.25	....
Height at eleventh spine	.10	....
Height of fin above sheath	....	7.25
Caudal:		
Length of middle rays	2.00	....
Length of external rays	16.00	....
Distance between lobe tips	....	24.25
Pectoral:		
Distance from snout	28.50	29.00
Length	14.75	18.50
Ventral:		
Distance from snout	....	30.50
Length of groove from base of ventrals to vent	10.00	18.50
Dorsal	40 + 6	39 + 5
Anal	11 + 6	14 + 6
Caudal	6 + 4 + 4 + 5	....
Pectoral	18	20
Ventral	1	1
Weight, dressed (pounds)	55½	....
Number of vertebræ:		
Dorsal	11	....
Caudo-lumbar	13	....

* To vertical from upper caudal lobe.
† At origin of dorsal.
‡ Over vent.
§ Beyond tip of lower jaw.
‖ "Length of anal groove."

10.—POEY'S DESCRIPTIONS OF TETRAPTURUS ALBIDUS AND TETRAPTURUS AMPLUS.

It is quite probable that the larger species of *Tetrapturus*, *T. amplus*, Poey, which frequents the waters of Cuba, in company with the species now so often seen on our coast, may yet be found on the coast of the United States. It seems desirable, therefore, to quote here, in full, translations of the original descriptions. These species should both be critically compared with the *Tetrapturus Georgii*, described by the Rev. H. T. Lowe from Madeira.*

"It is very strange that the fishes known at Havana by the names *Aguja* and *Aguja de Paladar* have never been described in ichthyological works. Their size would naturally attract the attention of travelers, and since they are very common for four months in the year it would have been very easy to obtain them. Their flesh is palatable and always wholesome. They may have been confounded with *T. belone* of the Mediterranean, especially since the *Xiphias gladius*, here known as the Emperador, is often taken in our waters.

It is only necessary to glance at the figure of *T. belone* given by Cuvier and Valenciennes, and to carefully follow the description, to be satisfied that it is another species. The *Histiophorus americanus*, which we call *Aguja prieta* or *Aguja voladera*, is also found on our shores. Of the true *Tetraptures* we have two species, very distinct, the *Aguja blanca* (*Tetrapturus albidus*) and the *Aguja de Casta* (*Tetrapturus amplus*).

Tetrapturus albidus is abundant during the month of June and up to the middle of July; some are taken in August. The ordinary weight is 40 pounds, though they are sometimes taken of 100 pounds weight.

Tetrapturus amplus makes its appearance at the end of July, and is most abundant during August. Its ordinary weight is 200 to 300 pounds, but it reaches a much greater size, and is often taken weighing 400 to 500 pounds, and even 800.

The males are the smaller. These two species swim at the depth of 100 fathoms. They journey in pairs, shaping their course toward the Gulf of Mexico, the females being full of eggs.

Only adults are taken. It is not known whence they come, where they breed, or how the young return; it is not even known whether the adult fishes return by the same route.

When the fish has swallowed the hook it rises to the surface, making prodigious leaps and plunges; exhausted at last, it is dragged to the boat, secured with a boat-hook, and beaten to death before it is hauled on board.

Such fishing is not without danger, for the *Tetrapture* sometimes rushes upon the boat, drowning the fisherman or wounding him with his terrible weapon.

The fish becomes furious at the approach of sharks, which are its

* Proceedings Zoological Society of London, 1840, p. 36; Transactions Zoological Society of London, iii, 1840, p. 3.

natural enemies. They engage in violent combats, and when the *Tetrapture* is attached to the fisherman's line it often receives frightful wounds from its adversary.

The ovaries are large; the ova are small and yellow, and nearly one-eighth of an inch in diameter.

The Cuban fishermen agree in admitting under the name *Aguja blanca* two species, one called *Cabezona* (large-headed); the other smaller, the nape lower. I agree with them to some extent; yet, although I have drawn and measured many individuals of the two kinds, I do not dare to describe them as distinct, since I find remarkable variations, which lead me to suspend my judgment. I only describe one individual from those considered the large-headed variety."

For the more technical part of the description of these two species see paragraph 64.

11.—NOTES ON THE SAIL-FISH, HISTIOPHORUS AMERICANUS.

Strange as it may seem, the American species of *Histiophorus* has never been studied by an ichthyologist, and no attempt has ever been made to describe it or to compare it carefully with the similar species occurring in the Indian Ocean. The identity of the two has been assumed by Dr. Günther,* but since no American specimens have ever been seen by this authority, I hesitate for the present to follow his lead.

The history of the Sail-fish in ichthyological literature is as follows:

The first allusion to the genus occurs in Piso's "Historia Naturalis Braziliæ," printed at Amsterdam, in 1648. In this book† may be found an identifiable though rough figure of the American species, accompanied by a few lines of description, which, though good, when the fact

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* Catalogue of the Fishes in the British Museum, ii, 1860, p. 513.

† 1648. PISO AND MARCGRAVE.

Historia Naturalis | Brasiliæ, | Auspicio et Beneficio | Illustriss. | Mauritii Com. Nassau | illius Provinciæ et Maris summi Præfecti Adornata: | In qua | Non tantum Plantæ et Animalia, sed et In- | digenarum morbi, ingenia et mores describuntur et | Iconibus qungentus illustrantur | (Elaborate engraved title-page, upon which the preceding inscription is inserted upon a scroll, the following upon a shell.) Lvgyn Batauorum, | Apud Franciscum Hackium, | et | Amstelodami, | Apud Lud. Elzevirium. 1648. | pp. (12) 122 (2) (8) 293 (7).

Second title.

Guilielmi Pisonis, M. D. | Lugduno-Batavi, | de Medicina Brasiliensi | Libri Quatuor: | I. De Aëre, Aquis & Locis. | II. De Morbis Endemiis. | III. De Venenatis & Antidotis. | IV. De Facultatibus Simplicium | et Georgi Marcgravi de Liebstad, | Misnici Germani, | Historiæ Rerum Naturalium | Brasiliæ, | Libri octo: | Quorum | Tres priores agunt de Plantis. | Quartus de Piscibus. | Quintus de Avibus. | Sextus de Quadrupedibus & Serpentibus. | Septimus de Insectis. | Octavus de Ipsa Regione, & Illius Incolis. | Cum | Appendice de Tapuyis, et Chilensibus. | Ioannes de Læt, | Antwerpianus, | In ordinem digessit & Annotationes addidit, & varies ab Auctore | Omissa supplevit & illustravit. |

that they were written in the seventeenth century is brought to mind, are of no value for critical comparison. [See paragraph 64.]

The name given to the Brazilian Sail-fish by Marcgrave, the talented young German who described the fishes in the book referred to, and who afterward sacrificed his life in exploring the unknown fields of American zoology, was *Guebucu brasiliensibus*. The use of the name *Guebucu* is interesting, since it gives a clue to the derivation of the name "Boohoo", by which this fish, and probably the Spear-fishes, are known to English-speaking sailors in the tropical Atlantic.

Sail-fishes were observed in the East Indies by Renard and Valentijn, explorers of that region from 1680 to 1720, and by other eastern voyagers. No species of the genus was, however, systematically described until 1786, when a stuffed specimen from the Indian Ocean, eight feet long, was taken to London, where it still remains in the collections of the British Museum. From this specimen M. Broussonet prepared a description, giving it the name *Scomber gladius*, rightly regarding it as a species allied to the mackerel. In 1803 Lacépède established the genus *Histiophorus* for the reception of this species.

When Cuvier and Valenciennes published the eighth volume of their Natural History of Fishes, they ignored the name *gladius*, which had been given to the East Indian fish by Broussonet, redescribing it under the name *Histiophorus indicus*. At the same time they founded another species upon the figure in Piso's Natural History of Brazil, already mentioned. This they called *Histiophorus americanus*.

In a paper printed in 1833, Dr. Nardo, of Venice, proposed the establishment of a new genus allied to *Tetrapturus* and *Xiphias*, to be called *Skeponopodus*. In this he included the fish described by Marcgrave, under the name *Skeponopodus guebucu*, and also a form observed by him in the Adriatic in 1829, which he called *S. typus*. I am not aware that ichthyologist have yet learned what this may have been.*

From the time of Marcgrave until 1872 it does not appear that any zoologist had an opportunity to study a Sail-fish from America, or even from the Atlantic, yet in Günther's "Catalogue" the name *H. americanus* is discarded and the species of America is assumed to be identical with that of the Indian Ocean.†

Günther restores Lacépède's name, *H. gladius*, for the Indian species. Possibly, indeed probably, this name will be found to include the Sail-fish of our own coast. At present, however, it seems desirable to retain a separate name. To unite species from widely distant localities with-

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* *Isis*, 1833, Heft iv, pp. 415–419.

† The specimens in the British Museum are catalogued as follows:

a. Eight feet long; stuffed. Indian Ocean. Type of the species.
b. Seven feet long; stuffed. Cape of Good Hope.
c. Dorsal fin. N. S. Wales (?). Presented by Dr. G. Bennett.
d. Snout; dried.

out ever having seen them is very disastrous to a proper understanding of the problems of geographical distribution.

The materials in the National Museum consist of a skeleton and a painted plaster cast of the specimen taken near Newport, R. I., in 1872, and a drawing made of the same, while fresh, by Mr. J. H. Blake.

The occurrence of the Sail-fish is, as has been already stated, very unusual. Marcgrave saw it in Brazil as early as 1648. De la Sagra and Poey mention that it has been seen about Cuba, and Schomburgh includes it in his Barbados list. The specimen in the United States National Museum was taken off Newport, R. I., in August, 1872, and given to Professor Baird by Mr. Samuel Powell, of Newport. No others were observed in our waters until March, 1878, when, according to Mr. Neyle Habersham, of Savannah, Ga., two were taken by a vessel between Savannah and Indian River, Florida, and were brought to Savannah, where they attracted much attention in the market. In 1873, according to Mr. E. G. Blackford, a specimen in a very mutilated condition was brought from Key West to New York City.

12.—AN ENUMERATION OF THE SPECIES OF THE SWORD-FISH FAMILY.

1. XIPHIAS GLADIUS, Linn.

The synonymy of this species, with discussions of all the facts regarding it which have come within my observation, are given elsewhere in this paper. Professor Lütken, in recently published papers, has expressed the opinion that the genus *Xiphias* cannot be regarded, as has hitherto been customary, as the central type of the family *Xiphiidæ*, but rather as a divergent or aberrant form, while the round-billed Sword-fish provided with ventral fins are most typical and representative of the group.*

2. TETRAPTURUS IMPERATOR (Schneider).

Xiphias imperator, SCHNEIDER, Bloch's Syst. Ichth. 1801, p. 93, pl. xxi (poor figure), founded on Duhamel, iii, p. 333, pl. xxvi, fig. 2.

Tetrapturus belone, RAFINESQUE, Caratteri Animali e Pianti della Sicilia, 1810, p. 54, pl. i, fig. 1.—CUVIER, Règne Animal, 2d ed. 1829, ii, p. 201.—CUVIER & VALENCIENNES, Hist. Nat. Poiss. viii, 1831, p. 280, pls. ccxxvii (skeleton), ccxxviii (adult fish).—BONAPARTE, Catologo Metodico, 1846, p. 80.

Tetrapterus belone, AGASSIZ, Poissons Fossiles, 1843, v, p. 89, tab. E. (fine figure of skeleton).

Tetrapterurus belone, BONAPARTE.

Histiophorus belone, GÜNTHER, Cat. Fish Brit. Mus. ii, 1860, p. 513.

Skeponopodus typus, NARDO, Isis, 1833, Heft iv, p. 417 (Adriatic).

This species appears to be limited to the waters of the Mediterranean. It was not noticed by Linnæus, or indeed by any of the binomial writers before Schneider. In his posthumous edition of the writings of Bloch, the latter has made reference to a figure and description in Duhamel,

*1875. LÜTKEN, CHR.

Om rundnæbides Svaerdfiske, saerligt om *Histiophorus orientalis*, Schl. < Vidensk. Meddel. Naturhut. Foren. Kjöbenhavn, 1875, pp. 1-21 + 1-5.

and has given to a fish, which he figures in plate xxi of this work, the name *Xiphias imperator*. This name was rejected by Cuvier (Règne Animal, l. c.), and has not been recognized by later writers. It seems to me, however, that Schneider has, perhaps unintentionally, yet quite intelligibly, expressed the principal differential characters of *Tetrapturus*. By "dorso scabro" he covers the question of the scales; by "carnia caudali nulla" he refers to the absence of the single caudal carnia of *Xiphias*, while by figure and by implication in his description he admits the presence of ventral fins. His figure, though bad, is as good as most of the old figures of *Xiphias*—that in Lacépède for example.

T. imperator is said to attain the length of five or six feet, and the weight of 150 pounds. It has been taken in the Straits of Messina with the harpoon, but according to Rafinesque is very rarely seen on the coasts of Sicily, and then only in autumn, when it is following the dolphin and flying-fish, upon which it feeds. It is ordinarily seen in pairs, male and female together, and they are taken often in the nets together. Its flesh is white, but not particularly well flavored. At Messina it is call "*Aguglia imperiale* (Cuvier & Valenciennes, l. c.).

3. TETRAPTURUS INDICUS, Cuv. & Val.

> *Tetrapturus indicus*, CUV. & VAL. Hist. Nat. Poiss. viii, 1831, p. 286 (on figure belonging to Sir Joseph Banks).

A species founded on a figure of a specimen obtained in Sumatra, communicated by Sir Joseph Banks to Broussonet, who refers to it at the end of his "Memoire sur le Volier".*

The description is worthless. It is stated by Cuvier and Valenciennes that this fish had been supposed to be the male of *Histiophorus gladius*, but that it is much more nearly related to *Tetrapturus* of the Mediterranean, though with a longer beak.

The notes accompanying the figure state that it attains the length of nine feet and the weight of 200 pounds, and was known to the Malays by the name "*Joo-hoo*".

Günther regards it as perhaps synonymous with *T. Herschelii*, Gray.†

4. TETRAPTURUS HERSCHELII, Gray.

> *Tetrapturus Herschelii*, GRAY, Ann. Nat. Hist. i, 1838, p. 313, pl. x.—LÜTKEN, ll. c.
> *Histiophorus Herschelii*, GÜNTHER, l. c.

This species was described from a specimen eleven feet long obtained at Table Bay, Cape of Good Hope, in 1837. The description is reproduced in the appendix, and the plate is also here presented. The type of *T. Herschelii* is in the British Museum. The United States National Museum has some fine skins, apparently of this species, brought from Mauritius by Col. Nicholas Pike, United States consul. There is no reason to doubt that this species may be the same with *T. indicus*, Cuv. & Val., just described, there being little probability that there

* Hist de l'Acad. des Sciences Paris, 1786, pp. 450–455.
† Günther, l. c. p. 513, sub. *Histiophorus Herschelii*.

are two species in waters so close together as those of Sumatra and the Cape of Good Hope.

5. TETRAPTURUS GEORGII.

Tetrapturus Georgii, LOWE, Proc. Zool. Soc. viii, 1840, p. 36: Trans. Zool. Soc. iii, 1849, p. 3 (reprint of first).—GÜNTHER, op. cit. p. 512, foot-note.—LÜTKEN, ll. c.

This species, known at Madeira as "*Peito*", was described by Lowe thus briefly: "I am enabled to state that it forms a new and very distinct species of *Tetrapturus*, Raf., differing from *T. belone*, Raf., as described by MM. Cuvier and Valenciennes, especially in having the pectoral fins proportionately twice as long, and the body clothed with large scales of a peculiar shape and character."

Lütken believes it to be identical with the two species of the Indian Ocean just discussed, as well as with the two Cuban species. It should surely be carefully compared with the latter.

6. TETRAPTURUS ALBIDUS, Poey.

Tetrapturus albidus, POEY, Mem. Hist. Nat. Cuba, ii, 1858, p. 237, pl. xv, fig. 1; pl. xvi, figs. 2–13; pl. xvii, figs. 1, 5, 6–9, 10–11, 26: Ib. p. 258: Rep. Fis. Nat. Cuba, ii, 1868, p. 380.—GILL, Cat. Fish E. Coast N. A. 1873, p. 24.—LÜTKEN, ll. c.

7. TETRAPURUS AMPLUS, Poey.

Tetrapturus amplus, POEY, op. cit. p. 243, pl. xv, fig. 2; pl. xvi, figs. 12–25: Rep. Fis. Nat. Cuba, ii, 1868, p. 380.—LÜTKEN, ll. c.

These two species described by Poey from Cuba, one of which, *T. albidus*, is not uncommon on the Atlantic Coast of the United States, have already been partially discussed, and a translation of Poey's description is given in the appendix. Lütken is disposed to consider them both identical with the *T. indicus* type, and it seems to me that there is as much reason for doing this as for throwing together the Sail-fishes of the Atlantic and Indian Ocean, as has been persistently done by all writers on ichthyology.

8. TETRAPTURUS BREVIROSTRIS (Günther & Playfair).

"*Histiophorus brevirostris*, GÜNTHER & PLAYFAIR, Fishes of Zanzibar, 1866, pp. 53, 145, figure."—DAY, Fishes of India, 1876, p. 199, pl. xvii, fig. 3.

Tetrapturus brevirostris, LÜTKEN, ll. c.

Histiophorus, KNOX, Trans. New Zealand Institute, ii, 1870, pp. 13–16, fig. 1.

This species, the habitat of which is given by Day as "? East coast of Africa, seas of India, perhaps New Zealand", is referred by Lütken to the same species with *T. indicus* and *T. Herschelii*. Day considers it closely allied to *Tetrapturus Lessonæ*, Canestrini.

9. TETRAPTURUS LESSONÆ, Canestrini.

Tetrapterus Lessonæ, CANESTRINI, Arch. Zool. 1861, i, p. 259, pl. vii.—LÜTKEN, ll. c.—DAY, ll. c.

This species, described by Canestrini from the Mediterranean, is referred by Lütken to the general cosmopolitan type, of which *T. indicus* and *T. Herschelii* are the representations.

10. HISTIOPHORUS GLADIUS (Broussonet) Lacép.

Scomber gladius, BROUSSONET, Mém. Acad. Sci. 1786, p. 454, pl. x.
> *Scomber gladius*, BLOCH, Ichthyology, pl. cccxlv: Hist. Nat. Poiss.
> *Istiophorus gladius*, LACÉPÈDE, "iii, pp. 374–5", 2d ed. 8°, 1819, p. 542.
Histiophorus gladius, GÜNTHER, l. c. p. 513.—GILL, ll. c.
> *Xiphias velifer*, SCHNEIDER, l. c. p. 93.
Histiophorus indicus, CUV. & VAL. l. c. p. 293, pl. ccxxix.

This species, described first by Broussonet from specimens brought from the Indies—"la mer des Indes"—by Banks, has usually been considered, perhaps rightly, by later authors as identical with the American form.

11. HISTIOPHORUS AMERICANUS, Cuv. & Val.

Guebucu brasiliensibus, MARCGRAVE, Hist. Brasil. 1648.
> *Scomber gladius*, BLOCH, l. c.
> *Histiophorus gladius*, authors.
Histiophorus americanus, CUV. & VAL. l. c. p. 303.
Skeponopodus guebucu, NARDO, Isis, Heft iv, p. 416.

The history of this species has already been detailed under paragraph 11. Lütken follows the general lead in identifying this with *H. gladius*.

12. HISTIOPHORUS ORIENTALIS, Temminck & Schlegel.

Histiophorus orientalis, TEMM. & SCHLEG. Fauna Japonca, Pisces, 1842, p. 103, pl. lv (specimen 7 feet long, from Japan).—GÜNTHER, op. cit. p. 514.—LÜTKEN, Vid. Med. Nat. Foren. 1875, p. 1. pl. i (specimen 7 feet 1¼ inches long, from Singapore).

In his first paper on the Sword-fishes Lütken seemed inclined to consider this a distinct species, though doubtful. In "Spolia Atlantica" he speaks of two species of *Histiophorus*, but I am unable to decide whether it is this or *H. gracilirostris* which he regards as well separated from *H. gladius*. Speaking of the occurrence of this fish in the seas of Japan, Temminck and Schlegel remark that its Japanese name is "Herivo"; that it is occasionally taken in autumn on the southwest coast of Japan, during the progress of the tunny fishery, and that its flesh is much esteemed.

13. HISTIOPHORUS IMMACULATUS, Rüppell.

Histiophorus immaculatus, RÜPPELL, Proc. Zool. Soc. iii, 1835, p. 187 (abstract): Trans. Zool. Soc. ii, p. 71, pl. xv: "N. W. Fische, p. 47, taf. xi, fig. 3."—GÜNTHER, l. c.—LÜTKEN, ll. c.—DAY, Fish. India, 1876, p. 199.

Rüppell's specimen came from Djetta on the Red Sea, where the Arabs caught it in a net. He regards it as rare because the Arabs had no common name for it. The specimen is preserved in the museum at Frankfort, and, if I rightly understand Dr. Lütken, is 18 inches long. Dr. Lütken unhesitatingly pronounces it the young of *H. gladius* or *H. orientalis*, considering it as being slightly older than the one figured by Cuvier and Valenciennes as *H. pulchellus*. Day mentions a specimen of this species in the Madras Museum 5 feet 9 inches long. This, to be consistent with Lütken's theory, must be regarded as a specimen in which the colors have disappeared in drying.

14. HISTIOPHORUS PULCHELLUS, Cuvier & Valenciennes.

Histiophorus pulchellus, CUV. & VAL. Hist. Nat. Poiss. viii, 1831, p. 305, pl. ccxxx.—GÜNTHER, op. cit. p. 514.—LÜTKEN, ll. c.

Cuvier and Valenciennes described under this name a specimen 4 inches long taken in the Eastern Atlantic, north of the Cape of Good Hope, probably somewhere on the west coast of Africa, by M. Raynaud. There were said to have been a great many more of the same size in the region of the Atlantic where it was taken.

Lütken regards it as the young of *Histiophorus gladius*. He uses it to complete the series of development between the small specimens described by Günther and the adult forms.

15. HISTIOPHORUS GRACILIROSTRIS, Cuv. & Val.

Histiophorus gracilirostris, CUV. & VAL. l. c. p. 308 (description of a snout from Seychelles).—LÜTKEN, ll. c.

Cuvier and Valenciennes had in their possession, and described, a beak of a Spear-fish, the breadth of which was contained 25 to 26 times in its length, and the sides of which were more rounded than in the other specimens accessible to them. This was from Seychelles. Lütken is inclined to admit this provisionally as a distinct species. Günther, on he other hand, ignores *H. gracilirostris*, but regards *H. ancipitirostris* as a possibly existing form.

16. HISTIOPHORUS ANCIPITIROSTRIS, Cuv. & Val.

Histiophorus ancipitirostris, CUV. & VAL. op. cit. p. 309.—GÜNTHER, op. cit. p. 512, note.

A snout (locality unknown), having a flattened surface, its width contained 19 or 20 times in its length. Probably a species of *Tetrapturus*.

17. MAKAIRA NIGRICANS, Lacép.

Makaira nigricans, LACÉPÈDE, Hist. Nat. Poiss. "iv, pp. 688, 689, pl. xiii, fig. 3".—CUV. & VAL. Hist. Nat. Poiss. viii, p. 287.

Xiphias makaira, SHAW, Zool. iv, Fish. p. 104.

Machæra velifera, CUVIER, Nouv. Ann. Mus. Hist. Nat. 1832, p. 43, pl. 3.—LÜTKEN, ll. c.

Xiphias vilifer, GÜNTHER, op. cit. p. 512.

This species is undoubtedly mythical. Lütken and others have pointed out the error of arranging it, as Günther has done with *Xiphias*. He suggests that in the specimens described by Lacépède the ventral rays were hidden in the ventral furrow, and unperceived. In this case, he remarks, it would be identical with *Histiophorus gracilirostris*; but, at all events, whether it has ventral fins or not, its right place is with the subfamily *Histiophorinæ*.

The specimen described by Lacépède was never seen by him. It was driven ashore near Rochelle, and his sole acquaintance with it was from a drawing and description given him by M. Traversay, *sous-préfet* of that town. It seems strange that so much stress has been laid upon this description and so much discussion has been held over the true classification of a form so evidently incorrectly described.

Fossil forms.

Agassiz, in his "Poissons Fossils," has described two species of *Tetrapturus:* one, *Tetrapturus priscus* (vol. v, p. 91, tab. 31), from the London Clay, in the Isle of Shepley; the other, *Tetrapturus minor* (vol. v, p. 91, tab. 60 *a*, figs. 9–13), from the Lewes Crag. The types of the former are in the Paris Museum (other similar specimens are stated to be preserved in the collections of Lord Enniskellen and Sir Philip Egerton); of the latter, in the collection of Mr. Mantell.

He has also described the genus *Cœlorhynchus*, from fossil fish-beaks which appear to belong to members of the Sword-fish family. These are very long, slender, tapering more gently even than in the living forms, and are hollow throughout the entire length. There are two species, distinguished by name, but not described, viz, *C. rectus* and *C. sinuatus*, both from the London Clay of the Isle of Shepley.

Four extinct species of *Histiophorus* have been described: *H. priscus*, Ag., from the London Clay, the beak of which is not known; *H. minor*, Ag., which has a deeply fluted beak; *H. robustus*, Leidy (Post-pliocene Foss. S. Car. p. 119, *Xiphias*), which is from the Post-pliocene of Ashley River, South Carolina, with beak much depressed, the dentigerous surface a continuous plane, separated by a deep groove; *H. antiquus* (Leidy) Cope, from the New Jersey Eocene, has also a more depressed beak, with the dentary surfaces on one plane.

At a meeting of the Boston Society, October 6, 1852, Professor Wyman exhibited three fragments of the beak of a fossil *Istiophorus*, from the Tertiary deposits at Richmond, Va.

Paleorhynchus, of the schists of Glaris, has a bill like *Xiphias;* also *Hamorhynchus DesHayes*, first described by Agassiz as *Histiophorus Des Hayes*, a Scombroid with elongated bill.

D.—GEOGRAPHICAL DISTRIBUTION AND MOVEMENTS.

13.—Early allusions to the Sword-fish in Europe.

The Sword-fish was known to Pliny, who writes: "The Sword-fish, called in Greeke Xiphias, that is to say in Latin Gladius, a sword, hath a beake or bill sharp pointed, wherewith he will drive through the sides and plankes of a ship, and bouge them so, that they shall sinke withall. The experience whereof is scene in the ocean, neare to a place in Mauritania called Gotta, which is not far from the river Lixos."*

Many other classical and mediæval writers made curious allusions to the Sword-fish. A very good summary of their views is given by Bloch

* Holland's Pliny, ii, p. 428.

and is here quoted. The skepticism of this author is sometimes a little too sweeping, but is in general judicious:

"This fish is found in the North Sea and the Baltic, but is rare in those waters. In the Mediterranean, however, it is very abundant. It lives for the most part in the Atlantic, where in winter it is found in mid-ocean In spring it appears on the coast of Sicily, where its eggs are deposited on the bottom in great numbers. However, according to what I have been told by the illustrious Chevalier Hamilton, it is never seen in that region more than three or four feet long. The larger ones, often weighing four or five hundred pounds, and eighteen to twenty feet long, are found on the coast of Calabria, where they appear in June and July. Pliny remarked that they often exceed the dolphin in size. * * *

"Various writers have spoken of the 'Emperor of the Sea' as occurring in the Baltic. Olearius and Schelhammer record its capture near Holstein; Schoneveld mentions one from Mecklenburg; Walbaum one from the vicinity of Lübeck; Hanover and Klein one from the vicinity of Danzig; Hartmann one from near Pillau; and Wolf another taken near Königsberg.

"One mentioned by Schoneveld as taken near Mecklenburg was so large that it required two strong horses to draw it from the water. The body, without the sword, was eleven feet long, the sword three. The eyes were as large as hens' eggs, and the tail was two feet broad. Of four seen by Professor Koelpin during his stay at Greifswald, one measured more than three and one-half feet in circumference. * * *

"These fish, according to the story of the Chevalier Hamilton, always appear in pairs as they approach Messina, a female and a male together."

[Then follows a description of the method of capture, very similar to that given below in paragraph 56.]

"This fish lives upon marine plants and fish. It has such a terrible defensive weapon that other voracious fishes do not dare to attack it. According to Aristotle, it is, like the tunny, tormented by an insect, and in its fury leaps out of the sea and even into vessels. According to Statius Müller, the skin is phosphorescent at night. Although such large fishes are not usually well flavored, this one is considered palatable. Pieces of the belly and the tail are especially esteemed, and hence they are expensive. The fins are salted and sold under the name '*callo*'. * * *

"Aelian errs in saying that it enters fresh water, and in cataloguing it among the fishes of the Danube.

"Oppian and Ovid consider it, on account of its sword, one of the most terrible denizens of the sea. It is not at all probable that, as Pliny and many other later ichthyologists have written, it pierces the sides of vessels with its sword and sends them to the bottom; its sword is not sufficiently strong.

"Salviani, who gave the first figure of the fish, was wrong, like many writers who followed him, in giving two dorsal and two anal fins.

"Gesner, Aldrovandus, and Jonston have represented the species with two ventral fins. Bellon and Bomare were wrong in classing it among the whales. Subsequent authors have failed to find the scales represented in the figure given by the former and the teeth of which the latter spoke."*

14.—ALLUSIONS TO THE SWORD-FISH IN AMERICA BY EARLY WRITERS.

The ancient city of Siena, secluded and almost forgotten among the hills of Northern Italy, should have a peculiar interest for Americans. Here Christopher Columbus was educated, and here, in the height of his triumphs as a discoverer, he chose to deposit a memento of his first voyage across the seas. His votive offering hangs over the portal of the old collegiate church, closed for many years, and rarely visited save by enterprising American tourists. It consists of the helmet and armor worn by the discoveror when he first planted his feet on New World earth, his weapons, and the weapon of a warrior killed by his party when appoaching the American coast—the sword of a Sword-fish.†

It is not probable that Columbus or some of his crew, sea-faring men of the Mediterranean, had never seen the Sword-fish. Still, its sword was treasured up by them, and has formed for more than four centuries and a half a striking feature in the best preserved monument of the discoverer of America.

The earliest allusion in literature to the existence of the Sword-fish in the Western Atlantic seems to occur in Josselyn's Account of Two Voyages to New England, printed in 1674, in the following passage:

"First Voyage:—The Twentieth day, we saw a great number of Sea-bats, or Owles, called also flying fish, they are about the bigness of a Whiting, with four tinsel wings, with which they fly as long as they are wet, when pursued by other fishes. Here likewise we saw many Grand-pisces, or Herring-hogs, hunting the scholes of Herrings, in the after-noon we saw a great fish called the Vehuella or Sword-fish, having a long, strong and sharp finn like a Sword-blade on the top of his head, with which he pierced our Ship, and broke it off with striving to get loose, one of our Sailers dived and brought it aboard."

A half century later the species is referred to in Catesby's work.‡

Pennant, though aware of the statement made by Catesby, refuses the species a place in his List of the Fishes of North America,§ supposing him to refer to the orca or high-finned killer-whale: "I am not certain whether *Catesby* does not mean the high-finned *Cachelot* by his Sword-

* Bloch, Ichthyologie, iii, pp. 24–26.

† For this fact, which I do not remember to have ever seen on record, I am indebted to my friend Col. N. D. Wilkins, of the Detroit Free Press, who visited the locality in 1879.

‡ Historia Naturalis Carolinæ, &c., 1731.

§ Arctic Zoology, vol. iii, 1784, p. 364.

fish; yet as it is found in most seas, even to those of *Ceylon* (Mr. Loten,) I give it a place here."

Catesby's testimony was soon confirmed by Dr. Alexander Garden. This enthusiastic collector, through whose correspondence with Linnæus so many of our southern plants and animals were first brought to knowledge and named, writes to John Ellis, from Charleston, S. C., March 25, 1755: "I have sent you one of the rostrums of a fish found on the Florida coast, which I take to be a species of the *Ziphias rostr. apice ensiforme, pinnis ventralibus nullis.** I have been told that they are frequently found on the Carolina coast, though I have never seen any of them, and I have been all along the coast to the Florida shore."†

Another allusion occurs in a communication by Prof. S. L. Mitchill, of New York, in the American Monthly Magazine:

"An individual of this species was taken, off Sandy Hook, by means of a harpoon, on the 19th June, 1817. The next day it was brought to New York Market and cut up like halibut and sturgeon for food. The length was about 12 feet, and girth, by estimation, 5. * * * The stomach contained seven or eight mackerel. The flesh was remarkably firm; it was purchased at a quarter of a dollar the pound. I tasted a chop of it, broiled, and found it savory and excellent. It resembled the best sturgeon, without its strong and oily flavor. While I ate it I thought of veal cutlet. * * * I have been informed by my friend John Renny that a Sword-fish 16 feet long was exhibited at New York in the year 1791."‡

15.—Distribution of Xiphias gladius in the Eastern Atlantic

The Sword-fish is abundant in the Mediterranean§ even as far east as Constantinople. Aelian said that it was frequent in the Black Sea, entering the Danube. Unfortunately, this is neither confirmed nor contradicted by any later writer whose works I have seen, except Bloch, whose skepticism is as unreliable as the statements of Aelian. Aelian says that this species, with several others, is frequently taken in the Danube at the breaking up of the ice in spring. This is so contrary to the known habits of the fish that it throws discredit on the whole story, for the present at least. From the entrance to the Mediterranean they range south to Cape Town. Berthelot saw great numbers of them off the Canaries. They have been frequently noticed on the coasts of Spain and France. They occur sparingly in summer in the British waters, even to the Orkneys and the Hebrides. They occasionally reach

* The name by which this fish was designated in the earlier editions of Linnæus's writings.

†A selection of the correspondence of Linnæus and other naturalists, from the original manuscripts. By Sir James Edward Smith, M. D., F. R. S., &c., &c., president of the Linnæan Society. In two volumes. London. Printed for Longman, Hurst, Rees, Orme and Brown, Paternoster Row, 1821. (Vol. i, p. 353.)

‡ American Monthly Magazine, ii, 1818, p. 242.

§ Risso, Cuvier & Valenciennes, Guichenot, &c.

Sweden and Norway, where Linnæus observed them, and, according to Lütken, have been taken on the coast of Finmark. They are known to have occurred in Danish waters and to have found their way into the Baltic, thus gaining a place in the fauna of Russia. A number of instances of the occurrence of Sword-fish in the Baltic are mentioned above in paragraph 13.

16.—DISTRIBUTION ON THE COAST OF THE UNITED STATES.

Allusion has been made to the early accounts of the Sword-fish on the coast of the United States both in the work of Catesby and the letters of Garden to Ellis and Linnæus; also, to Mitchill's account of it in 1818. Though it is strange that this very conspicuous species *was not recorded more frequently by early American authors, it is still more remarkable that its right to a place in the fauna of the Western Atlantic was either denied or questioned, as late as 1836, by such well-informed authors as Sir John Richardson and MM. Cuvier and Valenciennes.

Storer's "Report on the Ichthyology and Herpetology of Massachusetts", published in 1839, was the first American faunal list, after Catesby's, in which the Sword-fish was mentioned among the American fish.

The range of the species on the eastern coast of America can now be defined with some accuracy. Northward and eastward these fish have been seen as far as Cape Breton and Sable Island Banks.

Captain Rowe states that during a trip to George's Banks he has seen them off Chebucto Head, near Halifax, where the fishermen claim occasionally to have taken them with a seine.

Capt. Daniel O'Brien, of the schooner "Ossipee", took five Sword-fish on his halibut-trawl, in 200 fathoms of water, between La Have and Brown's Banks, in August, 1877.

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*Richardson remarks: "The habits of the *Scomberoidæ* are quite in accordance with their great powers of natation. We found among them many fish that pass their lives remote from the land, in the middle districts of the ocean, and the family may be termed *pelagic* with as much propriety as some of the preceding ones have been named after the countries where they most abound. The bonitos and dolphins, or *Coryphænæ*, especially, roam about the tropics, pursuing schools of various kinds of flying fish. There is a greater number of species that cross the Atlantic belonging to this family than to any preceding one. Among these are *Scomber grix*, *Pelamys sarda*, *Trichiurus lepturus*, *Elacate atlantica*, *Lichia glaucus*, *Caranx carangus*, and *Nomens mauritii*. Several not only traverse the Atlantic from side to side, but also range through other seas; thus, *Thynnus pelamys* and *Sariola cosmopolita* are known on both sides of the Atlantic and in the Indian Ocean. *Auxis vulgaris*, which is common to the Mediterranean and Caribbean Seas, also extends to the Indian Archipelago, if the *Taso* of New Guinea be the same species. *Vomer Brownii* visits both sides of the Atlantic, and also the sea of Peru. *Many of the species mentioned above as traversing the Atlantic exist also in the Mediterranean; and there are several others which have an extensive range in the latter sea and through the whole eastern side of the Atlantic, though they do not cross to America*, such as *Scomber scombrus*, *Lepidopus argyreus*, XIPHIAS GLADIUS, and *Naucrates ductor*. * * * *Xiphias gladius* is enumerated by Dr. Smith, in his list of the fish of Massachusetts; but as he has included several other European species in his list on very insufficient grounds, further evidence is required of its being an American fish."—(Richardson, Fauna Boreali-Amerocani, p. 78.)

Capt. Jerome B. Smith, of the schooner "Hattie Lewis", of Gloucester, killed a Sword-fish off Cape Smoke, near Sidney, Cape Breton.

Mr. J. Matthew Jones, of Halifax, N. S., writes, in 1877: "The Sword-fish is by no means common on our coast, and only makes its appearance at intervals in our harbors and bays. One was taken in 1864 in Bedford Basin, at the head of Halifax Harbor. September 6, 1866, an individual weighing 200 pounds was taken in a net at Devil's Island. November 12, 1866, the Rev. J. Ambrose sent me a sword, 3 feet and 6 inches long, from a fish taken at Dover, N. S., a few days previously."

The Sword-fish has, once at least, penetrated into the Gulf of St. Lawrence. In September, 1857, Capt. J. W. Collins was one of the crew of the schooner "Mary Ellen", of Truro, Mass., and harpooned a Sword-fish four miles southwest of the eastern part of Prince Edwards Island.

On the coasts of Maine, Massachusetts, and Rhode Island they abound in the summer months. Southward they are less frequently seen, though their occurrence off New York is not unusual. I have never known one to be taken off New Jersey, and in our southern waters they do not appear to remain. Uhler and Lugger vaguely state that they sometimes enter the Chesapeake Bay.† This is apparently traditionary evidence.

Dr. Yarrow obtained reliable information of their occasional appearance near Cape Lookout, N. C.‡

Mr. A. W. Simpson states, in a letter to Professor Baird, that Sword-fish are sometimes seen at sea off Cape Hatteras, in November and December, in large quantities. They sometimes find their way into the sounds.

An item went the rounds of the newspapers in 1876 to the effect that a Sword-fish 4 feet long had been captured in the Saint John's River, near Jacksonville. After personal inquiry in Jacksonville, I am satisfied that this was simply a scabbard-fish or silvery hair-tail (*Trichiurus lepturus*).

Professor Poey states that the fishermen of Cuba sometimes capture the *Pez de espada* when in pursuit of *Agujas* or Spear-fishes.§

They have also been seen in Jamaica.

Lütken gives instances of the capture of young Sword-fish at various points in the open Atlantic, as follows:

(1) Lat. 32° 50′ N., long. 74° 19′ W. (about 150 miles SE. of Cape Hatteras).

(2) Lat. 23° W., long. 55° W. (about 500 miles NE. of the Island of Antigua).

(3) Lat. 20° N., long. 31° W. (about 150 miles NW. of Teneriffe and 250 SW. of Madeira).

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* Capt. R. H. Hulbert.

† List of the Fishes of Maryland. By P. R. Uhler and Otto Lugger, in Report of the Commissioners of Fisheries of Maryland, January, 1876, p. 90.

‡ Notes on the Natural History of Fort Macon, N. C., and vicinity (No. 3). By H. C. Yarrow, in Proceedings of the Academy of Natural Sciences of Philadelphia, 1877, p. 207.

§ Synopsis Piscium Cubensium, Cataloga Razonado de los Peces de la Isla de Cuba, in Repertorio Fisico-Natural de la Isla de Cuba, ii, 1868, p. 379.

(4) On the equator, long. 29° (about 500 miles NE. of Cape St. Roque).
(5) Lat. 25° 4′ S., long. 27° 26′ W. (about 500 miles S. of the Island of Trinidad, South Atlantic).

17.—Occurrence in the Pacific and Indian Oceans.

We have no record of the occurrence of Sword-fishes on the eastern coast of South America, but the species is found on the Pacific coast of the same continent, and north to California.

Professor Jordan writes: "Occasionally seen about Santa Catalina and the Coronados, but never taken, the fishermen having no suitable tackle. One seen by us off Santa Monica, in 1880, about eight feet in length."

Mr. Willard Nye, of New Bedford, Mass., kindly communicates the following notes: Captain Dyer, of this port, says that Sword-fish are plentiful off the Peruvian coast, a number being often in sight at one time. The largest he ever saw was one caught by himself about 150 miles from the shore, and which he estimates to have weighed 900 to 1,000 pounds; the ship's crew subsisted on it for several days and then salted 400 pounds.

Captain Allen also states that while cruising in the Pacific for whales he has found the Sword-fish very abundant on the coasts of Peru and Chili, from the immediate coast 300 miles out, though outside of that limit they are seldom seen. They are most plenty during the month of January, when they are feeding on the common mackerel, with which those waters at that time abound. The largest he ever caught weighed about 600 pounds.

Both Captain Allen and Captain Dyer have made several voyages as masters of whaling ships, and are perfectly familiar with Sword-fish on our coast; both speak of seeing plenty of Bill-fish in the Pacific, but they never had taken the trouble to catch them. Günther mentions them in his book on the Fishes of the South Sea.

In 1874 Dr. Hector discovered a Sword-fish snout in the museum at Auckland, New Zealand, and his announcement of the discovery was followed by the publication of two other instances of its occurrence in this region.*

18.—Sword-fish entering rivers.

Sword-fish have been known to enter the rivers of Europe. We have no record of such a habit in those frequenting our waters.†

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*Hector, Trans. New Zealand Inst. vii, (1874) 1875, p. 246.
Hutton, ibid. viii, (1875) 1876, p. 211.
Cheeseman, ibid. p. 219.

†They sometimes approach very near the shore, however, as is shown by the following extract from a Cape Cod paper:

"*A Sword-fish in close quarters.*—Monday afternoon, while Mr. A. McKenzie, the boat-builder on J. S. Atwood's wharf, was busily at work, his attention was attracted by a splashing of water under his work-shop, as if a score of boys were swimming and

Aelian's improbable story that they were taken in the Danube in winter has been mentioned. Southey and others relate that a man was killed while bathing in the Severn, near Worcester, by one of these fishes, which was afterwards caught.

Couch states that a Sword-fish, supposed to weigh nearly 300 pounds, was caught in the river Parrett, near Bridgewater, in July, 1834.

According to De la Blanchère, one of them was taken, in the ninth year of the French Republic, in the river of Vannes, on the coast of Rhuys.†

In the great hall of the *Rathhaus* in the city of Bremen hangs a large painting of a Sword-fish which was taken in the river Weser by some Bremen fishermen some time in the seventeenth century.

Underneath it is painted the following inscription:

"ANNO. 1696. DEN. 18. JULI. IST. DIESER.
FISCH. EIN. SCHWERTFISCH. GENANNT. VON. DIESER.
STADT. FISCHERN. IN. DER. WESER. GEFANGEN.
UND. DEM. 20. EJUSDEM. ANHERO. NAEHER.
BREMEN. GEBRACHT. WORDEN. SEINE. GANZE.
LENGTE. WAR. 10. FUSS. DAS. SCHWERT. WAR.
7½. VIRTEL. LANG. UND. 3. ZOLL. BREIT."

19.—GEOGRAPHICAL RANGE OF THE SWORD-FISH FAMILY.

Although it may not seem desirable at present to accept in full the views of Dr. Lütken regarding the specific unity of the Spear-fishes and the Sail-fishes of the Atlantic and Indian Oceans, it is convenient to group the different species in the way he has suggested in discussing their geographical distribution.

THE SWORD-FISH, *Xiphias gladius*, ranges along the Atlantic coast of America from Jamaica, lat. 18° N., Cuba, and the Bermudas to Cape Breton, lat. 47°. Not seen at Greenland, Iceland, or Spitzbergen, but occurring, according to Collett, at the North Cape, lat. 71°. Abundant along the coasts of Western Europe, entering the Baltic and the Mediterranean. I can find no record of the species on the west coast of Africa south of the Cape Verdes, though Lütken, who may have access to facts unknown to me, states that they occur clear down to the Cape of

making all the noise they possibly could by beating the water with their feet and hands. After this had been kept up a while his curiosity became excited, and upon investigating the cause of the disturbance discovered a Sword-fish among the, where, in his attempts to escape, he had become bewildered and imprisoned. Quickly getting a harpoon, Mr. McKenzie fastened the fish, and with the aid of bystanders drew it alive upon the wharf, where it was visited by many spectators, and subsequently dressed and sold. It measured ten feet from the end of its sword to the tip of the tail—the sword itself being three feet in length. It is the first instance known of one of these fish being so near the shore, and why it should have been there at that time described is not easily explained."—*Provincetown Advocate, September 29, 1875.*

* History of British Fishes, ii, p. 148.

† Dictionnaire Général des Pêches.

Good Hope, South Atlantic in mid-ocean, west coast of South America and north to Southern California, lat. 34°, New Zealand, and in the Indian Ocean off Mauritius. Good authorities state that sperm-whales, though constantly passing Cape Horn, never round the Cape of Good Hope. Can this be true in the case of the Sword-fish ?

THE SAIL-FISH, *Histiophorus gladius* (with *H. americanus* and *H. orientalis*, questionable species, and *H. pulchellus* and *H. immaculatus*, young), occurs in the Red Sea, Indian Ocean, Malay Archipelago, and south at least as far as the Cape of Good Hope, lat. 35° S.; in the Atlantic on coast of Brazil, lat. 30° S. to 0, and north to Southern New England, lat. 42° N.; in the Pacific to Southwestern Japan, lat. 30° to 10° N. In a general way the range may be be said to be in tropical and temperate seas, between lat. 30° S. and 40. N., and in the western parts of those seas.

THE BILL-FISH OR SPEAR-FISH, *Tetrapturus indicus* (with the various doubtful species mentioned in paragraph 12), occurs in the Western Atlantic from the West Indies, lat. 10° to 20° N., to Southern New England, lat. 42° N.; in the Eastern Atlantic from Gibraltar, lat. 45° N., to the Cape of Good Hope, lat. 30° S.; in the Indian Ocean, the Malay Archipelago, New Zealand, lat. 40° S., and on the west coast of Chili and Peru. In a general way, the range is between lat. 40° N. and lat. 40° S.

The species of *Tetrapturus* which we have been accustomed to call *T. albidus*, abundant about Cuba, is not very unusual on the coast of Southern New England. Several are taken every year by the Sword-fish fishermen. I have not known of their capture along the Southern Atlantic coast of the United States. All I have known about were taken between Sandy Hook and the eastern part of George's Banks.

THE MEDITERRANEAN SPEAR-FISH, *Tetrapturus belone*, appears to be a land-locked form, never passing west of the Straits of Gibraltar.

20.—PERIODICAL MOVEMENTS OF THE SWORD-FISH—TIMES OF ARRIVAL AND DEPARTURE.

Before entering upon a discussion of the movements of the Sword-fish and their causes, it seems desirable to bring together the facts which have been learned, by conversation with fishermen and otherwise, in one group. Each man's views are given in his own style, and as nearly as possible in his own words. There is no attempt at a classification of the facts. This will be made subsequently.

An old swordfisherman at New York informed Mr. Blackford that the season opens in the neighborhood of Sandy Hook about the 1st of June, and continues along the coast as far east as Martha's Vineyard and Nantucket Shoals until about the middle of September. He has heard of their being caught as far east as Cape Sable. At the first cold winds of September they disappear. They are, like the mackerel, at first very poor and lean, but as the season advances they grow fatter.

Mr. John H. Thomson, of New Bedford, who kindly interviewed some of the local fishermen, writes: "The Sword-fish appear on our coast, south of Block Island, about May 25 to June 1. They appear to come from the southwest, or just inside the track of the Gulf Stream. They gradually approach the Vineyard Sound and vicinity during June and until July 10 or 15, then appear to leave, working to the southeast, and are to be found to the southeast of Crab Ledge about the middle of July. This school is composed of comparatively small fish, averaging about 150 pounds, gross, or about 100 pounds without head and tail, as they are delivered in the market. The smallest are 4 feet long, including the sword, and weigh from 30 to 40 pounds; the largest 8½ feet long, with sword, and weighing 300 pounds gross. These fish are of a light plumbeous hue, darker on the back and white on the belly.

"Of late years another school has appeared southeast of Cape Cod and George's Banks about the 1st of August. These fish are altogether different, being much larger, weighing from 300 to 800 pounds gross, and are entirely black. I have this week conversed with an old smackman, M. C. Tripp, who has all his life been a fisherman, and has this year (1874) captured about ninety fish, and his opinion is that they are not the same school. They appear to be of about the same abundance in average years, the catch depending on weather, fogs, &c. They come and leave in a general school, not in close schools like other fish, but distributed over the surface of the water, the whole being called by the fishermen the 'annual school', though it cannot strictly be so named."

According to Mr. Willard Nye, Sword-fish appear on the coast of Massachusetts from the 8th to the 20th of June, and are first seen southwest of Block Island. They begin to leave in August, but stray ones are sometimes seen as late as the last of October. The usual explanation of their movement is that they are following their food—mackerel and menhaden—which swarm our waters in the season named, and which are of course driven off by the approach of winter and rough weather.

Capt. R. H. Hurlbert took a very large Sword-fish on George's Banks, in November, 1875, in a snow-storm.

The first Sword-fish of the season of 1875 was taken June 20, southwest of Montauk Point; its weight was 185 pounds.

One taken off Noman's Land, July 20, 1875, weighed when dressed 120 pounds, and measured 7 feet. A cast was taken (No. 360), which was exhibited in the Government Building at Philadelphia.

Capt. Benjamin Ashby, of Noank, Conn., tells me that the New London and Noank vessels leave home on their swordfishing cruise about the 6th of July. Through July they fish between Block Island and Noman's Land; in August between Noman's Land and the South Shoals Light Ship. The fish "strike in" to Block Island and Montauk Point every year about the 1st of July. They are first seen 20 to 25 miles southeast of Montauk. At the end of August they are most abundant in the South Channel. Captain Ashby never saw them at any time so abundant as August 15, 1859. He was cruising between George's Banks and the South Shoals. It was a calm day, after a fog. He could at any time see twenty-five or thirty from the mast-head. They turn south when snow comes.

Capt. George H. Martin, of East Gloucester, tells me that the Gloucester vessels employed in this fishery expect to be on the fishing grounds south of George's Banks by the 10th of June. They almost always find the fish there on their arrival, following the schools of mackerel. They "tend on soundings", like the mackerel. The first Sword-fish of 1877 was taken June 10; the first of 1878, June 14.

The statements already quoted, and numerous conversations with fishermen not here recorded, lead me to believe that Sword-fish are most abundant on the shoals near the shore and on the banks during the months of July and August; that they make their appearance on the frequented cruising grounds between Montauk Point and the eastern part of George's Banks some time between the 25th of May and the 20th of June, and that they remain until the approach of cold weather in October or early in November. The dates of the capture of the first fish on the cruising ground referred to are recorded for three years, and are reasonably reliable: 1875, June 20; 1877, June 10; 1878, June 14.

South of the cruising ground the dates of arrival and departure are doubtless farther apart; north and east the season shorter. There are no means of obtaining information, since the men engaged in this fishery are the only ones likely to remember the dates when the fish are seen.

21.—REASONS OF THE COMING OF SWORD-FISH UPON OUR COAST.

The Sword-fish comes into our waters in pursuit of its food. At least this is the most probable explanation of their movements, since the duties of reproduction appear to be performed elsewhere. Like the tunny, the bluefish, the bonito, and the squeteague, they pursue and prey upon the schools of menhaden and mackerel which are so abundant in the summer months. "When you see Sword-fish, you may know that mackerel are about!" said an old fisherman to me. "Where you see the finback whale following food, there you find Sword-fish!" said another. The Sword-fish also feeds upon squid, which are at times abundant on our banks.

22.—THE INFLUENCE OF TEMPERATURE UPON THE MOVEMENTS OF THE SWORD-FISH.

To what extent this fish is amenable to the influences of temperature is an unsolved problem. We are met at the outset by the fact that they are frequently taken on trawl-lines which are set at the depth of 100 fathoms or more on the off shore banks. We know that the temperature of the water at those localities and at that depth is sure to be less than 40° Fahrenheit. How is this fact to be reconciled with the known habits of the fish, that it prefers the warmest weather of summer and swims at the surface in water of temperature ranging from 55° to 70°, sinking when cool winds blow? The case seemed clear enough until this perplexing discovery was made, that Sword-fish are taken on bottom trawl-lines. In other respects their habits agree closely with those of the mackerel tribe, all the members of which seem sensitive to slight changes in temperature, and which, as a rule, prefer temperature in the neighborhood of 50° or more.

There is one theory by which this difficulty may be avoided. We may suppose that the Sword-fish take the hooks on their way down to the bottom; that in their struggles they get entangled in the line and hooks, and when exhausted sink to the bottom. This is not improbable. A conversation with some fishermen who have caught them in this way develops the fact that the fish are usually much tangled in the line, and are nearly lifeless when they are brought to the surface. A confirmation is found in the observations of Captain Baker, of the schooner "Peter D. Smith", of Gloucester, who tells me that they often are taken on the hand-lines of the codfishermen on George's Banks. His observations lead him to believe that they only take the hook when the tide is running very swiftly and the lines are trailing out in the tide-way at a considerable distance from the bottom, and that the Sword-fish strike for the bottom as soon as they are hooked. This theory is not improbable, as I have already remarked, but it is not at present very strongly advocated. I want more facts before making up my own mind. At present the relation of the movements of the Sword-fish to temperature must be left without being understood.

The appearance of the fish at the surface depends apparently upon temperature. They are seen only upon quiet summer days, in the morning before ten or eleven o'clock and in the afternoon about four o'clock. Old fishermen say that they rise when the mackerel rise, and that when the mackerel go down they go down also.

23.—Probable winter habitat of the Sword-fish.

Regarding the winter abode of the Sword-fish conjecture is useless. I have already discussed this question at length with reference to the menhaden and mackerel. With the Sword-fish the conditions are very different. The former are known to spawn in our waters, and the schools of young ones follow the old ones in toward the shores. The latter do not spawn in our waters. We cannot well believe that they hibernate, nor is the hypothesis of a sojourn in the middle strata of mid-ocean exactly tenable. Perhaps they migrate to some distant region, where they spawn. But then the spawning time of this species in the Mediterranean, as is related in a subsequent paragraph, appears to occur in the summer months, at the very time when our Sword-fishes are thronging our own waters, apparently with no care for the perpetuation of their species.

24.—Movements of individual Sword-fishes.

A Sword-fish when swimming near the surface usually allows its dorsal fin and the upper lobe of its caudal fin to be visible, projecting out of the water several inches. It is this habit which enables the fisherman to detect the presence of the fish. It swims slowly along, and the fishing schooner with a light breeze finds no difficulty in overtaking it. When excited its motions are very rapid and nervous. Sword-fishes are sometimes seen to leap entirely out of the water. Early writers attributed this habit to the tormenting presence of parasites, but this theory seems hardly necessary, knowing what we do of its violent exertions at other times. The pointed head, the fins of the back and abdomen snugly fitting into grooves, the absence of ventrals, the long, lithe, muscular body, sloping slowly to the tail, fit it for the most rapid and forcible movement through the water. Prof. Richard Owen, testifying in an English court in regard to its power, said:

"It strikes with the accumulated force of fifteen double-handed hammers. Its velocity is equal to that of a swivel-shot, and is as dangerous in its effects as a heavy artillery projectile."

Many very curious instances are on record of the encounters of this fish with other fishes or of their attacks upon ships. What can be the inducement for it to attack objects so much larger than itself it is hard to surmise. Every one knows the couplet from Oppian:

> "Nature her bounty to his mouth confined,
> Gave him a sword, but left unarmed his mind."

It surely seems as if a temporary insanity sometimes takes possession of the fish. It is not strange that, when harpooned, it should retaliate by attacking its assailant. An old swordfisherman told Mr. Blackford that his vessel had been struck twenty times. There are, however, many instances of entirely unprovoked assault on vessels at sea. Many of these are recounted in a later portion of this memoir. Their movements when feeding are discussed below, under section 35, as well as their alleged peculiarities of movement during the breeding season, under section 37.

It is the universal testimony of our fishermen that two are never seen swimming close together. Captain Ashby says that they are always distant from each other at least 30 or 40 feet.

25.—Movements of Spear-fishes.

The Spear-fish in our waters is said by the fishermen to resemble the Sword-fish in its movements and manner of feeding. Professor Poey narrates that both the Cuban species swim at a depth of 100 fathoms, and they journey in pairs, shaping their course toward the Gulf of Mexico, the females being full of eggs. Only adults are taken. It is not known whence they come, or where they breed, or how the young return. It is not even known whether the adult fishes return by the same route.

When the fish has swallowed the hook it rises to the surface, making prodigious leaps and plunges. At last it is dragged to the boat, secured with a boat-hook, and beaten to death before it is hauled on board. Such fishing is not without danger, for the Spear-fish sometimes rushes upon the boat, drowning the fisherman, or wounding him with its terrible weapon. The fish becomes furious at the appearance of sharks, which are its natural enemies. They engage in violent combats, and when the Spear-fish is attached to the fisherman's line it often receives frightful wounds from these adversaries.

In *Land and Water* for August 31, 1872, Col. Nicholas Pike, author of "Subtropical Rambles", at that time United States consul at Mauritius, describes the habits of a species of *Tetrapturus* occurring in that vicinity. He states that they have the habit of resting quietly on the surface in calm weather, with their dorsals expanded and acting as sails. They are taken in deep water with hook and line or speared when near the surface, like Sword-fish. When hooked or speared they make for the boats, taking tremendous leaps in the air, and if care is not taken they will jump into the boats, to the great consternation of the fishermen, or else pierce the boats with their bills. The fish is highly esteemed in the Mauritius, the flesh being of a salmon color near the vertebræ; lower down it is red and like coarse beef. The species attains a large size, one having been seen measuring 26 feet.

.26.—Movements of Sail-fishes.

No observations have been made in this country, and recourse must be had to the statements of observers in the other hemisphere.

In the life of Sir Stamford Raffles there is the following account from Singapore, under date of November 30, 1822:

"The only amusing discovery we have recently made is that of a sailing fish, called by the natives *Ikan layer*, of about 10 or 12 feet long, which hoists a mainsail, and often sails in the manner of a native boat, and with considerable swiftness. I have sent a set of the sails home, as they are beautifully cut and form a model for a fast-sailing boat. When a school of these are under sail together they are frequently mistaken for a fleet of native boats."

The fish referred to is in all likelihood *Histiophorus gladius*, a species very closely related to, if not identical, with our own.

E.—SIZE AND RATE OF GROWTH.

27.—Maximum and average size of American Sword-fish.

The only individual of which we have the exact measurements was taken off Seaconnet, R. I., July 23, 1874. This was 7 feet and 7 inches long, weighing 113 pounds. Another, taken off Noman's Land, July 20, 1875, and cast in plaster for the collection of the National Museum, weighed 120 pounds, and measured about 7 feet. Another, taken off Portland, August, 15, 1878, was 3,999 millimeters long, and weighed about 600 pounds. Many of these fish doubtless attain the weight of 400 and 500 pounds, and some, perhaps, grow to 600; but after this limit is reached, I am inclined to believe larger fish are exceptional. Newspapers are fond of recording the occurrence of giant fish, weighing 1,500 pounds and upwards, and old sailors will in good faith describe the enormous fish which they saw at sea, but could not capture; but one well-authenticated instance of accurate weighing is much more valuable. The largest one ever taken by Capt. Benjamin Ashby, for twenty years a swordfisherman, was killed on the shoals back of Edgartown, Mass. When salted it weighed 639 pounds. Its live weight must have been as much as 750 or 800 pounds. Its sword measured nearly 6 feet. This was an extraordinary fish among the three hundred or more taken by Captain Ashby in his long experience. He considers the average size to be about 250 pounds dressed, or 325 alive. Captain Martin, of Gloucester, estimates the average size at 300 to 400 pounds. The largest known to Captain Michaux weighed 625 pounds. The average about Block Island he considers to be 200 pounds.

There are other stories of large fish. Capt. R. H. Hurlbert, of Gloucester, killed one on George's Banks, in September, 1876, which weighed when dressed 480 pounds. Capt. John Rowe, of the same port, salted one which filled two and one-half barrels. This probably weighed 600 pounds when alive. I have been told that a Sword-fish loses one-third of its weight in dressing, but I should think that one-fourth would be nearer to the truth. Captain Baker, of the schooner "Peter D. Smith", of Gloucester, assures me that he killed, in the summer of 1874, off Portland, a Sword-fish which weighed 750 pounds.

Mitchill and DeKay state that in 1791 a Sword-fish 16 feet in length was exhibited in New York. It is questionable whether they often exceed this measurement. My own observations have been made on specimens from 7 to 12 feet long. A stuffed specimen in the United States National Museum measures eleven feet, and this seems to be very nearly the average size.

28.—Minimum size of American Sword-fish.

The size of the smallest Sword-fishes taken on our coast is a subject of much deeper interest, for it throws light on the time and place of breeding. There is some difference of testimony regarding the average size, but all fishermen with whom I have talked agree that very small ones do not find their way into our waters. I have collected several instances from the experiences of men long wonted to this fishery.

Capt. John Rowe has seen one which did not weigh more than 75 pounds when taken out of the water.

Capt. R. H. Hurlbert killed, near Block Island, in July, 1877, one which weighed 50 pounds, and measured about 2 feet without its sword.

Captain Ashby's smallest weighed about 25 pounds when dressed;

this he killed off Noman's Land. He never killed another which weighed less than 100. He tells me that a Bridgeport smack had one weighing 16 pounds (or probably 24 when alive), and measuring 18 inches without its sword.

In August, 1878, a small specimen of the mackerel shark, *Lamna cornubica*, was captured at the mouth of Gloucester Harbor. In its nostril Dr. Bean found the sword, between 1 and 2 inches long, of a young Sword-fish. When this was pulled out the blood flowed freely, indicating that the wound was recent. The fish to which this sword belonged cannot have exceeded 10 or 12 inches in length. Whether the small Sword-fish met with its misfortune in our waters, or whether the shark brought this trophy from beyond the sea, is a question I cannot answer.

Lütken speaks of a very young individual taken in the Atlantic, lat. 32° 50′ N., long. 74° 19′ W. This must be about 150 miles southeast of Cape Hatteras.

29.—Size of Sword-fish in the Mediterranean.

In the Mediterranean, near Sicily and Genoa, young fish, ranging in weight from half a pound to 12 pounds, are said to be abundant between November and March.

About La Ciotat and Martigues, in the south of France, many are taken too small to injure the fishing-nets, and very rarely reaching the weight of 100 pounds.

From the statements of Bloch and later writers it appears that large Sword-fish also are abundant in the Mediterranean. Late Italian fishery reports state that the average weight of those taken on the coast of Italy is 50 kilograms (110 pounds).

Of the coasts of Spain and Portugal Steindachner remarks: "More abundant on the southern coasts of Spain than on the northern, western, and eastern sides of the Iberian peninsula. We saw quite large examples in the fish-markets at Gibraltar, Cadiz, Lisbon, La Coruña, and Barcelona, and at Santa Cruz, Teneriffe. The largest of three specimens in my possession is 43 inches long, another 24 inches."*

30.—Rate of growth.

Little is known about the rate of growth. The young fish taken in winter in the Mediterranean, ranging in weight from half a pound to 12 pounds, are thought to have been hatched during the previous summer. Those of a larger size, ranging from 24 to 60 pounds, taken on the New England coast in the summer, may perhaps be the young of the previous year. Beyond this even conjecture is fruitless. As in other species, the rate of growth depends directly upon the quantity of food consumed. It is to be presumed that a summer passed in feasting among the crowding schools of menhaden and mackerel in our waters

*Sitzb. Ak. Wiss. Wein, 1868, p. 396.

would bring about a considerable increase in weight. That this is the case is clearly shown by the testimony of the fishermen, who say that in the spring Sword-fish are thin, growing fatter and heavier as the season goes on.

Dr. Lütken and Dr. Günther have lately made some exceedingly interesting observations upon the young of the Sword-fish and of the Spear-fish and Sail-fish. A translation of Dr. Lütken's paper, furnished by Dr. T. H. Bean, is given in the Appendix (paragraph 64).

Dr. Günther's studies were made upon very small specimens of undetermined species, belonging to either *Tetrapturus*, *Histiophorus*, or both. In his latest work, "The Study of Fishes," he summarizes the facts observed by him as follows:

"The Sword-fishes with ventral fins (*Histiophorus*) belong to the Teleosteans of the largest size. In young individuals, 9 millimeters long, both jaws are produced and armed with pointed teeth, the supraorbital margin is ciliated, the parietal and preoperculum are prolonged into long spines, the dorsal and anal fins are a long fringe, and the ventrals make their appearance as a pair of short buds. When 14 millimeters long the young fish has still the same armature of the head, but the dorsal fin has become much higher, and the ventral filaments have grown to a great length. At the next stage, when the fish has attained to a length of 60 millimeters, the upper jaw is considerably prolonged beyond the lower, losing its teeth, the spines of the head are shortened, and the fins assume nearly the shape which they retain in mature individuals.

"Young Sword-fishes without ventral fins (*Xiphias*) undergo similar changes, and, besides, their skin is covered with small, rough excrescences, longitudinally arrayed, which continue to be visible after the young fish has attained the form of the mature in other respects."

Dr. Lütken's description of the young Sword-fishes is an exceedingly valuable contribution to knowledge.

I have collected together, in the plates which accompany this paper, the various published figures of young Sword-fishes, and have had them redrawn as nearly as possible to a uniform scale.

Of the Sword-fish, *Xiphias gladius*, two figures are given. One, taken from Lütken's "Spolia Atlantica" (pl. ii, fig. 10), is 37 millimeters long; the other is a reproduction of the often-copied figure in Cuvier and Valenciennes's "Histoire Naturelle des Poissons" (pl. ccxxv), 12 to 18 inches long. Lütken had a smaller specimen, 10 millimeters long, but it was too poorly preserved to be figured.

Of the various species of *Tetrapturus* and *Histiophorus*, six figures are given. The smallest is that from "Spolia Atlantica" (pl. ii, fig. 11), and is of a fish 5½ millimeters long. Lütken remarks that he has a series from 5½ to 12 millimeters long which differ very little from each other. The next in size is copied from Günther, and is probably about 10 millimeters long; the third, also from Günther, is 14 millimeters long. Lütken has another link in the series, a specimen 21 millimeters long, which he has not figured. The fourth stage is from Günther, a specimen 60 millimeters long; the fifth, from Cuvier and Valenciennes (pl. ccxxx), their *Histiophorus pulchellus*, about 410 millimeters long; the sixth, from Rüppell, a copy of his figure of *H. immaculatus*, said to be about 1,800 millimeters long. These illustrations show the development in a very satisfactory manner.

F.—ABUNDANCE.

31.—ABUNDANCE AT THE PRESENT TIME.

For many years from 3,000 to 6,000 of these fish have been taken annually on the New England coast. It is not unusual for twenty-five or more to be seen in the course of a single day's cruising, and sometimes as many as this are visible from the mast-head at one time. Captain Ashby saw twenty at one time, in August, 1839, between George's Banks and the South Shoals. One Gloucester schooner, the "Midnight", Capt. Alfred Wixon, took fourteen in one day on George's Banks, in 1877.

Capt. John Rowe obtained twenty barrels, or 4,000 pounds, of salt fish on one trip to George's Banks; this amount represents twenty fish or more.

Captain Ashby has killed 108 Sword-fish in one year; Capt. M. C. Tripp killed about 90 in 1874.

Such instances as these indicate in a general way the abundance of the Sword-fish. A vessel cruising within 50 miles of our coast, between Cape May and Cape Sable, and during the months of June, July, August, and September, cannot fail, on a favorable day, to come in sight of several of them. Mr. Earll writes that the fishermen of Portland never knew them more abundant than in 1879. This is probably, in part, due to the fact that the fishery there is of very recent origin.

32.—ABUNDANCE IN THE PAST AND PROBABILITY OF FUTURE DECREASE.

There is no evidence of any change in their abundance, either increase or decrease. Fishermen agree that they are as plenty as ever, nor can any change be anticipated. The present mode of fishing does not destroy them in any considerable numbers, each individual fish being the object of special pursuit. The solitary habits of the species will always protect them from wholesale capture, so destructive to schooling fish. Even if this were not the case, the evidence proves that spawning Sword-fish do not frequent our waters. When a female shad is killed thousands of possible young die also. The Sword-fish taken by our fishermen carry no such precious burden.

33.—EFFECTS OF OVERFISHING IN THE MEDITERRANEAN.

A very different tale was once told of the winter fishery in the Mediterranean. Meunier quotes this testimony by Spallanzani: "I took part many times in this fishery, and I dare not tell how many young fish are its victims; being of no value they are thrown back into the sea, mutilated or already dead from the rubbing of the net-meshes. I write denouncing this destructive method, and I urge forcibly the harm which results from it. They tell me it is true that there is a law of Genoa which forbids its use, or rather its abuse, but this does not do away with the fact that each year there sail from the Gulf of Spezzia three or four pairs of fishing boats which go to the sea to carry on this fishery. Still more, the governor of the place, who should carry out this law, is the first to favor, by means of a gift of silver, the abuse which it is intended to prevent."

This, however, was a century ago. I have met with no complaints of decrease in the works of later writers, though in Targioni Tozzetti's report, published in 1880, it is stated that there is much opposition to the capture of small fish.

G.—FOOD.

34.—NATURE OF FOOD.

Dr. Fleming found the remains of *Sepiæ* in its stomach, and also small fishes. Oppian says that it eagerly devours the *Hippuris* (probably *Coryphæna*).

A specimen taken off Seaconnet, July 22, 1875, had in its stomach the remains of small fish, perhaps *Poronotus*, and jaws of a squid, perhaps *Loligo Pealii*.

Their food in the Western Atlantic consists for the most part of the common schooling species of fishes.

35.—MANNER OF OBTAINING FOOD.

They feed on menhaden, mackerel, bonitoes, bluefish, and other species which swim in close schools. Their habits of feeding have often been described to me by old fishermen. They are said to rise beneath the school of small fish, striking to the right and left with their swords until they have killed a number, which they then proceed to devour. Menhaden have been seen floating at the surface which have been cut nearly in twain by a blow of the sword. Mr. John H. Thomson remarks that he has seen them apparently throw the fish in the air, catching them on the fall.

Capt. Benjamin Ashby says that they feed on mackerel, herring, whiting, and menhaden. He has found half a bucket full of small fish of these kinds in the stomach of one Sword-fish. He has seen them in the act of feeding. They rise perpendicularly out of the water until the sword and two-thirds of the remainder of the body are exposed to view. He has seen a school of herring crowding together at the surface on George's Banks as closely as they could be packed. A Sword-fish came up through the dense mass and fell flat over on its side, striking many fish with the sides of its sword. He has at one time picked up as much as a bushel of herrings thus killed by a Sword-fish on George's Banks.

H.—REPRODUCTION.

36.—LOCATION OF THE BREEDING GROUNDS.

But little is known regarding their time and place of breeding. They are said to deposit their eggs in large quantities on the coasts of Sicily, and European writers give their spawning time as occurring the latter part of spring and the beginning of summer. In the Mediterranean they occur of all sizes from 400 pounds down, and the young are so plentiful as to be a common article of food. Except in this region the young are never taken; on our own coast, plentiful as they are, they are never seen less than 3 feet, and are usually much larger. M. Raynaud, who brought to Cuvier a specimen of *Histiophorus* four inches long, taken in January, 1829, in the Atlantic, between the Cape of Good Hope and France, reported that there were great numbers of young Sail-fish in the place where this was taken.

Old fishermen who have taken and dressed them by the hundreds assure me that they have never seen traces of spawn in them. The absence of young fish and spawning females on the coast of North America would indicate that they do not breed with us. Judging from the locations where young fish have been taken, it seems probably that they breed in the open ocean. (See paragraph 16, and the paper by Dr. Lütken in the Appendix, paragraph 64.)

37.—HABITS OF THE SWORD-FISH IN THE BREEDING SEASON.

Meunier,† quoting Spallanzani, states that the Sword-fish does not approach the coast of Sicily except in the season of reproduction; the males, are then seen pursuing the females. It is a good time to capture them, for when the female has been taken the male lingers near and is easily approached. The fish are abundant in the Straits of Messina from the middle of April to the middle of September; early in the season they hug the Calabrian shore, approaching from the north; after the end of June they are most abundant on the Sicilian shore, approaching from the south.

From other circumstances, it seems certain that there are spawning grounds in the sea near Sicily and Genoa, for from November to the 1st of March young ones are taken in the Straits of Messina, ranging in weight from half a pound to twelve pounds.

* Cuv. & Val., Hist. Nat., Poiss., viii, p. 305.

† Les Grandes Pêches, p. 142.

38.—Absence of ordinary habits of breeding season among our Sword-fish.

In the Mediterranean, as has been already stated, the very young fish are found from November to March, and here from July to the middle of September the male fish are seen pursuing the female over the shoals, and at this time the males are easily taken. Old swordfishermen assure me that on our coast, out of thousands of specimens they have taken, they have never seen one containing eggs (Captain Ashby and Captain Kirby). I have myself dissected several males, none of which were near breeding time. In the European waters they are said often to be seen swimming in pairs, male and female. Many sentimental stories were current, especially among the older writers, concerning the conjugal affection and unselfish devotion of the Sword-fish, but these seem to have originated in the imaginative brain of the naturalist rather than in his perceptive faculties. It is said that when the female fish is taken the male seems devoid of fear, approaches the boat, and allows himself easily to be taken; but if this be true, this appears to be the case only in the height of the breeding season, and is easily understood. I cannot learn that two Sword-fish have ever been seen associated together in our waters, though I have made frequent and diligent inquiry.

There is no inherent improbability, however, in this story regarding the Sword-fish in Europe, for the same thing is stated by Professor Poey as the result of his studies upon the habits of *Tetrapturus.*

39.—Curious ancient beliefs concerning the viviparous reproduction of the Sword-fish.

A curious fancy was prevalent in former days regarding an anatomical character of the Sword-fish. In an article by Mr. Dale in Philosophical Transactions (abridged edition, ii, p. 835), he remarks: "I cannot conceive it to be consonant to that Care and Industry of Nature, in providing convenient Receptacles for preserving the *Fœtus;* neither is it agreeable to Reason to believe, that when Nature hath provided an Uterus in all Animals, not only the Viviparous, and such as only cherish the Embryo in Utero, but in the Oviparous also and Insects, the *Eel* and the *Xiphia*, or Sword-fish, should be the only Animals without it."

I.—ENEMIES AND FATALITIES.

40.—Pugnacity.

The pugnacity of the Sword-fish has become a by-word. Without any special effort on my part, the following instances of their attacks upon vessels have, in the last six years, found their way into the pigeon-hole labeled "A, III, 76, Sword-fish"

Aelian says (B. xxxii, C. 6) that the Sword-fish has a sharp-pointed snout with which it is able to pierce the sides of a ship and send it to the bottom; instances of which have been known near a place in Mauritania known as Cottè, not far from the river Lixus, on the African side of the Mediterranean. He describes the sword as like the beak of the ship known as the trireme, which was rowed with three banks of oars.

One of the earliest accounts is that given in the second part of vol. i, lib. ii, p. 89, 1615, of Purchas' Pilgrims:

"The sixth Circum-Navigation, by William Cornelison Schovten of Horne; who Sovthwards from the Straights of Magelan in Tierra-Del-fvogo, fovnd and discovered a new passage through the great Sovth-Sea, and that way sailed rovnd about the World," &c.

Off the coast of Sierra Leone:

"The fift of October we were vnder foure degrees seuen and twentie minutes, the same day about noone, there was such a noyse in the Bough of our Shippe, that the master, being behind in the Gallerie, thought that one of the men had fallen out of the Fore-ship, or from the Boe-sprit into the sea, but as hee looked out over the side of the Ship hee saw the Sea all red, as if great store of bloud had beene powred into it, whereat hee wondred, knowing not what it meant, but afterward hee found, that a great Fish or a Sea monster having a horne had therewith stricken against the ship with most great strength. For when we were in Porto Desire where we set the Ship on the Strand to make it cleane, about seven foot under water, before in the Ship, wee found a Horne sticking in the Ship, much like for thicknesse and fashion to a common Elephants tooth, not hollow, but full, very strong hard Bone, which had entered into three Plankes of the Ship, that is two thicke Plankes of greene and one of Oken wood, and so into a Rib, where it turned upward, to our great good fortune, for if it had entered between the Ribbes, it would happily have made a greater Hole and have brought both Ship and men in danger to be lost. It strucke at least halfe a foote deepe into the Ship and about half a foote without, where, with great force it was broken off, by reason whereof the great monster bled so much."

More than a century later C. Mortimer, M. D., records this experience:

"Mr. Bankley shewed me the *Horn* of a *Fish* that had penetrated above 8 inches into the Timber of a Ship and gave me the following Relation of it: 'His MAJESTY'S Ship *Leopard*, having been at the *West Indies* and on the Coast of *Guiney*, was ordered by Warrant from the Honorable *Navy-Board*, dated Aug. 18, 1725, to be cleaned and refitted at Portsmout for Channel-Service: Pursuant thereto, she was put into the great Stone-dock; and, in stripping off her Sheathing, the Shipwrights found something that was uncommon in her Bottom, about 8

Feet from her Keel, just before the Fore Mast; which they searching into, found the Bone or Part of the Horn of a Fish of the Figure here described; the Outside Rough not unlike *Seal-Skin;* and the End, where it was broken off shewed itself like coarse Ivory. The Fish is supposed to have followed the Ship, when under Sail, because the sharp End of the Horn pointed toward the Bow: It penetrated with that Swiftness or Strength that it went through the Sheathing 1 Inch thick, the Plank 3 Inches thick, and into the Timber 4½ Inches.'"*

Don Joseph Cornide, in his "Essayo de Una Historia de los Peces de la Costa de Galicia", 1787:

"This fish is taken in the seas of Galicia, where it is more common toward the Rio de Vigo, where it is well known that the Balandia (a small fishing vessel) of S. M. le Ardilla was pierced in its side and sunk by the arm of one of these fishes, which is preserved in the Royal Cabinet of Natural History."

In 1871 the little yacht "Redhot", of New Bedford, was out swordfishing, and a Sword-fish had been hauled in to be lanced, and it attacked the vessel and pierced the side so as to sink the vessel. She was repaired and used in the service of the Commission at Wood's Holl. (Professor Baird.)

Couch quotes the personal statement of a gentleman, who says:

"We have had the pleasure of inspecting a piece of wood cut out of one of the fore planks of a vessel (the 'Priscilla', from Pernambuco), through which was struck about 18 inches of the bony weapon of the Sword-fish. The force with which it must have been driven in affords a striking exemplification of the power and ferocity of the fish. The 'Priscilla' is quite a new vessel. Captain Taylor, her commander, states that when near the Azores, as he was walking the quarter-deck at night, a shock was felt which brought all hands from below, under the impression that the ship had touched upon some rock. This was, no doubt, when the occurrence took place."

The New York Herald of May 11, 1871, states:

"The English ship 'Queensberry' has been struck by a Sword-fish, which penetrated to a depth of 30 inches, causing a leak which necessitated the discharge of the cargo."

The London Daily News of December 11, 1868, contained the following paragraph, which emanated, I suspect, from the pen of Prof. R. A. Proctor:

"Last Wednesday the court of common pleas—rather a strange place, by the by, for inquiring into the natural history of fishes—was engaged for several hours in trying to determine under what circumstances a Sword-fish might be able to escape scot-free after thrusting his snout into the side of a ship. The gallant ship 'Dreadnought', thoroughly repaired, and classed A1 at Lloyd's, had been insured for £3,000

*An Account of the horn of a Fish struck several Inches into the side of a Ship, by C. Mortimer, M. D. F. R. S. Philos. Trans. xl, No. 461, p. 862, 1741. Abr. ed. ix, p. 72.

against all the risks of the seas. She sailed on March 10th, 1864, from Colombo, for London. Three days later the crew, while fishing, hooked a sword-fish. Xiphias, however, broke the line, and a few moments after leaped half out of the water, with the object, it should seem, of taking a look at his persecutor, the 'Dreadnought'. Probably he satisfied himself that the enemy was some abnormally large cetacean, which it was his natural duty to attack forthwith. Be this as it may, the attack was made, and at four o'clock the next morning the captain was awakened with the unwelcome intelligence that the ship had sprung a leak. She was taken back to Colombo, and thence to Cochin, where she was hove down. Near the keel was found a round hole, an inch in diameter, running completely through the copper sheathing and planking.

"As attacks by Sword-fish are included among sea risks, the insurance company was willing to pay the damages claimed by the owners of the ship if only it could be proved that the hole had really been made by a Sword-fish. No instance had ever been recorded in which a Sword-fish had been able to withdraw his sword after attacking a ship. A defense was founded on the possibility that the hole had been made in some other way. Professor Owen and Mr. Frank Buckland gave their evidence, but neither of them could state quite positively whether a Sword-fish which had passed its beak through three inches of stout planking could withdraw without the loss of its sword. Mr. Buckland said that fish have no power of 'backing,' and expressed his belief that he could hold a Sword-fish by the beak; but then he admitted that the fish had considerable lateral power, and might so 'wriggle its sword out of a hole'. And so the insurance company will have to pay nearly six hundred pounds because an ill-tempered fish objected to be hooked, and took its revenge by running full tilt against copper sheathing and oak planking."

The Gloucester schooner "Wyoming", on a last trip to George's Banks, records the New York World of August 31, 1875, was attacked by a Sword-fish in the night time. He assailed the vessel with great force, and succeeded in putting his sword through one of her planks some two feet, and after making fearful struggles to extricate himself, broke his sword off, leaving it hard and fast in the plank, and made a speedy departure. Fortunate was it that he did not succeed in drawing out his sword, as the aperture would undoubtedly have made a leak sufficient to have sunk the vessel. As it was, she leaked badly, requiring pretty lively pumping to keep her free.*

Another instance of a similar nature is this, which was recorded in the Liverpool Mercury about the year 1876:

"Mr. J. J. Harwood, master of the British brigantine 'Fortunate', in dock at Liverpool, reports that whilst on his passage from the Rio Grande, when in latitude 20° 12′ north and longitude 47° 9′ west, this

*New York World, August 31, 1875.

ship was struck by a large fish, which made the vessel shake very much. Thinking the ship had been merely struck by the tail of some sea-monster, he took no further notice of the matter; but, after discharging cargo at Runcorn, and coming into the Canada half-tide dock, he found one of the plank ends in the stern split, and on closer examination he discovered that a Sword-fish had driven his sword completely through the plank, four inches in thickness, leaving the point of the sword nearly eight inches through the plank. The fish in its struggle broke the sword off level with the outside of the vessel, and by its attack upon the ship lost nearly a foot length of the very dangerous weapon with which it was armed. There is no doubt that this somewhat singular occurrence took place when the vessel was struck as Captain Harwood describes."

Forest and Stream of June 24, 1875, recorded the following incident:

"On Wednesday of last week a Sword-fish attacked the fishing-boat of Capt. D. D. Thurlow while he was hauling mackerel-nets off Fire Island, thrust its sword clear through the bottom, and stuck fast, while the fishermen took several half-hitches around its body and so secured it. It was afterwards brought to Fulton Market, and found to weigh 390 pounds. Its sword measured 3 feet and 7 inches, and its entire length was over 11 feet. The stuffed skin will adorn the Central Park Museum."

The Landmark, of Norfolk, Va., also mentioned a similar occurrence in February, 1876:

"The brig 'P. M. Tinker', Captain Bernard, previously mentioned as having arrived here from Richmond, leaking, for repairs, has been hauled up on the ways at Graves's ship-yard. On examination it was discovered that the leak was caused by a Sword-fish, the sword being found broken off forward the bands, about sixteen feet abaft the forefoot. The fish, in striking the vessel, must have come with great force, as the sword penetrated the copper sheathing, a four-inch birch plank, and through the timbers about six inches—in all about ten inches. It occurred on the morning of the 23d of December, when the brig was eighteen days out from Rio, and in the neighborhood of Cape St. Roque. She was pumped about 4 o'clock in the morning, and found free of water. About 6 o'clock the same morning she was again pumped, when water was obtained, and on examination it was found that she had made ten inches of water. The men were kept steady at the pumps until her arrival at Richmond, and while there, and on her trip here."

Mr. Willard Nye sends me this note:

"A few years ago Captain Dyer, of New Bedford, struck a Sword-fish, from a thirty-foot boat, forty miles southwest of Noman's Land, threw overboard the keg, tacked, and stood by to the windward of it. When nearly abreast of it the man at the masthead called out, 'Why here he is, right alongside.' The fish was then about 10 feet from the boat, and swimming in the same direction, but when he got where he could see the splash of water around the bow he turned and struck the boat about 2 feet from the stern and just below the water-line. The sword went through the planking, which was of cedar an inch and three-quarters thick, into a lot of loose iron ballast, breaking off short at the fish's head. A number of boats, large and small, have been 'stove' by Sword-fish on our coast, but always after the fish had been struck."

A nameless writer in Harper's Weekly, October 25, 1879, narrates these instances, for which I am unable to give the original authority:

"In a calm day in the summer of 1832, on the coast of Massachusetts, a pilot was rowing his little skiff leisurely along, when he was suddenly roused from his seat by a thrust from below by a Sword-fish, who drove his sharp instrument more than three feet up through the bottom. With rare presence of mind, with the butt of an ore he broke it off level with the floor before the fish had time to withdraw it. Fortunately, the thrust was not directly upward. Had it been so, the frail boat would have been destroyed.

"A Boston ship hauled up on the ways for repair, a few years since, presented the shank of a Sword-fish's dagger, which had been driven considerably far into the solid oak plank. A more curious affair was brought to light in 1725 in overhauling His Majesty's ship 'Leopard', from the coast of Africa. The sword of this marine spearsman had pierced the sheathing one inch, next it went through a three-inch plank, and beyond that three inches and a half into the firm timber. It was the opinion of the mechanics that it would have required nine strokes of a hammer weighing twenty-five pounds to drive an iron bolt of the same dimensions to the same depth in the hull. Yet the fish drove it at a single thrust.

"On the return of the whale-ship 'Fortune' to Plymouth, Mass., in 1827, the stump of a sword-blade of this fish was noticed projecting like a cog outside, which, on being traced, had been driven through the copper sheathing, an inch-board undersheathing, a three-inch plank of hard wood, the solid white-oak timber twelve inches thick, then through another two-and-a-half-inch hard-oak ceiling, and lastly penetrated the head of an oil-cask, where it stuck, not a drop of the oil having escaped."

Such instances could be found by the score, if one had the time and patience to search. The thing happens many times a year, and nearly as often affords a text for some paragrapher or local editor.

Captain Beechy, in the narrative of the voyage of H. M. S. "Blossom", mentions the following incident which occurred in the Pacicific, near Easter Island: "As the line was hauling in, a large Sword-fish bit at the tin case which contained our thermometer, but fortunately failed in carrying it off."

41.—PUGNACITY OF THE SPEAR-FISH.

The Spear-fish (*Tetrapturus albidus*, &c.) also strikes vessels. I am indebted to Capt. William Spicer, of Noank, Conn., for this note:

Mr. William Taylor, of Mystic, a man seventy-six years old, who was in the smack 'Evergreen', Capt. John Appleman, states that he started from Mystic, October 3, 1832, on a fishing voyage to Key West, in company with the smack 'Morning Star,' Captain Rowland. On the 12th they were off Cape Hatteras, the wind blowing heavily from the northeast, and the smack under double-reefed sails. At ten o'clock in the evening they were struck by a 'Woho' (*sic*), which shocked the vessel all over. The smack was leaking badly, and they made a signal to the 'Morning Star' to keep close by them. The next morning they found the leak, and both smacks kept off to Charleston. On arrival they took out the ballast, hove her out, and found that the sword had gone through the planking, timber, and ceiling. The plank was 2 inches thick, the timber 5 inches, and the ceiling 1½ inches white oak. The sword projected 2 inches through the ceiling, on the inside of the "after-run".* It struck close by a butt on the outside, which caused the leak. They took out and replaced a piece of the plank, and proceeded on their voyage."

J. Matthew Jones, esq., of Halifax, N. S., in his delightful little book "The Naturalist in Bermuda", records the case of the Bermudian schooner "Earl Dundonald", arrived in the port of Hamilton, which was pierced by one of these formidable fish off the coast of British Guiana.

In the museum of Charleston College, Charleston, S. C., is preserved a fragment of the snout of a Bayonet-fish, apparently *Tetrapturus albidus*. By the kindness of the curator, Dr. G. E. Manigault, I was allowed to examine it and copy the label, which reads as follows: "The brig 'Amsterdam', bound to Charleston, owned by F. C. Bray, was struck in the Gulf Stream by a monster or Sword-fish, which caused the vessel to leak considerably. By great exertion she was kept free, and gained the port in safety."

Messrs. Foster, Waterman & Co., of Boston, presented to the Boston Society of Natural History, in 1869, a plank of Southern pine perforated by and containing a portion of the sword of a Sword-fish (*Histiophorus*) from the side of the ship "Pocahontas", owned by them. (Proc. Bost. Soc. Nat. Hist. xiii, 1869, p. 64.)

42.—ATTACKS OF THE SWORD-FISH UPON WHALES.

One of the traditions of the sea, time-honored, believed by all mariners, handed down in varied phases in a hundred books of ocean travel, relates to the terrific combats between the whale and the Sword-fish, aided by the thrasher-shark. The Sword-fish was said to attack from

*A hold under the cabin.

below, goading his mighty adversary to the surface with his sharp beak, while the thrasher, at the top of the water, belabored him with strokes of his long, lithe tail.

An early explorer of the Bermudas gives the following version of the story, with tone so fresh and enthusiastic that we might well believe him to have seen the occurrence with his own eyes. The passage occurs in "Newes from the Bermudas", a pamphlet dated "Burmuda, July, 1609", and reprinted in "Force's Historical Tracts", vol. ii:

"*Whale, Sword-fish & Threasher.*—The sword-fish swimmes under the whale, & pricketh him upward. The threasher keepeth above him, & with a mighty great thing like unto a flaile, hee so bangeth the whale, that hee will roare as though it thundered, & doth give him such blowes, with his weapon, that you would thinke it to be a crake of great shot."—(Page 22.)*

Skeptical modern science is not satisfied with this interpretation of any combat at sea seen at a distance. It recognizes the improbability of aggressive partnership between two animals so different as the Sword-fish and a shark, and explains the turbulent encounters occasionally seen at sea by ascribing them to the attacks of the killer-whale, *Orca* sp., upon larger species of the same order.

There can be little doubt though that Sword-fish sometimes attack

* The following is a fair example of the average newspaper paragrapher's treatment of the subject:

"*Combats of the ocean.*—Among the extraordinary spectacles sometimes witnessed by those who "go down to the sea in ships" none are more impressive than a combat for the supremacy between the monsters of the deep. The battles of the Sword-fish and whale are described as Homeric in grandeur. The Sword-fish go in schools like whales, and the attacks are regular sea-fights. When the two troops meet, as soon as the Sword-fish have betrayed their presence by a few bounds in the air, the whales draw together and close up their ranks. The Sword-fish always endeavors to take the whale in the flank, either because its cruel instinct has revealed to it the defect in the carcasses—for there exists near the brachial fins of the whale a spot where wounds are mortal—or because the flank presents a wider surface to its blow. The Sword-fish recoils to secure a greater impetus. If the movement escapes the keen eye of his adversary the whale is lost, for it receives the blow of the enemy and dies instantly. But if the whale perceives the Sword-fish at the instant of the rush, by a spontaneous bound it springs clear of the water its entire length, and falls on its flank with a crash that resounds for many leagues, and whitens the sea with boiling foam. The gigantic animal has only its tail for its defense. It tries to strike its enemy, and finishes him at a single blow. But if the active Sword-fish avoids the fatal tail the battle becomes more terrible. The aggressor springs from the water in his turn, falls upon the whale, and attempts, not to pierce, but to saw it with the teeth and garnish its weapon. The sea is stained with blood; the fury of the whale is boundless. The Sword-fish harrasses him, strikes him on every side, kills him, and flies to other victories. Often the Sword-fish has not time to avoid the fall of the whale, and contents itself with presenting its sharp saw to the flank of the gigantic animal about to crush it. It then dies like Maccaæus (*sic*), smothered beneath the weight of the elephant of the ocean. Finally, the whale gives a last few bounds in the air, dragging its assassin in its flight, and perishes as it kills the monster of which it was the victim."

whales just as they do ships. The habit is mentioned by Pliny, and is the motive for one of the *Visions of the World* of Edmund Spenser:

Toward the sea turning my troubled eye
I saw the fish, (if fish I may it cleepe)
That makes the sea before his face to flye
And with his flaggie finnes doth seeme to sweepe
The fomie waves out of the dreadfull deep.
The huge Leviathan, dame Nature's wonder,
Making his sport, that manie makes to weep:
A Sword-fish small, him from the rest did sunder,
That, in his throat him pricking softly under,
His wide abysse him forced forth to spewe,
That all the sea did roare like heavens thunder,
And all the waves were stained with filthie hewe.
Hereby I learned have not to despise
Whatever thing seems small in common eyes.*

I give also a few lines from an old play quoted by Scott as a heading to one of the chapters of the "The Antiquary":

Who is he?—One that for the lack of land
Shall fight upon the water—he hath challenged
Formerly the grand whale; and by his titles
Of Leviathan, Behemoth, and so forth
He tilted with a Sword-fish.—Marry, sir,
Th' aquatic had the best—the argument
Still galls our champion's breach.†

Baron Lahontan, in a letter from Quebec, November 8, 1783, described an engagement between a whale and a Sword-fish which took place within gun-shot of his frigate. He remarks:

"We were perfectly charmed when we saw the Sword-fish jump out of the water in order to dart its spear into the body of the whale when obliged to take breath. This entertaining show lasted at least two hours, sometimes to the starboard and sometimes to the larboard of the ship. The sailors, among whom superstition prevails as much as among the Egyptians, took this for a presage of some mighty storm."‡

Another early observer wrote as follows:

"Concerning the Death of the Whale, which hath been related to have been stranded upon *New England*, it is not very improbable but that it may have been killed by a certain *Horny Fish*, which is said by Mr. *Terry*, in his East India Voyage, to run his Horn into the *Whale's* Belly; and which is known sometimes to run his Horn into Ships, perhaps taking them for Whales, and there snapping it asunder, as happened not long since to an English Vessel in the West Indian Seas."§

* Spenser's Visions of the Worlds Vanitie, 1591.
† "Old Play," Antiquary, chap. xxx.
‡ Travels in Canada, 2d ed., London, 1785, 2 vols. 8vo.
§ An account of Whale fishing about the Bermudas by an understanding and hardy *Seaman*. Phil. Trans. abr. ed. ii, p. 844.

"In the month of August, 1861," says Couch, "near Westra, one of the northernmost islands of the Orkneys, an individual of the smaller species of whales, known as the herring-hog, was attacked by a Sword-fish; and when thus compelled to leap out of the water, which it did to the height of six feet, it was observed that the sword had been thrust into the whale's body behind the pectoral fins. Its leaps continued, and then it was perceived that a thrasher was assailing it on the sides."*

Captain Crow, quoted by Parnell, relates the following incident as having occurred on a voyage to Memel: "One morning, during a calm, when near the Hebrides, all hands were called up at 3 a. m. to witness a battle between several of the fish called thrashers or fox-sharks and some Sword-fish on one side, and an enormous whale on the other. It was the middle of summer, and the weather being clear and the fish close to the vessel, we had a fine opportunity of witnessing the contest. As soon as the whale's back appeared above the water, the thrashers, springing several yards into the air, descended with great violence upon the object of their rancor, and inflicted upon him the most severe slaps with their long tails, the sound of which resembled the reports of muskets fired at a distance. The Sword-fish, in their turn, attacked the distressed whale, stabbing from below, and thus beset on all sides and wounded, when the poor creature appeared the water around him was dyed with blood. In this manner they continued tormenting him and wounding him for many hours, and I have no doubt they in the end completed his destruction.†

The following is a story given to Frank Buckland by Mr. Hill, captain of an English trawling vessel:

"The thrasher-sharks just do serve out the whales. The sea sometimes is all blood. A whale once got under our vessel—the 'Hurricane'—to get away from these thrashers, and when she was there we were afraid to throw a rope overboard, almost to walk out, for fear she would chuck her tail, and punch a hole in our vessel. She was full length in water, as clear as gin, right under our bottom, and laid as quiet as a lamb for an hour and a-half, and never moved a fin. Where they had been a-thrashing of her the sea was just like blood. I have seen these 'ere thrashers fly out of the water as high as the mast-head and down upon the whale, while the Sword-fish was a-pricking of 'im up from underneath. There is always two of 'em, one up and one under, and I think they hunts together; and you can see the poor whale blow up in great agitation; and I be bound the pair on 'em don't leave him until they have their penn'orth out of him. It is just for wengeance they does it. Whether Master Whale has offended them or not, it's hard to tell. If they eats him they must have a tidy blow-out of him, but I don't think they like the oil. I saw one engagement off the Staples; it

* History of British Fishes, ii, p. 174.

† Parnell, Fishes of the Firth of Forth, 1838, p. 216.

was all two or three hours they was at it. I don't think they leaves him till they kills him."

Egede puts on record the belief of Danish explorers of the last century: "The *Sword-fish* who is the Whales greatest Enemy; and when he kills one eats nothing but his Tongue, leaving the rest to the Shark, Walrus and Birds of Prey."*

The last quotation is especially important, since it shows how the Sword-fish and the killer-whale have been confused. It is still held, on good authority, that the killers eat the tongues of their victims.†

At a meeting of the Boston Society of Natural History in 1864, in reply to a question of Dr. J. B. S. Jackson about the thrasher or swingle-tail shark recently exhibited in Boston, Captain Atwood said that they were abundant at Provincetown, though not so common as the mackerel-shark. He also observed that he placed no confidence whatever in the stories current of attacks on the whales by the thrasher, believing them to be quite harmless and unable to hurt a dolphin. The story very likely arose from some peculiar movements made by the hump-backed whale. Sword-fish, he believed, might attack a whale and kill him, from what he had seen of the force of their thrusts into the bottom of vessels, though he has no evidence that they ever do attack them. He was not aware, either, that the thrasher ever uses his tail for offensive purposes.‡

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* Hans Egede, Natural History of Greenland, 1741, p. 37.

† "Three or four of these voracious animals do not hesitate to grapple with the largest baleen-whales, and it is surprising to see those leviathans of the deep so completely paralyzed by the presence of their natural although diminutive enemies. Frequently the terrified animal—comparatively of enormous size and superior strength—evinces no effort to escape, but lies in a helpless condition, or makes but little resistance to the assaults of its merciless destroyer. The attack of these wolves of the ocean upon their gigantic prey may be likened, in some respects, to a pack of hounds holding the stricken deer at bay. They cluster about the animal's head, some of their number breaching over it, while others seize it by the lips and haul the bleeding monster under water; and when captured, should the mouth be open, they eat out its tongue. We saw an attack made by three killers upon a cow-whale and her calf, in a lagoon on the coast of Lower California, in the spring of 1858. The whale was of the California gray species, and her young was grown to three times the bulk of the largest killers engaged in the contest, which lasted for an hour or more. They made alternate assaults upon the old whale and her offspring, finally killing the latter, which sunk to the bottom, where the water was five fathoms deep. During the struggle the mother became nearly exhausted, having received several deep wounds about the throat and lips. As soon as their prize had settled to the bottom the three orcas descended, bringing up large pieces of flesh in their mouths, which they devoured after coming to the surface. While gorging themselves in this wise, the old whale made her escape, leaving a track of gory water behind. Instances have been known on the northwestern coast where a band of orcas laid siege to whales that had been killed by whalemen, and which were being towed to the ship, in so determined a manner that, although they were frequently lanced, cut with boat-spades, they took the dead animals away from their human captors, and hauled them under water out of sight."—(C. M. Scammon, Marine Mammals, p. 89.)

‡ Proc. Bost. Soc. Nat. Hist. vol. x, 1864-'66, p. 82.

Captain Scammon, in his "Marine Mammals", gives the following confirmation of Captain Atwood's views, speaking of the habits of the hump-back whale of the Pacific:

"In their wanderings they are addicted more than any other roqual to 'breaching', 'bolting', and 'finning'. In the mating season they are noted for their amorous antics. At such times their caressings are of the most amusing and novel character, and these performances have doubtless given rise to the fabulous tales of the Sword-fish and thrasher attacking whales. When lying by the side of each other the *Megapteras* frequently administer alternate blows with their long fins, which love-pats may, on a still day, be heard at a distance of miles. They also rub each other with these same huge and flexible arms, rolling occasionally from side to side, and indulging in other gambols which can easier be imagined than described."

43.—ENEMIES.

Such a large animal as the Sword-fish can have but few antagonists whose attacks would be disastrous. The tunny or horse-mackerel, *Orcynus thynnus*, other Sword-fishes, and sharks are its only peers in size, and of these the sharks are probably its worst foes.

Capt. N. E. Atwood exhibited to the Boston Society of Natural History, December 7, 1864, the lower jaw of a large shark, taken at Provincetown, Mass., in whose stomach nearly the whole of a large Sword-fish was found. Some ten or twelve wounds were noticed in the skin of the shark, giving an idea of the conflict. The shark was doubtless the tiger shark *Galeocerdo tigrina*.

Couch was told by a sailor that he had watched with interest the anxious motions of one as it was followed closely and rapidly in all its turnings by a blue-shark. Twice did it leap above the surface to escape the near approach of its pursuer, but with what success at last the observer had no opportunity of knowing.

Mr. John A. Thomson states that the Bill-fish (probably *Tetrapturus albidus*) is their especial enemy. Bill-fish, six to twelve feet long, appear about the last of the season, and their appearance is a signal that the Sword-fish are about leaving.

44.—INVERTEBRATE PARASITES OF THE SWORD-FISH.

Aristotle thus explains the leaping movements of the fish: "The tunny and the *Xiphia* suffer from the œstrus at the rising of the dog-star, for both these fish at this season have beneath their fins a little worm which is called œstrus, which resembles a scorpion, and is about the size of a spider; they suffer so much from this torment that the *Xiphias* leaps out of the sea as high as the dolphin, and in this manner frequently falls upon ships."

This description of the parasite is somewhat vague; yet it is evident that allusion is made to one of the Lerneans or gill-lice, little crustaceans remotely resembling crabs and lobsters, which attach themselves to the gills and skin of many kinds of fishes, sucking the blood from their veins, and often causing death; dreadful to their victims as was their namesake, the fabled Lernæan Hydra, to the Argives of old, and not to be destroyed by any piscine Hercules and Iolaus.

In one of the early volumes of the Philosophical Transactions is an account by S. Paulo Boccone of "an extraordinary *Sanguisuga* or *Leech*, found sometimes sticking fast in the Fish called *Xiphias* or *Sword-fish*." It is described as "about four Inches long, the Belly of it white, cartilaginous and transparent, without Eyes or Head, but instead of a Head it had a hollow Snout, encompassed with a very hard Membrane; which Snout it thrusts whole into the Body of the Fish, as strongly as an *Augre* is wound into a piece of Wood, and fills it full of Blood into the very Orifice". He names it "*Hirudo* or *Acus cauda utrinque pennata*".*

A specimen taken off Seaconnet, July 22, 1875, had fluke-worms in the external coat of the stomach and in the air-bladder.

I am indebted to Mr. Frederick W. True for the following account of the parasites of the Sword-fish:

The Sword-fish is infested by many species of parasites. Some hang on the gills, others fasten themselves to different parts of the alimentary canal—the œsophagus, the stomach, and the intestines—and others, still, bore into the flesh. Several species, as might be expected from the size of the fish, are among the giants of their races. All undoubtedly cause more or less pain to their host, but especially those which attach themselves to the gills, disturbing their action and destroying their substance.

The parasites of the Sword-fish, for convenience, may be classified in two groups, the Worm-like parasites (*Helminthes*) and the Crustacean parasites.

a. The Worm-like parasites (*Helminthes*).—Seven species of *Helminthes* from the Sword-fish have been described, of which one belongs to the group *Nematoda*, or Round-worms, four to the *Trematoda*, or Flukes, and two to the *Cestoda*, or Tape-worms.

NEMATODA.

1. ASCARIS INCURVA, Rudolphi.

Ascaris incurva, RUDOLPHI, Entozoorum Synopsis, 1819, pp. 51, 292.—DUJARDIN, Hist. Nat. des Helminthes, 1845, p. 203.—DIESING, Systema Helminthum, ii, 1851, p. 163.—SCHNEIDER, Monographie der Nematoden, 1866, p. 48, pl. ii, fig. 11.†

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* The | Philosophical | Transactions | and | Collections | To the End of the Year MDCC | Abridged | and | Disposed under General Heads | —— | Vol. II | —— | Containing all the | Physiological Papers | —— | By John Lowthorp, M. A. and F. R. S. | —— | The Fourth Edition | ═══ | London * * * * * MDCCXXXI, p. 821.)

† This synonymy does not profess to be complete. Reference is given only to the authority in which the original description occurs, to one or two later ones giving an accurate description, and to one in which the species is figured.

This round-worm belongs to the genus which is characterized by the possession of a mouth with three lips. It is found only in the Sword-fish, and may be readily distinguished by its large size. The male is about 55 millimeters in length, the females about 122 millimeters. It makes its home principally in the intestines and stomach of the fish, causing the growth of morbid tubercles. It has been discovered also in the gills and the œsophagus.

TREMATODA.

2. DISTOMA DENDRITICUM, Rudolphi.

Distoma dendriticum, RUDOLPHI, Entozoorum Synopsis, 1819, pp. 93, 364.—DUJARDIN, Hist. Nat. des Helminthes, 1845, p. 460.
Distomum dendriticum, DIESING, Systema Helminthum, i, 1850, p. 336.

(This species, as far as I am aware, has never been figured).

This fluke is peculiar to the Sword-fish. It is lanceolato-ovate in outline and quite flat. When alive the color of its body is white, with ramifications of black, a character by which it may be distinguished from other species. It varies in length from 3.37 to 6.75 millimeters, and in width from 1 to 2.25 millimeters. It locates itself in the intestines of the Sword-fish, where it is frequently found in large numbers.

3. DISTOMA VENTRICOSA (Pallas) True.

Fasciola ventricosa, PALLAS, Spicilegia Zoologica, fascic. x, 1774, p. 18.
Distoma clavatum, RUDOLPHI, Entoz. Hist. ii, 1809, p. 391.—OWEN, Trans. Zool. Soc. London, i, pp. 381–384, pl. xli, fig. 17.—DUJARDIN, Hist. Nat. des Helminthes, 1845, p. 459.

This species, which is well displayed in the figure, is somewhat cylindrical in form, but has a globular expansion at the posterior extremity. It often reaches a length of two inches, and a specimen five inches long and nearly half an inch in breadth is said to have been taken from the stomach of a fish captured in the Gulf of Venice. Menzies says of it: "In moving, it fastens itself alternately by the ventral aperture and its mouth, raising its slender neck between them into an arched form, like a leech, and in this manner drags its body along with a slow motion. It is of a whitish color, somewhat pellucid, discharging at its mouth a black-colored fluid, which can easily be perceived through its body."* It lives in the stomach of the Sword-fish and other fishes.

4. TRISTOMA COCCINEUM, Cuvier.

Tristoma coccineum, CUVIER, Règne Animal, 1st ed. iv, 1817, p. 62, pl. xv, fig. 10.—DUJARDIN, Hist. Nat. des Helminthes, 1845, pp. 322, 323.—BLANCHARD, Recherches sur l'Organization des Vers, Ann. des Sci. Nat. 3d series, viii, 1847, pp. 322–325, pl. x, fig. 2, and pl. xiv, figs. 2–2 c.
Tristomum coccineum, DIESING, Systema Helminthum, i, 1850, p. 429.

The species composing the genus *Tristoma* are characterized by the possession of three suctorial disks.

* Trans. Linn. Soc. i, 1790, pp. 187, 188.

T. coccineum is almost orbicular in outline and quite flat. The posterior border is never scalloped, as in a closely allied species. The diameter of the posterior sucker is nearly equal to one-fifth the length of the body, and presents seven rays. The total length of the animal is about 25 millimeters. Its color, according to some authors, is rose-red, but, according to others, red approaching vermilion. Like all other species of the genus, it lives in the gills of the fish it infests.

5. TRISTOMA PAPILLOSUM, Diesing.

Tristoma papillosum, DIESING, Nov. Act. Nat. Curios. xviii, 1836, pp. 313–316, pl. xvii, figs. 13–18.

Tristomum papillosum, DIESING, Systema Helminthum, i, 1850, pp. 430–431.

This fluke is oblong in outline. The posterior sucker is quite as large as that of the preceding species, but is situated nearer the posterior margin. The dorsal surface is covered with many little papillary appendages. The animal is about nine-tenths of an inch in length and three-tenths in breadth. Its color is a dusky yellowish white. It lives, in company with the preceding species, in the gills of the Sword-fish and other fishes.

CESTODA.

6. TETRARHYNCHUS ATTENUATUS, Rudolphi.

Tetrarhynchus attenuatus, RUDOLPHI, Entozoorum Synopsis, i, 1819, pp. 130, 449, 688.

Tetrarhynchus discophorus, BREMSER, Icones Helminthum, 1824, pl. xi, figs. 14–15.

The tape-worms of this genus possess a very short body, a long and narrow neck, and a head furnished with four long proboscises, armed with a great number of recurved hooks. The species under consideration varies in length from 2 to 5.9 millimeters. The head is somewhat conical in shape, and bears two round and strongly concave suckers. The neck is narrow behind, and transversely rugose. As it is the only species of the genus found in the Sword-fish, it cannot be easily mistaken. It has been found on the gills of the Sword-fish, and also in the walls of the abdomen.

7. BOTHRIOCEPHALUS XIPHIÆ (Gmelin) True.

Echinorhynchus xiphiæ, GMELIN, Linn. Syst. Nat. vi, 1788, p. 3047.

Bothriocephalus plicatus, RUDOLPHI, Entozoorum Synopsis, 1819, pp. 136, 479, pl. iii, fig. 2.

This tape-worm varies in length from 30 to 300 millimeters. Its head is elongated arrow-shape or fusiform in outline. The anterior articulations of the body are very narrow, but they widen towards the center; the posterior ones, again, are narrow. It usually inhabits the rectum of the Sword-fish, but has been also occasionally found buried in the walls of the intestines.

b. The Crustacean parasites.—The Crustacean parasites of the Sword-fish belong to the group known as *Copepoda*. They are five in number.

1. PENNELLA FILOSA (Linn.) Cuvier.

Pennatula filosa, LINN. Syst. Nat. 10th ed. i, 1758, p. 819.

Pennella filosa, CUVIER, Règne Anim. 2d ed. iii, 1830, p. 257.—GUÉRIN, Iconogr. de Règne Anim. de Cuvier, pt. v (Zoophytes), 1829–'39, pl. ix, fig. 3.

The females of this genus are characterized by the presence of hooks attached to the head—by which they cling to the animal they infest—four pairs of rudimentary feet on the ventral side, and an abdomen very well developed and furnished with a number of penniform appendages, directed obliquely backward. The male is very small and nearly orbicular. The species *P. filosa* has a long, narrow, and straight body, and a large head, carrying behind two short, obtuse hooks.

It fastens itself in large numbers to the gills of the Sword-fish, greatly inconveniencing it in the act of breathing.

2. PENNELLA COSTAII, Richiardi.

Pennella Costaii, RICHIARDI (name only), Expos. Intern. di Pesca, Berlin, Sez. Ital. Cat. 1880, p. 150.

No description of this species is given in the place cited above. It lives in the flesh of the Sword-fish.

3. PHILICHTHYS XIPHIÆ, Steenstrup.

Philichthys xiphiæ, STEENSTRUP, Soc. R. Scient. Hafn. Act. Consp. 1861, p. 295.

This animal lives in the cavities and canals of the frontal bone of the Sword-fish. The descriptions of this and the two succeeding species were not accessible to me.

4. BRACHIELLA RAMOSA, Richiardi.

Brachiella ramosa (name only), RICHIARDI, Expos. Intern. di Pesca, Berlin, Sez. Ital. Cat. 1880, p. 151.

This parasite hangs on the gills of the Sword-fish.

5. CHONDRACANTHUS XIPHIÆ, Cuvier?

Chondracanthus xiphiæ, GUÉRIN, Icon. Règne Anim. de Cuvier, pt. v (Zoophytes), 1829–'39, pl. ix, fig. 20.—MILNE-EDWARDS, Hist. Nat des Crust. iii, 1840, p. 504.

This species also lives on the gills of the Sword-fish.

45.—FISH-PARASITES—THE SUCKERS OR REMORAS.

Several species of "stay-ships" or "remoras" occur on our coast. The ordinary kinds, such as *Leptecheneis naucrateoides*, the one with a black stripe down its side and white corners to its caudal fin, appears to choose companionship with the sharks, while the oceanic species, *Echeneis remora*, is most often found clinging to ships.

A third species, *Remoropsis brachyptera*, is the particular parasite of the Sword-fish. I have several times identified it when found attached to the fish, and have never known it to be found on any other species. It has never come to us, moreover, from locality and season which would be inconsistent with a theory that it had been brought near shore by a Sword-fish.

Still another, *Rhombochirus osteochir*, seems equally inseparable from *Tetrapturus albidus*. This fact is known to the Cuban fishermen, who call it by the name *Pega de los Agujas*, the parasite of the Spear-fish. The two species last referred to are figured in the plates accompanying this article.

Perhaps the two species are not so fixed in their likings that they will change from *Xiphias* to *Tetrapturus*. My friend Professor Giglioli, of Florence, who speaks of *R. brachyptera* as a fish new to the Mediterranean, obtained from Taranto a specimen said to have been taken from the gills (operculum?) of *Tetrapturus belone*.

These parasites probably prefer to cling with their curious suckers to the hard exterior surface of the opercular flap of the Sword-fish.

K.—THE FISHERIES.

46.—THE LOCATION OF THE FISHING GROUNDS.

In what has already been said regarding the dates of appearance and local movements of the Sword-fish in our waters may be found all the facts relating to the location of the fishing grounds, for the fishermen follow the Sword-fish wherever they appear to be most abundant.

Early in the season the Sword-fish are most abundant west of Montauk Point, and later they spread over the shoal-grounds along the coast even as far north as the Nova Scotia Banks. They may be found wherever mackerel and menhaden are abundant, as may be inferred from the almost universal practice of carrying Sword-fish irons on board of mackerel vessels.

I quote the statements of three or four correspondents who have taken the trouble to interview the fishermen of their respective localities.

Mr. E. G. Blackford writes: "The following information I received from an old swordfisherman, a man whose statements may be relied on. The season first opens early in June in the neighborhood of Sandy Hook, and continues along the coast as far east as Martha's Vineyard and Nantucket Shoals until about the middle of September. They are said to have been caught as far north as Cape Sable. At the first cold wind blowing in September they disappear, and are not found again on the coast that season." This is the statement of a New York man.

Capt. Benjamin Ashby, of Noank, Conn., informs me that the Sword-fish vessels of Noank and New London are accustomed to leave the home-port about the 6th of July, and throughout the month they find fish most abundant between Block Island and Noman's Land; in August between Noman's Land and the South Shoal Light Ship. They first meet the fish twenty to twenty-five miles southeast of Montauk Point. In August and September they are found on George's Banks. There is no fishing after the snow begins to fly.

A little farther east is the New Bedford fleet. Capt. I. H. Michaux, of the schooner "Yankee Bride", tells me that Sword-fish strike in about Block Island in the middle of June, and stay in that vicinity until the 15th or 20th of August. North of Cape Cod they are taken up to the 20th of October.

The statements of Mr. John H. Thomson, of New Bedford, have already been quoted, but may be epitomized in this connection. From May 25 to June they are found south of Block Island, approaching the Vineyard Sound and the neighboring waters through June and to the middle of July. A little later they are more abundant to the southeast of Crab Ledge, and after August 1 to the southeast of Cape Cod and George's Banks.

The schooner "Northern Eagle", of Gloucester, Capt. George H. Martin, when engaged in swordfishing, is accustomed to leave Gloucester so as to be on the ground south of Block Island by the 10th of June, and the fish are followed as far east as Portland.

Mr. Earll ascertained that the Sword-fish are mostly fished for on the coast of Maine from July 1 to September 1.

Halibut vessels on La Have and Sable Island Banks occasionally take these fish upon their lines.

Mackerel vessels on the New England coast are always prepared for Sword-fish when cruising among mackerel schools. I am not aware that they have more than once been seen on the mackerel grounds of the Gulf of Saint Lawrence.

47.—APPARATUS OF CAPTURE.

The apparatus ordinarily employed for the capture of the Sword-fish is simple in the extreme. It is a harpoon with detachable head. When the fish is struck the head of the harpoon remains in the body of the fish, and carries with it a light rope, which is either made fast or held by a man in a small boat, or is attached to some kind of a buoy, which is towed through the water by the struggling fish and which marks its whereabouts after death.

The harpoon consists of a pole 15 or 16 feet in length, usually of hickory or some other hard wood, upon which the bark has been left, so that the harpooner may have a firmer hand-grip. This pole is from an inch and a half to two inches in diameter, and at one end is provided with an iron rod, or "shank", about two feet long and five-eighths of an inch in diameter. This "shank" is fastened to the pole by means of a conical or elongated cup-like expansion at one end, which fits over the sharpened end of the pole, to which it is secured by screws or spikes. A light line extends from one end of the pole to the point where it joins the "shank", and in this line is tied a loop, by which is made fast another short line which secures the pole to the vessel or boat, so that when it is thrown at the fish it cannot be lost.

Upon the end of the "shank" fits somewhat securely the head of the harpoon, known to the fishermen by the names *Sword-fish iron*, *lily-iron*, or *Indian dart.* The form of this weapon has undergone much variation, as is shown in the series of figures of specimens in the National Museum in one of the accompanying plates. The fundamental idea may very possibly have been derived from the Indian fish-dart, numerous specimens of which are in the National Museum, and one form of which is shown in the plate by the side of the others. However various the modifications may have been, the similarity of the different shapes is no less noteworthy from the fact that all are peculiarly American. In the enormous collection of fishery implements of all lands in the late exhibition at Berlin, nothing of the kind could be found. What is known to whalers as a toggle-harpoon is a modification of the lily-iron, but so greatly changed by the addition of a pivot by which the head of the harpoon is fastened to the shank that it can hardly be regarded as the same weapon. The lily-iron is in principle exactly what a whaleman would describe by the word "toggle". It consists of a two-pointed piece of metal, having in the center, at one side, a ring or socket the axis of which is parallel with the long diameter of the implement. In this is inserted the end of the pole-shank, and to it or near it is also attached the harpoon-line. When the iron has once been thrust point first through some solid substance such as the side of a fish, and is released upon the other side by the withdrawal of the pole from the socket, it is free, and at once turns its long axis at right angles to the direction in which the harpoon-line is pulling, and thus is absolutely prevented from withdrawal. The principle of the whale-harpoon or toggle-iron is similar, except that the pole is not withdrawn, and the head, turning upon a pivot at its end, fastens the pole itself securely to the fish, the harpoon-line being attached to some part of the pole. The Sword-fish lily-iron head, as now ordinarily used, is about four inches in length, and consists of two lanceolate blades, each about an inch and a half long, connected by a central piece much thicker than they, in which, upon one side, and next to the flat side of the blade, is the socket for the insertion of the pole-shank. In this same central enlargement is forged an opening to which the harpoon-line is attached. The dart-head is usually made of steel; sometimes of iron, which is generally galvanized; sometimes of brass.

The entire weight of the harpoon-pole, shank, and head should not exceed 18 pounds.

The harpoon-line is from 50 to 150 fathoms long, and is ordinarily what is known as "fifteen-thread line". At the end is sometimes fastened a buoy, and an ordinary mackerel keg is generally used for this purpose.

In addition to the harpoon, every swordfisherman carries a lance. This implement is precisely similar to a whaleman's lance, except that it is smaller, consisting of a lanceolate blade perhaps one inch wide and two inches long, upon the end of a shank of five-eighths-inch iron, perhaps two or three feet in length, fastened in the ordinary way upon a pole 15 to 18 feet in length.

48.—THE MANNER OF FITTING A VESSEL FOR SWORDFISHING.

The Sword-fish are always harpooned from the end of the bowsprit of a sailing-vessel. It is next to impossible to approach them in a small boat. All vessels regularly engaged in this fishery are supplied with a special apparatus for the support of the harpooner as he stands on the bowsprit, and this is almost essential to success, although it is possible for an active man to harpoon a fish from this station without the aid of the ordinary frame-work. Not only the professional swordfishermen but many mackerel schooners and packets are supplied in this manner.

An illustration of the Sword-fish "pulpit" is given in one of the plates. It is constructed as follows: The harpooner stands upon the tip of the bowsprit, outside of the jib-stay. At this point is fastened a square plate of iron as wide as the bowsprit. In the middle of this plate is a mortise two inches square and extended three or four inches down into the wood, forming a socket for an upright iron bar two inches square and three feet high. At the top of this bar is a bow of iron bent backward in semicircular form to surround the waist of the harpooner, the ends of the bow being separated by a distance of perhaps two feet. In the ends of the bow-iron are holes through which are passed irons to hold the dart when not in use. Through these same holes are sometimes passed ropes, by which is suspended a swinging seat for the use of the harpooner when not in action. When not in use the dart is lashed in a horizontal position to the top of the "rest". The lance is usually allowed to rest against the jib-stay, to which it is secured by passing it through loops of rope arranged for the purpose. Upon the tip of the bowsprit, at the base of the *rest*, is a platform of wood about two feet square, large enough to afford a firm foot-hold to the harpooner. The harpoon-line is coiled upon the bow of the vessel, the buoy usually resting upon the bulkhead or close at hand. A second harpoon-line, attached to the reserve or second harpoon, is coiled upon the other side.

The structure above described is usually called a "rest", though not infrequently the "pulpit". Capt. Benjamin Ashby always called it an "oresembo". I was unable to obtain from him any derivation of this remarkable word. He informed me that he had always used this name because the thing looked to him as if it ought to be called by that name, and that he had never heard any one else call it so except members of his own crew, who had learned the word from him. This is a curious illustration of the arbitrary manner in which fishermen are accustomed to coin names for new articles of apparatus. Although many archaic and provincial terms whose etymology is plainly traceable are in use among our sea-faring men, there are numerous others for whose meaning and origin it would be vain to search.

I have been unable to learn when and by whom this peculiar piece of apparatus was devised.

49.—Manner of capture.

The Sword-fish never comes to the surface except in moderate, smooth weather. A vessel cruising in search of them proceeds to the fishing ground, and cruises hither and thither wherever the abundance of small fish indicates that they ought to be found. Vessels which are met are hailed and asked whether any Sword-fish have been seen, and if tidings are thus obtained the ship's course is at once laid for the locality where they were last noticed. A man is always stationed at the masthead, where, with the keen eye which practice has given him, he can easily descry the tell-tale dorsal fins at a distance of two or three miles. When a fish has once been sighted, the watch "sings out", and the vessel is steered directly towards it. The skipper takes his place in the "pulpit", holding the pole in both hands by the small end, and directing the man at the wheel by voice and gesture how to steer. There is no difficulty in approaching the fish with a large vessel, although, as has already been remarked, they will not suffer a small boat to come near them. The vessel plows and swashes through the water, plunging its bowsprit into the waves, without exciting their fears. Noises frighten them and drive them down. Although there would be no difficulty in bringing the end of the bowsprit directly over the fish, a skillful harpooner never waits for this. When the fish is from 6 to 10 feet in front of the vessel it is struck. The harpoon is never thrown, the pole being too long. The strong arm of the harpooner punches the dart into the back of the fish, right at the side of the high dorsal fin, and the pole is withdrawn and fastened again to its place. When the dart has been fastened to the fish the line is allowed to run out as far as the fish will carry it, and is then passed in a small boat which is towing at the stern. Two men jump into this, and pulling in upon the line until the fish is brought in alongside, it is then killed with a whale-lance or a whale-spade, which is stuck into the gills.

The fish having been killed, it is lifted upon the deck by a purchase-tackle of two double blocks rigged in the shrouds.

The fishermen have a theory to the effect that the Sword-fish can see nothing directly in front of him, on account of the peculiar location of the eyes, and there are instances of their having been approached, and killed, by men in a skillfully-managed dory.

50.—The perils and the romance of swordfishing.

The pursuit of the Sword-fish is much more exciting than ordinary fishing, for it resembles the hunting of large animals upon the land, and partakes more of the nature of the chase. There is no slow and careful baiting and patient waiting, and no disappointment caused by the accidental capture of worthless "bait-stealers". The game is seen and followed, and outwitted by wary tactics, and killed by strength of arm and skill. The Sword-fish is a powerful antagonist sometimes, and sends his pursuers' vessel into harbor leaking, and almost sinking, from injuries which he has inflicted. I have known a vessel to be struck by wounded Sword-fish as many as twenty times in one season. There is even the spice of personal danger to give savor to the chase, for the men are occasionally injured by the infuriated fish. One of Captain Ashby's crew was severely wounded by a Sword-fish which thrust his beak through the oak floor of a boat on which he was standing, and penetrated about two inches in his naked heel. The strange fascination draws men to this pursuit when they have once learned its charm. An old swordfisherman, who had followed the pursuit for twenty years, told me that when he was on the cruising ground he fished all night in his dreams, and that many a time he has bruised his hands and rubbed the skin off his knuckles by striking them against the ceiling of his bunk when he raised his arms to thrust the harpoon into visionary monster Sword-fishes.

51.—A LANDSMAN'S DESCRIPTION OF SWORDFISHING.

Mr. C. F. Holder, of New York, published in the New York "Forest and Stream", February 17, 1876, the following description of a trip after Sword-fish in Block Island Sound:

"Lying all night in the harbor of Wood's Holl, we had ample time to prepare for sport, and at three o'clock in the morning our little sloop was swinging around, and, gathering herself together, headed for Gay Head. The vessel was a common sloop of about sixty tons, its only peculiarity being a stanchion with a curved top, to hold the harpooner, rigged on the extreme end of the bowsprit. At nine o'clock we were out of sight of the Vineyard. The wind settling, I was informed that I could go aloft and use my weather-eye, and the better I used it the more fish we would get. After not a few attempts to climb the greasy pole of a mast I found myself aloft, with a firm grasp upon the throat of the gaff, my weather-eye, contrary to orders, full of tar, and my port one on the lookout for the game. We were just moving along, and I was taking in the horizon for miles around, when the man at the bow uttered a sound, which was a sort of a cross between a cluck and a groan, which I saw meant 'port', and that something had been sighted. The old craft fell lazily away, and I then saw two dark forms with their razor-like fins out of the water slowly moving along ahead of us. The captain signaled at once for me to come down, and as I reached the deck the fun commenced. The man waited until we were almost upon them, and as one of them turned, as if in idle curiosity, to see what the great shadow meant, he hurled a spear, and the next moment the huge fish sprang from the water and with a furious twist tried to shake out the iron. So great was the effort that it fell on its side with a crash, and for a moment was still, but it was only for a second. The line jumped into activity and rushed out so you could not follow it, now swaying to and fro, and making the water fly like rain. About 50 feet of line had gone out, when six of us managed to get a fair hold on the line, and attempted to try our strength. If six individuals were ever jerked around in a more vivacious manner they have my utmost sympathies. Now the Sword-fish would land us altogether in a heap, then slacken up, and take us unawares, throwing us to the deck with a force that fully came up to my preconceived ideas of the sport. He would undoubtedly have dragged us all overboard if the rope had not been sure and fast. This sort of fun was kept up for about fifteen minutes, when the fish perceptibly weakened, and the long rushes to the right and left grew feebler and feebler, until we ventured to haul in. At last we had the brute alongside. A rope was rigged from the peak and fastened around the long sword, and the monster was rolled on board the sloop. We measured our game, which was 9 feet 6 inches long. Though I have frequently caught sharks which measured 13 feet, I never saw any that showed near the strength of this peculiar creature.

"We cruised about all day in the vicinity, and succeeded in capturing three more, varying in length from 6 to 9 feet, and as we returned to Wood's Holl I felt that I had well earned my experience."

52.—THE CAPTURE OF SWORD-FISH BY HOOK AND LINE.

One or two instances are on record of the capture of Sword-fish upon an ordinary hand-line, and it is probable that this is much more common than has been usually supposed. Capt. George H. Martin, of Gloucester, informed me that he had seen seven caught in this manner in one day in the South Channel. They were caught in water fifteen to twenty-five fathoms deep, on the old-fashioned George's cod-hook, with a six-inch shank. Mackerel were used for bait; these were split down the tail so that the shank of the hook could be entirely hidden in the gash. I have been told that they are also taken in this way about Block Island, and a similar method of fishing is described by Italian writers.

Within the past three years it has not been unusual for Sword-fish to become entangled in the long lines of the halibut fishermen on the northern banks. The manner in which this occurs has already been discussed above.

I have collected several instances. In 1877, in the month of August, Capt. Daniel O'Brien, of the schooner "Ossipee", of Gloucester, fishing in 200 fathoms of water, between Le Have and Western Bank, caught, in one voyage, five Sword-fish.

At about the same time, Capt. R. L. Morrison, of the schooner "Laura Nelson", fishing in 275 fathoms, on Sable Island Bank, caught three Sword-fish. Another vessel, in August, 1877, fishing on Le Have, in from 175 to 180 fathoms, caught twelve, as well as three or four more in September. August 17, 1878, Capt. Joseph W. Collins, of the schooner "Marion", fishing on the southwest prong of Banquereau, in 200 fathoms of water, caught one Sword-fish; again, on October 1, fishing southeast of Sable Island, in 175 fathoms, caught one Sword-fish on his trawl and saw several others swimming at the surface; October 8, caught another on Banquereau, in the locality first mentioned. In August, 1878, Captain Greenleaf, of the schooner "Chester R. Lawrence", of Gloucester, fishing in 140 fathoms, caught thirteen in one trip. I cannot learn that this manner of capture was ever known before 1876, but it has since become so frequent that it excites no remark for a halibut-catcher to unload several Sword-fish among its halibut. This manner of taking the Sword-fish is of course purely accidental, and is rather a vexation than otherwise to the fishermen. It is probable that the fish take the bait when the line is being set and they are swimming near the surface, and they are involuntarily carried down by its great weight.

53.—SWORD-FISH VESSELS.

The vessels engaged in swordfishing are sloops and small schooners of generally less than fifty tons. The crew is also small, consisting of two or sometimes three men besides the cook and a boy. Although many vessels are employed in this fishery for several successive years, there are many others which fit out for a single season or for a part of a season. Others, on the south coast of New England, divide their time between fishing for sea-bass and hunting for Sword-fish, all warm and quiet days being devoted to the latter pursuit. Six or eight vessels from New London are thus employed, as well as others from Noank and Bridgeport. On the coast of Maine, as has already been mentioned, many of the smaller fishing vessels fitted for the capture of mackerel and cod devote a part of the season to swordfishing. Other vessels, among them occasionally a gentleman's yacht, enter the field for a cruise or two in the course of a summer. To do this is a favorite recreation for old swordfishermen engaged in other work. Numerous mackerel schooners carry the Sword-fish "pulpit" on their bows, and so do various coasters and packets.

It has therefore not been thought desirable to attempt to make a list of the vessels engaged in the swordfishery, or even an exact enumeration of them. In 1879 estimates by careful men engaged in the business fixed the number belonging in different ports as follows:

New York (hailing from New London)	2
Greenport (sloops)	2
New London	8
Newport	1
Fall River	2
Cuttyhunk	3
Westport	2
New Bedford	13
Dartmouth	2
South side of Cape Cod	5
Total	40

In 1874, according to Mr. Thompson, New Bedford had twelve vessels in this fishery. In 1877 the estimates of total number of vessels made by different men varied between thirty and forty.

To show how uncertain the continuance of vessels in this fishery may be I will refer to the annals of Gloucester. In 1876, one schooner, the "Meteor", was engaged; in 1877, the schooner "Champion"; in 1878, the schooner "Northern Eagle"; while in 1879 and 1880 the field is abandoned by this port.

54.—Financial profits to fishermen.

I have before me the record of a single schooner for the season of 1878, from which it appears that in the season of four months eight trips were made, averaging about twelve days in continuance. One hundred and sixty-three fish were taken between June 7 and September 20, weighing, in the aggregate, in round numbers, about 47,000 pounds, dressed. These were sold at an average price of three cents per pound. The gross stock of the season would amount to about $1,300. From this must be deducted the expense of living, the interest on capital invested, and the wages of the cook and the boy. The remainder would probably not exceed eight or nine hundred dollars, and the profits have to be divided among the two or three men composing the crew and the owner of the vessel. It is not probable that many vessels stock as large a proportionate amount as did the "Northern Eagle". The success of one New Bedford vessel in the season of 1878 was spoken of as extraordinary, the return being $311 to each of the crew's share.

The price of Sword-fish is low, and the success of the voyage is always somewhat precarious. A few small vessels with experienced skippers apparently succeed in making a fair living, but that the profits are not great is clearly indicated by the fact that there is no great increase in the number of vessels engaged, and that so many are constantly undertaking and abandoning the swordfishery.

55.—History of the American swordfishery.

There are few data upon which to found conjecture as to the time when the Sword-fish came to be regarded as sufficiently useful to be sought for by fishermen. One of the earliest records of its use for food is found in the *Barnstable Patriot* of June 30, 1841, in which it is stated that the fishermen of the island south of Cape Cod take a considerable number of these fish every year by harpooning them, and that about two hundred pounds a year are pickled and salted at Martha's Vineyard.

Captain Atwood remembers seeing Sword-fish on the coast of Maine as early as 1826, although up to the time of his retirement from active participation in the fisheries, in 1867, no effort was made by the fishermen north of Cape Cod to capture them.

The fishery apparently sprang into existence and importance between the years 1840 and 1855, upon the south coast of New England. Captain Ashby first engaged in it in 1859, when it was apparently a well-established industry. In 1861 it is recorded that some thirty vessels from New Bedford were profitably engaged in this business on the favorite ground, 15 to 20 miles southeast of Noman's Land.*

Mr. Earll ascertained that little attention was paid by the fishermen of Portland, Me., to Sword-fish until within two or three years. This fishery is carried on at odd times by mackerel gill-net fishermen, and by cod-trawling vessels when their regular industry is interfered with by the abundance of dog-fish. The season for dog-fish is also the time for Sword-fish, and at the present time, when the price of Sword-fish justifies it, smaller fishermen, when they are driven from their regular work by the dog-fish, make trips for the express purpose of capturing Sword-fish. Mackerel-seiners are beginning to carry Sword-fish irons, and are often very successful in killing the fish.

At the present day, and for five or six years past, perhaps much longer, there has been very little change in the number of vessels engaged, this varying from thirty to forty approximately in different years.

Capt. Epes W. Merchant, of Gloucester, who has been familiar with the fisheries since 1804, tells me that the first Sword-fish ever brought to Gloucester within his recollection was caught on George's Bank about the year 1831, by Captain Pugh, who brought it in and sold it at the rate of eight dollars a barrel, salted. Fishermen had before that been very much afraid of them, but afterwards a good many were caught.

56.—The capture of the Sword-fish in the Mediterranean.

M. Victor Meunier, in his little treatise, "Les Grandes Pêches", p. 141, describes the various methods formerly and at present in use in the fisheries of the Mediterranean. The Greeks were accustomed to use boats with projecting bows, modeled to resemble a Sword-fish, and painted with its peculiar colors. This the unsuspecting fish would approach, thinking to meet one of its own kind. The fishermen, taking advantage of the mistake, would pierce it through and through with their lances. Although surprised, the Sword-fish would defend itself with vigor, striking the treacherous boat with its sword and endangering its safety, while the fishermen strove to seize it by the head and, if possible, to cut off its sword. Having overcome their captive, they would fasten it behind their boat and carry it ashore. Oppian compared

* "Sword-fish have been taken this season in large numbers. New Bedford vessels have made a good thing in them. Few of the boats failed to take one or two daily. Captain Cobb, of the pilot-boat 'Vision', in a day and a half took nine, the largest weighing 400 pounds. Thirty vessels are fifteen miles south and east of Noman's Land, or sixty miles out from New Bedford, and same distance from Nantucket. The season extends from June to September. The fish generally weigh 400 or 500 pounds, and are from 10 to 12 feet long. They are sold in New York. After a fish is harpooned it scuds away, with a coil of rope paying out, and sometimes an hour is used before he is brought on board."—*Barnstable Patriot, Aug. 20, 1861.*

this method of fishing to a military stratagem. This ruse was known also to the Romans, and in their time the swordfishery was one of the most important. They also captured these fish in *madragues*, in which they were easily entangled while pursuing tunnies and other fishes of the mackerel tribe. "Although he is able to break the nets," said Oppian, "he shrinks from it; he fears some snare, and his timidity counsels him ill; he ends by remaining a prisoner within the ring of the net, and becomes the prey of the fishermen, who with united effort drag him to the shore." This does not always occur, to be sure, for often, to the grief of his would-be captors, he breaks the walls of his sepulcher, liberating also the other fishes buried with him.

There is at the present day a fishery in the Straits of Messina, continuing on the Calabrian shore from the middle of April to the latter part of June; on the Sicilian shore from the first of July to the end of September. The Calabrian fish appear to approach by the Pharos, the Sicilian ones by the southern entrance of the straits. This summer fishery has for its object the capture of the large fish, which are killed with a lance. The boats used are about 18 feet long, 4 feet deep, and broader at the stern than at the bow. There is a single mast, 17 feet high, surmounted by a brace of a curved form, intended to support the lookout, who gains access to it by steps fastened to the mast. The lookout from this elevated station views the movements of the fish, and by voice or gesture directs the movements of the oarsmen. At the proper time he descends, and standing on a narrow thwart amidships he aids the waist-oarsmen and performs the office of steersman.

At the bow stands the man who strikes the fish. His lance is about 12 feet long, with an iron head, which, from the vague description of Meunier, appears to resemble closely the American lily-iron. This is detachable, and to it is fastened a line as thick as one's little finger and 600 feet long (200 meters).

Two guards are also stationed on the shore. On the Calabrian coast they climb upon high rocks and cliffs; on the opposite shore, where there are none, they stand on a tower, built expressly for this purpose, about 800 feet in height.

"Everything being arranged," says Spallanzani, "behold the order of the fishery. When the two watchmen perched upon the tops of the rocks or of the mast judge that a Sword-fish approaches from afar, by the change in the color of the water, at the surface of which he swims, they signal with the hand to the fishermen, who row toward it with their boats, and they do not cease to cry out and to make signs until the other lookout on the mast of the boat has perceived the fish and follows it with his eye. At the voice of the latter the boat veers now to the right, now to the left, until the lancer, standing at the bow, weapon in hand, catches sight of the fish. Now the lookout descends from his mast, stations himself among the oarsmen, and directs their movements in accordance with signals given him by the lancer; he, seizing a favorable opportunity, strikes the fish, often at the distance of 10 feet. Immediately he slackens out the rope, which he holds in his hands, while the boat, with the force of all its oars, follows the wounded fish until he has expended all his strength. Then he rises to the surface; the fishermen, approaching, fasten to him with an iron hook and carry him to the shore. Sometimes the fish, furious from his wound, strikes the boat and pierces it with his sword, so the fishermen stand on their guard, especially if the animal is large and active."

The young fish are captured in nets about 300 feet long, called *palimadaras*. These are stretched between two boats with lateen sails, moving along, entangling in their meshes everything which they touch. Spallanzani protested vehemently against this fishery. It is carried on from October to March.

Oppian describes a method of capture used in the Mediterranean. A bait was fastened with a sliding noose to the line at a distance above the naked hook. and the whole was so contrived that when the Sword-fish seized the bait with its mouth the hook seized it from behind with great force. This story is declared by writers of the present day to have been fanciful and without foundation.

I am indebted to Mr. Frederick W. True for the following translation from Prof. Adolfo Targioni Tozzetti's essay on "The Fisheries of Italy", published in 1870,* which gives briefly a description of the methods now employed in the vicinity of Messina and elsewhere on the Italian coast:†

"Sword-fish are taken from time to time, together with the tunnies, in the *tonnare*;‡ but hook-and-line and gill-net fisheries are also carried on, the methods of which we may describe somewhat at length.

"Two very distinct fisheries are prosecuted—one by day, the other by night. The former is carried on by means of peculiarly constructed nets called *palamitare*; the latter by the use of harpoons, or *draffiniere*, as they are called. The harpoon fishery is prosecuted in the Straits of Messina, on the coasts of Calabria and Sicily, and among the Eolian Islands.

"The fish appear earliest along the coasts of Calabria, between Gioia Tauro, Palmi, Bagnara, and Scilla, and hence it is in these localities that the fishery first begins. It is prosecuted later in the season on the Sicilian coast, between S. Teresa al Faro, Gazzi, Salvatore dei Greci, and Capo Peloro.

"The net fishery on the Calabrian coast is carried on most extensively between Palmi and Scilla, the harpoon fishery between Palmi and Capo

* La Pesca nei Mari d'Italia e la Pesca all'Estero Esercitata da Italiani. < Catalogo degli Espositori e delle cose esposte, Sezione Italiana, Esposizione Internazionale di Pesca in Berlino, 1880. Firenze, Stamperia Reale, 1880, pp. xv–cxxxvi.

Swordfish Fishery—Pesca della Pesce spada, pp. lxix–lxxiii.

† The author states that the material for the following article is derived from the writings of Duhamel, Oppian, Spallanzani, and Vetrioli.

‡ A kind of pound-net constructed for the capture of tunnies or horse-mackerel (*Orcynus thynnus*).

delle Volpi. On the Sicilian coast nets are employed principally between S. Teressa and Gazzi, but between Salvatore dei Greci and Capo Peloro, where the management of nets would be very difficult on account of the deep water and rapid currents, the harpoon fishery prevails.

"The season of the regular fishery in Calabria extends from the middle of April to the end of June, and in Sicily from the middle of July to the middle of August. The capture of young Sword-fish, however, continues to increase long after this time, the season often extending to the middle of October. Fish weighing little more than a single kilogram are frequently taken, and the practice, therefore, has been strongly censured. In the latter part of October both adult and young fish disappear, retreating, as many suppose, to the depths of the ocean. They reappear in spring prior to spawning time, and remain on the fishing grounds throughout the entire season.

"Fisheries are also carried on, but with more or less irregularity, among the Liparian Islands, near Tropea, in Calabria, in the tunny-nets of Milazzo, Oliveri, and S. Giorgio, near Patti, and in the waters of Sardinia.

"The fishery on the Sicilian and Calabrian coasts is prosecuted at certain fixed stations. At some of them, such as station 25, in Calabria, net and harpoon fisheries are carried on with equal success; but at others, as for instance at station 21, in Sicily, only the harpoon fishery can be prosecuted, and at others, again, as at station 20, the net fishery alone prospers.

"The stations are occupied by the gangs (*poste*) of fishermen. The conformation of some portions of the coast of Calabria is such that the day fishery with nets cannot be carried on, and at these points each gang comprises two boats, or feluccas, of from 10 to 16 tons, two skiffs for each felucca, and one additional skiff used in carrying on communication between the boats.

"The *palamitara* is set from time to time, and at each station is fitted up in the manner deemed most suitable by the fishermen. It is made of strong hemp twine, and is hung to two ropes, the upper being buoyed by cork floats and the lower weighted with leads. The length of the net varies between 600 and 800 meters, the breadth is 16 meters, and the area 14,000 to 15,000 meters, more or less, according to the depth of water, which on these coasts varies between 40 and 600 meters; the mesh measures about 17 centimeters, bar. Each end of the upper rope is tied to a large cork buoy, to which a bell is attached, which sounds with every motion of the net.

"By these arrangements the net has sufficient play, so that it is not liable to injury by the sea. At the same time, when a fish strikes the net and is gilled, the more it struggles to get free the more it becomes entangled. In the mean time the ringing of the bell gives the fishermen the signal that a fish is captured, and they hasten to free the net and set it again.

"The method of the harpoon fishery is very different. A watchman is employed, who has his station on the cliffs overlooking the water, or at the masthead of the felucca. The mast of the felucca is usually 20 meters or more in height, and the watchman climbs to his station by means of a rope ladder. From his elevated position he scans the sea far and near, and when he perceives a Sword-fish gives the signal to a lookout, called fariere, foriere, or foliere, standing at the masthead of some one of the boats, or *lontro*, at the station.

"The watchman indicates the movements of the fish by certain signals. For instance, he cries out '*va susu*', meaning that the fish goes yonder, or toward Il Faro; or '*va jusu*', he goes down, that is, toward Messina; or '*va fora*', he goes out, or toward Levante; or sometimes '*va n'terra*', meaning that the fish is swimming toward the shore.

"The lookout, at first obeying these signals, and then relying on his own observation, guides the *lontro* toward the fish. When the boat has approached sufficiently near, the harpooner strikes the fish with his *draffiniera*, or harpoon.

"The *draffiniera* consists of a wooden staff 12 feet long, furnished with an iron 7 inches in length. The iron has two wings, and is constructed in such a manner that when it strikes the fish the point enters the flesh and the wings spread in the wound.* A rope, or *protese*, often 600 feet or more in length, is fastened to the harpoon-head, so that it may be recovered when the fish, weakened by loss of blood, is captured and brought into the boat.

"A short warp is tied to the staff of the harpoon, by which when the head is detached it is brought back into the boat. After the fish is struck, the *lontro* puts back to the station, leaving the chase and capture of the wounded fish to a second boat. Usually he is easily captured, but sometimes by dashing against the boat or by other movements he manages to free himself and make his escape.

"A fishery very similar to that carried on at the present time was described by Polibius, according to Strabo, more than two thousand years ago. The account of the fishery at Messina given by Oppian† is somewhat fanciful and inaccurate, but in the last century Spallanzani gave a more strictly technical description of it.‡ Recently the fishery has been accurately described in elegant Latin verse by Vetrioli.§

"The following table gives the number of fishermen and boats engaged in the Sword-fish fishery on the Sicilian and Calabrian coasts:

1. *The harpoon fishery.*

	Calabria.	Sicily.
Large boats (or feluche)	6	52
Small boats (lontri)	26	52
Small boats (barche)		52
Fishermen	275	384

* This iron resembles closely the American lily-iron.

† Oppiano, Della Pesca, lib. iii.

‡ Spallanzani, Viaggi alle due Sicilie ecc. vol. iv, p. 308, et seq.

§ Vetrioli, Xyphias Carmen, Naples, 1870.

2. *The gill-net fishery.*

	Calabria.	Sicily.
Boats of three tons burden	80–90	50
Fishermen	650	400

"The fishery is extremely productive. On the coasts of Sicily a gang of fishermen frequently capture fifty fish, each weighing from 100 to 200 kilograms, in a single day, and on the Calabrian coast, 20 fish.

"The following table shows the average annual catch in Sicily and Calabria:

1. *The harpoon fishery.*

	Kilograms.
On the Calabrian coast	60,000
On the Sicilian coast	40,000

2. *The gill-net fishery.*

On the Calabrian coast	25,000
On the Sicilian coast	15,000

"The products of the fishery are consumed principally in Sicily and on the mainland of Italy. A portion, however, is preserved in salt or oil, and sometimes exported. The flesh of the Sword-fish is excellent when fresh, and is not so liable to become soft when canned as that of the tunny or horse-mackerel. It, therefore, always commands a high price.

"It has been claimed that, in order to prevent a decline in the fishery, hook-fishing should be prohibited from the middle of January to the first of April, and that a fine should be imposed on those who capture the young fish. It has been suggested also that no nets should be allowed to be set in the Straits of Messina within 200 meters from the shore.

"The result of the experiments in artificial hatching of Sword-fish in certain inclosures and marshes in the vicinity of Il Faro appears to be somewhat uncertain; but, at all events, they may open the way for more practical and successful operations in the future."

L.—PRODUCTS OF THE FISHERY.

57.—Record of a Gloucester schooner for the season of 1878.

As an example of the manner in which a season of swordfishing is passed, and of the yield of a very successful period of work, a record is here given of the trips of the schooner "Northern Eagle", of Gloucester, Capt. George H. Martin.

Trips of schooner "Northern Eagle", Capt. George H. Martin.

No. of trips.	Date of start.	Length of trip.	No. of fish taken.	Where sold.	Price.
		Days.			*Cents.*
1	June 7	10	16 (5,000 lbs.)	Boston	8
2	June 19	7	22 (6,600 lbs.)	....do	4½
3	June 30	14	12 (3,700 lbs.)	Newport	2¾
4	July 12	11	20 (5,800 lbs.)	Boston	8
5	July 27	18	37 (9,000 lbs.)	....do	5
6	August 15	15	26 (6,500 lbs.)	....do	8
7	September 1	16	16 (5,600 lbs.)	....do	(2)
8	September 20	14	14 (4,500 lbs.)	....do	(8)
			163 (46,700 lbs.)		

58.—RESULTS OF TRIPS BY OTHER VESSELS.

Capt. Benjamin Ashby went swordfishing in the schooner "N. H. Dudley" two successive years, in 1859 and 1860. In July and August, 1859, he took 108 fish; the next year 88.

The schooner "Yankee Bride", of New Bedford, visited in Provincetown Harbor, August, 1879, had already that season taken 60 fish.

Mr. Earll reached Portland in the progress of the fishery census investigation, July 29, 180. On this day, he writes, 35 to 40 fish were brought in, and on the 1st of August 200 more were landed, 60 by one vessel.

59.—STATISTICS OF CAPTURE.

It is at present only possible to give estimated statistics of capture, though a year hence, when the returns of the fishery census, at present in progress, shall have been tabulated, much more accurate figures will be attainable. Putting the number of vessels regularly employed in swordfishing at forty, estimating their annual catch at eighty fish each, which is only half the quantity taken by the "Northern Eagle", as shown in the preceding paragraph, the aggregate number of fish taken would be 3,200.

Competent authorities estimate that each vessel in the mackerel fleet captures and brings in an average quantity of eight barrels of pickled fish, or perhaps eight fish each. The number of vessels in the mackerel fleet is at least four hundred. Allowing four fish to each, there is an aggregate of 1,600 fish. Estimating one for each vessel in the halibut fleet yearly, we add fifty more in the aggregate.

Mr. Earll judged that in 1878, as for several years previous, 2,000 Sword-fish had been brought into Portland, Me. Allowing 1,000 of these to the regular swordfishermen and the mackerel vessels, we have a remainder of 1,000 taken by the occasional fishermen of Portland already spoken of, and to be added to the aggregate, which now amounts to 5,850.

Add 150 more for the coasters, sea-bass fishermen, and pound-tending vessels of Southern Massachusetts, Rhode Island, and Connecticut, and the sum is 6,000.

The average weight of a Sword-fish dressed is estimated by several persons, Captain Ashby, Mr. Earll, Mr. Thompson, and others, to be 300 pounds, and that this is not far from the truth may be seen by referring back to the records of the "Northern Eagle". If the average weight is assumed to be 250 pounds, the aggregate weight of a year's catch of Sword-fish amounts to 1,500,000 pounds, valued at $45,000, the average price being estimated at three cents per pound.

To estimate the number of men employed is almost impossible, since the season continues only four months, and many are employed for a much shorter period. The crews of the forty vessels number from 160 to 200; the number of men employed for shorter periods it seems scarcely necessary to estimate.

In 1874 the annual catch for the United States was estimated by Mr. E. G. Blackford at 2,000 fish, weighing 1,000,000 pounds.

M.—ECONOMICAL USES AND THE MARKETS.

60.—SWORD-FISH AS AN ARTICLE OF FOOD.

"The small Sword-fish is very good meat," remarked Josselyn, in writing of the fishes of New England in the seventeenth century. Since Josselyn probably never saw a young Sword-fish, unless at some time he had visited the Mediterranean, it is fair to suppose that his information was derived from some Italian writer.

It is, however, a fact that the flesh of the Sword-fish, though somewhat oily, is a very acceptable article of food. Its texture is coarse; the thick, fleshy, muscular layers cause it to resemble that of the halibut in consistency. Its flavor is by many considered fine, and is not unlike that of the bluefish. Its color is gray. The meat of the young fish is highly prized on the Mediterranean, and is said to be perfectly white, compact, and of delicate flavor.* Sword-fish are usually cut up into steaks, thick slices across the body, and may be broiled or boiled.

Considerable quantities of Sword-fish are annually salted in barrels in Portland, Gloucester, Boston, New Bedford, and New London. Sword-fish pickled in brine is in considerable demand in certain sections of the country, and particularly in the Lower Connecticut Valley, where a barrel may be found in almost every grocery store. By many persons it is considered much more palatable than salted mackerel. The following table gives the amounts of Sword-fish, by barrels, pickled and inspected in Massachusetts from 1805 to 1877. It will be observed that before 1839 none were packed. In 1872, 1,245 barrels, or 249,000 pounds, were put up. The average amount to the year is 93,490 pounds, or about 467 barrels; the total for the thirty-nine years, 3,645,732 pounds:

*The flesh, which is much esteemed by the better classes at Palermo, is dressed in almost as many modes as that of the tunny, and fetches a higher price. During our sojourn there it was as two to one, the price of the first averaging four pence per *robolo*, while the *ρoτυμαι* of the latter were disposed of at two pence or two pence-half-penny. The fiber is invitingly white, and the round segments look, as they lie in rows along the stalls, like so many fillets of veal. Four to six feet is the usual run of those taken off the Trinærian coast and displayed in the fish markets of Sicily.—*Badham.*

Number of barrels of Sword-fish inspected in Massachusetts from 1839 *to* 1877, *inclusive.*

Inspection ports.	Jan. 1, 1839, to Jan. 1, 1840.	Jan. 1, 1840, to Jan. 1, 1841.	Jan. 1, 1841, to Jan. 1, 1842.	Jan. 1, 1842, to Jan. 1, 1843.	Jan. 1, 1843, to Jan. 1, 1844.	Jan. 1, 1844, to Jan. 1, 1845.		During 1845.	During 1846.	During 1847.	During 1848.	During 1849.
						No. 1.	*No.* 2.					
Rockport					4							
Newburyport												
Ipswich												
Gloucester			14	10		28	4	26				
Beverly												
Salem												
Marblehead												
Boston	42	97	23	27	190	120	6	200		2		3
Hingham						7		23				
Cohasset		49	85		44	6						16
Scituate		5										
Duxbury												
Plymouth												
Harwichport												
Sandwich												
Barnstable		84				14						
Provincetown		21		4	10					12½		45
Truro			6		27			37		24		46
Wellfleet		5	4	3	22	17		87		49¼		23
Harwich		20										223
Chatham	10	78	44	59	56	109						28
Dennis	40	200	128	137	75	141		145		15½		90
Yarmouth												
West Fisbury												
Swangey												
Nantucket												
Dartmouth												
Total	92	560	254	240	428	452		477	550½	103½	805½	474

Inspection ports.	During 1850.	May 17, 1851, to Dec. 31, 1851.	During 1852.	During 1853.	During 1854.	During 1855.	During 1856.	During 1857.	During 1858.	During 1859.	During 1860.	During 1861.
Rockport												
Newburyport												
Ipswich												
Gloucester	2											
Beverly												
Salem												
Marblehead												
Boston	15	13							2			
Hingham												
Cohasset		14										
Scituate												
Duxbury												
Plymouth												
Harwichport										5		
Sandwich												
Barnstable												
Provincetown	12								6			
Truro	12	¾										
Wellfleet	6	10										
Harwich	37	6½								2¼		16
Chatham	8	87½							218½	76½	445½	59
Dennis	52	2¼							10¾	8		1½
Yarmouth												
West Fisbury												
Swangey												
Nantucket												
Dartmouth												
Total	144	105¾	1,111	821½	284½	534¾	210½	464¾	236⅞	91⅝	445½	76½

Number of barrels of Sword-fish inspected in Massachusetts, &c.—Continued.

Inspection ports.	During 1862.	During 1863.	During 1864.	Jan 1, 1865, to Dec. 1, 1865.	Dec. 20, 1865, to Dec. 20, 1866.	Dec. 21, 1866, to Dec. 20, 1867.	Dec. 21, 1867, to Dec. 20, 1868.	Dec. 21, 1868, to Dec. 20, 1869.	Dec. 21, 1869, to Dec. 20, 1870.
Rockport	......	......	......	......	......	......	......	......	......
Newburyport	......	......	......	......	......	......	......	......	......
Ipswich	......	......	......	......	......	......	......	......	......
Gloucester	9½	8	......	134½	......	25¼	23¾	24	79
Beverly	......	......	......	......	......	......	......	......	......
Salem	......	......	......	......	......	......	......	......	......
Marblehead	......	......	......	......	......	......	......	......	......
Boston	7½	2¼	......	2	10	54½	197¾	164⅝	187⅝
Hingham	......	......	......	......	......	......	89½	57⅞	15⅜
Cohasset	......	6	......	89	20½	3	......	6¾	80½
Scituate	......	......	......	......	......	......	......	......	......
Duxbury	......	......	......	......	......	......	......	......	......
Plymouth	......	......	......	......	......	......	......	......	......
Harwichport	......	......	......	......	......	......	......	......	......
Sandwich	......	......	......	......	......	......	......	......	......
Barnstable	......	......	......	......	......	......	......	......	......
Provincetown	......	......	10	121½	......	54	850	142¼	209⅜
Truro	......	......	......	......	......	......	......	......	......
Wellfleet	......	......	......	......	......	99	154½	167⅞	295¾
Harwich	6	95	16½	202¼	62½	98½	166	110½	195½
Chatham	481¾	49¼	42¾	69¼	21¾	21¾	21¼	35	28
Dennis	61	104½	104	293⅝	70⅝	162¼	214½	123	87
Yarmouth	......	......	......	......	......	......	......	......	......
West Fisbury	......	......	......	......	......	......	......	......	......
Swangey	......	......	......	......	......	......	......	......	......
Nantucket	......	......	......	82	28¾	21	127	13½	9
Dartmouth	......	......	......	......	6⅜	......	......	......	89½
Total	565¾	259⅞	172¾	804½	225¾	538⅞	1,343¾	845¼	1,163

Inspection ports.	Dec. 21, 1870, to Dec. 20, 1871.	Dec. 21, 1871, to Dec. 20, 1872.	Dec. 21, 1872, to Dec. 20, 1873.	Dec. 21, 1873, to Dec. 20, 1874.	Dec. 21, 1874, to Dec. 20, 1875.	Dec. 21, 1875, to Dec. 20, 1876.	Dec. 21, 1876, to Dec. 20, 1877.	Total for each town.	Grand total.
Rockport	......	......	5	5	......	5	4	23	
Newburyport	......	......	2½	......	......	......	......	2½	
Ipswich	......	......	......	......	......	......	......	......	
Gloucester	90½	260¾	102½	86	40¼	80½	84½	978	
Beverly	......	......	......	......	......	......	......	......	
Salem	81½	......	......	......	1½	......	......	83	
Marblehead	......	......	......	......	......	......	......	......	
Boston	97½	95⅜	10½	57½	143 7/16	76½	56⅞	1,913 3/16	
Hingham	7⅜	......	......	......	......	......	......	200	
Cohasset	25	......	......	......	......	......	......	297¾	
Scituate	......	......	......	......	......	......	......	5	
Duxbury	......	......	......	......	......	......	......	......	
Plymouth	......	......	......	......	......	......	......	......	
Harwichport	......	......	......	......	......	......	......	5	
Sandwich	......	......	......	......	......	......	......	......	
Barnstable	......	......	......	......	8	11	22½	89½	
Provincetown	162	176 11/16	82 7/16	87 1/16	8⅞	87 13/16	83 3/16	1,537 1/16	
Truro	......	......	......	......	......	......	......	152¾	
Wellfleet	169½	158¼	48	60½	10¾	30	42¼	1,402¾	
Harwich	125	878½	64¼	86⅞	89	109½	27⅜	2,038	
Chatham	88¾	103	42	81	11	25	22	2,271 3/16	
Dennis	116¾	44½	......	5	......	25	21½	2,560⅜	
Yarmouth	......	......	......	......	......	......	......	......	
West Fisbury	......	......	......	......	......	......	......	......	
Swangey	......	......	......	......	......	......	......	......	
Nantucket	......	......	......	......	......	......	......	230⅞	
Dartmouth	4	28½	......	104½	5	27½	......	215¾	
Total	808 1/16	1,245 15/16	307⅜	413 13/16	267 13/16	877 7/16	265 1/16	......	18,228⅜*

* 10 barrels are marked No. 2.

61.—MARKETS.

Mr. Thompson remarks: "Previous to 1862 the market for fresh fish was limited to New Bedford, Fall River, Providence, and the adjoining towns, and a large proportion of the fish then taken was salted and shipped to the West Indies and the Southern States. This was especially the case with those taken about Noman's Land and Martha's Vineyard. Now nearly all are consumed fresh, and the average price is somewhat higher than formerly."

The Gloucester Telegraph of September 7, 1850, contained the following item, which shows that Sword-fish were eaten in Boston at least thirty years ago, and, highly esteemed:

"A Sword-fish weighing about 250 pounds was caught near our cape on Tuesday. It was taken to Boston and retailed out from Quincy Market, by Messrs. Covill, at 12½ cents per pound. The sword, measuring from the eye to the tip, is 37 inches in length."*

Mr. John H. Thomson writes: "At present the great bulk of the catch is sold fresh. Most of the fish are brought to this port, and a few are carried to New London. Until within a *very* few years nearly all were disposed of in this vicinity. About 1864 a few were sent to Boston on trial, and the consumption of Sword-fish in that vicinity has since rapidly increased. Still, the principal market for fresh Sword-fish may be said to lie between New London and the eastern end of Massachusetts. Providence, R. I., consumes a large quantity."

Mr. Earll writes: "About 2,000 Sword-fish, averaging in weight 300 pounds dressed, have been landed yearly in Portland for several years. Most of them are sent to Boston fresh, and the remainder are cut up and salted here."

Mr. Eugene G. Blackford informs me that Sword-fish are not much esteemed in New York market, and that in 1874 not more than 2,000 pounds in the aggregate were consumed.

62.—PRICES.

Regarding the price of fresh fish at New Bedford, Mr. Thomson remarks: "When the first fish arrives here it is eagerly sought at 20 cents a pound, retail. In 1873, within forty-eight hours of the arrival of the first one, fifty-two were brought in, bringing the general retail price down to 8 and 10 cents. At this price, clear of bone, they are usually retailed throughout the season. The wholesale price is about 12 cents for the first catch, falling rapidly to 2 or 3 cents. This is for 'clean fish', without head, tail, and viscera. Fish from George's Bank are sometimes brought here from Boston. They then retail at 15 and 20 cents."

According to the record of the "Northern Eagle", the price in June,

* A Sword-fish weighing over 700 pounds was one of the sensations at Faneuil Hall Market last week.—*Gloucester Telegraph, August* 13, 1870.

1878, ranged from 2 to 4½ cents, in July from 3 to 5 cents, and in August from 2½ to 3.

In July, 1879, Mr. Earll found the price in Portland, Me., 4 cents, but the arrival of 200 fish on August 1 brought the price down to 1¼ cents. He estimates the average wholesale price at 2 cents.

In New London, according to Captain Ashby, the price has varied within his recollection from 3 to 8 cents, the latter high price being paid in 1877.

According to Captain Martin, the price of salt Sword-fish in Gloucester is always about the same as that of No. 3 mackerel. In July, 1878, there being no mackerel in the market, they were valued at $7 a barrel.

APPENDIX

63.—LETTERS.

I.

FROM E. G. BLACKFORD, COMMISSIONER OF FISHERIES FOR NEW YORK.

NEW YORK, *November* 30, 1874.

Prof. G. BROWN GOODE:

DEAR SIR: Your favor of 26th instant at hand this a. m. The following information I received from an old swordfisherman, and he is a man whose statements may be relied on:

The season first opens in the neighborhood of Sandy Hook about the first part of June, and continues along the coast as far east as Martha's Vineyard, Nantucket Shoals, until about the middle of September; have heard of their being caught as far north as Cape Sable. At the first cold wind blowing in September they disappear, and are not found on the coast again that season. They are like the mackerel, the first poor and lean, but as the season advances they grow fatter. They feed on fresh mackerel and herring. Largest ever caught, 1,200 pounds; smallest about 50 pounds; the large ones about 20 feet long. Average weight of a catch, 500 pounds each fish. Largest number caught at one cruise of a smack, 350, in the fall of 1872; they were carried into Portland and sold.

Most of the fish caught are salted. Principal markets for the sale of the fish are New Bedford, Fall River, Portland, and Boston; are not much esteemed in New York market, and not over 2,000 pounds sold in this market the entire season. Total catch from beginning to close of season estimated at 2,000 fish, weighing 1,000,000 pounds.

Would advise you to write to some party in New Bedford if you desire any further details.

The man I received my information from is full of incidents in reference to the fish. He says the vessel he was in had been struck nearly twenty times by the Sword-fish, and the blades imbedded in the hull. It seems that if the fish is not killed by the stroke of the harpoon it becomes enraged and goes for the vessel.

The Bill-fish I know nothing of except the one I saw at Noank, in your fish-house.

Of the Sail-fish I have seen only one specimen, and that was in bad condition, and came from Key West, Florida.

Respectfully yours,

E. G. BLACKFORD.

II.

FROM C. B. FULLER, CURATOR PORTLAND (ME.) SOCIETY OF NATURAL HISTORY.

Answers to questions relative to the food-fishes of the United States.

A.—NAME.

1. What is the name by which this fish is known in your neighborhood?—*Answer.* Sword-fish.

B.—DISTRIBUTION.

2, 3. Is it found throughout the year, or only during a certain time, and for what time? If resident, is it more abundant at certain times of the year, and at what times?—*Answer.* Rare in July and October; most abundant in August and September.

C.—ABUNDANCE.

5. Has the abundance of the fish diminished or increased within the last ten years, or is it about the same?—*Answer.* About the same.

D.—SIZE.

What is the greatest and least size to which it attains (both length and weight), and what the average?—*Answer.* Heaviest, 800 pounds; pounds; smallest, 10 pounds; average, 300 pounds.

E.—MIGRATIONS AND MOVEMENTS.

11. By what route do these fish come in to the shore, and what the subsequent movements?—*Answer.* They appear first on the South Shoals.

12. By what route do they leave the coast?—*Answer.* As they come.

15. When do the fish leave shore, and is this done by degrees or in a body?—*Answer.* In October.

16. Is the appearance of the fish on the coast regular and certain, or do they ever fail for one or more seasons at a time, and then return in greater or less abundance? If so, to what cause is this assigned?—*Answer.* About the same; some years more caught than others.

F.—RELATIONSHIPS.

33. Do these fish go in schools after they have done spawning, or throughout the year, or are they scattered and solitary?—*Answer.* Scattered.

35. To what extent do they prey on other fish, and on what species?—*Answer.* Herring.

G.—FOOD.

37. What is the nature of their food?—*Answer.* Mostly herring, some mackerel.

38. Are there any special peculiarities in the manner of feeding of these fish?—*Answer.* By killing; striking with the sword.

H.—Reproduction.

46. Where do these fish spawn, and when?—*Answer.* Do not spawn here.

M.—Parasites.

70. Are crabs, worms, lampreys, or other living animals found attached to the outside or on the gills of these fish?—*Answer.* Lerneæ on body.

O.—Economical Value and Application.

78. What disposition is made of the fish caught; whether used on the spot, or sent elsewhere, and if so, where?—*Answer.* Sent to Boston.

84. What were the highest and lowest prices of the fish per pound during the past season, wholesale and retail, and what the average, and how do these compare with former prices?—*Answer.* From ½ to 8 cents, retail; $4 a barrel (salted). Ten years ago, $10 to $12 a barrel, salted.

III.

FROM MR. JOHN H. THOMSON, NEW BEDFORD, MASS.

[N. B.—The numbers correspond to the questions printed under letter No. II, preceding.]

NEW BEDFORD, *December* 5, 1874.

G. BROWN GOODE, Esq.:

Yours 30th November received. Having been for several years engaged in the fisheries of this vicinity, and also since then being located alongside of one of our principal fish-markets, I think I can answer some of your inquiries. I will reply somewhat in the shape of answers to the questions named in the circular (the number of question on the margin).

Nos. 3, 11, 12. They appear on our south coast, south of Block Island, about May 25 to June 1; they appear to come from the southwest, or just inside the track of the Gulf Stream; they gradually approach Vineyard Sound and vicinity during June to July 10 to 15; they appear to leave, working to southeast, and are off southeast of Crab Ledge about the middle of July. This school is of comparative small size, averaging about 150 pounds gross, or, say, denuded of head, tail, &c., about 100 pounds as delivered in market. These fish are of a light plumbeous hue, darker on back and white on belly, the smallest being, say, 4 feet long (including sword), &c., weighing 30 to 40 pounds; the largest, say, 8½ feet (including sword, &c.), weighing 300 pounds gross. At about that time (August 1), another school of late years has appeared southeast of Cape Cod and George's Bank, consisting of altogether different fish, being much larger (weighing an average of 300 pounds), some as large as 800 pounds (gross), and entirely black. I have this week conversed with an old smackman (M. C. Tripp) who all his life has been a fisherman, and has this year captured about 90 fish, and his opinion is that they are *not the same school.*

Nos. 5, 16. They appear to be of about the same abundance in average years; the catch depends on the weather, fogs, &c.

No. 15. They come and leave in a general school.

No. 32. Not in *close* schools, like other fish, but distributed over the surface of the water; the whole are called by the fishermen the annual school, but cannot strictly be so named.

No. 34. The Bill-fish (ranging from 6 to 12 feet in length) is their especial enemy, appearing about the last of the season, and when they appear is a signal to the fishermen that the Sword-fish are about leaving.

Nos. 35, 37, 38. They feed on blue-fish, mackerel, and menhaden. Their mode of catching these fish is generally to rise beneath the school of small fish and strike right and left with their sword, so as to kill the fish, and I have seen them *apparently* throw the fish in the air and catch them on the fall.

No. 70. They are infested with a species of boring-worm, which burrows in their sides, say, 3 to 6 inches in depth.

No. 71. Captured with a species of harpoon named "Sword-fish iron", the peculiarity of which is the head is movable and connected with the shaft by a line, and being secured only by a peg, easily slips off and forms a "toggle" on the underside of the fish. Ordinary harpoons will draw out from the flesh, there being only one general bone, and that small in size, viz, the backbone.

No. 78. At present the great bulk of the catch is sold fresh; the most of the catch is brought to this port; a few are carried to New London, but until a *very* few years since very nearly all were disposed of in this vicinity. Some ten years since a few were sent to Boston on trial, and the consumption in that vicinity has rapidly increased; still, the market for fresh fish may be said to be from New London, Conn., to the east end of Massachusetts. Providence, R. I., is quite a large consumer of the fresh fish.

No. 84. When the first fish arrives here (New Bedford) it is eagerly sought for at about 20 cents per pound, retail; but last year, within 48 hours from the arrival of the first fish, 52 were brought in, bringing the general retail price to 8 and 10 cents, clear of bone, at which price they continued to be retailed the season until its close, when fish were brought here from Boston, caught on George's Bank, and then retailed from 15 to 20 cents. The wholesale price is about 12 cents, first catch, falling rapidly to 2 and 3 cents per pound; this is clean fish, denuded of head, tail, viscera, &c.

Nos. 82, 85. Previous to 1862 the market for fresh fish was limited to New Bedford, Fall River, Providence, and adjoining towns, and a large proportion of the fish then taken were salted and shipped to West Indies and the Southern States; especially was this the case with the fish taken around Noman's Land, Vineyard Sound; now nearly all are consumed fresh, and the average price is somewhat higher than then.

It is impossible to say how many smacks, &c., are engaged in the fishery; there are about a dozen from here, but every Vineyard boat, packet, &c., carry the gear in the season, with outrigger or stand on the bowsprit for taking them. Captain Tripp told me yesterday he had brought in 52; some have caught 80 or 90 each. About 1,000 fish have been brought here the past year, and passed through the hands of our marketmen; about 500 more have been consumed on the Vineyard and Nantucket. The catch carried to New London and Boston I am unable to state.

It will keep good packed in ice perhaps longer than any other fish, and is therefore more easily transported fresh to the surrounding towns and cities.

Should any of the above statements be of account to you, I think you can rely on their general accuracy.

Yours, truly,

JOHN H. THOMSON.

IV.

FROM WILLARD NYE, JR., OF NEW BEDFORD, MASS.

NEW BEDFORD, *March* 24, 1875.

DEAR SIR: I find that the Sword-fish which Capt. Dyer caught was at the west, not east, of South America. He says they are very plenty off the Peruvian coast, a number being often in sight; the largest he ever saw was one caught by himself about 150 miles from shore; the ship's crew lived on it for several days, and they then salted 400 pounds—supposed the fish must have weighed from 900 to 1,000.

A few years ago Captain Dyer struck a Sword-fish from a 30-foot boat, about 40 miles southwest of Noman's Land, threw over the keg, tacked, and stood by to the windward of same. When about abreast of it the man at masthead said, "Why, here he is, right along side." The fish was then about 10 feet from the boat, going in the same direction. On getting where he could see the splash of the water around the bow, he turned and struck her about two feet from the stem, just below the water-line. The sword went through the plank, 1¾-inch cedar, into a lot of loose iron ballast, breaking off short at the fish's head.

Captain Allen says, while cruising for whales, he has found the Sword-fish very abundant off Peru and Chili, from the immediate coast to 300 miles out, beyond which they are seldom seen; are very plenty during the month of January, when they feed on the common mackerel, with which the waters at that time abound. The largest he has ever caught weighed about 600 pounds. Both Captains Allen and Dyer have been several voyages masters of whaling-ships, and are perfectly familiar with Sword-fish on our coast, and both speak of seeing plenty of Bill-fish in the Pacific Ocean, but never took the trouble to catch them.

The Sword-fish appears on the coast of Massachusetts from the 8th to the 20th of June, and is first seen southwest from Block Island. They begin to leave in August, but stray ones are sometimes seen as late as the last of October. The general opinion of their coming and going is that they follow their food, which swarms on our coast (between the seasons named) in the form of mackerel and menhaden; these fish are of course driven off by the approach of winter and rough weather. A number of boats, large and small, have been struck by Sword-fish on our coast but always after the fish has been struck. The people of Block Island sometimes catch them with hook and line, bait with fresh mackerel and throw just ahead of the fish, when he will stick it with his sword and then swallow it, after which he is easily managed.

Yours, truly,

WILLARD NYE, JR.

V.

FROM CAPT. WILLIAM E. SPICER, NOANK, CONN.

NOANK, CONN., *January* 11, 1875.

DEAR SIR: I made inquiry at Mystic concerning the question you wanted information on. I found that the crews of the two smacks were all dead but one man, Mr. William Taylor, a man 76 years old, and he lived five miles back of Mystic. I went and saw the man. He says he was in the smack, her name was the Evergreen, Capt. John Appleman; they started from "Mystic" in company with the smack "Morning Star", Captain Rowland, for Key West, on a fishing voyage; they left October 3, 1832, and he thinks that on the 12th, off Cape Hatteras, blowing heavy wind northeast, under double-reefed sails, at 10 o'clock at night, she was struck by a Woho, which shocked the smack all over. They made a signal to the other smack to keep close by them, for she was leaking badly. The next morning they found the leak; the same kept off for Charleston, both smacks. Took out her ballast, hove her out and found his sword had gone through the plank, timber, and ceiling. The plank was 2 inches thick, timber 5, the ceiling 1½-inch white oak, and the end of his sword 2 inches through on the inside of the ceiling in the after-run. It struck close by a butt on the outside, which split the plank and caused the leak. They took out a piece of the plank and proceeded on their voyage.

Yours, truly,

WM. E. SPICER.

64.—ON THE YOUNG OF THE SWORD-FISH AND SAIL-FISH.

By Prof. CHR. LÜTKEN, *of the University of Copenhagen*.

[Translated by Dr. TARLETON H. BEAN.]

For some years past I have had occasion to occupy myself with the Sword-fishes and the requirements for a critical examination of the genera and species of this group.† Such an examination is certainly precarious, since the material for it must be sought to a great extent in the literature, and can be based only in small part upon an examination of the natural object itself. Without this it will, as a matter of course, be impossible, and the more meager the material at hand the more uncertain must the result be. This is one of the cases in which one cannot entirely neglect such examinations, but must prosecute them as thoroughly as possible; only one must always recognize clearly where are the limits of reasonable certainty and when these limits are overpassed. The approximate result at which I think we must arrive is this: that the genus *Xiphias* (with its single species, *X. gladius*) cannot be considered as the peculiar type of the Sword-fish, as the central point of the group, but rather as one of its more divergent, peripheral, or strongly "differentiated" forms; that of the round-billed Sword-fish furnished with ventral fins two genera may be maintained, *Histiophorus* and *Tetrapturus*, but that in each of these can be established with certainty only two species, *H. gladius* and *gracilirostris*, *T. belone* and *Herschelii*; that the genus *Machæra* (round-billed Sword-fish without ventrals), on the contrary, must be regarded with suspicion and as requiring further confirmation. Whether the future will show that this reduction of species is too radical must be determined later; but if more species than those mentioned are truly valid, the limits between them must be defined by more positive characters than have been stated hitherto; and to this end it is necessary that museums shall become richer in these forms than there is, perhaps, a prospect of for a long time to come. So much is then, at all events, certain, that the two examples 4 and 18 inches long of the "species" established as *Histiophorus immaculatus*, Rüpp.,‡ and *H. pulchellus*, C. & V., cannot claim to represent distinct species, but merely young forms, stages of development; and one may certainly with strong probability refer the little "*H. pulchellus*" to *H. gladius* or *H. orientalis*, and thereby unite this specific type with the much younger *Histiophori*, which Dr. Günther has figured and described. In his first contribution (Journal of the Museum Godeffroy, second part, p. 170) Dr. G. describes and figures three small fish of 9, 14, and 60 mil-

* Vidensk. Selsk. Skr. 5, Række, naturvidensk. og math. Afd. xii, 6, pp. 441–447.

† Ichthyographiske Bidrag, iv. On the Round-billed Sword-fish, especially on *Histiophorus orientalis*, Schl. Vid. Medd. Nat. For. 1875, pp. 1–21, with a postscript, p. 243, 1877–'78.

‡ A specimen 5 feet 9 inches long is mentioned by Day, Fishes of India, p. 199.

limeters in length, which he at first supposed to belong partly to *Xiphias*, partly to *Histiophorus*, but in which he afterward (in another contribution, same journal, third part, p. 265) rightly recognized that he had before him only young *Histiophori*. I have before me such a series of young *Histiophorus*,* of from 5½ to 21 millimeters in length, the smallest of them so little that they could have been only a very short time out of the egg. It is possible that they represent more than one species; however, it can scarcely be established with certainty. Not very much that is new can be added from this material to the information contributed by Dr. Günther, but since some of them are smaller than the least of Dr. Günther's examples, I have been able to follow the history of the metamorphoses of the genus a little step farther back towards its starting-point. The largest specimen before me is 21 millimeters long, and stands in this respect between the two examples figured by Dr. Günther (2 and 3, p. 443), which were from 14 to 60 millimeters long. (*H. pulchellus* may be regarded as the next link in the series after Günther's largest [3].) Because of the somewhat dried condition of his example, he could not give full information about the unpaired fins, and I have therefore not figured it in the example measuring 21 millimeters. The head from the point of the snout to the margin of the gill-cover was 10 millimeters, or nearly the half; and of these 10 millimeters the snout (that is, the upper jaw as far back as the eye) again made the half, or 5 millimeters; the portion of the lower jaw which extends forward in front of the eye equalled two-fifths of this, or 2 millimeters. The supraorbital margin is strongly projecting and finely toothed; the forehead sinks abruptly towards the snout; the orbito-temporal crest is continued behind in a horizontal, backward-directed, pointed, three-sided, serrate nuchal spine. The spine arising from the angle of the preoperculum has a similar form and sculpture, but is somewhat curved and much longer and more compressed; it reaches nearly half as far back as the pectorals. Far beyond both of these extend the ventrals, apparently composed of but a single ray. The skin is smooth; the caudal not forked; the jaw-teeth strong; the anterior teeth in the lower jaw are especially distinguished in this respect. Besides this example, the Museum possesses a series of young of 5½ to 12 millimeters in length, which differ very little one from another. All these small fish (in which one, if he did not know the above description or the intermediate link restored by Günther, would have difficulty in recognizing *Histiophori*, but would more readily suspect a developmental stage of a *Dactylopterus*-like fish) have a marked frontal depression and a short, broad, pointed snout or "bill," of which the upper jaw, beset with strong teeth, is very little longer than the lower jaw; strong curved teeth distinguish the points of both jaws. The form is comparatively plump,

* The localities in which these small *Histiophori* or *Tetrapturi* were taken are: 37° 30′ N. lat., 52° 15′ W. long.; 23° 2½′ N. lat., 31° 48′ W. long.; 14° 44′ N. lat., 61° 19′ W. long.; 4° N. lat., 29° W. long.

short, and compressed. The smaller they are the broader and shorter the snout is, until at last its length is not greater than one eye-diameter. The preopercular spine in all of them is much longer than the short pectorals. The ventrals appear only as the least little rudiment. Like the larger example, all have one or two small spines below, two above, the preopercular spine (of which spine nothing is seen in Figs. 1 and 2, p. 443). The dorsal and anal fin in all of them is low, without evident rays, even if such are present in the caudal; in the younger one is seen very plainly the notochord curved upward at a right angle, but in the smallest of all (Plate II, Fig. 11) it is not yet curved upward, and all three fins are connate; in the very earliest stage of development of *Histiophorus* is seen finally, as in certain other young Scombroids, a little supraorbital spine, but it disappears comparatively early.

Of *Xiphias gladius* Cuvier has described and figured the younger stages of 12 and 18 inches; Plates 225 and 226 of the great ichthyological work are in this respect exceedingly instructive. Young forms of 12½ millimeters and 2½ inches are mentioned by Günther (*l. c.*), who has given a brief account of their differences from the very young *Histiophori*. One may obtain from these data alone a very good idea of the history of the development of "the common Sword-fish". There are before me, besides young Sword-fish of 27 and 41½ inches (to the cleft of the caudal), a specimen 190 millimeters long found in the stomach of an albicore, but tolerably well preserved, besides the series of smaller specimens from 10 to 46 millimeters long.* In the young Sword-fish of 27 inches† the keel is present on the tail; the gills have the *Xiphias* character, but the dorsal is single, continuous; likewise the anal; and the skin is now rough from the close covering of rough scales, which will be immediately described more fully in a younger example, and between which the four series of large, pointed bone-bucklers on each side are now very evident. Of the smaller, pelagic specimens the largest (190 millimeters) and the smallest (10 millimeters) are especially interesting; this last because it is so much smaller than any hitherto described, and makes it possible to give a representation of the appearance of the genus at a very considerably earlier stage of development, and at the same time to

*The places where these young Sword-fish were caught, so far as recorded, are the following: 38° 53′ N. lat., 19° 37′ W. long.; 32° 50′ N. lat., 74° 19′ W. long.; 23° N. lat., 55° W. long.; 20° N. lat., 31° W. long.; 0° N. lat., 29° W. long.; 25° 4′ S. lat., 27° 26′ W. long. Indian Ocean: 21° 30′ W. lat., 57° 50′ E. long.; 22° S. lat., 57° 40′ E. long.; 23° 40′ S. lat., 57° 40′ E. long.

†For comparison with the measurements of the example 190 millimeters long, I give some measurements of the 27-inch Sword-fish:

	Inches.
Head, with upper jaw	12
Height of body behind the head	3⅛
Length of dorsal ray near the middle of the back	2⅛
Length of pectoral	4
Lower jaw (5¼ inches shorter than upper jaw)	5
From the front margin of the eye (socket) to gill-opening	3⅓

institute a comparison with the corresponding stage in *Histiophorus*. I shall confine myself to a brief mention of the smaller and a little more extended one of the largest of these youthful examples. This is unfortunately somewhat obscured by the stomach juices, and on this account is not fit to be made the subject of an illustration, which is so much the more unlucky since there exists no representation of a young Sword-fish at just this stage of development. It has a much slenderer form; the height is only 10 millimeters, and is contained 19 times in the total length; the length of the head (from the tip of the upper jaw to the gill-opening) is 68 millimeters, over one-third of the total; the "bill" itself (from the tip of the upper jaw to the anterior margin of the socket of the eye) is more than 3 times as long (52 millimeters) as the distance from the anterior margin of the socket to the gill-opening; the lower jaw is only 12 millimeters shorter than the upper jaw; measured to the angle of the jaw it is, however, only 4 millimeters shorter (48 millimeters) than the length when taken to the anterior margin of the socket. The upper jaw is arched above, flat below, nearly as in *Tetrapturus*, twice as wide as high (in the same place), and its form is very different from what it is later. The caudal is not deeply forked; the height of the dorsal appears to have been nearly double that of the body; the pectoral is comparatively short (21 millimeters); no trace of ventrals is seen; the caudal keel is likewise invisible (see below); the skin is everywhere covered with pointed scales or shield-like plates, which lie side by side, not imbricated; among which may be distinguished larger and smaller ones.* Of the larger a series extends parallel with the dorsal outline on each side of the dorsal fin from the head to the root of the tail, and close below each of these series is a similar one formed of somewhat smaller plates; also parallel with the ventral outline on each side of the anal fin extends such a series of larger plates, accompanied above at some distance by a somewhat smaller one; but in front of the anal, towards the under part of the belly, these two series of larger plates disappear gradually in the common covering of pointed, small scales, which here on the belly are larger than up towards the back; on the whole hind part of the body and tail is seen, on the contrary, quite plainly its four regular series of larger skin-tubercles, separate, along the sides of the fish, with a comparatively small belt of little scales. Its larger shields are strongly compressed, keeled and ribbed, so that the ribs radiate from the keel backwards and downwards towards the basal margin of the shield; from each keel project three to six sharp, curved points, directed backward, of different sizes, the smallest of each group in front, the largest behind. The small scales, furnished in a similar manner with little points, extend out over the whole head and bill, as well as the upper and under jaw. The margin of the upper jaw is

* The small scales repeated in *Tetrapturus* as a fine layer of diminutive roughnesses outside the bony scales, especially characteristic of this genus and the *Histiophori* (which likewise occur in *Thynnidæ*), are not homologous with these.

furnished, besides, with a like series of vertically placed, conical, strong teeth of a comparatively uniform size, alternating with smaller, 1 to 3 pair between each of the larger; small teeth cover, further, the greatest portion of the palatal region. The teeth in the under jaw are somewhat smaller, but more closely placed; instead of the outer principal series is seen a belt of smaller teeth. The gills show nothing different from the ordinary fish-gills, neither have they yet the *Xiphias* character.

Very young Sword-fish 37 millimeters long, of which the head constitutes nearly the half (17 millimeters), have the lower jaw 3½ millimeters shorter than the upper jaw; in a somewhat larger example (50 millimeters), the height of the dorsal and anal fins equals that of the body behind the head (3 millimeters); dark cross-bands descend over the sides of the body and the unpaired fins; the two small keels of the tail are of like form and size, with a median keel; the caudal is rounded. (Plate II, Fig. 10). In this small fish, in other respects, the armament of the skin and the jaws is essentially as in the above-described young Sword-fish four to five times as large; the larger pointed skin-plates are also here perceptible as such, likewise their above-described regular arrangement. The lateral margin of the forehead is toothed; the preoperculum, likewise, in the smaller of these two examples is even furnished with a group of long spines, which in the space of this treatise will be described in various other Scombroids. In still younger examples the larger skin-plates diminish in number, and each plate bears only two or three small points of equal size; there is here as little trace of ventrals as in the very youngest developmental stage (10 millimeters). The head, which constitutes nearly half of the total length, though the bill is still short, is here compressed, without the frontal depression of the *Histiophori*, and extends out into a comparatively short bill, broad at the root, the under jaw of which is just as long as the upper jaw, both being well provided with teeth. The frontal margins are serrate just as in the above-described larger young; likewise the opercular spines; the larger nuchal spine and the preopercular spine, which are so colossal even in the youngest *Histiophori*, are wanting. On the contrary the pointed skin-covering is already perceived like fine bristles which project from the skin; in the nuchal region, over each gill-opening, occurs a little projecting pointed crest.

Despite certain analogies between *Xiphias* and *Histiophorus* at their appearance from the egg, there are very considerable differences between them in their very first conduct—differences which show well enough that the separation between these two genera is rather wide. To this result one must come also by comparison of the bony structure of a *Histiophorus* or a *Tetrapturus* with that of a *Xiphias*. The closest generic ally of the *Histophori*, especially of the *Terapturi*, we will, in a later section, find in the genus *Acanthocybium*, which presents decided resemblances. If these show nothing more than a very close relationship, they at any rate unite the tie too firmly for one to regard the Xiphioids as other than a subsection of the great mackerel family.

65.—MARCGRAVE'S DESCRIPTION OF THE SAIL-FISH.

GVEBVCV BRASILIENSIBUS: Lusitanis Bicuda; Piscis rostratus; oblongo & ferme tereti est corpore ut *Dorada;* capite porcino, rostrato, cauda in duo cornua deducta ut *Abacara* rostrum acutum, osseum, durum: partis superioris longitudo tredecim digitorum: utramque autem rostri partem movere potest. Branchias habet amplas: os interius orbicularis figuræ, in medio sui hyperbolico foramine; lingua oblonga, alba, dentibus omnino caret. Oculos habet solidi magnitudine, pupilla crystallina, circulo argenteo. A rostri insertione caput in altum assurgit, ut in *Dorada* mare: est autem caput ab oculis ad occiput longum septem digitos, novem altum.

[Length occiput to origin of tail 4 feet. Tail-lobes 18 inches; 2 flaps, 6 fins. Pectoral 11 inches, 2 broad at base. Ventrals black, hard like cuttle-fish bone, whip-like, 19 inches, closed in furrow (received in furrow). First anal 6 inches, second anal.

Dorsal 3 feet base, membrane like parchment, with ribs, received in furrow, 1½ feet high. Skin hard, brownish. No scales, but with spine-like bodies. Belly and throat white, sides silvery and ashy, back silvery grayish brown. Fins grayish silvery.]

Carnem copiosam habet, non spinosam, pinguem, non glutinosam. ideo ad commededendum aptiorem quam caro Marsorum.

66.—DESCRIPTIONS OF TETRAPTURUS ALBIDUS AND T. AMPLUS.

By Prof. FELIPE POEY.

The type of *Tetrapturus albidus* is a male 2,150 millimeters in length; this is the ordinary size; the female has the abdomen a little more convex and the body slightly more elongated; the general form is lengthened; the nape elevated, so that the greatest height is about the operculum; this height is $\frac{2}{11}$ less at the tip of the opercule, and the height of the body at that point is contained about 10 times in the total length of the body. The head, from the extremity of the lower jaw, is contained in the body-length more than 4 times; the eye is placed midway between the margin of the operculum and the tip of the lower jaw. From the tip of the lower jaw to the end of the upper jaw, or snout, the distance is equal to the height of the head. The maxillary extends beyond the orbit a distance equal to ⅓ of the diameter of the eye; at a distance of ⅔ of the diameter of the eye, in front of it, are placed the nostrils, having two orifices, which are separated by a cup-shaped space, but are contained in a common cavity; the gill-membrane has a squarish opening below the suboperculum; the palatine-bones have a narrow band of asperities upon them; the vomer does not project into the mouth, but the membrane which covers the palate is rough, the very minute points of its asperities being turned backward; there are also asperities upon the lower jaw. The intermaxillaries, which form part of the base of the beak and all of its tip, have upon their sides very small denticulations which point forward, and are used by the animal in an offensive attack against an enemy, in case it has not been able to touch it with the sharp point of the beak, which pierces like a dagger; the beak is extremely hard, especially at its extremity; it is depressed in form, with rounded edges; its height is greater than half its width. The preoperculum is somewhat far back; it begins about midway between the eye and the extremity of the operculum; the other opercular bones are not visible externally, but may be seen in the skeleton. The lateral line is indicated by a series of little holes in a continuous series, and it commences above the operculum, and, after having traversed a short distance longitudinally, it bends in a direction opposite to that of the line of the back, and reaches the middle of the body in the region of the tip of the pectoral. The scales of the body are bony, linear, and are absent upon the head, except upon the cheeks; those in the lateral line are not perforated, but they have upon their upper surface a groove which, in connection with the skin, completes the tube which opens at the exterior surface of the body. All the scales are covered by the "epidermis". Br. 7; D. 3, 39-6; A. 2, 13-6; P. 19; V. 1, 4; C. 12.

All the fin-rays are osseous, not articulated; those which are indicated in the above formula as bony are only distinguished from the soft ones by the fact that they terminate in a point, and this point is not free; the others, like those of the "pectorals" and of the "ventrals", are flattened at their extremity, and are divided into fibers which are visible rather in the form of striations than of branches or digitations. The three first dorsal spines and the two first spines of the "anal" are so anchylosed to each other and to the ray which follows them, and so covered by skin, that, upon first touch, one would say that they formed but a single bone. Dissection demonstrates that the first dorsal spine is very small (20 millimeters); the second is twice and a half as high (50 millimeters); the third more than twice as long as the second (115 millimeters); the fourth extends to the tip of the fin, and is more than twice as long as the third; it is not articulated any more than those which follow it, but it is branched and much compressed towards its tip, like those which are posterior to it. This same arrangement exists in the two first rays of the anal and those which follow them. The first is small (30 millimeters), the second 70 millimeters, the third corresponds to the fourth of the dorsal in form, and is twice and a half as long as the second. The greater part of these two fins is situated in a furrow, and their last rays are so small that they can be seen only by dissection. The first ray of the second dorsal, like that of the second anal, is very flat and striated throughout its entire length; both these fins are emarginate in their outline. The fourth ray of the first dorsal and the third of the first anal extend to the tip of the point, which is slightly rounded. The first ray of the pectoral is very strong, and reaches clear to the extremity of the fin; the last eight are short, and make up the subbrachial dilatation. The ventral appears to be, at first sight, composed of a single ray, but there are actually five rays, the three first being anchylosed together; these fins are received into a furrow upon the belly, which extends back to the anus. The caudal fin is stiff, and its bifurcation is at an angle of 72°, measured from the middle of the two cutaneous caudal crests to the tip of the lobes; if the tips of the lobes, which bend forward, are ignored, the angle is 80°. At the beginning of the tail, above and below, there are slight nicks. The first dorsal originates above the preoperculum; the height of its tip, measured along its anterior edge, exceeds by one-sixth the height of the head, measuring immediately below it. The length of the pectoral is one-sixth of the length of the body, measuring the latter from the tip of the lower jaw; the first anal is much lower than the dorsal. The two other vertical fins are small and opposite each other, though the second dorsal is slightly farther back, a little higher in its anterior parts, and a little more emarginate.

The color is a deep blue above, a little lighter upon the sides, passing into white below. The vertical fins are of a deep blue, the second anal a little lighter, as is also the outer side of the pectoral. The first dorsal has, along the dorsal line, round spots of a deeper color. The eye revolves in every direction in its orbit upon the center which holds it; the iris is of a light blue, while the cornea is blackish.

There are four double gills and an accessory gill; these are cancellated as in the Sword-fish; the pylorus is placed very high up, and has great longitudinal folds; likewise the duodenum, which is swelled, and receives, through two openings, the secretions of the compact and glandular mass which surrounds it. The intestine is slender, with two very short plications, in the course of the second plication embracing the spleen; the stomach contains many species of intestinal worms. The swimming bladder is cellulous, showing great puffs, which extend far behind the anus.

Sometimes an atrophied ray is found in the second dorsal on the second anal; this also occurs in *Tetrapturus amplus*.

The skull is permeated by cells filled with oil, especially the "ethmoid" bone, which has a spongy appearance, and parts of the prefrontals; the anterior sphenoid bone exists. Cuvier could not find this in the *T. belone*; for my part, I could not find the predorsal. The anterior frontal bone forms the anterior wall of the orbit, but is not visible from without. The lower jaw exhibits a peculiar feature, which has not been noticed in the Sword-fish nor in *T. belone;* it is the single anterior bone which forms the point of the beak; the two mandibular bones are joined to this bone, and hold it between themselves by projecting denticulations, which call to mind the articulation of the dentaries of the crocodile.

The snout is made up of the ethmoid, the nasals, the maxillaries, and the intermaxillaries. The ethmoid, from above, appears only like a little wedge; the nasals articulate with the frontals, and are prolonged above to the middle of the snout, where they join with the superior arms of the intermaxillaries. The maxillaries form the sides of the base, making up internally a cylindrical body, which extends through the beak and terminates a little beyond the tip of the lower jaw. The intermaxillaries commence in a narrow area below the maxillaries, increase by degrees in extent, and finally take up the entire upper part of the beak, as far as its tip, and all the lower part as well, for more than a half of its length; it is these bones which alone form the anterior half of the beak, and it is they that carry the denticulations which make of it a kind of rasp, as has already been described. This weapon varies in individuals of the same sex, in its length as well as in its height, in the shape of its transverse section. Figures are given representing the beak of a specimen of the *T. albidus*, which is here described.

I have, however, thought it necessary to consider this beak as not perfect, because it can be seen that it has accidentally lost its tip when the fish was young, although this has been replaced later. I give also another figure of a beak which belongs to another male. I have figured 3 beaks cut across 30 millimeters behind the tip of the lower jaw. Letter A indicates the point at which the tip of the lower jaw terminates; the first is 270 millimeters long, and its section, in the place indicated, is 12 millimeters in height and 19 in width, and denticulations are visible through half its length. Thirty millimeters behind the tip it is 8 millimeters high and 18 wide; the point is obtuse and the base is depressed. The second beak is 300 millimeters long; its section is 10 millimeters high and 19 wide; toward the point it is 6 millimeters high and 10 wide; the point is sharp, the base high. The third beak, which is that of a female, is 330 millimeters long; its section is 11 millimeters high and 18 wide; toward the tip, which is very sharp, it is 4 in height and 8 in width; the base is higher than in the two which have been already mentioned. The same variations occur in *T. amplus*.

TETRAPTURUS AMPLUS.

The smaller individuals, which are ordinarily males, weigh 150 pounds, and measure, in all, 2½ meters, while those which weigh 250 pounds are at least 3 meters in length. Individuals of 600 pounds are ordinarily females; their ovaries weigh more than 30 pounds, and yield from forty millions to fifty millions of eggs, of which half at least seem to be capable of fertilization. These eggs have an exquisite flavor; they are sold in the markets for from 2½ francs to 3 francs per pound.

The fishermen distinguish two kinds of *Aguja de casta;* one they designate by the name *Varcteada*, because its body is vertically marked with stripes of pale blue, while the other is entirely black or blackish blue. The first, they say, has the smaller head, and is *trabajadona*—that is to say, "difficult to conquer". The second grows much larger, and it has been seen to weigh 1,000 pounds to 1,500 pounds, and with a tail 6 feet in width; it is called *bomba*—that is, "easy to conquer". I have never succeeded in characterizing these species. It is difficult for the fishermen to judge well, for the bands disappear after death, and it is probable that they also disappear with age. I have seen them, however, in individuals of 500 pounds. The size of the head depends upon sex, the females always having the largest. The opinion of Messieurs Baretto and Dulzaides is that there is but a single species of *Aguja de casta*. This is also my own opinion, but not that of M. Jácome. This description is of the *Vareteada*.

The *T. albidus* having been taken as a type, the description of *T. amplus* may be shorter. The individual described is a male, 2,453 millimeters long; the head is larger, and it is more depressed between the eyes; the nape and the back, in the neighborhood of the insertion of the dorsal, are more elevated; the total length of the body is less. The mouth is a little smaller, so that the tip of the maxillary is slightly less extended. D. 3, 38–7; A. 2, 13–7. The anterior edge of the dorsal is over the base of the pectoral fins; the length of the pectoral is one-fifth of the length of the body, measuring from the tip of the lower jaw. The spreading of the lobes of the caudal is a differential character, which is very remarkable, for the angle of bifurcation is 90°; if the tips, which bend inward, are ignored, at least 100°. The beak, which is much stronger, has permanent denticulations on its sides and asperities below. There is no lateral line, and the scales are very frequently falcated in shape. The color is dark blue above and below, but the belly and the sides have a slightly silvery tint; the body is crossed vertically by fifteen bands or stripes of a light color, which are, however, only visible upon the back, and when the fish is fresh.

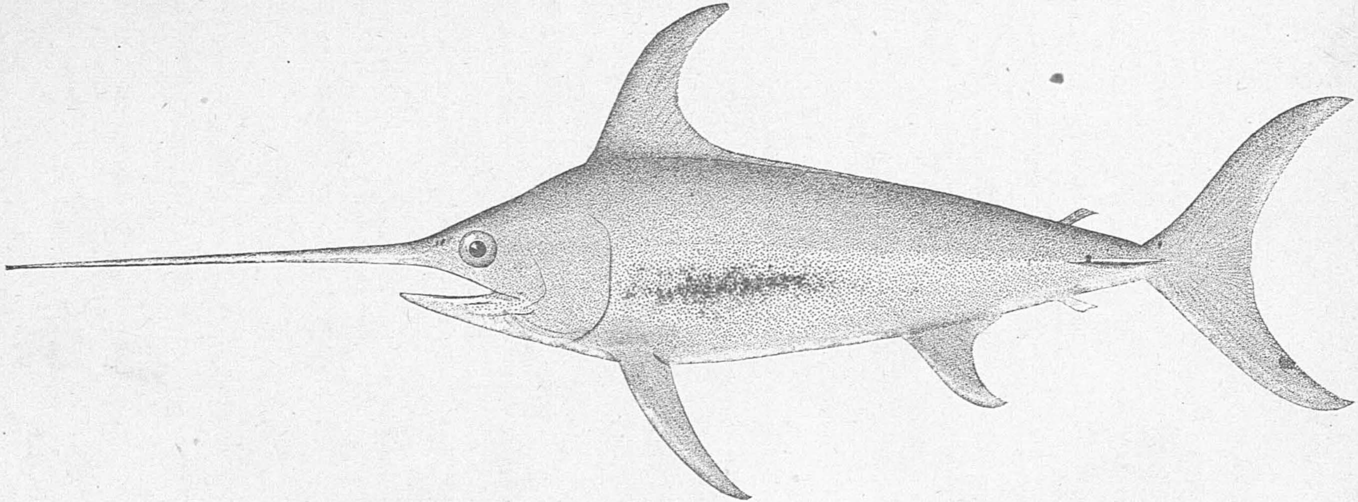
The skull is harder than that of the *T. albidus*, less cellular, less oily; the ethmoid is less spongy. The vomer is visible, covering a considerable space in the roof of the mouth. It is upon this surface that we find the asperities such as have been mentioned as belonging to the vomer and the palatines; but these asperities actually belong only to the skin which covers it, for the vomer does not descend so low, and the palatines are exposed only in a band 20 millimeters long and 3 broad. The beak is much more robust in proportion, and its denticulations are stronger; they also extend higher up.

I have shown in figures three beaks of *Tetrapturus amplus*, drawn to their natural size, and it may be seen how much they vary. The first is that of a male; it is 420 millimeters long, and its section, taken at the same place as those already described, is 19 millimeters high and 28 wide; 20 millimeters back of the tip it is 10 millimeters high and 12 wide; its base is high.

The second beak which has been figured is that of a female; it is 480 millimeters long; its section is 22 millimeters high and 33 wide; toward the tip it is 11 millimeters high and 12 wide; its base is depressed.

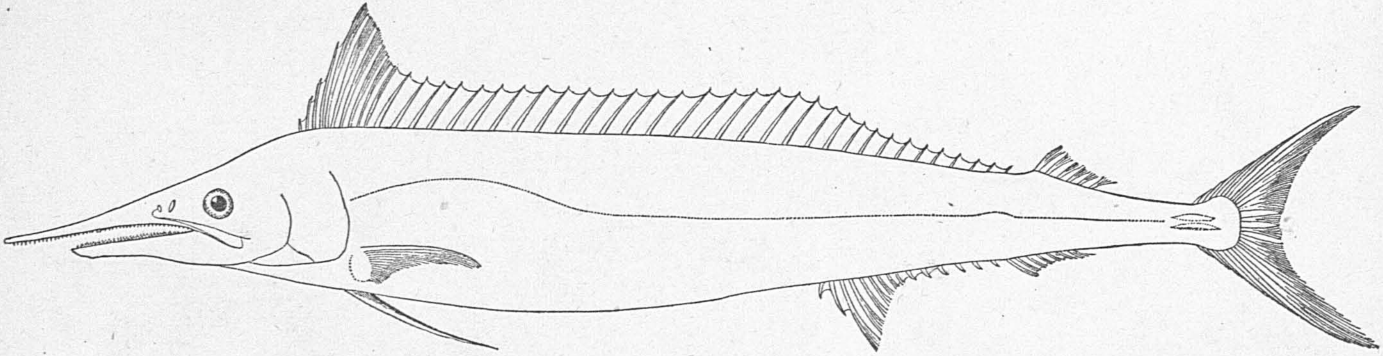
The third is that of a female; it is 540 millimeters long; its section is 23 millimeters high and 37 wide; toward the tip it is 11 millimeters high and 16 wide; the base is high. The beak, which has been described by me, cut at the same place, is 385 millimeters long; its section is 28 millimeters high and 45 millimeters wide; toward the tip it is 10 high and 24 wide; its base is depressed.

LIST OF PLATES.



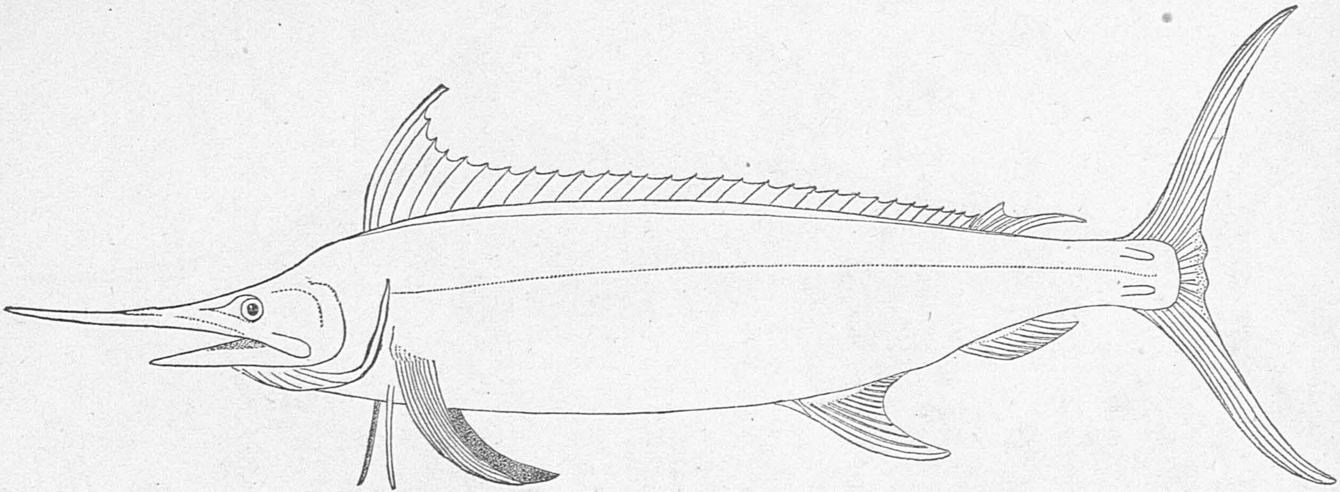
The Sword-fish, *Xiphias gladius*.

Drawing by H. L. Todd, from specimen taken on the coast of Rhode Island, now stuffed and preserved in the National Museum. Length, 8 feet 4 inches.



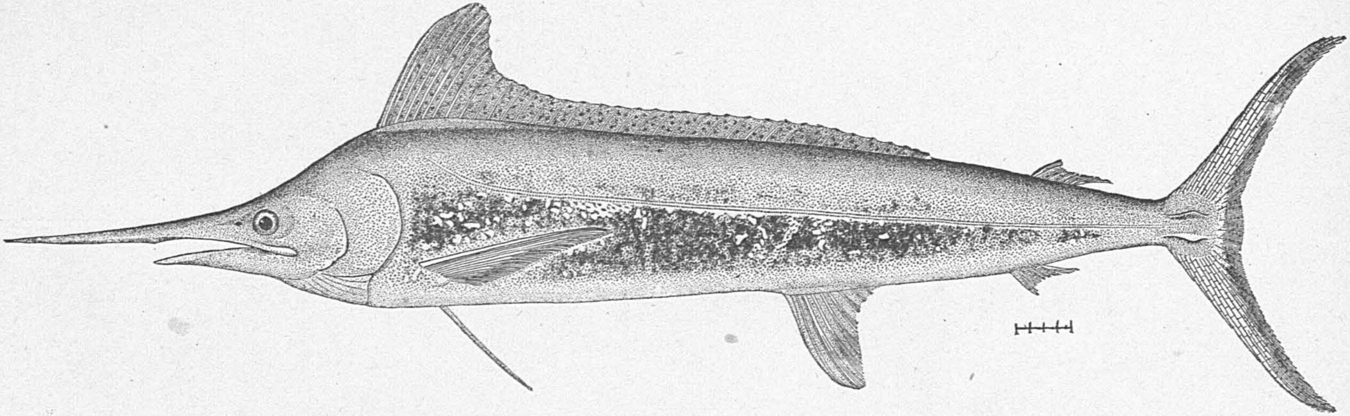
The Mediterranean Spear-fish, *Tetrapturus imperator*.

Outline from figure in Cuvier & Valenciennes' *Histoire Naturelle des Poissons*, pl. ccxxix.



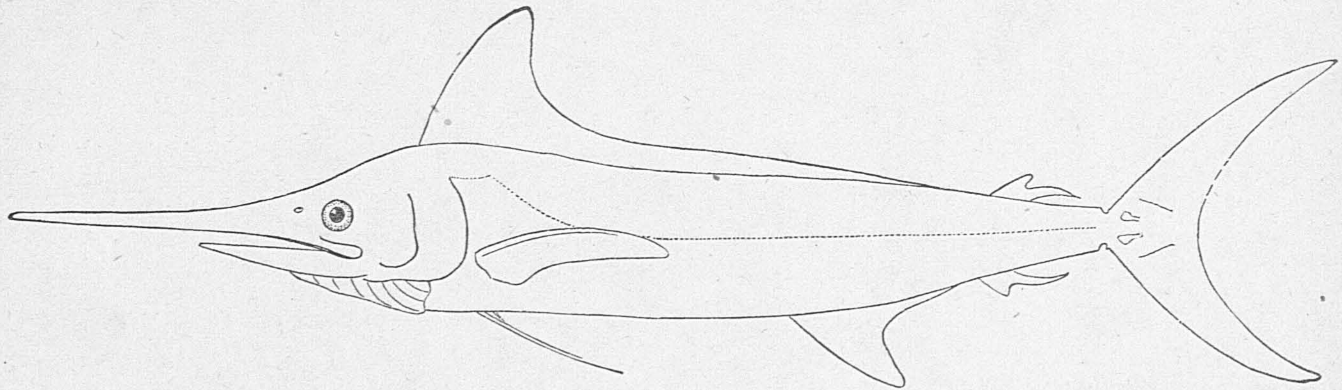
The Cape Spear-fish, *Tetrapturus Herschellii.*

Outline from figure in *Annals of Natural History*, vol. i, pl. x.



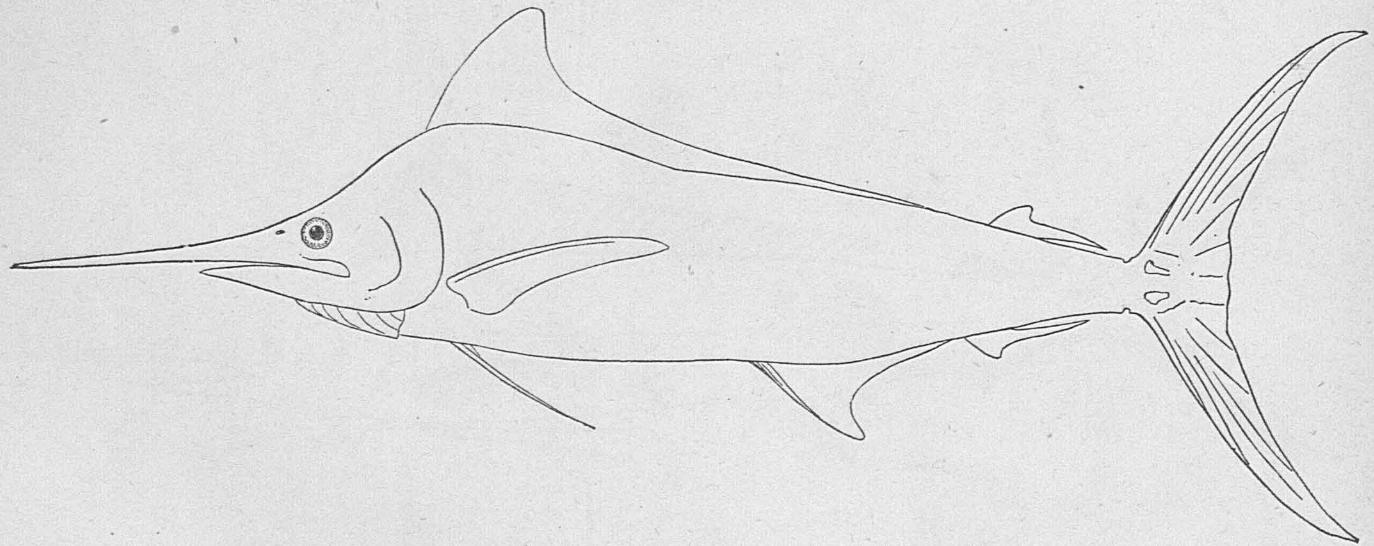
The Western Atlantic Spear-fish, *Tetrapturus albidus*, Poey.

Drawing by H. L. Todd, from cast of specimen taken on coast of Massachusetts, and preserved in National Museum.



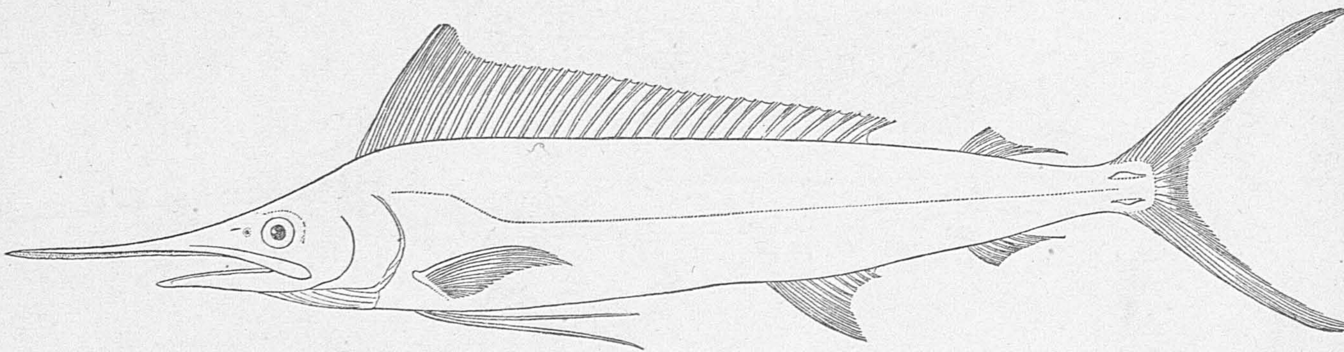
The Western Atlantic Spear-fish, *Tetrapturus albidus.*

Fac simile of figure in Poey, *Mem. Hist. Nat. Cuba*, ii, pl. xv, fig. 1.



The Cuban Spear-fish, *Tetrapturus amplus.*

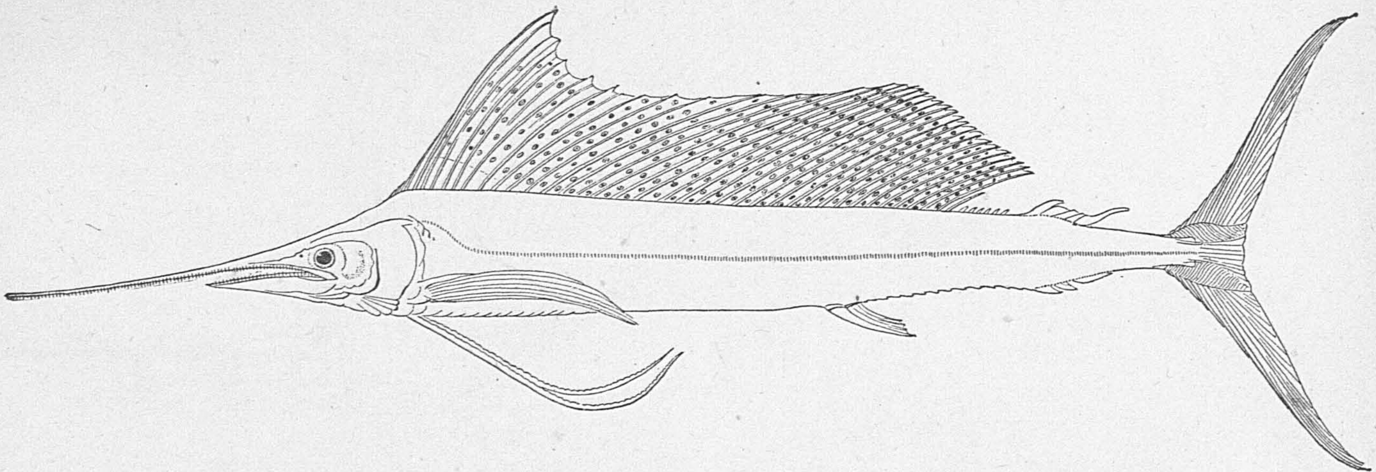
Fac simile of figure in Poey, *Mem. Hist. Nat. Cuba*, ii, pl. xv, fig. 2.



The Indian Ocean Spear-fish, *Tetrapturus brevirostris.*

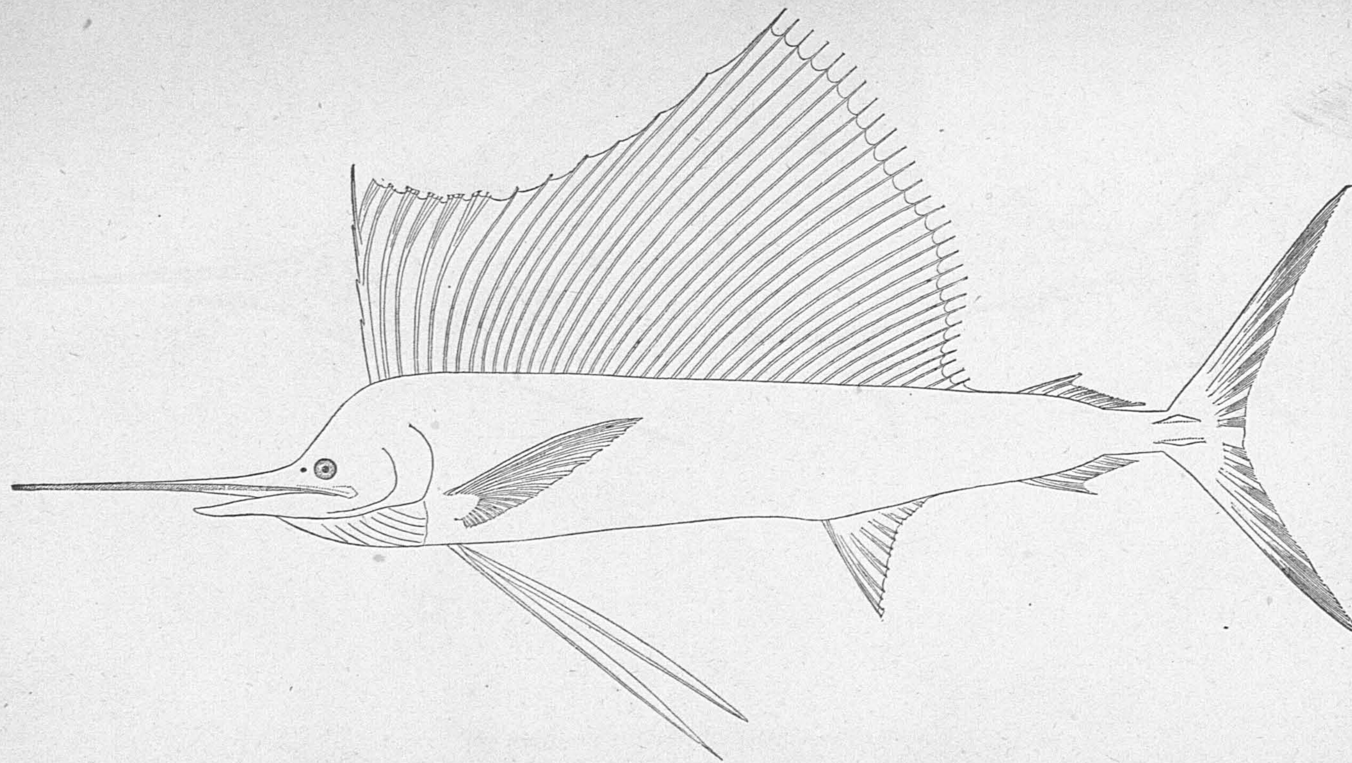
Outline from figure in Day's *Fishes of India*, pl. xlvii.

PLATE VIII.



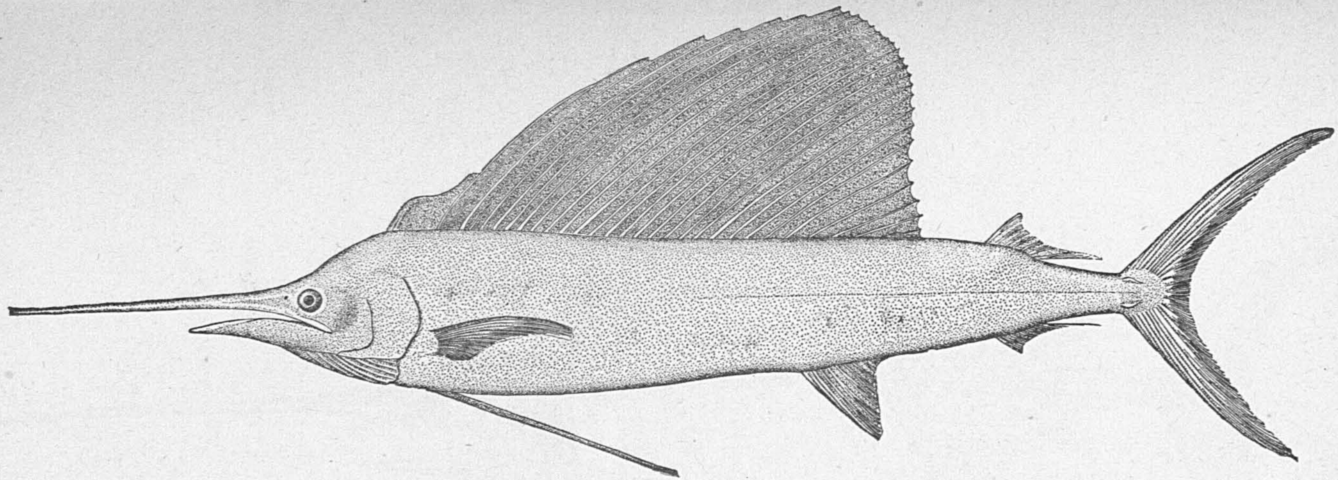
The Old World Sail-fish, *Histiophorus gladius.*

Outline from figure in Cuvier & Valenciennes' *Histoire Naturelle des Poissons*, pl. ccxxix.



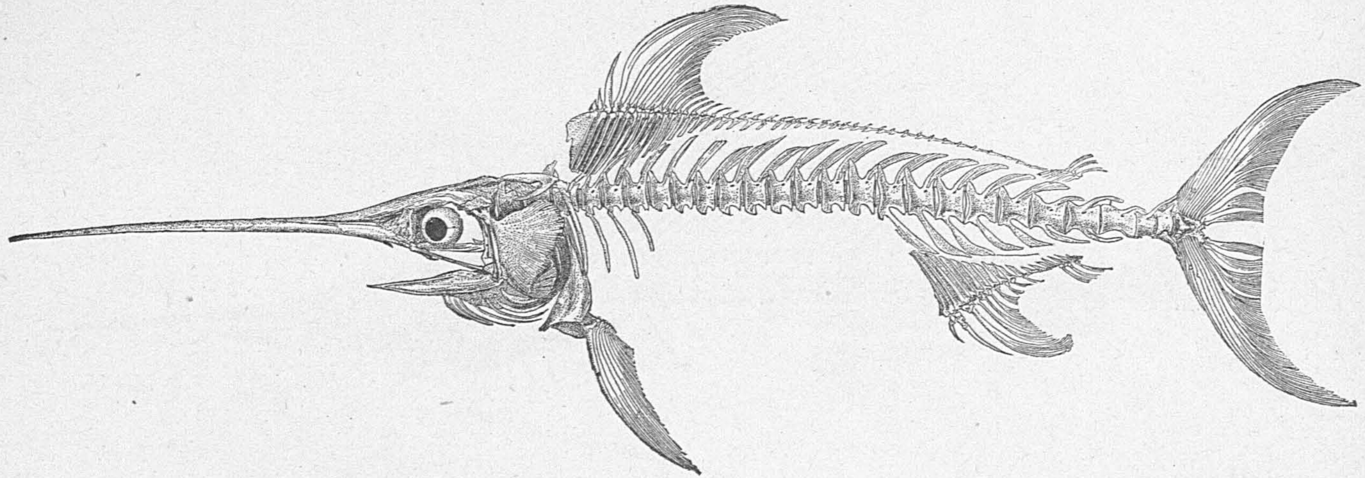
The Japanese Sail-fish, *Histiophorus orientalis.*

Outline from figure in Temminck & Schlegel's *Fauna Japonica*, pl. lv.



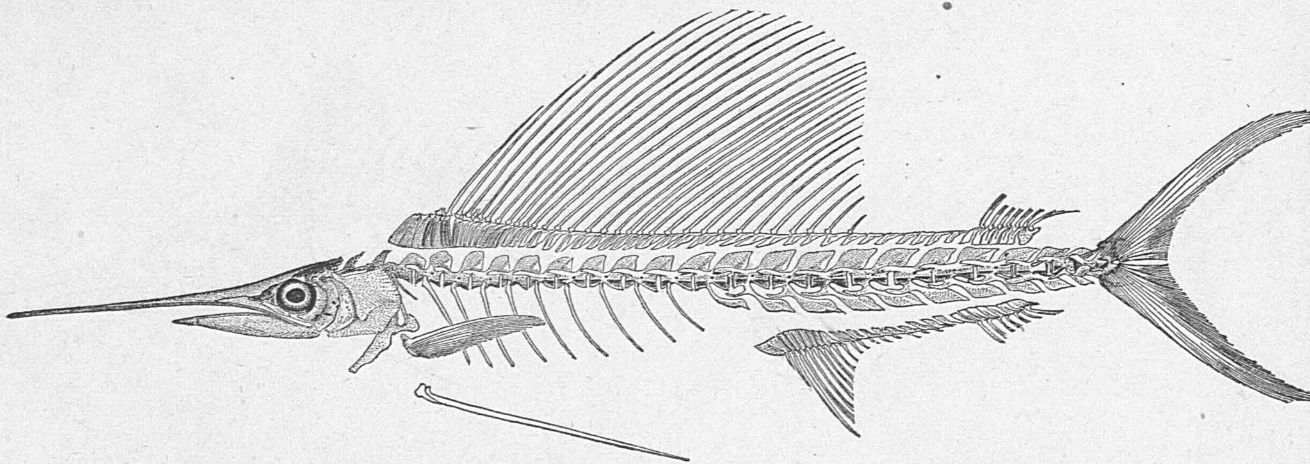
The American Sail-fish, *Histiophorus americanus*.

Drawing by H. L. Todd, from cast of specimen taken near Newport, R. I. Preserved in the National Museum.



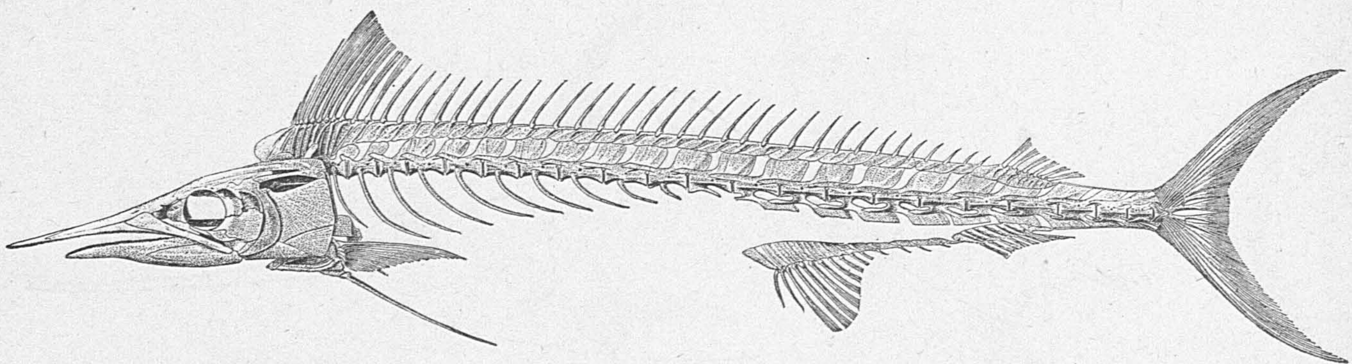
Skeleton of the Sword-fish, *Xiphias gladius.*

From the somewhat imperfect specimen in the National Museum.



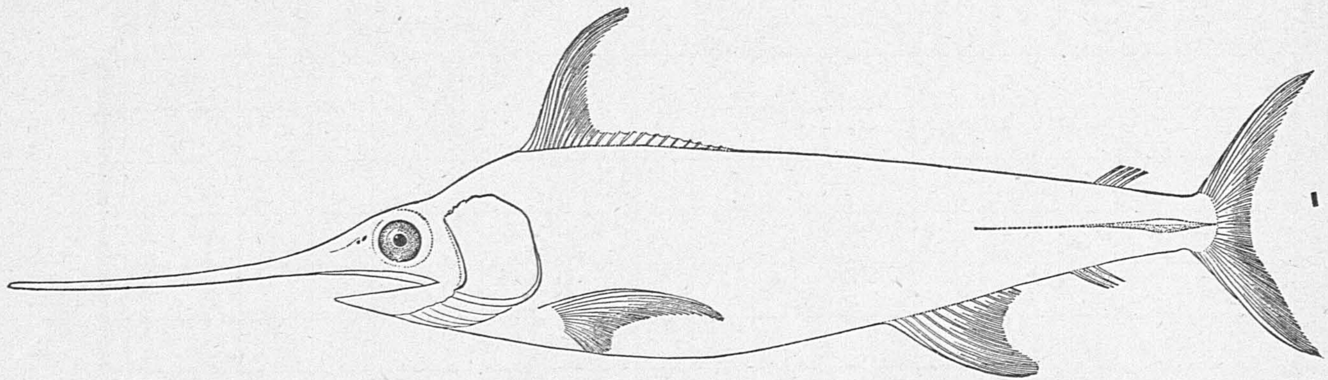
Skeleton of the Sail-fish, *Histiophorus americanus.*

From the somewhat imperfect specimen in the National Museum.



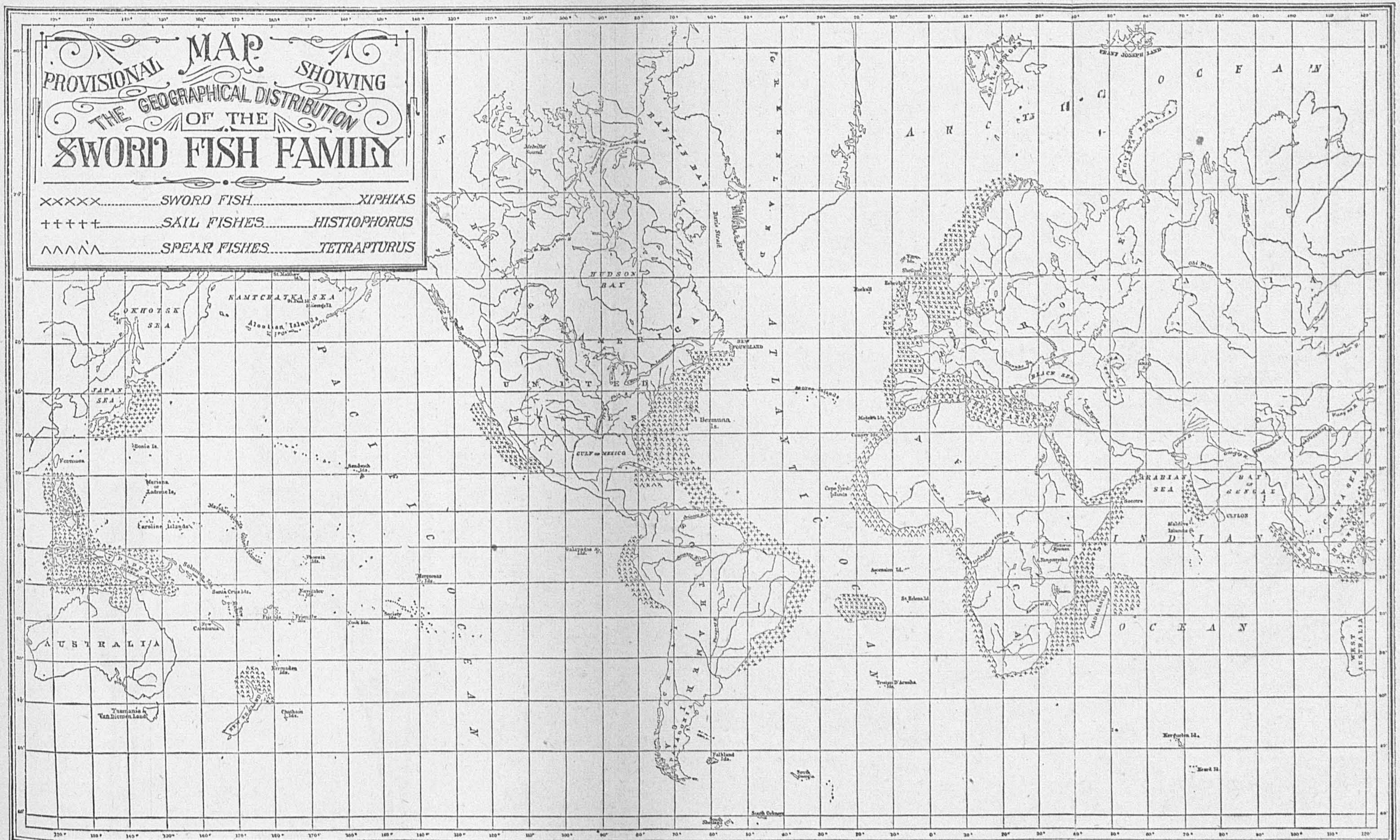
Skeleton of *Tetrapturus imperator*.

From lithograph in Agassiz's *Poissons Fossiles*, v, p. 89, tab. E.



Fac simile of figure of *Xiphias gladius*.

In Cuvier & Valenciennes' *Histoire Naturelle des Poissons*, pl. ccxxvi.


PROVISIONAL MAP SHOWING THE GEOGRAPHICAL DISTRIBUTION OF THE SWORD FISH FAMILY
XXXXX .... SWORD FISH .... XIPHIAS
+++++ .... SAIL FISHES .... HISTIOPHORUS
ΛΛΛΛΛ .... SPEAR FISHES .... TETRAPTURUS
OKHOTSK SEA
KAMTCHATKA SEA
JAPAN SEA
HUDSON BAY
GULF OF MEXICO
BLACK SEA
ARABIAN SEA
BAY OF BENGAL
CHINA SEA
AUSTRALIA
WEST AUSTRALIA
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
ARCTIC OCEAN

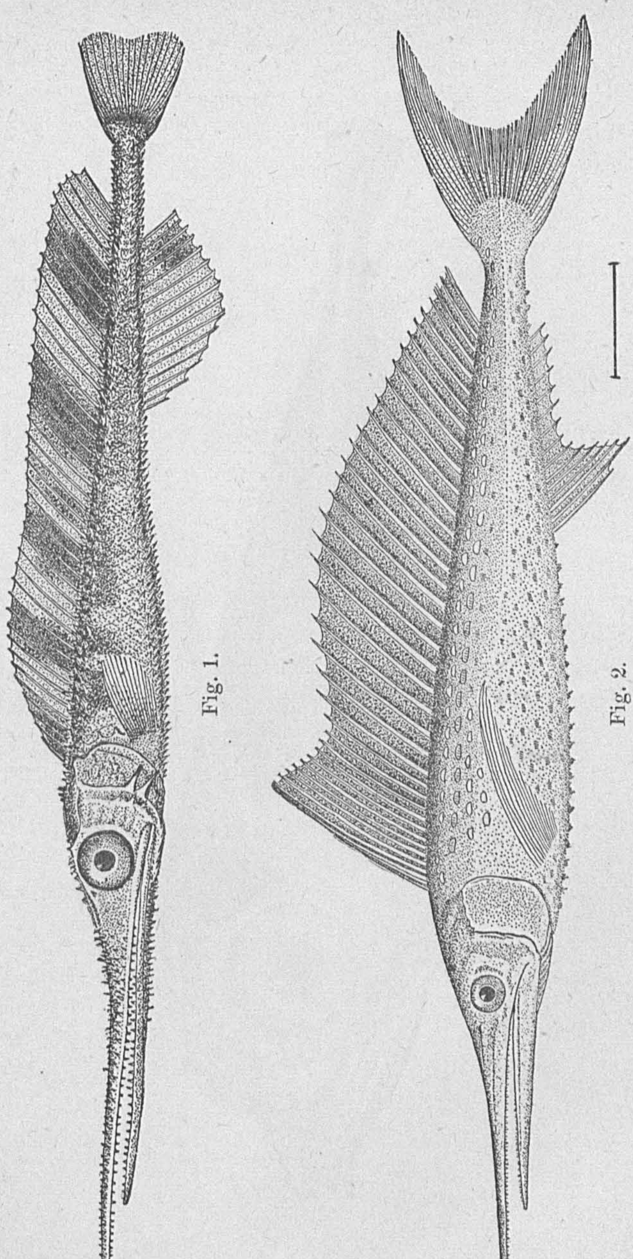


Fig. 1.

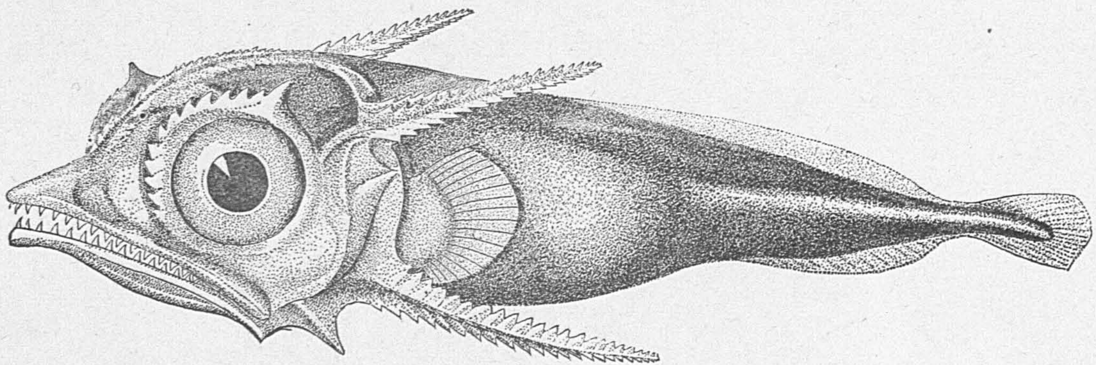
Fig. 2.

ig. 1. Young of Sword-fish, 37^{mm} long.

le of figure in Lütken's *Spolia Atlantica*, pl. ii, fig. 10.

Fig. 2. Young of Sword-fish, 12 inches long.

Fac simile of figure in Cuvier & Valenciennes' *Histoire Naturelle des Poissons*, pl. ccxxv.



Young of Sail-fish, $\frac{3}{14}$ of an inch long.

Fac simile of figure in Lütken's *Spolia Atlantica*.

PLATE XVIII.

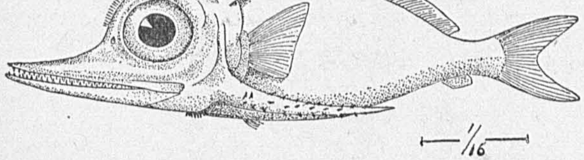


Fig. 1. Young of Sail-fish, about 9mm long.

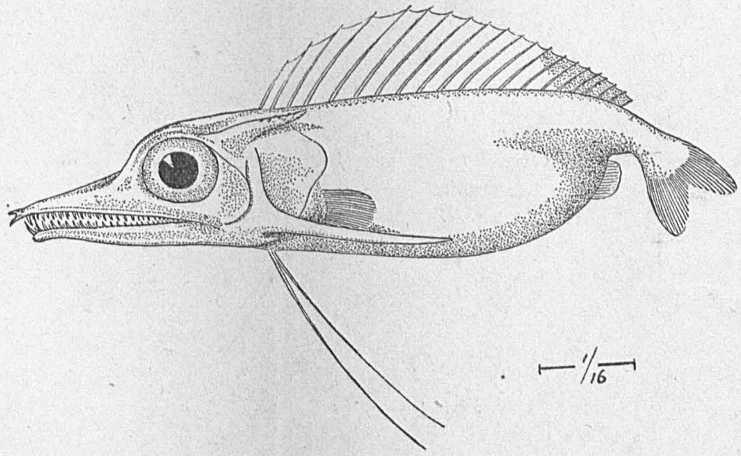


Fig. 2. Young of Sail-fish, about 14mm long.

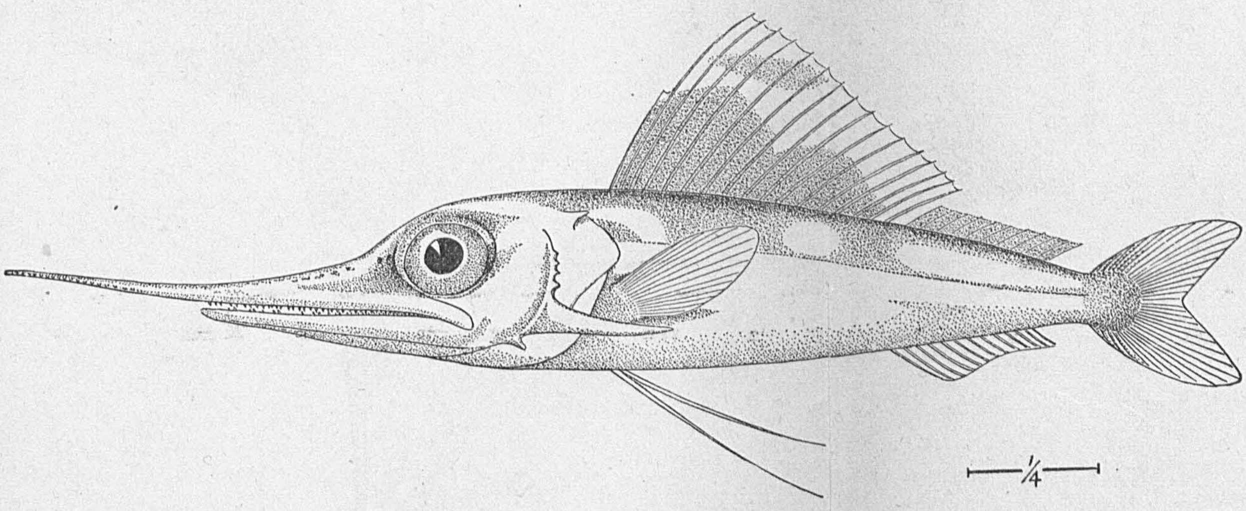
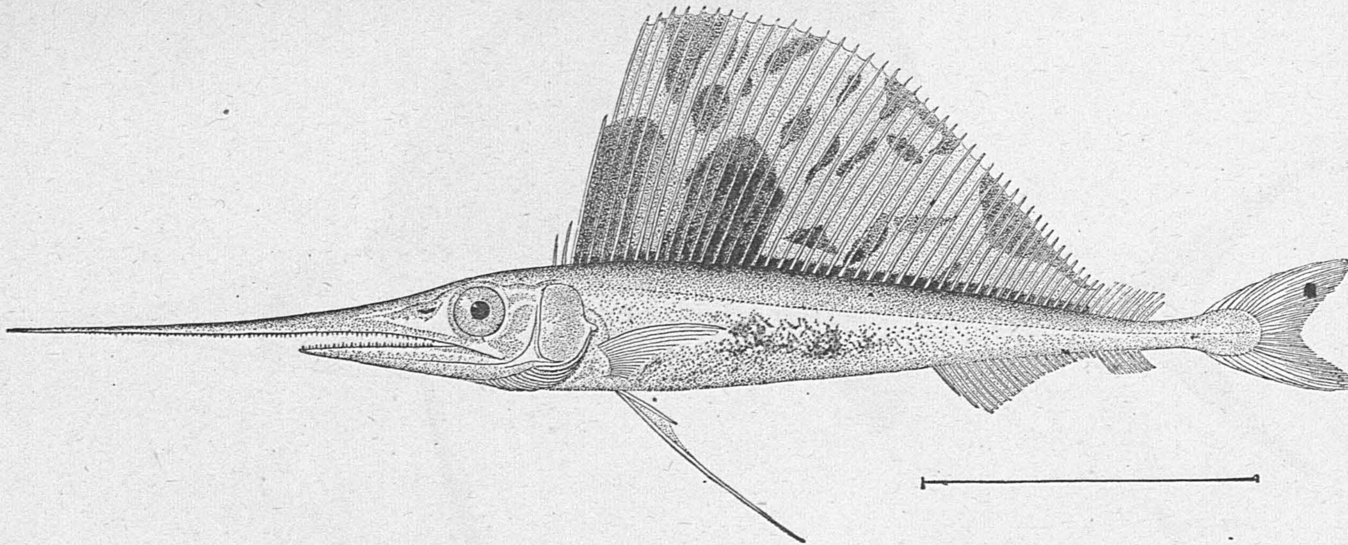


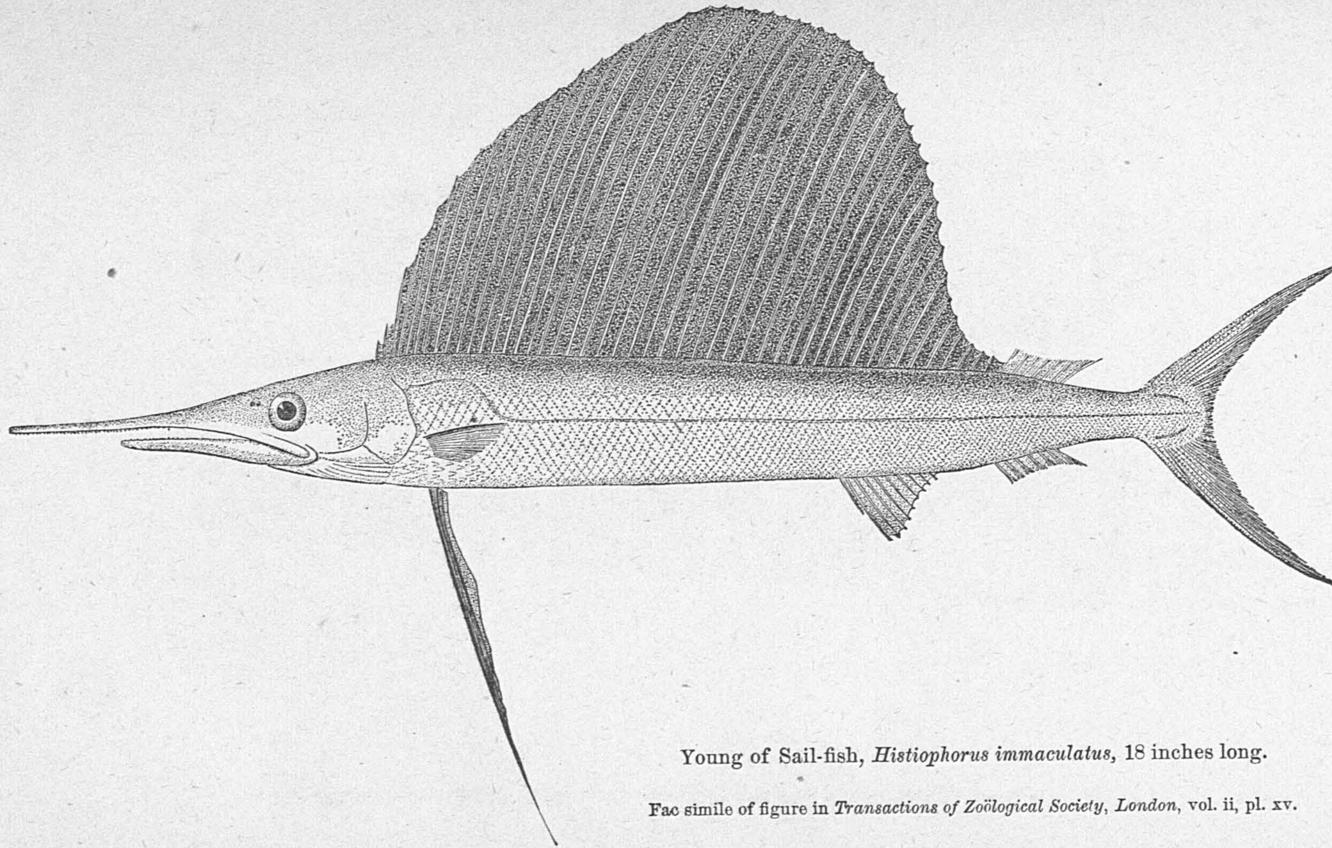
Fig. 3. Young of Sail-fish, about 60mm long.

Fac similes of figures in Günther's Fishes of the South Sea, and in Lütken's *Spolia Atlantica*, in Vidensk. Selsk. Skr., 5, 1880, p. 443.



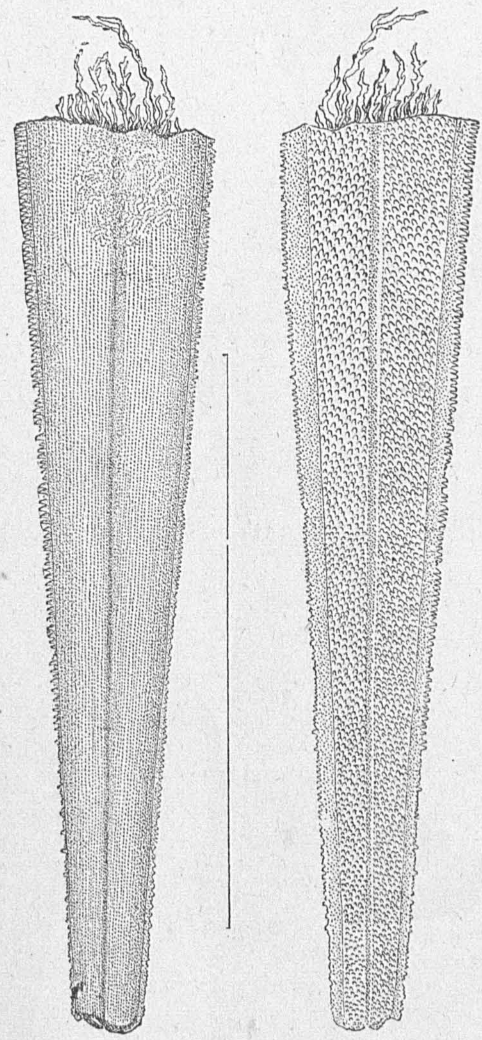
Young of Sail-fish, *Histiophorus pulchellus*, 4 inches long.

Fac simile of figure in Cuvier & Valenciennes' *Histoire Naturelle des Poissons*, pl. ccxxx.



Young of Sail-fish, *Histiophorus immaculatus*, 18 inches long.

Fac simile of figure in *Transactions of Zoölogical Society, London*, vol. ii, pl. xv.



Sword of young Sword-fish, taken from nostril of shark at Gloucester, Mass., magnified thrice.

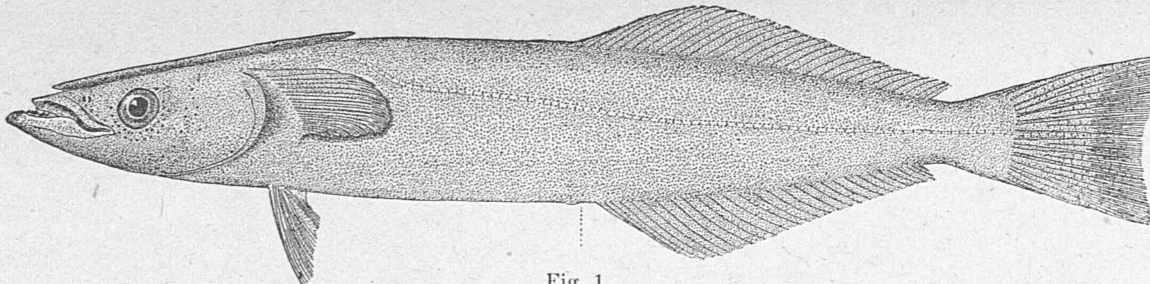


Fig. 1.

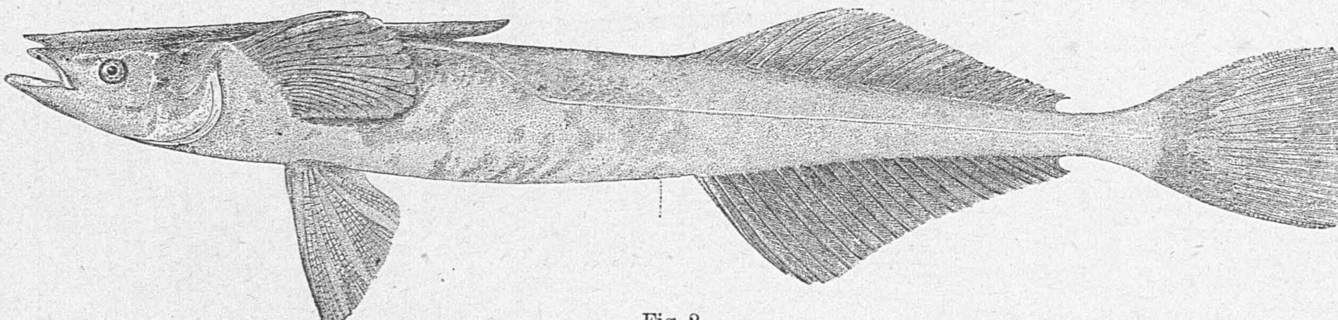
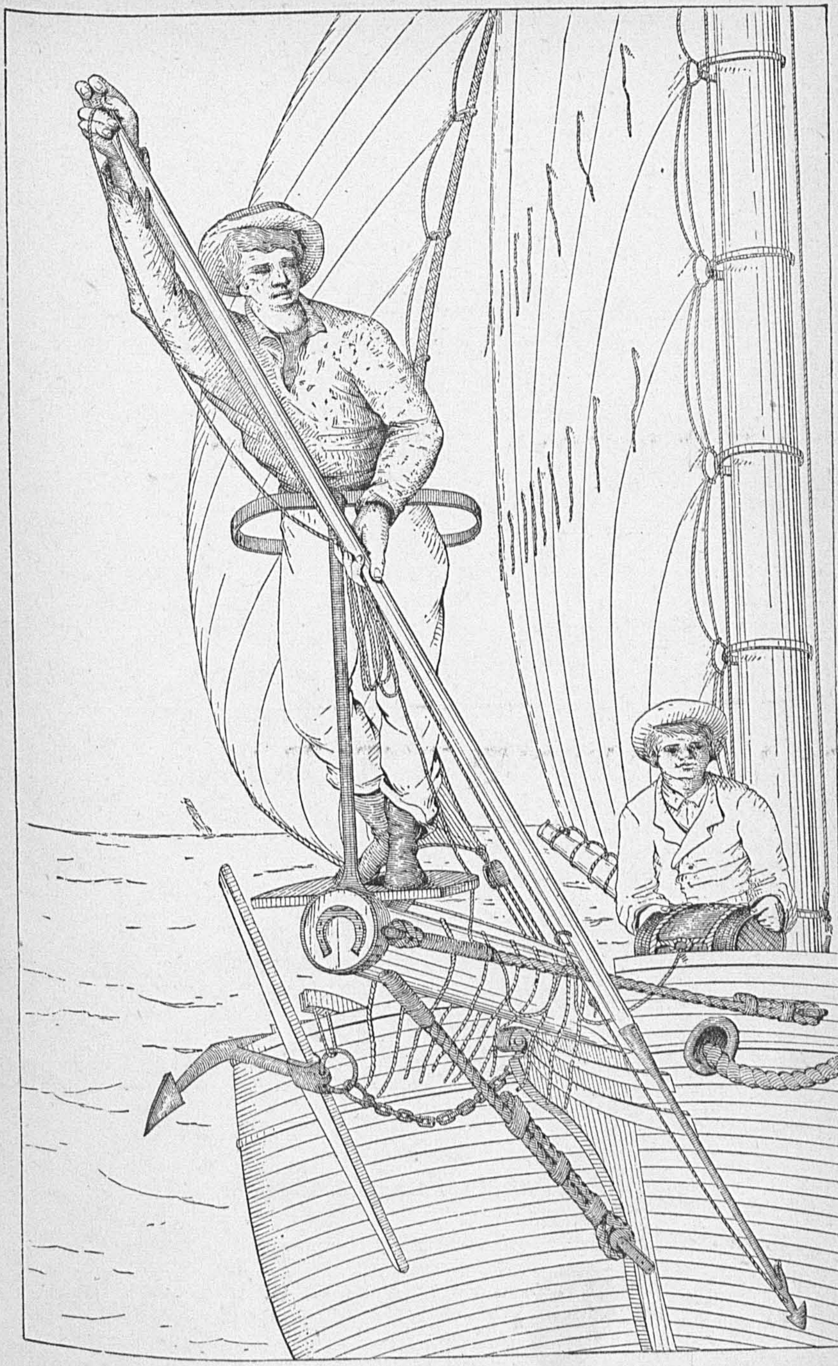


Fig. 2.

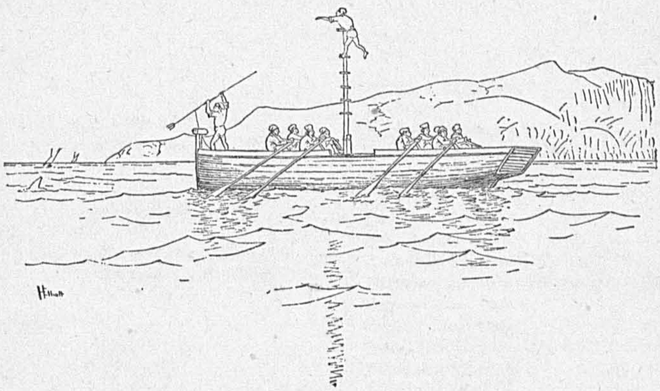
Fig. 1. The Sword-fish Remora, *Remoropsis brachypterus.*

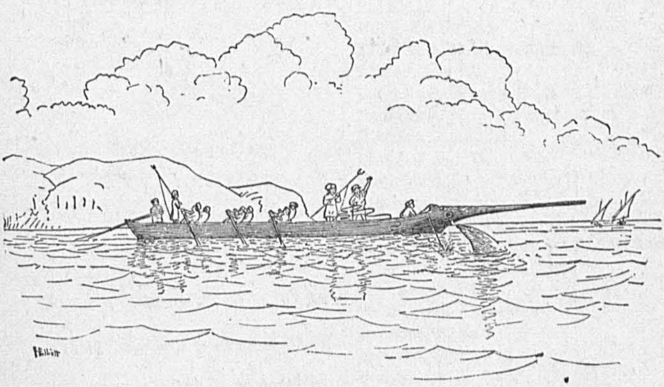
Fig. 2. The Spear-fish Remora, *Rhombochirus osteochir.*

Vertebrate parasites of Sword-fish.



Swordfisherman in position for action.





Sword-fish fishing in the Mediterranean.

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XIII.—THE SPANISH MACKEREL, CYBIUM MACULATUM (MITCH.), AG.; ITS NATURAL HISTORY AND ARTIFICIAL PROPAGATION, WITH AN ACCOUNT OF THE ORIGIN AND DEVELOPMENT OF THE FISHERY.

By R. EDWARD EARLL.

SYNOPSIS.

A.—NATURAL HISTORY

1.—THE COMMON NAME.

The term Spanish mackerel is by no means an uncommon one. It has long been and is still applied to one or more species of fishes in nearly all countries where the English language is extensively spoken. As nearly as can be ascertained, it was first applied to the *Scomber colias* of Europe by the British fishermen, on account of the peculiar abundance of the species on the coast of Spain. The name was introduced into the United States by the early English colonists, who, on reaching America found a great variety of fishes in the waters of the newly-discovered continent. Some of the species were entirely new to them, while others resembled to a greater or less extent the species with which they were familiar in their early homes. To all of these fish they must assign names, and it was very natural for the colonists to apply to them the names of the European species which they most nearly resembled.

Those settling on the New England coast found a species of mackerel which was very similar in its general appearance to the *Scomber colias*, and they at once gave to it the name Spanish mackerel, supposing it to be the common English species. In fact, so close was the resemblance that, until recently, most naturalists have considered the two species identical, though they are now generally acknowledged to be distinct. The colonists settling in the Middle and Southern States, where the species already mentioned was not found, applied the term Spanish mackerel to the *Cybium maculatum;* and it has, by many, been commonly applied to the other members of the genus, namely, the *C. regale* and the *C. cabella.*

The name, however, does not properly belong to either of the last-named fishes, for the adults of these species are usually known as "cero," "king-fish," or "horse-mackerel," though in localities where the *C. maculatum* is taken the fishermen apply the term alike to all small fishes of the genus, few, if any, owing to the marked similarity in their general appearance, recognizing the difference between them. Even here, however, the difference is recognized in the larger individuals, and the name is changed accordingly.

The Northern species continued to be abundant along the New England coast up to 1855, when it entirely disappeared from our shores, and not a single individual is known to have been taken from that date until the summer of 1879, when the United States Fish Commission secured several specimens off Provincetown, Mass.* Since the disappearance of the New England species the *Cybium maculatum* has practically enjoyed

* We find the following in the Fisherman's Memorial and Record Book, which gives an idea of the abundance of the species in Massachusetts Bay in the early part of the present century:

"In 1812 a large school of Spanish mackerel visited this bay, and so plenty and numerous were they that they would bite readily at the bare hook, and seize upon small bits of line hanging from the vessel. Standing-room boats were then mostly in use, holding from 15 to 20 tons. These rooms held from 15 to 20 barrels, and the crews would catch them full in a few hours. Mr. Timothy Rogers, at Rowe's Bank [at Gloucester, Mass.], bought most of these mackerel fresh, after being dressed, at 2 cents per pound, salting them in his buildings, and the business, which lasted two months, was a lively one. These mackerel did not continue on this coast but a few years, and have now almost entirely disappeared. There were a few caught with the other mackerel as late as 1825, since which time it is very rare to see one during the entire season."—(Fisherman's Memorial and Record Book, p. 61.)

a monopoly of the name within the limits of the United States. But though this is the only species to which the name Spanish mackerel properly belongs, it must not be inferred that the fish is always called by its right name. On the contrary, the fishermen have several names for it. In the Gulf of Mexico and along the Southern Atlantic coast it is universally known as the "Spanish mackerel." About Wilmington, N. C., it is occasionally taken by the fishermen, some of whom call it by its proper name, while others know it as the "horse-mackerel". In Chesapeake Bay it is called "bay mackerel", or, almost as frequently, simply "mackerel". On the New Jersey coast it is frequently called the "spotted mackerel" to distinguish it from the *Scomber scombrus*, which is known as the "mackerel" or "banded mackerel". Again, Josselyn, who visited the New England coast in the early part of the sixteenth century, spoke of the "speckled hound-fish" in such a way that Professor Goode thinks he could have referred to no other species than our *Cybium maculatum*. DeKay described it as the "spotted cybium"

2.—Description of the Species.

Six species of the genus *Cybium* are found in American waters, but thus far only three of them have been taken within the limits of the United States, the others occurring about the West Indies. The species frequenting our coast, namely, *C. maculatum*, *C. regale*, and *C. cabella*, have already been mentioned. These are very similar in general appearance, and were it not for the difference in size, few fishermen would recognize them as distinct species.

The *Cybium maculatum*, the species at present under consideration (see Plate I) was first described by Mitchill, under the name of *Scomber maculatus*. Later, Agassiz referred it to the genus *Cybium*, calling it the *Cybium maculatum*, a name that is now universally adopted. The species is similar in form to the common mackerel, though in size and color it is quite different. It is, without question, one of the most beautiful fishes of our coast, and few of the fishes of the tropical seas surpass it in brilliancy. Its back has a greenish tint, which gradually shades into leaden or dove color on the sides. All of the under parts, including the lower sides, gill-covers, and ventral and anal fins, are pearly white. About twenty yellowish spots, varying from one-eighth to one-third of an inch in diameter, and forming a brilliant contrast with the leaden background, are scattered irregularly along the upper sides, chiefly on the anterior portion of the body. A prominent lateral line begins just above the operculum, rising slightly at first, then bending downward and continuing in a crooked or wavy path almost to the tail. The head is long and pointed, the eyes large and yellowish, with double nostrils situated slightly in front of them. The mouth is very large and the powerful jaws are armed with strong, slightly compressed, or nearly conical teeth, except in their anterior portion, where these are rudimentary or even entirely wanting. The spinous dorsal has a black marking on the upper anterior margin, the remainder being pure white. The soft dorsal, like the dorsal finlets, which are eight in number, is slightly brownish. The somewhat acuminated pectorals are brown on the outer surface, and darker within. The ventrals are quite small, while the tail is peculiarly large and broadly forked, the extremities being several inches apart. The radial formula is Br. 5; D. 17–16; A. 18; P. 20; C. 24; V. 4.

The other species of the genus, though much less abundant, resemble very closely the one already described. *C. regale*, the king-fish of our southern coast, like the Spanish mackerel, has 17 spinous rays in the dorsal, and also similar black markings, but it is distinguished by longitudinal bands of gold along the sides. It often attains a length of 4 to 6 feet, and a weight of 15 or even 20 pounds. The *Cybium caballa* readily distinguished by the absence of black markings on the first dorsal, as well as by its fewer rays, these being only 14 in number. The young of the species has indistinct circular markings, which entirely disappear with age.

Spanish mackerel vary somewhat in size, according to the locality, the largest individuals, as a rule, being found farthest north or at a considerable distance from the shore. The largest specimens of which we have any record weigh about seven pounds. The majority of those seen in the markets weigh between 1½ and 3 pounds, and their average length is from 17 to 22 inches. Those taken in the pounds-nets at Mobjack Bay, on the western shores of the Chesapeake, do not exceed 1½ pounds in weight, while on the eastern shore, directly opposite, they are somewhat larger. Those taken at Crisfield, Md., in gill-nets, average about 2 pounds. Off Sandy Hook, N. J., they are larger still, the size apparently increasing as we proceed seaward, the largest individuals being taken 10 to 15 miles from land. The gill-net catch averages 3½ pounds to the fish, but the average for those taken in the pounds along the beach is only 2¾ pounds.

3.—Geographical distribution.

The geographical distribution of the Spanish mackerel is still unsettled. Along our own shores it is chiefly confined to the coastal waters, and is less abundant in the open ocean, apparently preferring the shoal soundings, where its food occurs in greater quantities. It, however, pursues its prey to a considerable distance from land, and is often seen 40 to 50 miles to seaward.

The southern limit of the species has not yet been determined, and many claim that its northern range has been greatly extended within the last few years. Professor Goode, in writing of the species, says: "Spanish mackerel visit the north as marauders. Their home is among the reefs of the Gulf of Mexico and the Caribbean Sea, and they come to us only to feed on the small fishes which frequent our waters in immense schools." He gives their northern limit as Cape Cod, adding that stray individuals have been found on the coast of Maine. Narragansett Bay is, however, the most northern point where they occur in sufficient numbers to warrant a special fishery. Farther south, especially off Sandy Hook, N. J., they are more abundant. They enter Chesapeake Bay in great numbers, and quantities of them are secured by the fishermen. According to Mr. Thaddeus Norris, they occur in considerable numbers in the Gulf of Mexico, and are quite abundant along the Florida coast; many being shipped from Cedar Keys to Savannah and other Southern cities.

4.—Movements.

Spanish mackerel are gregarious in their habits. They are sometimes seen in enormous schools, covering several square miles of ocean surface. A single school seen off Long Island a few years ago was estimated to contain several million individuals. The density of these schools, however, is very different from that of the schools of menhaden, on which they feed. The latter are usually found in compact masses, often many feet in thickness; while the former are considerably scattered, a large percentage of them being at or near the surface of the water.

The fish make annual excursions to the coast of the United States in summer; starting from their home in the warmer waters of the South, or, perhaps, from the deeper waters along the inner edge of the Gulf Stream, in the early spring, and proceeding northward, or landward, as the season advances. After remaining for a few weeks, or months at most, they again move southward, or seaward, and at the approach of cold weather entirely disappear. They seem to prefer water ranging from 70° to 80° Fahr., and seldom enter that which is colder than 65°.

Off Charleston, S. C., the fish are first seen about the last of March, and late in April they enter the sounds of the North Carolina coast. By the 20th of May the vanguard reaches the Chesapeake, and others follow in rapid succession, so that by the middle of June the capture of mackerel constitutes the principal occupation of the fishermen. Off Sandy Hook they are seldom seen till late in July,† though from that time they continually increase in numbers till the middle, or even the last, of August. Their time of arrival at Narragansett Bay is about the same as that for the New Jersey coast. In this northern region they remain till the middle of September, after which the number grad-

*The Canadian fishery report for 1880 contains the following notice of the capture of a Spanish mackerel at Prince Edward's Island, in the Gulf of Saint Lawrence, which (if there is no mistake in the identification) extends by several hundred miles the range of the species. The report says: "An undoubted specimen of the Spanish mackerel, male, *Cybium maculatum*, of the United States, was caught by hook at New London, Queen's County, on the 7th of September. It is rare to find this fish in so high a latitude."—(Supplement No. 2 to the Eleventh Annual Report of the Minister of Marine and Fisheries for the year 1880, p. 229.)

†Mr. Scott states that the young of the species are sometimes taken off the Long Island coast in June.

ually diminishes, and by the 1st of October the last individuals have disappeared. A little later they leave the Chesapeake, and few are seen on the Carolina coast after the 1st of November.

Their summer movements are doubtless affected to a considerable extent by the movements of the menhaden and other small fishes on which they feed, as they are usually most plenty in the localities where these fish are found. They exhibit great activity in the capture of their prey, darting through the water with great speed, and often leaping into the air in long and graceful curves, cutting the water neatly as they re-enter it. This peculiar leap is characteristic of the species, and by it the fishermen are enabled to distinguish the mackerel from their allies, the blue-fish, that after jumping from the water fall back upon its surface with a splash.

During the spawning season the mackerel enter the warmer and shoaler water of the bays, the individuals at this time being quite generally distributed and the schools often considerably scattered. On entering the Chesapeake, they remain about "The Capes" for some time, but as the season advances, according to Mr. Sterling, of Crisfield, Md., they start for the upper waters, and distribute themselves over the large spawning grounds of the region. Some weeks later they reassemble, and proceed down and out of the bay on the way to their winter quarters.

In moving along the coast the mackerel seem to avoid fresh or even brackish water, and for this reason are seldom taken near the mouth of the larger rivers. This habit is thought to account for their greater abundance on the eastern than on the western side of the Chesapeake. Along the last-named shore the saltness of the water is considerably affected by the enormous quantity of fresh water brought down by the large rivers of the State; no rivers of importance occur along the eastern shore, and this portion of the bay is, therefore, nearly as salt as the ocean.

During its stay on our coast, the Spanish mackerel may properly be styled a surface fish. It seldom descends to any great depth, but rather remains at or near the surface, and may often be seen leaping into the air or sporting at the top of the water. On a calm, bright day the surface of the ocean is sometimes broken for miles together by the movements of a large school of these fish.

5.—ABUNDANCE, PAST AND PRESENT.

There are many and conflicting opinions with reference to the first appearance of the Spanish mackerel in our waters. Many sportsmen, whose opinions should be entitled to some weight, agree with the majority of the marketmen and fishermen in saying that the species was seldom seen prior to 1850, and that it did not become an important food-fish till some years later. Others, who have studied the movements of the species more carefully, claim, and with reason, that it has visited the coast of the United States each summer since the earliest settlement of the country. Professor Goode, in his *Game Fishes of the United States*, says: "The early chronicles of the colonists contain no references to the Spanish Mackerel under its present name; but it seems quite probable that this fish was the Speckled Hound-fish spoken of in that renowned work, 'New England's Rarities discovered in Birds, Beasts, Fishes, Serpents, and Plants, of that Country, etc. By John Josselyn, Gent.,' published in 1672. Josselyn wrote of 'blew-fish or hound-fish, two kinds, speckled hound-fish and blew hound-fish, called horsefish.' The Blue Hound-fish can be nothing else than the common Bluefish of our coast, *Pomatomus saltatrix*, and no species in the Western Atlantic, other than our Spanish Mackerel, resembles the Bluefish closely enough to warrant the use of a similar name." If this supposition be correct, the Spanish mackerel was very abundant during the seventeenth century. But the species must certainly have decreased greatly in numbers after that date, especially along the New England coast, for though it was not entirely absent, as shown by the fact that reference is made to it by various ichthyologists from time to time, yet it was not sufficiently abundant to be generally known to the fishermen of the country, or to be sent in any quantities to the principal markets. Mr. Scott, in writing of the species, in 1875, says it "is a comparative stranger to us, and though never known to venture as far north as the fortieth degree of latitude until about ten years since, yet his families are now as numerous on our coast as are those of most other estuary fishes."

The date of its first appearance in the New York market could not have been far from 1840; and as late as 1854 Professor Gill reported the species as having very little commercial importance.

Prior to 1850 almost nothing was known of the fish about Sandy Hook. About this time, Mr. Robert Lloyd, a fisherman of Seabright, while engaged in trolling for blue-fish, secured quite a number of Spanish mackerel, these being the first he had ever seen. He carried them with the blue-fish to one of the hotels, the proprietor of which had entered into an agreement with him to take his entire catch; but that gentleman, knowing nothing of the mackerel, refused to buy them at any price.

From this date they were taken more frequently, and soon came to be highly prized as an article of food. They were caught wholly by trolling, the average daily catch being from ten to twenty fish to the boat; the fishing being best when the water was a little rough. Later they continued to increase in number, or at least came to be more generally noticed by the fishermen, until 1866, when it is said they were often nearly as plenty as the blue-fish, though comparatively few were taken, owing to the lack of suitable apparatus, and it was not until the introduction of properly arranged gill-nets and pound-nets that the fishermen were successful in securing any considerable quantities.

Since 1875 it is claimed that their numbers have gradually decreased on the inshore grounds, though they are said to be as numerous as formerly 8 to 10 miles from land, where they remain beyond the reach of gill-nets and pounds.

Many of the fishermen of Chesapeake Bay never saw the species prior to 1875, though there are authentic records showing that individuals were occasionally taken in the haul-seines along the Eastern Shore as early as 1860, and hauls of between one and two hundred are reported by Dr. J. T. Wilkins in 1866. It is, however, very easy to explain the ignorance of the fishermen as to the abundance of the species in that region, for, until recently, the fisheries of the Chesapeake appear to have been of small commercial importance, having been prosecuted only during the spring and fall by means of gill-nets and haul-seines. During the summer months, when the mackerel are most plenty, no fishing of importance was done. Pound-nets were introduced into the Chesapeake region in 1875, and it was through their use that the fishermen came to know of the abundance of the species in these waters.

On the North Carolina coast most of the fishermen, and, indeed, a majority of the dealers, are still unacquainted with either the name or the value of the mackerel, and when, in 1879, several thousand pounds of them were brought to Wilmington the dealers refused to buy them, supposing them to be a species of horse-mackerel (*Orcynus*), which they understood had no value as a food-fish. As no purchasers could be found for them they were finally thrown away. Farther south few have been taken, owing to the lack of suitable apparatus as well as to the fact that the fishermen seldom fish beyond the inlets. The smack fishermen of Charleston catch a few on troll-lines during the pleasant weather of the spring and early summer, but they fish only occasionally in this way.

Though the fishing is at present limited to certain localities, there is no reason to believe that the fish are absent from other places; on the contrary, it seems probable that, should proper apparatus be employed, the species could be taken at almost any point along the outer shore where the menhaden are abundant.

In the Chesapeake region there seems to be no diminution in the catch; on the contrary, it has increased rapidly from year to year, until in 1879 it amounted to fully 1,000,000 pounds, and in 1880 the quantity was increased to 1,609,663 pounds. The average daily catch for the pound-nets about Cherrystone, Va., is fully 500 fish; while as many as 4,000 have been taken at a single "lift", and hauls of 2,500 are not uncommon during the height of the season. At Sandy Hook the catch is quite large; in 1879, 3,500 pounds were taken at one haul in a pound-net at Seabright, and the average stock for the pound-nets in that locality often exceeds $1,000 for mackerel alone, while the catch of other species is proportionately large.

We see no reason for believing that the present enormous catch will have any serious effect upon the future abundance of the species; for, assuming that the fish are plenty all along the coast, the catch, though extensive at certain points, must be insignificant in comparison with the immense number of individuals in the water. As has been shown, however, there is good reason for believing that the quantity has varied from time to time in the past, and it may be that natural causes, of which we are still ignorant, and over which we have no control, may cause a like variation in the future.

6.—FOOD.

No careful examination has yet been made of the stomach contents of the Spanish mackerel, and little is known of his food, beyond the knowledge of its habit of feeding upon various small fishes, chief among which are menhaden and alewives, of which it consumes enormous quantities. It is an exceedingly voracious fish, its powerful jaws, armed with strong teeth, being peculiarly adapted to cutting and tearing its prey; and, like the blue-fish, it often mutilates its victims, biting only a small portion from the body, and leaving the remainder to be eaten by other fishes that follow in its wake. It seems probable that its food consists almost exclusively of these small fishes, and that it seldom, if ever, preys upon the invertebrates of the bottom, as it is in no sense a "bottom feeder." In speaking of the food of the mackerel, Mr. Scott says: "These fish surround a shoal of gar-eels, butter-fish, shiners, spearing or young menhaden, when the tiny bait—anxious to escape—rise to the surface, followed by the Spanish mackerel, which may be seen two miles distant, leaping, a thousand at a time, their forked tails conspicuous, and their bodies gleaming like miniature rainbows."*

7.—REPRODUCTION.

Prior to 1880 nothing was definitely known regarding the spawning habits of the Spanish mackerel. Neither the time nor place of spawning had been discovered. Mr. Scott had surmised that they spawned in the waters of our Atlantic States in the spring, as small ones which he supposed to be the young of the previous year were occasionally seen in June.† Prof. Goode, in his *Game Fishes*, had ventured the assertion that they probably spawned in mid-winter, in the Gulf of Mexico and about the West Indies. These were, as far we know, the only writers that had referred to the spawning habits of the mackerel. During an extended tour of the Atlantic coast, in company with Col. Marshall McDonald, the writer had an excellent opportunity for examining the species in different localities, and succeeded in proving that the theory advanced by Mr. Scott was the more nearly correct, and that the Spanish mackerel spawn along many portions of the Atlantic coast

*Fishing in American Waters, by Genio C. Scott, 1875, p. 129.

†The following is the language of Mr. Scott on this point: "Both the Spanish mackerel and cero are spring-spawning fishes, and no doubt spawn in our bays, for there are occasionally small ones taken by the anglers in June, before the large ones visit our shores, and I argue, thererore, that the small half-pounders are of last year's hatch."—*Ibid.*, p. 129.

in mid-summer. The investigation of the Southern fisheries began in Florida in January, 1880, and when the fishery interests of that state had been sufficiently studied, we proceeded northward, visiting every important fishing station along the coast of Georgia and the Carolinas, reaching the Chesapeake early in May. After spending some time at Norfolk, and at the fishing shore of Capt. W. E. Taylor, at Willoughby, we accepted the invitation of Mr. O. E. Maltby to visit his fishing station at New Point, 40 miles up the bay. Here we spent a number of days in examining the spawning condition of the different species taken in the pound-nets of the locality, and soon discovered that many of the male mackerel were nearly ripe, while the eggs in the ovaries of some of the females were well developed. A little later we succeeded in finding thoroughly ripe males and one or two females from which ripe eggs could be taken. Appreciating the importance of this discovery, we continued our investigation, and soon satisfied ourselves that the spawning time was near at hand, as the eggs and milt in all of the specimens examined were well advanced. Later, the writer visited the Eastern Shore of Virginia, including the counties of Accomack and Northampton, and found ripe eggs and milt in a large number of individuals. Further investigation proved that the spawning season, as in many migratory species, varies with the locality, being earliest on the Southern coast, and latest about Long Island. The temperature of the water seems to have a decided effect upon the spawning time of the mackerel, and the ovaries and spermaries do not develop very rapidly until it has risen to upwards of 72° Fahrenheit. The time of spawning for the Carolinas begins in April, while the season at Long Island commences by the 20th of August, and continues till the latter part of September. On the arrival of the species in the Chesapeake, in May, a few of the males are nearly ripe, and the ovaries of the females are very much enlarged. By the 1st of June occasional ripe fish are seen. The spawning season proper begins about two weeks later, and continues during the greater part of the summer. The fishermen report many of the mackerel to be full-roed when they reach the Sandy Hook region, and claim that by the last of August the eggs begin to separate and run from the female. From this date to the close of the season numerous individuals are taken from which eggs or milt will run freely.

The limits of the spawning grounds have not yet been definitely ascertained, though enough has been learned to show that the mackerel spawn at numerous points between Narragansett Bay and South Carolina, and it seems probable that when a thorough investigation is made the southern limits will be found to extend as far as Mississippi and perhaps to Texas. It is certain that they spawn in some of the sounds of the Carolinas, in Chesapeake Bay, off Sandy Hook, and along the southern shores of Long Island; the Chesapeake and Sandy Hook regions being visited by immense numbers of mackerel for this purpose.

As has been said, the spawning season for our coast continues throughout the entire summer, and, in any particular locality, it lasts from six to upwards of ten weeks. The time of spawning for individuals of the same school varies considerably, the ovaries of some of the fish being fully mature while those of others are still quite green. Again, a single individual is a number of weeks in depositing its eggs, as shown by the fact that when the first are excluded a large percentage are still small and immature. All of the eggs in the ovaries of a shad, salmon, or white-fish develop uniformly, and the whole number are deposited at about the same time, so that the spawning season for the individual lasts only a few days at most. Up to the winter of 1878–'79 it had been supposed that all fishes were alike in this particular; but our study of the cod at that time proved that the individuals of that species were several months in depositing their eggs, and the same is found to be true, within smaller limits, of the Spanish mackerel.

The number of eggs varies with the size of the parent fish, that for a one-pound mackerel being estimated at 300,000, while that for a six-pound fish can scarcely be less than 1,500,000. To ascertain definitely the number for the average fish, an immature female, weighing one pound and thirteen ounces, and measuring 18½ inches was selected, and the number of eggs was carefully computed. The ovaries, when placed on accurately adjusted balances, were found to weigh 34.275 grams. These were then opened, and a 100 milligrams, selected from different portions of the roe-bags, so that all sizes might be represented, were weighed out. When counted this mass was found to contain 1,536 eggs. From these data it was found that the ovaries of the fish should contain 526,464 eggs. This number would be too great, as no allowance was made for the weight of the ovary walls; allowing for these, the number would be not far from 525,000. It is thus seen that the species is more prolific than the salmon, shad, or white-fish, though it is much less so than many of the gadoids, a 75-pound codfish yielding fully nine millions.

The eggs of the Spanish mackerel are smaller than those of any other species with which we are familiar. During the early part of the season they can scarcely be distinguished by the unaided eye, and although they gradually increase in size, when fully ripe they have a diameter,—varying somewhat with the size of the parent and the condition of the eggs when pressed from the ovaries—of only one twenty-second to one twenty-eighth of an inch. Most of those secured by us were of the last-named size, and taking these as a basis it will be seen that a cubic inch would contain 21,952 eggs, and that 1,267,728 could be placed in a quart cup.

After impregnation the eggs have a specific gravity between that of fresh and salt water, as shown by the fact that they sink in one and float in the other. When thrown from the parent they rise to the surface, and are driven hither and thither by the winds and tides during the earlier period of development. Many are lost from lack of fertilization, others are destroyed by the animals of the water, and considerable quantities are doubtless driven upon the shore during stormy weather, where they soon perish.

When first hatched the little mackerel is quite transparent, its length scarcely exceeding one-tenth of an inch, while its diameter even with the comparatively large yelk-sac is so small as to allow it to pass through wire cloth having 32 wires to the inch. For several hours after hatching it remains comparatively quiet at the surface in an almost helpless condition, a small oil globule attached to the yelk-sac keeping it from sinking and causing it to lie belly upper-most. Later the umbilical sac with its oil globule is gradually absorbed, and the little fish begins to manifest greater activity, and by vigorous and spasmodic efforts penetrates to the depth of an inch or so below the surface. In a few hours it finds little or no difficulty in swimming at various depths and even lies at the bottom of the vessel in which it is confined, darting off with surprising rapidity when disturbed.

So far nothing is known of the rate of growth. We know of but two instances where small mackerel have been caught or even seen along our shores. The first is that mentioned by Mr. Scott, in the passage already quoted, of half pound fish having been taken off the Long Island coast in June. A second instance was made known to us by Mr. Robert Bosman, superintendent of a fishing station at New Point, Va., who, in a letter dated Norfolk, Va., September 25, 1880, says: "I have recently noticed large numbers of young Spanish mackerel, varying from four to six inches in length." Assuming that the fish referred to were the young of the Spanish mackerel, there still remains a difficulty in determining the rate of growth. Some species grow very rapidly, reaching the last-named dimensions in a few months, while others develop more slowly and would not attain a weight of half a pound for several years. From our limited knowledge of the growth of other species we would suppose that the fish mentioned by Mr. Bosman as being 4 to 6 inches long in September were the fry of the previous year, and were therefore about fourteen months old, while the half-pounders mentioned by Mr. Scott were probably nearly two years old.

B.—ORIGIN AND DEVELOPMENT OF THE FISHERY.

8.—THE FISHING GROUNDS.

Spanish mackerel may be taken with trolling hooks along almost any portion of the coast between Key West and Long Island; but as this method of fishing is practically restricted to a few localities the troll-line catch is quite unimportant. Enough are caught, however, to show that the species occurs, and to indicate that the fishing grounds may be considerably extended in the future.

Professor Goode states, upon the authority of Thaddeus Norris, that in the Gulf of Mexico they are sometimes taken by means of hook and line with shrimp bait, at the ends of the long piers where the steamboats land in going from Mobile to New Orleans, and that they are so abundant on the Gulf coast of Florida, as to be shipped in considerable numbers from Cedar Keys. Since the statement by Mr. Norris, a careful study of the fisheries of the Gulf has been made by Mr. Silas Stearns, of Pensacola, Fla., under the direction of the United States Fish Commission and the Census Office. The reports forwarded by him lead us to believe that, whatever may have been the catch of the past, that of 1880 was so small as to be of little commercial importance, though this is perhaps due to a lack of suitable apparatus of capture rather than to any scarcity of the mackerel.

Off the east coast of Florida a few are landed by a smack fishing for the Savannah market. Off Charleston small numbers are secured by the crews of the vessels employed in the blackfish fishery, who claim to see occasional schools of mackerel, and think that in case they should make a practice of fishing for them considerable quantities could be secured.

On the North Carolina coast there are no summer vessel fisheries, and but few boats fish along the outer shore, none using methods suited to catching the mackerel. Parties fishing with seines along the inner bays caught few of these fish prior to 1879. During this season they are said to have been quite plenty for a short time, and many were taken by the fishermen, who, being unacquainted with the species, did not recognize its value, and, instead of saving their mackerel, threw the greater part of them away. Some, however, were taken to Wilmington, but, as has already been stated, the dealers refused to purchase them, thinking them to be a species of horse-mackerel, which they supposed to be of little value for food.

Chesapeake Bay has by far the most extensive fishery for Spanish mackerel in the United States; the other fisheries, in order of importance, being those of Sandy Hook, Southern Long Island, and Narragansett Bay. Few are taken on the southern coast of New Jersey, as little fishing is done along the outer shore. Some are, however, secured by the vessels trolling in the vicinity of Barnegat Inlet, and the menhaden fishermen of Tuckerton occasionally catch them in their purse-seines.

The commercial fishery is of recent origin, and it is only within the past few years that any considerable quantities have been taken for market. The fishery practically began off the New Jersey coast in 1873, and the mackerel were first extensively taken in Chesapeake Bay in 1875. This fact has little or no significance in its bearing upon the abundance of the fish, for the increased catch is almost wholly accounted for in both localities by the change in the methods of fishing.

9.—Apparatus and methods of capture.

Three kinds of apparatus are used in the Spanish mackerel fishery, namely, the trolling-line, the gill-net, and the pound-net. The trolling-line is more extensively employed off the Long Island coast and along the shores of Northern New Jersey than in any other locality. It was introduced into the region at an early date, and for some time was the most important method in the fishery. It has been less extensively used during the past ten years, and is now chiefly employed by parties fishing several miles from the shore. Large open boats and small sloops carrying from two to five men each are used for trolling. The trolling-hooks, or "squids," as they are frequently called, differ greatly. Some are made of bright metals in the form of a fish, while others more nearly resemble the body of a squid, these being usually painted in brilliant colors. The number of hooks varies from one to three, according to circumstances. In the absence of manufactured squids, the fishermen frequently improvise very good ones by attaching pieces of red or white cloth to ordinary fish-hooks. In fishing, the hooks are attached to lines several fathoms in length, four or five of these being towed behind the boat, which spreads enough canvas to drag them through the water at a speed of two to four miles per hour. The fishermen are often successful in catching large numbers of mackerel in this way.

At Sandy Hook gill-nets were first employed in the capture of mackerel in 1866, but being "set taut," they were not very successful, the fish usually detecting their presence and refusing to enter them. When it was found that, although abundant, the fish did not gill readily, schools were often surrounded by the nets, after which the fishermen attempted to frighten them into the meshes by splashing with oars in the center of the circle. The majority, however, would pass under the lead-lines, or jump over the cork-lines, and escape, so that comparatively few were taken. Still the nets continued to be used with varying success, though the bulk of the catch was taken by trolling. About 1872 or 1873 it was accidentally discoverd that the mackerel would gill more readily in nets set in such a way as to present sharp angles, quite a number having been secured in a net that had become twisted and tangled by the currents. This fact suggested a change in the manner of setting, and various experiments were made by the fishermen of Sea-bright with good results. The first "sets" were somewhat crude, but experience enabled the fishermen to improve upon them from year to year.

The figures in Plate II represent the principal methods of setting the gill-nets for the capture of Spanish mackerel off Sandy Hook from 1866 to the present time. Figure 1 shows the first method, locally known as the "straight-set." The other figures represent, in their order, the more important methods that have since been introduced. At the present time the three sets shown in Figures 6, 7, and 8 are commonly employed. These are locally known as the "square-set," "T-set," and "harpoon-set," the names describing, to a certain extent, the shape of the nets as they appear in the water. In the square-set, Figure 6, two nets are employed, one being placed perpendicular to the shore to form a leader, while the other is set in the form of a square at the outer end, openings of three or four feet being left on either side of the leader to allow the fish to enter. The T-set, shown in Figure 7, somewhat resembles the one already described, the chief difference being that the ends of the outer net, instead of being bent at right angles, are turned inward to form a triangle at the outer extremity of the leader. In the third set, Figure 8, the two nets are so arranged as to form a harpoon, from which the set takes its name.

The gill-nets of this region are worth from $90 to $100 apiece. They are about one hundred fathoms long and one hundred meshes deep, the size of the mesh varying from 3½ to 4 inches. The men fish in "gangs," one net being owned by the crew of each boat. The nets are set on the best fishing grounds at daybreak, and are left for several hours, while their owners fish with hand-lines in the vicinity. The catch is divided equally, the share for a single net being sometimes as high as five hundred dollars for a season which lasts from six weeks to two months.

Gill-nets were introduced into the Spanish mackerel fisheries of Chesapeake Bay in 1877, and proving fairly successful, they soon came into general favor among the fishermen of the Eastern Shore, though they are even now seldom employed by those living on the opposite side. There are, at present, about 175 men engaged in "gilling" for mackerel between Crisfield, Md., and Occohannock Creek, which is 30 or 40 miles from the capes. The nets were at first set only in the night, but during 1880 the fishermen of Tangier Island obtained the best results by fishing from the middle of the afternoon until midnight. The nets range from 75 to 100 fathoms in length, and have a similar mesh to those already mentioned. The catch varies considerably, as many as 500 mackerel having been taken at one set, though the average is only 20 to 40 daily to the net.

The pound-net is now the principal apparatus for the capture of mackerel in all localities where the fishery is extensively prosecuted. According to Mr. R. B. Chalker, of Saybrook, Conn., pound-nets were first used in the fisheries of New England at Westbrook, Conn., in 1849, and from that locality they spread rapidly to other portions of the coast. They were first introduced at Sandy Hook, N. J., by Mr. George Snediker, of Gravesend, Long Island, about 1855. Mr. Snediker has probably done more to develop the pound-net fisheries of the United States than any other man in the country. It was from him that the fishermen of New Jersey, as well as those of Chesapeake and Delaware Bays, obtained their first idea of pound-nets, he being the first to introduce them unto the fisheries of each of these regions. He has also engaged in the pound-net fisheries of Albemarle Sound, though he cannot claim the credit of introducing the net into those waters.

The first pounds fished in New Jersey were very small, and being placed along the inner shore of Sandy Hook, they were hardly a success, as the fish are much less abundant there than along the outer shore. The same style of pounds were, however, fished with varying success until about 1873, when larger ones were placed along the ocean shore; and then, for the first time, their importance in connection with the Spanish mackerel fishery was discovered. The majority of the mackerel secured about Sandy Hook are now taken in this way. One hundred fish in number was considered an average daily catch for the fishing season of 1879, and 100 to 140 for 1880, though much larger catches were occasionally secured. The best day's fishing for a pound-net in that locality occurred in the summer of 1879, when Mr. Robert Potter took 3,500 pounds, valued at $700, at a single lift.

An effort was made as early as 1858 by Capt. Henry Fitz Gerald to introduce the pound-net into the waters of Chesapeake Bay, but his net was not properly constructed, and was so unsuccessful that it was soon taken up. No other attempt was made to fish with pound-nets in this region until about 1870, when Mr. Snediker and Charles Doughty, of Fairhaven, N. J., came to Virginia and located on the banks of James River, a few miles above its mouth. They fished chiefly for shad and alewives, continuing their work for about three years, after which they disposed of their property and returned to the North. In 1875 Mr. Snediker again visited the Chesapeake, located at New Point, Va., where he built a large pound in the waters of Mobjack Bay for the capture of shad and other species. The fishermen of the neighborhood being wholly unacquainted with the pound-net, were very jealous of the stranger that came among them with such destructive apparatus. They watched Mr. Snediker's movements closely for several weeks, and after seeing the enormous quantities of fish taken by him, at once informed him that he must take his "traps" and leave the country. Refusing to comply with their demands, a number of them sawed off the stakes of the pound even with the water and carried the netting to the shore, assuring Mr. Snediker that if he attempted to put it down again they would destroy it. Seeing it was impracticable to continue the fishery here, he decided to seek some more favorable locality. Before leaving he sold the stakes that remained in the water to a resident fisherman, who obtained from them a pattern of the pound, and in a short time had one properly arranged for fishing. This was also destroyed by the fishermen, but not until enough had been learned to convince them that pound-nets could be used with great profit; and within a year from that time 12 pounds were fished in Mobjack Bay. In 1879 the number had been more than doubled, and on our visit to the region, in 1880, we found that every available site was taken up, and often three, or even four, nets were placed in line, the leader of one being attached to the outer end of another, for the purpose both of economizing space and of securing the fish that chanced to be passing at a distance from the shore.

Mr. Snediker on leaving New Point proceeded to the Eastern Shore of the Chesapeake, and associated with himself one of the most popular fishermen of the region, hoping in this way to prevent any organized opposition on the part of the residents against the use of the pound. In this way he was successful in avoiding any open hostilities, and it was not long before others adopted the new apparatus.

Though the pound-net was introduced into the Chesapeake against the prejudice of the fishermen, it has entirely revolutionized the fisheries of Virginia. Prior to 1870 the fisheries of the region were of little importance, being carried on almost exclusively by farmers, who fished with hand-lines and drag-seines for a few weeks in the spring and fall, their chief object being to secure a supply of fish for themselves and their neighbors; while to-day the Chesapeake is the center of one of the most important shore fisheries in the United States. The pound-net has not only more than doubled the catch of ordinary fishes, but it has brought to the notice of the fishermen many valuable species that were previously almost unknown to them, the most important of these being the Spanish mackerel. In 1880, 162 pounds were fished in Virginia waters, with two others located at Crisfield, Md., just above the Virginia line.

As the pound-net is such an important apparatus in the Spanish mackerel fishery, a brief description will not be out of place. The accompanying diagram (Plate III) represents the particular kind of net used on the shores of Northampton County, Va. All pounds are constructed on a similar principle, though they differ considerably in size and shape in different States. Few are provided with pockets, and many have only one heart.

The leader and hearts are vertical walls of netting, extending from the surface to the bottom, and simply answer the purpose of directing the fish into the pound, which has not only sides but also a bottom made of netting, there being but one opening (A B) through which the fish can enter or escape. This opening is rectangular in shape; it is about three feet wide, and extends from top to bottom, the netting being so arranged that the aperture can be entirely closed before the pound is lifted. The poles, M, N, A, C, D, &c., to which the netting is attached, are from 4 to 8 inches in diameter, each being driven from 5 to 8 feet into the mud or sand of the bottom by means of a maul or pile-driver. The hearts and bowls are placed in water 15 to 18 feet deep. From these the leader extends to within a few yards of the shore. It varies greatly in length according to the slope of the bottom, the average being about 150 fathoms. The netting is of ordinary material with a three-inch stretch-mesh. The hearts are made of stouter twine, having a mesh of 2½ inches. The opening to the "Big Heart" is 25 feet across, while that to the "Fore Bay" is only 8 feet. The pound or bowl is a rectangular inclosure 45 by 60 feet. The netting of which it is composed is of heavier material than that used for either the leader or the hearts, the mesh being one inch from knot to knot. The pocket is simply a bag of netting, 15 to 30 feet square and 6 to 8 feet deep, in which the fish are placed when, for any reason, it is found desirable to keep them alive for some time before marketing them. In many localities where the bottom is level or slopes very gradually, two, three, or even four, pounds are placed in line, one outside of the other, in order to intercept any fish that may be swimming beyond the reach of the first one. The fish, striking the leader in their migrations along the shore, at once attempt to swim around it by going into deeper water, and are naturally led through the hearts into the pound, their habit of moving in curves rather than by angular turns making their escape quite difficult. If, however, the pound becomes well filled with fish and they are allowed to remain in it for a considerable time, some of them succeed in finding the opening A B and others soon follow them into the inner heart, from which they find less difficulty in escaping. It is known that many fish pass out in this way, for large quantities are sometimes seen in the pound before the hauling time arrives, which when the net is lifted a few hours later are found to have made their escape. Another proof that the fish often escape from the nets is found in the fact that nets fished twice a day will stock a third or a half more than those that are visited but once in twenty-four hours. In properly constructed pounds, however, only a small percentage of the fish are successful in reaching the outer waters, for even though they may pass out of the bowl, they are apt to be led into it again before they succeed in running the gauntlet of both hearts.

The pound, as described, costs about $1,000, if we include the second set of netting, which must be used when the first is taken out to be dried and repaired. In the warm waters of this region the netting cannot remain down more than two or three weeks without being seriously injured. Three or four men are required for fishing a pound-net, though by adding one or two to the force several nets are frequently tended by the same gang.*

The average stock for marketable fish during the season for this locality is about $4,200 to the net; the marine species, named in order

*The nets are usually fished at slackwater, as at this time they are more easily lifted. As the hour of low-water approaches, a boat with a crew of three or four men is rowed out from the shore to the pole P. A man at once unfastens the line that holds the bottom of the pound to its base; after which the boat is pulled to the poles G, Q, R, F, K, E, &c., in the order named, until a circuit of the pound has been made and the lines that hold the bottom of the net in position have been loosened. The top of the net at C is then lowered into the water and the boat passes over it into the pound, after which the netting is again raised and fastened. The boat then proceeds to the mouth of the pound, and two men, by means of ropes attached to the lead line at the bottom of the opening A B, raise this portion of the net entirely out of the water, placing the weighted line which forms the lower side over the gunwale of the boat, thus effectually cutting off all means of escape. The men then take position in either end of the boat and gradually raise the net toward the poles P and C, driving the fish around towards G and D. This work is continued until the fish have been driven past Q and I, when the netting is pulled up on the opposite side of the boat and the fish are confined in the small basin between it and the outer side of the pound. The weighted line at the bottom of A B is now thrown off, and the boat is gradually pulled towards the outer end, the basin growing constantly smaller until the fish are brought into a limited space at K, when they are at once transferred to the boat by of value, being Spanish mackerel, tailors, trout, sheepshead, porgies, and mixed fish. If the value be neglected and the number of individuals taken be considered, the order should be changed so as to read: trout, tailors, mackerel, mixed fish, porgies, and sheepshead; in addition to the refuse fish, which are either thrown away or used for fertilizing purposes.†

On the western shore of the Chesapeake the pounds are much smaller and the catch is proportionately less, while the fishing season is also different. Here the pounds are put out in time for the run of shad, which begins early in March and continues till the last of May. After the shad season is over many of the nets are taken up. Almost none remain down throughout the summer, though a number are fished in the fall for trout and other species. On the eastern shore the law allows pounds to be fished only between the 25th of June and the 1st of October, during which time they are lifted regularly every day when the weather will permit.

10.—Fishing season for the different localities.

Owing to the enormous extent of sea-coast over which Spanish mackerel are taken and to the variation of the fishing season with the locality, these fish may be seen in the New York markets during a greater part of the year. According to the report of the Fulton Market dealers, their first appearance in 1879 occurred in April, when 98 pounds were received. The quantity gradually increased till July, during which month 114,309 pounds were handled. From this date the catch fell off rapidly until in November only 657 pounds were received, and in December but a single mackerel was seen in the market.

The fishing season for Long Island and New Jersey extends over several months; but the bulk of the catch is taken between the 20th of August and the 20th of September; and, allowing for Sundays and

means of dip-nets. When there is a large run of "scrap fish," or when the catch is large, a signal is given and a flat-boat or scow is sent out from the shore to receive the surplus. It is taken to the point K on the outside of the net, and the worthless fish are thrown into it as fast as the marketable ones are sorted out. Frequently both boats are loaded and the fish are culled after reaching the shore.

After the fish have been secured the netting is thrown off, and the fishermen proceed to re-set the pound, drawing the bowl into place by means of ropes which extend from the tops of the stakes through rings at their bases to its lower corners and sides. The boat first proceeds to the opening A B, and after this has been properly secured it passes out of the pound and visits the different stakes in their order until all the lines have been fastened. The pound is now ready for fishing, and is left to itself until the next slackwater, while the fishermen are icing and boxing their catch.

†According to the best-informed fishermen, 100,000 trout, 40,000 blue-fish, locally known as tailors, 30,000 Spanish mackerel, 10,000 mixed fish, 3,000 porgies, and 1,000 sheepshead represent the catch of the average pound for 1879. The money value of the catch is divided among the species as follows: Mackerel, 36 per cent.; tailors, 24 per cent.; trout, 21 per cent.; sheepshead, 6 per cent.; porgies, 5 per cent.; mixed fish, 8 per cent.

stormy weather, there are ordinarily only 20 good fishing days, though small quantities are taken almost every day during the stay of the fish on the coast.

In the Chesapeake the fishing season is somewhat longer, owing perhaps to the warmer temperature of the water in the early spring. It begins late in May, and is at its height from the 10th of June to the 1st of September, when the mackerel start for the ocean.

11.—DISPOSITION OF THE CATCH.

Almost the entire catch of Spanish mackerel is consumed in a fresh state. A few are salted by the fishermen of North Carolina, who, owing to their ignorance of the value of the species in the Northern markets, as well as to the lack of suitable shipping facilities, seldom market their catch in a fresh state. Those salted are not considered very valuable, and the inhabitants are seldom willing to pay more than $5 or $6 a barrel for them, placing them on a par with the blue-fish and other common species. It is doubtless true that the fine flavor of the mackerel is very much impaired by salting, and that as a salt fish it is inferior to the common mackerel (*Scomber scombrus*), with which every one is familiar.

In 1879 the owner of the oyster and clam cannery at Ocracoke Inlet purchased small quantities of mackerel and put them up in two-pound cans, but the business was very limited, and no extensive trade was developed, only a few hundred cans having been prepared. Recently, at the suggestion of Professor Baird, experiments were made in canning the Spanish mackerel at Cherrystone, Va., for the purpose of ascertaining their relative value as compared with other kinds of canned fish. The report from the canneries is to the effect that they were no better than fish of ordinary grades, though there seems to be a difference of opinion on the subject. However this may be, there is certainly no prospect of an extensive business either in the salting or canning of the species, as the demand for the fresh mackerel is sufficient to offer an outlet for all that can be secured; while the price ranges so high as to make their canning or salting entirely impracticable.

As a fresh fish, the Spanish mackerel has few equals. It is one of the most valuable species taken in the United States, and is a great favorite with epicures. The price paid for the mackerel in the different markets is often extravagant. Instances are not uncommon where the wholesale price has exceeded one dollar per pound. The first fish sent to New York in the spring usually sell as high as 75 cents a pound, and the price does not fall below 60 cents for some time; but as the quantity increases the price is gradually reduced, until, at times of oversupply, when the market becomes glutted, they occasionally sell as low as 6 or 7 cents a pound. The average wholesale price in New York in 1880, for all grades, is said to have been about 18 cents a pound. Mr. C. W.

Smiley, who has made a careful study of the Philadelphia market, puts the average price for that city at 16½ cents per pound during the same period. The fish taken in the northern waters reach the market in much better condition than those shipped from a distance, and for this reason they sell more readily and at better figures. They are, as a rule, much larger and fatter than those taken in Chesapeake Bay, this fact alone making considerable difference in their value. While the Virginia fish are selling in New York at 15 cents, the larger ones from Sandy Hook and Long Island frequently bring more than twice as much.

Many of the fishermen of the lower Chesapeake do not ship their own fish, but sell to the dealers in Norfolk and other places at 7 to 10 cents apiece. Others pack in ice and ship directly to Baltimore by steamer; but, as their facilities for packing and shipping are limited, the amount realized, after deducting the necessary expenses, is little, if any, in advance of that received by parties selling in Norfolk.

The principal markets, in their order of importance, are Baltimore, New York, Norfolk, and Philadelphia; from these points the catch is distributed to the larger cities of country, where the fish are consumed by the wealthy classes, few going into the country towns of the interior. Few cities keep any accurate statistics of their fish trade, and for this reason it is impossible to give the quantity of mackerel handled by their dealers. No figures can be given for the Baltimore trade, though it is safe to say that the merchants of that city handle fully three-fourths of a million pounds annually. The report of the New York Fish-Mongers' Association shows that 274,913 pounds were handled in that city in 1878. This quantity, according to the same authority, was increased to 309,168 in 1879, and to 390,000 pounds in 1880. Mr. Smiley, in his report on the Philadelphia market for 1880, gives the quantity of Spanish mackerel handled as 65,880 pounds, valued at $10,870. Mr. W. A. Wilcox, secretary of the Boston Fish Bureau, estimates the quantity handled in Boston in 1879 at 15,865 pounds, while that in 1880 was about 20,000 pounds.

12.—Statistics of the Fishery.

It is not possible to state the exact quantity of Spanish mackerel taken by the fishermen of the United States during any season, but a careful study of the fisheries in the interests of the Fish Commission and Census enables us to give the following table, compiled from the preliminary statistical reports recently prepared by Col. Marshall McDonald, Mr. A. Howard Clark, and the writer, for publication by the Census Office. The catch for New York is obtained from the manuscript notes of Mr. Fred. Mather, while the figures for the Gulf of Mexico are gathered from data forwarded by Mr. Silas Stearns.

Table showing by States the quantity of Spanish mackerel taken in 1880, and the total catch for the United States.

State.	Pounds of mackerel taken.
Massachusetts	60
Rhode Island	2,000
Connecticut	1,200
New York	25,000
New Jersey	200,000
Maryland	18,000
Virginia	1,609,663
North Carolina	10,000
South Carolina	1,000
Eastern Florida	500
Gulf of Mexico	20,000
Total	1,887,423

From the above table it will be seen that Virginia produces 85 per cent. of all the mackerel taken, and that the New Jersey fishermen catch over two-thirds of the remainder. This, as has already been remarked, is largely due to the ignorance of the fishermen of many localities, both as to the abundance of the fish and to the proper methods of catching them. That the fishery will soon be extensively developed in other places seems quite certain.

C.—ARTIFICIAL PROPAGATION.

13.—CAUSES THAT LED TO THE EXPERIMENTS, AND OBJECTS TO BE ACCOMPLISHED.

The discovery of the spawning grounds of the Spanish mackerel was the result of an arrangement between Professor Baird and General Francis A. Walker, Superintendent of the Tenth Census, for gathering facts relating to the fisheries of the country, including notes on the life history of the more important species as well as the statistics for the different fisheries. To this end the writer visited the Southern coast in the winter of 1879–'80 for the purpose of studying the marine fisheries, while Col. Marshall McDonald, fish commissioner of Virginia, went to the same region to gather material for a report on the river fisheries of our Southern seaboard, special attention being given by him to the fresh-water fishes and the more important anadromous species like the shad, alewife, and sturgeon.

There are several localities along this coast where both the marine and anadromous species are taken together by the same parties. At such points it was found desirable to work together, and the fisheries of certain districts were carefully studied in this way. In the Chesapeake the anadromous and marine species are taken in nearly equal quantities. In order to better understand the fisheries of this region, we spent a week together at New Point, studying the various questions that presented themselves. While engaged in this work we learned of the abundance of Spanish mackerel, and noticed that many of those taken were nearly ripe. A further investigation of the subject proved that the Chesapeake was an important spawning ground for the species, and that the spawning season continued during the greater part of the summer. Colonel McDonald at once communicated these facts to Professor Baird by telegraph, and a little later the writer reported at Washington in person.

The great success that had attended the work in the hatching of shad, salmon, and whitefish, had definitely settled the question of the practicability of increasing the food supply by artificial propagation. Knowing the value of the Spanish mackerel, Professor Baird was anxious to include this in the list of fishes to be propagated by the Commission. It therefore became necessary to learn more about the spawning habits of the species, and to ascertain how and in what quantities the eggs could be obtained, and the kind of apparatus necessary for successfully hatching them. Accordingly the writer was requested to return to the Chesapeake to gather the necessary information, and to undertake the work of actually hatching the fish.

14.—PREPARATIONS FOR THE WORK.

It was not thought desirable to arrange for extensive experiments, but rather to give particular attention to the questions which bore upon the practicability of the artificial propagation of the species, and as soon as these had been settled to return to Washington, after which the question of extensive operations could be considered. During the earlier observations almost nothing had been learned regarding the character of the eggs, and it was necessary to again visit the spawning grounds before any definite ideas could be formed as to the kind of apparatus necessary for the work. Accordingly, on June 21, I secured a quantity of nickel-plated wire-cloth, and with this simple outfit started for the fishing grounds, intending to improvise the apparatus after reaching the Chesapeake. On a previous visit it had been ascertained that several pound-nets were fished in the vicinity of Crisfield, Md., and that considerable quantities of mackerel were taken in them as well as in the gill-nets of the fishermen of Tangier Island, only a few miles distant. Crisfield is a city of some importance on the eastern shore of the bay, a few miles north of the Virginia line. It was, for various reasons, selected as the most available place for the experiments.

15.—HATCHING OPERATIONS.

Arriving at Crisfield on the morning of June 22, I immediately called upon Mr. J. E. N. Sterling, the owner of the pound-nets, and made known to him the object of my visit. He at once became interested in the work, and, besides giving every opportunity for visiting the pounds and examining the fish, instructed his men to render such assistance as might be desired.

During our stay of ten days the run of mackerel was small, and the catch for this reason was very limited; but enough were taken to give an opportunity for settling most of the questions that presented themselves, and to furnish an abundance of eggs for the experiments. A visit to the pounds proved that the relative number of males and females in a school varied considerably. At times the males were taken in greater numbers, while again the females were more abundant. It was further found that a large percentage of the fish taken were still green, though ripe males were not uncommon, and half a dozen or more were seen at every lift of the pound. Ripe females were less plenty, though many containing a few clear eggs, which were usually too immature for hatching purposes, were captured.

On our first visit to the pound-nets one ripe female was found, from which about 50,000 eggs were taken and successfully impregnated. The manner of "stripping" the mackerel was similar to that employed with the shad and other species, the fish being held firmly with the left hand, while with the right the eggs were gently pressed from the abdomen into a large pan partially filled with water, where they were easily impregnated by being brought in contact with the milt of the males.

The eggs of the mackerel, and indeed of all other fishes thus far examined, are covered by an outer shell or membrane which surrounds and protects the germinal mass. When first excluded from the female the egg is soft and shapeless, owing to the looseness of this covering membrane, which is always more or less wrinkled or folded. It has but one opening in its surface, this being a small porous disk called the micropyle, through which the spermatozoa find their way to the germ cells. When placed in water in which the milt has been introduced, an absorption of water begins, and soon the membrane becomes somewhat distended and finally expands to its fullest extent, being separated from the germinal mass by a cushion or layer of water, which serves to protect the embryo in its earlier stages of development, and in addition furnishes oxygen to sustain the life of the fetus. When fully distended by the water the egg is much larger than at the time of its exclusion from the parent, the relative increase varying with the species from one-fifth to over half of the entire bulk. The egg-membrane becomes toughened during the process, and within half an hour after impregnation has assumed a globular form and is so strong that it can with difficulty be broken by pressure between the thumb and finger. This increase in the size of the eggs, due to the absorption of water, is, as has been said, very marked in many species, and a quantity of eggs that before impregnation scarcely more than half fill a dish, will, when fully expanded, often more than fill the vessel so that some will be forced over the top. When eggs have thus increased in bulk they are said by the spawn-takers to have "come up," and the vessel containing the milt should then be replaced by clean water, after which they are ready for the hatchery. A slight absorption of water often, though not always, takes place in the absence of spermatozoa, but in such cases the action is slower and the membrane is never expanded to its fullest extent. By this slighter expansion, as well as by the greater delicacy of the membrane, the spawn-taker usually knows that the eggs have not been properly fertilized.

The mackerel were examined as soon as they were taken from the pounds, and when ripe females were secured they were at once "stripped," and owing to the abundance of ripe males no difficulty was experienced in getting milt for impregnating them. As the pounds were some distance from the harbor, the eggs were carefully tended during the journey to the wharf, clean water being added every half hour to keep them in good condition.

It was at once seen that the eggs of the mackerel, like those of the cod, belonged to the class known as floating eggs, as after impregnation most of them floated at the surface, though a few remained suspended in the water at different depths, while others sank slowly to the bottom. When, however, there was the least current they were readily carried about by it, and became generally distributed throughout the liquid.

A small oil-globule was noticed in each egg. This served to keep the egg in position, remaining constantly at its upper surface, while the fish formed with the curve of its back at the lowest point directly opposite.

As the eggs were only a 22d to a 28th of an inch in diameter and perfectly transparent it was difficult for one not accustomed to handling them to detect their presence, and it was not at all surprising that the fishermen had never noticed them floating on the surface of the bay. In fact, had their attention been directed to them, they would probably have had no idea of what they were.

The number of eggs capable of impregnation that can be taken from a female at one "stripping" varies, with the size and condition of the fish, from 25,000 to 100,000, this being but a small portion of the number actually contained in the fish; for, as has been said, the eggs ripen very irregularly, some being fully developed while others are still green. As soon as an egg has reached maturity it frees itself from the enveloping membrane and passes down through the proper duct, and is soon excluded from the fish, to make way for others. Thus the spawning season for a single individual probably lasts for more than a month. The fish from which eggs were taken by me were so roughly handled that few survived the operation, though with proper care it seems probable that they could be penned up and "stripped" from time to time, until a greater part, if not all, of the eggs were secured. The mackerel is, however, a delicate fish, and the question of penning and handling it is by no means settled.

Our experiments with the eggs of the codfish had given us some experience in the treatment of floating eggs, which proved very valuable in suggesting the proper kind of apparatus to be used at this time. On reaching the harbor the eggs were allowed to remain in the pans until a crude hatching-box could be made for holding them during the night. This consisted simply of a small wooden box, with a wire-cloth bottom. When completed it was placed in the water, and, after being properly secured to the piling of a wharf, the eggs were poured into it. The following morning a number of larger and better boxes were made. The one giving the best results was so arranged that the smallest waves would cause a flow of water into it, and thus keep the eggs in constant motion. It was very similar in shape to the boxes used in hatching the eggs of the cod, having, in addition to the wire-cloth bottom, openings on two sides, even with the water-line. Just below these, on the outside of the box, were wooden floats about three inches wide, these being placed at an angle with the surface of the water, so that a portion of each wave, as it came in contact with the float, would run up the slight incline and, after reaching the highest point, pass down through the wire-cloth into the box, giving a constant circulation, the water being introduced from above and passing out through the bottom, thus giving the best possible motion to the eggs. Other boxes were arranged in the ordinary way to utilize the action of tides and currents; these were set obliquely in the water, so that the current would force the water through the wire-cloth bottom, thus keeping the eggs in constant motion.

The first eggs secured were washed out of the box during a storm and were lost, but the other boxes were at once provided with covers, to obviate any further loss from this source. From this time little difficulty was experienced, and the eggs were easily hatched. The number of eggs taken during the experiments was about half a million, these being secured from 8 or 9 females, at different times, the largest number taken from any fish being estimated at 100,000. The loss in hatching, if we except the eggs washed out, was very small, and in one instance did not exceed 10 per cent., while 60 or 70 per cent. of nearly every lot developed into young fish.

The time of hatching varied greatly with the temperature of the water, the embryo developing much more rapidly in warm than in cold water. The average temperature during the experiments at Crisfield was 84° Fahr. Under these thermal conditions the line of the fish could be readily seen by the unaided eye 10 hours after the egg had been brought in contact with the milt. In 15½ hours the first fish were seen; 2½ hours later, or 18 hours from the fish, fully half of the eggs had hatched, and inside of 20 hours all were out. Later experiments showed that in water at a temperature of 78° 24 hours were required for hatching. It is thus seen that the eggs of the mackerel develop more rapidly than those of any other species with which the Commission is familiar.*

* During the experiments with the eggs of the mackerel many moon-fish (*Chætodipterus faber*) were taken in the pounds. A number of spawning fish were found among them, from which I secured several lots of eggs that were successfully hatched. These fish spawn in Chesapeake Bay during June, July, and August. The eggs are buoyant, and though a trifle larger than those of the mackerel they hatch in the same time. This is the first time that eggs of the moon-fish, or porgy, as it is more commonly called, have been artificially hatched.

Eggs of the shad require an average of three to five days, while the period of hatching for the other species handled is much greater. In water at 45° Fahr. eggs of the cod have been hatched in thirteen days; but when the temperature is reduced to 31°, as is not unfrequently the case in some of the bays and coves along the shores of Northern New England in mid-winter, the time of development is increased to fifty days. The eggs of the salmon and whitefish require even a longer period.

When first hatched the young fish are about one-tenth of an inch in length and are almost colorless. The food-sac, when compared with other species, is quite large in proportion to the body, the anterior margin reaching nearly to the end of the lower jaw; and the tail is relatively much smaller. The food-sac, containing as it does the oil globule already mentioned, is quite buoyant, and brings the fish to the surface of the water, where it remains belly uppermost for several hours. While in this condition it lies nearly motionless, though it occasionally indulges in spasmodic movements similar to those noticeable in its efforts to free itself from the shell. In a few hours it becomes slightly more vigorous, and moves about to a limited extent, going to the depth of an inch or more below the surface. When a day old the food-sac becomes less prominent, and also less buoyant, so that the fish experiences little difficulty in swimming at various depths.

It is found that both eggs and fish are quite hardy, and that little difficulty need be expected in hatching the eggs or in transporting the fry to any distance desired. In one case eggs taken at six in the evening were allowed to remain in a basin of water till the following morning, when clean water was supplied, after which they received no further attention. A few hours later a large percentage of them hatched out, the fish being in excellent condition.

About 40 young mackerel were confined in a goblet for two days without change of water before the first ones died. Others were placed in water that was allowed to cool gradually, and then suddenly transferred to water ten degrees warmer, but this change of temperature did not seem to injure them in the least. In fact it seems probable that wrong impressions have prevailed for some time with reference to the care necessary for the eggs and young of different species, and further experiments in this line will doubtless prove that both are much more hardy than has been supposed.

Experiments in other places.—When the necessary information had been gathered at Crisfield regarding the treatment of the eggs, it was thought desirable to proceed further down the bay, where the mackerel were more plenty, to find a more favorable locality for the establishment of a hatching station, as well as to enlist the sympathies of the fishermen of that region. Accordingly we visited Hunger's Creek, where the pounds of Dr. J. T. Wilkins are located, and spent a number of days in examining the catch and gathering additional information. Dr. Wilkins at once manifested a lively interest in the experiments, and assisted us in every possible way, accompanying us to the fishing station and helping in the examination of the fish. During our stay the weather was somewhat stormy, and the pounds could not be fished with any regularity. This interfered greatly with the results, as the mackerel seem to throw all their ripe eggs when remaining long in confinement. Plenty of males were seen with the milt running, but no thoroughly ripe females were secured.

16.—CONFIRMATION OF EXPERIMENTS.

Early in July the fish-hatching steamer Lookout, under the direction of Maj. T. B. Ferguson, proceeded down the bay, and made a number of experiments with the eggs of the species, all of which confirmed the results of my own observation. Mr. John A. Ryder, the embryologist of the Commission, accompanied the party, and, having a good microscope at hand, he improved the opportunity for making drawings of the embryos in different stages of development. Both Major Ferguson and Mr. Ryder watched the development of the species with considerable interest, and carried some of the young fry to Saint Jerome Creek, where their subsequent growth could be carefully studied.

17.—PRACTICAL RESULTS.

The experiments conducted by us naturally lead to the conclusion that the artificial propagation of Spanish mackerel is not only possible, but entirely practicable. The fish are very abundant in certain sections from the first of June until late in September, giving excellent opportunities for examination and study. The spawning season also lasts during several months, giving time for extensive operations; while the fact that the eggs are deposited gradually during a long period renders it highly

* In the summer of 1881 a station was established at Cherrystone, Va., on the eastern shore of Chesapeake Bay, a few miles above Cape Charles, for the purpose of making a further study of the Spanish mackerel. The work was at first conducted by Lieut. Z. L. Tanner, of the Fish Commission steamer Fish Hawk, and later by Colonel McDonald and Mr. Ryder. The last-named gentleman gave his attention to a most thorough and systematic study of the embryology of the mackerel. The advance sheets of Mr. Ryder's report come to us as this article is going to press, and are therefore too late to warrant us in making any extended quotations. We, however, take pleasure in referring the reader to the forthcoming Bulletin of the United States Fish Commission, in which it will appear.

In this report it is stated that comparatively few eggs were secured at the Cherrystone Station, and that, owing to defective apparatus, not more than 25 per cent. of any lot were hatched. He thinks that the spawning-grounds of the mackerel are farther up the bay, and that the eggs are deposited only at night. He does not give the temperature of the water in which the eggs were hatched, but says that the time required for the development of the embryo after the egg had been fertilized was 24 hours. He further states that the young fish begin feeding on the third day after they leave the egg, as traces of food were found in their stomachs at this time. Though unable to identify the food, he thinks it to be composed of several species of small articulates, animals that abound in the water in mid-summer. The microscope revealed the presence of teeth in the jaws at the end of the first week.

probable that many ripe fish can be secured. The number of eggs in the mackerel is also greater than that of most species to which the Commission has thus far turned its attention; while the number obtainable for hatching purposes greatly exceeds that of either the shad, whitefish, or salmon.

The short time required in hatching is also a strong point in favor of the artificial propagation of the mackerel. As has been said, with water at 84° F., but eighteen hours elapse from the time of the fertilization of the egg till the young fish comes from the shell; while the average time required for the development of the shad is about four days, and that for the codfish is fully six times as long. Thus five lots of mackerel can be hatched out in the time required for one lot of shad, and thirty-two lots in that required for one of codfish. In this way the Commission would be enabled to hatch a larger number of fish in a shorter time and with a smaller force.

18.—Relative merits of different localities for the establishment of a hatching station.

A number of localities are more or less suited for the establishment of a hatching station, in case such a step should be thought expedient; the principal ones are: Mobjack Bay, on the western shore of the Chesapeake; and Cherrystone, Puncoteague Creek, Onancock, and Crisfield, on the eastern shore.

The principal point in favor of Mobjack Bay is that the pound-nets are more numerous in that vicinity than in any other part of the Chesapeake; the catch, however, averages only 150 mackerel daily to the pound, and a majority of the nets are taken up in July, while few, if any, remain after the 1st of August. Another objection is the lack of a harbor affording comfortable anchorage for a hatching steamer in the vicinity of the fishing grounds.

At Cherrystone the pound-nets, though less numerous than at Mobjack Bay, are larger and catch a greater number of Spanish mackerel, the average daily yield being from 500 to 600 to each pound, while the fishing season lasts throughout the entire summer. On account of the large run of mackerel along this shore fewer pounds would have to be visited, and the work could be accomplished with a smaller force. There is also an excellent harbor with 9 feet of water at mean low tide; this being quite free from impurities, a condition very necessary to the successful prosecution of the work.

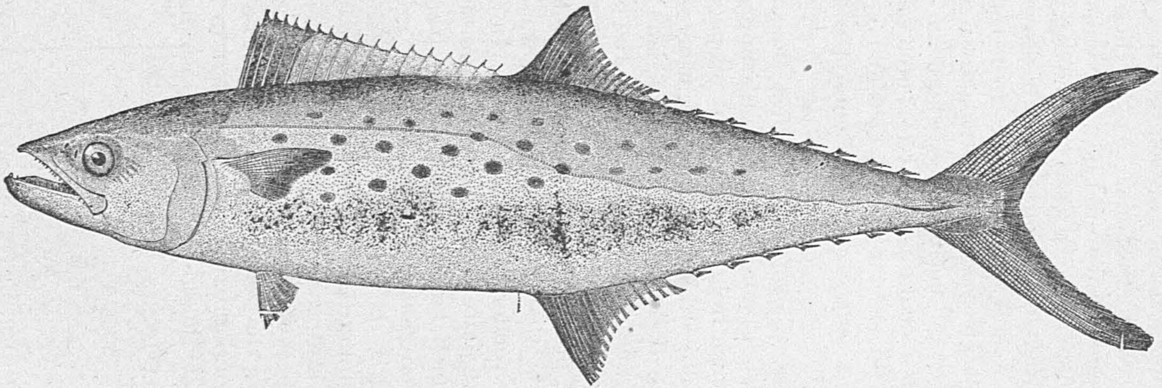
Both of the places mentioned are, however, open to the same objection, for, being situated near the mouth of the bay, they are somewhat removed from the principal spawning grounds. The water is also much colder than further up the bay, and, for this reason, would be less suitable for hatching purposes. Colonel McDonald, who visited Cherrystone some time after our return to Washington, found the same difficulty in securing ripe fish that has already been mentioned. He explains this by saying that the eggs of the mackerel do not fully develop until the female has passed into the warmer water; his opinion being that the region was too near the capes.

Puncoteague Creek, Onancock, or even Crisfield, Md., would scarcely be open to these objections, as they are considerably farther up the bay, and also nearer the spawning grounds. Any of these would furnish fair anchorage for the steamer, and would be a convenient point from which to visit the various fisheries. In case the tendency for the mackerel to throw their eggs when long confined should prove a serious obstacle in the way of securing sufficient quantities from the pound-nets, these places would possess a great advantage over those first named, as they are in the center of the gill-net fisheries, where the nets are hauled so frequently that the fish would usually be secured before many of their eggs had been lost. In case it should be found necessary to depend on the gill-net catch, no place could be more favorable than Crisfield or Tangier Island.

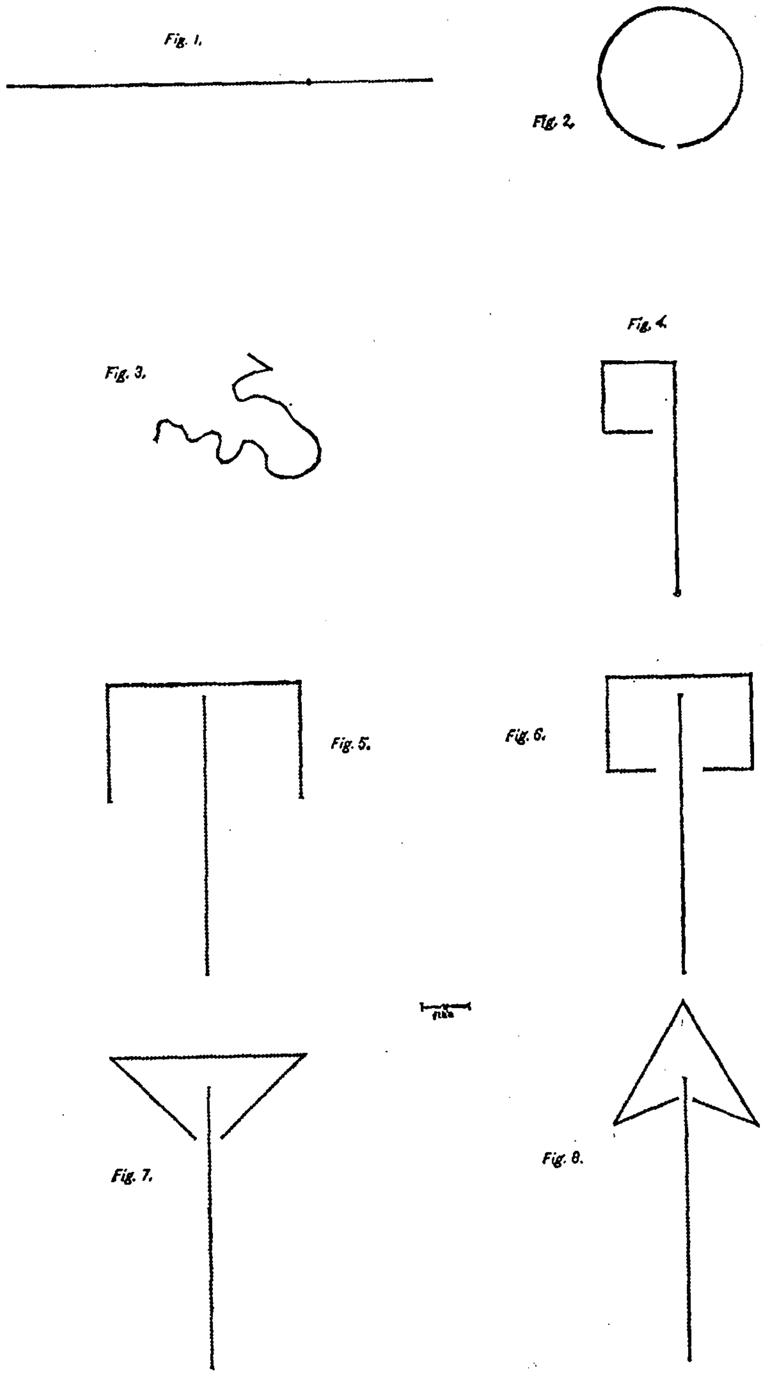
The fishermen of the Chesapeake manifest the most friendly disposition toward the Fish Commission, and fully appreciate the benefits already derived by them from the artificial propagation of the shad. They are thoroughly interested in the propagation of the mackerel, and realize the importance of this work. Many of them have not only consented to allow an examination of their fish for the purpose of securing eggs, but have kindly volunteered every possible assistance.

Sandy Hook, N. J., presents some advantages for the location of a hatchery not offered by the Chesapeake Bay towns, though there are drawbacks that may render it less desirable. In the first-named locality the mackerel are quite abundant; and those taken, being of large size, would yield a much larger number of eggs than the smaller fish of the South—a matter that may prove to be of great importance, for we must remember that the question of keeping the mackerel in confinement, and of stripping them from time to time until all of the eggs have been secured, is still unsettled. If the question of the transportation of the fry should become important, Sandy Hook would be especially suited for the work, for the young mackerel could be readily shipped to New York, from which point they could be sent to any portion of the coast where it might be thought desirable to introduce them.

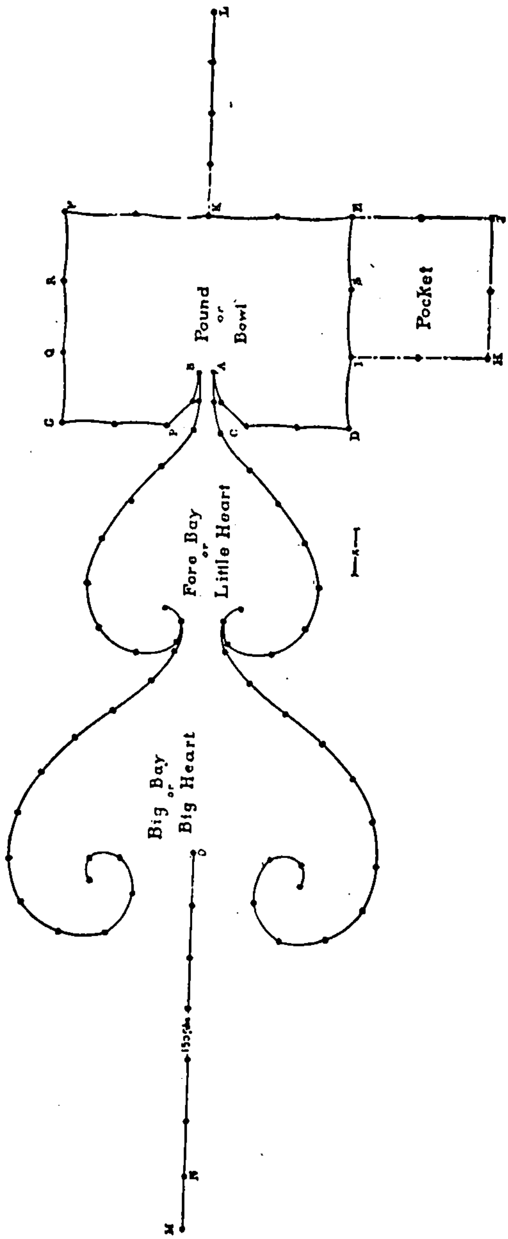
SMITHSONIAN INSTITUTION, *January* 10, 1882.



The Spanish Mackerel.



Different methods of setting Gill-nets off Sandy Hook.



The Pound-net of Northampton County, Va.

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XIV.—CONTRIBUTIONS TO THE BIOLOGY OF THE RHINE SALMON.*

BY DR. F. MIESCHER-RÜSCH.
Professor of Physiology at Basel.

[Reprint from the Swiss literary contributions to the International Fishery Exposition at Berlin, 1880.]†

The following description is based on various statistics and on—

(1.) Measurements, weighings, and notices as to the external appearance of 1,933 Rhine salmon, taken between Basel and Laufenburg, and 229 Lower Rhine salmon from Holland and Wesel, 2,162 fish in all; which observations were continued without interruption from November, 1877, till the spring of 1880.

(2.) Observations, weighings, microscopical, and also chemical investigations relative to the condition of the muscles, intestines, and especially of the growing sexual glands (made at all seasons of the year, during the years 1876–1880) of 97 male and 99 female salmon (196 in all); besides numerous observations—made for the sake of comparison—on sea salmon.

It is well known that the salmon caught in the Rhine at different seasons of the year vary greatly as to the looks and condition of the flesh. In comparing, in December or January, a male salmon, the so-called *winter salmon*, with the well-known *hook salmon*—the *former* with its bright, bluish scales, its well-rounded body, its short nose (about 4 to 5 per cent. of the whole length of the body, measured from the nostrils to the root of the tail), without the slightest trace of a hook and hardly distinguishable from a female; the *latter* with its nose of twice the length, an entirely different physiognomy on the front part of the head, with its thick skin resembling in its red and black spots a tiger's skin, made dark by the superabundant development of the epithelium, and with its flat body and thin flabby abdominal walls—it is difficult indeed to become convinced that these two fish are specimens of one and the same species.

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*Zur *Lebensgeschichte des Rheinlachses im Rhein.* Translated from the German by HERMAN JACOBSON.

†*Statistische und biologische Beiträge | zur Kenntniss | vom Leben des Rheinlachses, | unter Mitwirkung von | Herrn F. W. Glaser, Sohn, | Fischermeister in Basel, | bearbeitet von | Dr. F. Miescher-Rüsch, | Prof. der Physiologie in Basel. | Separatabzug aus der schweizerischen Litteratur sammlung zur | internationalen Fischerei-Ausstellung in Berlin.*

In the female the difference is less apparent. There is not much difference in the length and shape of the nose; the red spots on the body and head, which are entirely wanting in the "winter salmon," are not as strongly developed in the female as in the male salmon; the skin is dark and looks as if it was covered with impurities, but is not as thick. The principal difference in the outward appearance is caused by the different development of the ovaria, which in the winter salmon weigh 4 per cent., and in the spawning salmon fully one-fourth of the total weight of the body, so that they bloat the belly very considerably, making the back appear particularly thin. As soon as the eggs have been emptied out, the thin, limber walls of the abdomen make the leanness still more apparent.

It is well known that there is a considerable difference in the quality of the flesh, which in the winter salmon is peculiarly red (caused by coloring matter, which is soluble in alcohol and ether, but not in water, and which—partly at least—is inherent in the muscle-fibers) and interlarded with strips of fat; in the spawning salmon it is of a dirty white color. After the spawning season it becomes more transparent. The intestinal canal of the winter salmon is covered with fat; the appendages of the duodenum are actually enveloped in layers of fat, whilst in the spawning salmon it looks as if all the fat had been peeled off and at the same time the intestinal canal itself thinned, so that in the former the entire weight is about 2½ per cent. and in the latter one-half to three-fourths per cent. of the total weight of the body.

Although it cannot have escaped an attentive observer that between these two extremes (the winter salmon and the spawning salmon) there are different intermediate varieties, the mutual relations of all these fish have not yet been perfectly cleared up. Although it was known long since that those salmon which immigrate from the sea do not reach their full maturity till they have reached the Rhine, some people think that their stay in the fresh water is confined to a few months. The circumstance that in November and December there are caught, besides the mature fish, a few very fat fish, with very small and hardly developed sexual organs, has led people to suppose that besides those salmon which ascend the Rhine for the purpose of spawning, there are also found, temporarily or permanently, barren fish, which for some very strange reason occasionally stay in the Rhine, and which, when caught, of course, do not thereby interfere with the propagation of the species.

This opinion seemed to be further corroborated when *Barfurth** brought to the attention of science a view which had long since been entertained by practical men, such as Mr. Glaser, and which had also been made known to the scientific world by *His*,† viz, *that the Rhine salmon, during its stay in fresh water, does not take any food. Barfurth* has reached this

* TROSCHEL'S *Archiv für Naturgeschichte*, vol. xli, i, 122, 1875.

† HIS: *Untersuchungen über das Ei und die Eientwickelung bei Knochenfischen.* Leipzig, 1873, p. 24.

opinion by the examination of a number of intestines, and, in view of the enormous increase in the size of the ovaria, he reaches the conclusion that the winter and spring salmon and the spawning salmon do not belong to the same immigration. The stay in the Rhine of both kinds is much shorter than had been supposed hitherto. Immature salmon come and go, and are finally replaced by almost mature salmon, which ascend the river direct from the sea.

For my own part I feel that, after having for 4 years examined the intestines of Rhine salmon of both sexes, at all seasons of the year, I cannot but agree with the opinion expressed above, *that the Rhine salmon, from the time it ascends the river from the sea until it has finished spawning, never takes food, and that, as a rule, it does not take any food afterwards.* Even in winter and spring-salmon from Holland I have thus far looked in vain for any remnants of food. In comparison with the wide stomachs of the salmon from the Baltic and the North Sea, which had thin walls and were generally stuffed with fish almost to repletion, the *Kralingen* (Dutch) salmon had universally a contracted œsophagus, and the walls of their stomachs were laid in folds; the opening was very narrow; the appendages, not taking into consideration the contents and the layers of fat, were likewise thinner and not nearly as large as in the sea salmon. Occasionally I found a small stone, a piece of a blade of grass, or a stalk of some plant, which had entered with the river water and had been swallowed. Once I found in the small intestines a tolerably large larva of an insect, but entirely undigested and intact. Of secretion I found in the intestines proper sometimes a small, and at other times a large, quantity of slime, of more or less bilious color, although the gall-bladder was invariably empty. The bile, therefore, seems to flow from the liver direct into the intestines. The œsophagus and stomach did not, in most cases, contain anything, at least nothing but a faint trace of a sticky and almost transparent slime, which was only occasionally more plentiful and somewhat thinner, but never *acid.* The duodenum, with its appendages, occasionally (but not always), more especially in very flat fish which had recently come from the sea, contained a more plentiful secretion in the shape of a sticky, slimy mass, which, by numerous detached epithelium cells, had become turbid, and somewhat resembled pus. But in no case did I find traces of digestion, of a softening and dissolving influence on the walls of the stomach and the intestines, of these secretions. Although the glycerine extract from this pus-like substance, when dissolved in diluted hydrochloric acid, occasionally dissolved fibrous matter to a small extent, it must be said that, with the exception of the bile, *no effective gastric juice is secreted.*

It is, moreover, worthy of note, that even in the *Kralingen* (Netherlands) salmon there is no tendency whatever to early putrefaction, such as is found in the intestines of every animal which, with its food, introduces from outside germs of putrefaction. This seems to indicate that the salmon have not eaten anything for some time prior to their ascending the Rhine.*

So far I have only found one exception to this rule. On the 3d of January, 1879, I received from an *Istein* fisherman a male salmon which had been caught in the Rhine. It weighed 1.5 kilograms, had emitted all its milt, and was exceedingly lean. The transparent flesh had the smallest percentage of dry substance ever found by me in any fish—but 13.56 per cent. In its flabby, wide stomach it had two tolerably large fish, to judge from their scales, *Cyprinoids* (probably *Leuciscus*), whose forepart had been digested. In another male salmon, which had emitted its milt, I found no remnants of food, but at least a somewhat extended stomach, containing a small quantity of a thin secretion possessing *acid* reaction. In the majority of male fish, however, as well as in all the female fish of this stage, I found nothing of the kind. Necessity, which is the mother of invention, and which occasionally teaches the male salmon to eat, is probably not felt so much by the female salmon, because at the time when *they* begin their homeward journey to the sea (December to the beginning of February), they find a substitute for food in the numerous eggs which have not been emitted, and which often number several hundred.

I have been repeatedly assured that during the spawning months salmon are occasionally caught with the hook and line in the small streams such as the *Wiese* near *Basel*, whilst otherwise they will not bite. Although I have not been able to obtain positively trustworthy data with regard to this subject, I cannot, when thinking of my own experience, deny it entirely—only, however, for the time *after* spawning.†

Although it has been settled *beyond a doubt* that the Rhine salmon does not take any food whatever during the time it is ascending the river, including the spawning season, the facts which are given below compel me to maintain that at least in that portion of the Rhine which extends *from Basel to Laufenburg all Rhine salmon are of one and the same kind, and that all of them, from the (supposed to be) barren winter salmon to the emaciated spawning salmon, represent stages of one and the same development, which—without an interruption—is completed in the Rhine.*

I base this opinion upon the following facts:

(1.) There are in the different stages of development of the male and female sexual organs of our Rhine salmon no gaps which might justify the supposition that the barren winter salmon are replaced by comparatively much maturer salmon ascending from the sea. *Barfurth* has noticed this fact, but he has not followed it up to its last consequences. The instances given herewith in Table I show how the ovarium

* According to my experience, I must urgently advise to clean all sea salmon which are destined for a long journey, whilst with river salmon this is not necessary.

† According to Mr. Glaser it seems to be more certain that in the basin below the falls of the Rhine, near Schaffhausen nearly every year 1 to 4 salmon are caught with the hook and line, sometimes as early as October.

steadily increases in weight in geometrical progression. Table II contains an analogous tabular statement, relative to the increase in weight of the male sexual glands, in which statement small individuals, weighing less than 4 kilograms, and actual giants among the salmon tribe are not taken into consideration, as they exhibit an abnormal proportion between the sexual glands and the weight of the body.

TABLE I.—*Growth of the ovarium.**

	Salmon from—	Date.	Weight of the ovarium in per cent. of the weight of the body.		Salmon from—	Date.	Weight of the ovarium in per cent. of the weight of the body.
1	Holland	Dec. 21, 1877	0.38	15	Basel	July 28, 1879	5.30
2	Basel	Dec. 10, 1877	0.49	16	...do	Aug. 24, 1879	5.84
3	...do	Dec. 31, 1877	0.52	17	...do	Aug. 7, 1879	3.13
4	...do	Mar. 30, 1880	0.77	18	...do	Aug. 23, 1879	11.63
5	...do	May 8, 1880	1.13	19	...do	Aug. 25, 1879	6.52
6	...do	May 10, 1880	1.14	20	...do	Aug. 27, 1879	6.60
7	...do	June 9, 1879	1.31	21	...do	Aug. 27, 1878	9.81
8	...do	June 14, 1877	1.93	22	...do	Sept. 4, 1877	8.50
9	...do	June 22, 1878	3.44	23	...do	Sept. 6, 1877	9.89
10	...do	June 26, 1879	2.84	24	...do	Sept. 6, 1878	9.84
11	...do	July 1, 1879	2.03	25	...do	Sept. 5, 1878	10.39
12	...do	July 2, 1879	3.09	26	...do	Sept. 10, 1878	10.59
13	...do	July 9, 1879	3.40	27	...do	Sept. 13, 1878	12.49
14	...do	July 21, 1879	3.32	28	...do	Sept. 30, 1878	15.23

* As to the weighing of the ovaria of salmon in different stages of development see also *His*, I, 28.

Mature ovaria, November 1 *to* 16, 1877–1879.

Date.	Weight of the ovarium in per cent. of the weight of the body (eggs not yet ready for emission).	Date.	Weight of the ovarium in per cent. of the weight of the body (eggs not yet ready for emission).
Nov. 8, 1879	19.21	Nov. 1, 1879	24.37
6, 1879	19.23	8, 1878	25.06
4, 1879	19.24	1, 1879	26.10
16, 1879	20.12	3, 1879	26.36
16, 1879	23.80	10, 1879	26.72
15, 1879	24.00		

Average of the 11 ovaria = 23.09 per cent. of the weight of the body.

TABLE II.—*Increase of the male sexual glands in percentage of the total weight of the body.*

[Fish of 3,500 to 10,500 grams.]

Date.	Per cent.	Date.	Per cent.
Mar. 12, 1880	0.105	Sept. 15, 1879	2.07
May 3, 1880	0.182	18, 1878	4.91
12, 1880	0.099	19, 1878	1.34
26, 1880	0.106	19, 1878	3.90
June 4, 1878	0.20	20, 1874	2.48
5, 1879	0.26	24, 1874	1.89
26, 1879	0.23	26, 1874	1.54
30, 1879	0.31	26, 1879	4.75
July 7, 1879	0.41	27, 1878	5.58
Aug. 5, 1879	0.58	27, 1879	4.28
13, 1877	0.16	28, 1878	2.32
20, 1877	0.90	Oct. 1, 1876	5.00
23, 1877	0.59	1, 1879	[2]8.81
23, 1877	1.57	4, 1879	5.58
24, 1877	0.86	6, 1879	5.31
29, 1879	1.15	7, 1876	3.86
30, 1877	0.43	11, 1872	[3]5.90
30, 1877	1.45	15, 1878	4.34
Sept. 2, 1878	[1]0.48	16, 1872	6.10
8, 1876	0.82	18, 1873	5.25
13, 1879	1.13	Nov. 4, 1879	4.64

[1]Few spots; small hook. [2]Fish only weighed 4,350 grams. [3]October 14, 1872, 3.33.

The October weights are equal to the weights of mature fish, very probably even larger, but contain less firm substances. The highest grades of maturity (November and December) have not been taken into consideration on account of the loss of milt.

From these two tables it appears that during summer both testicles and ovaria of almost the same stage of development can show very considerable differences of weight. But the greater and lesser weights, each classed by themselves, can be chronologically arranged, and it will then be seen that the differences gradually cease with the females in August and with the males at the end of September and beginning of October, leaving those differences, however, which are found even among mature fish, and which, especially with the males, are very considerable.

According to Mr. Glaser's experience, which extends over many years, and which is corroborated by my own observations, extending over a period of eight years, *the normal spawning season* at Basel for the overwhelming majority of all fish may be said to last from the middle of November till the middle of December. From about the 1st of November Mr. Glaser keeps his fish alive in fish-boxes (tanks); at that time their ovaria do not emit anything when pressed. Generally about the 10th to the 15th of November artificial impregnation may be begun. As early as the 16th to the 24th of December it will be hard to find many, if any full females, and the occurrence of eight full females from the 5th to the 13th of January, 1880, and of one as late as the middle of February, must be considered as rare exceptions, caused possibly by some irregularity consequent upon the unusally severe cold. The occurrence of an empty female on the 26th of October, 1877, must also be considered as a very rare case.

According to my own observations, the maturity of the males sets in somewhat earlier. Beginning on the 20th of October, some seed may be squeezed out of a few, and from the 1st of November out of nearly all normally-developed males, which, however, cannot be considered as a sign of absolute maturity in the whole organ. All the data relative to the spawning season of both sexes have been fully corroborated by Mr. Glaser.

To return to the development of sexual maturity, it is very instructive to compare the respective tables with the following table, showing the monthly results of the fisheries in the Rhine between Basel and Laufenburg:

TABLE III.

Of 100 salmon caught during the year, there were caught in the month of—	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	Average of all the monthly percentages, 1872–1878.
January	....	0.58	....	0.14	0.08	0.61	0.16	0.49	0.28
February	....	0.03	....	0.14	....	1.85	0.32	0.49	0.29
March	1.60	2.78	0.86	0.19	0.55	8.71	1.69	1.26	1.45
April	1.52	2.19	5.41	0.87	2.84	8.03	8.98	1.36	2.52
May	4.57	7.77	5.78	2.12	4.72	5.86	8.04	2.04	5.11
June	11.86	18.77	27.36	18.40	5.89	15.29	14.26	7.57	14.24
July	21.82	17.97	18.34	10.05	19.57	29.38	19.32	11.86	18.41
August	10.78	7.18	14.24	12.01	8.62	10.18	10.59	24.08	12.21
September	18.70	16.08	19.64	8.14	29.24	17.18	16.09	21.46	17.69
October	15.70	14.62	1.88	24.80	19.18	8.17	17.24	19.42	14.50
November	15.06	9.69	3.10	20.89	7.25	4.45	5.81	9.03	9.41
December	4.98	2.87	3.83	0.65	2.57	5.79	2.59	1.46	3.78

If, really, as *Barfurth* supposes, the spawning salmon ascend the river from the sea only a short time before the spanwing season, "with eggs the size of peas," why does the large increase in the number of salmon caught, amounting to six times that of April, appear in June and July, at a time when the ovaria have reached 1.3 to 5.3 per cent. of the total weight of the body—therefore only about 5 to 22 per cent. of their weight when fully matured—and not in September and October? Do these July salmon make way again for other salmon? If, furthermore, in August and September, there is in the Rhine a mingling of returning salmon and new immigrants, why did the individual differences in the weight of the ovaria decrease instead of increase?

I am therefore of opinion, and shall adduce further proof of my assertion, *that our winter salmon, which arrive in the neighborhood of Basel from November to March, remain in this neighborhood all during summer and autumn, and that they reach their sexual maturity gradually, in common with the large schools of later immigrants, which begin to ascend the river from May on, so as to spawn at the same time, from the middle of November till the middle of December.* Mr. His, in his varied observations, has reached the same opinion.*

If we suppose, by way of approximation, that the majority of the

* I, § 25.

Basel spawning salmon* have again reached the sea about the middle of January, and if we, moreover, take into consideration the period of migration from Holland up the river, I feel justified in maintaining that the large majority of our Basel salmon stay in the Rhine between 6 and 9½ months, a small number staying 9½ to 12 months, and a few even 15 months, their sexual organs developing all this time, whilst they abstain from all food. I cannot, of course, positively deny that, in exceptional cases, a few individuals return to the sea in an immature condition; but nothing which has come under my observation points in that direction.

I shall also, for the present at least, be careful not to apply my data to the Lower Rhine. As I have not been able to observe the Dutch and North Sea salmon during this season of the year, I cannot decide whether, as *Barfurth* says, numerous large salmon in an almost mature condition immigrate from the sea late in summer and during autumn. All I maintain is this, that such *belated immigrants*, with the exception, perhaps, of a few male fish, *do not come up as far as Basel.*

The great differences in the degree of development of the sexual organs I interpret as indications of the dates of immigration. The later immigrants very possibly have entered upon the first stage of their ovarian development whilst still in the sea,† but still they seem to lag behind the earlier immigrants, and only catch up with them very gradually, but under all circumstances by the time the spawning season commences. Thus, two Dutch salmon had, on the 31st May, 1879, ovaria weighing 0.61 per cent. of the entire weight of the body, therefore less than half the weight of the ovaria of Basel salmon of the same period. The smallest fish furnished particularly numerous instances of this catching up of the young with the older immigrants. On the 19th of August, 1879, I found in three small salmon from Wesel ovaria weighing 0.56 and 0.80 per cent. of the entire weight of the body (therefore corresponding to the Basel March and April salmon) and testicles weighing 0.91 per cent. of the weight of the body, therefore corresponding to the Basel June testicles. The hook-formation (according to 20 measurements of the length of the nose) had been decidedly retarded. Five weeks later another batch of fish of the same size from Wesel

* Mr. Glaser supposes that the time occupied by the salmon in returning is very short, because, owing to the impetus which they receive, many of them land on sand banks and in shallow places, and thus fall into the hands of man.

† How far this development has advanced can only be decided by data from the Lower Rhine. How many per cent. of the total weight of the body are occupied by the ovaria of salmon caught near the mouth of the Rhine from the beginning of May till the middle of June? How many per cent. of the male organs from May till the middle and end of July? So far, only one individual (caught August 1, 1879) has given rise to the suspicion that it had finished a considerable period of its ovarian development while in the sea. This fish (differing in this entirely from other fish caught at the same time) had an ovarium weighing 7.2 per cent. of the total weight of the body, and muscle-flesh containing much (18.7 per cent.) albumen and fat.

showed ovaria and testicles of at least the same degree of maturity as the Basel fish (testicles weighing 7.7 and 6.1 per cent. of the total weight of thebody); and the small male fish of the spawning period, which had reached us, were fully matured.

The weights of the respective organs are not the only proofs in favor of the further development, in fresh water, of the semen and the oval rium. The microscopic examination of these organs shows lively growth and transformation, the detailed description of which, however, does not belong here. As regards the ovarium: Mr. His has, as early as 1873,* described the different stages of development, from the protoplasm-net with pale pellets in the meshes of the small eggs of the winter salmon, through several stages, to the mature egg, the size of a pea, with its skin delicately marked with small vessels, with its germ ready for impregnation, and the live plasm skin, half-sticky and half fluid, which incloses the clear and highly concentrated egg-fluid. I myself have watched the transformations of the male organ through all the varying seasons. When still resembling an insignificant, shriveled-up little strap, the testicles of the winter salmon often weigh only $\frac{1}{1000}$ to $\frac{1}{700}$ of the total weight of the body; with the first warm spring-days, however, towards the end of March—sometimes not till May—new life seems to be imparted to this organ; more blood is introduced into it; the small one-grained cells, in the diminutive shriveled-up canals, separate, become larger, form several grains, and finally form large bodies, full to repletion with numerous grains. From June to August we find dark-red organs, looking as if they were inflamed, and the looks do not deceive; for numerous pus-cells—probably originally colorless blood particles—are at this period found, between the seminal cells proper, in the canals; through their decay they furnish ample food for the further growth of the many-grained bodies, and for the further swelling of the organ. At the same time the inter-tissue and the walls of the canals grow luxuriantly. Rather late, in September, and even in the beginning of October, after the organ has reached a weight equal to one-half, three-fourths, and even more, of the total weight when matured (about 5 per cent. of the weight of the body), the transformation of the immature masses, of the many-grained cells to genuine *seminal cells*, takes place, not merely by bundles or "nests"—as occasionally in former months—but on a large scale. This is a very interesting process, and is accompanied by the most radical chemical changes, new substances making their appearance, whilst old ones vanish. In the beginning of November the testicles are snow-white, and consist of hardly anything but semen, which at every cut oozes out like cream; it is difficult to recognize this organ as the same which was observed some months previous, say about the beginning of October, when the testicles, though of nearly the same size, were a gray jelly-like mass; and still it is the same organ, which has only undergone a change.

* In the work already quoted.

From what has been said, it must be supposed that the early, and very immature, immigrants complete their entire sexual development in the Rhine. For the present, however, my assertion that this also applies as a rule to the later immigrants, lacks proof. There, is however, still a possibility that, besides these, more mature fish immigrate from the sea.

THE LOSS OF MATTER SUSTAINED BY THE BODY.

In order to decide with absolute certainty whether this course of development in fresh water, applies to the Rhine salmon from Basel to Laufenburg, not only in many cases, but *in all cases*, we followed another course.

The building-up of the mature ovarium of the winter salmon from very insignificant beginnings, is—viewed merely as a material process—a most astonishing performance. The weight amounts to from 19 to 27 per cent. of the total weight of the body, with 40 to 43 per cent. dry substance (at 110°), of which, taking the average of two fish, not quite one-fourth (equal to) about 9 per cent. of the fresh ovarium is oily *fat*. As at this period the muscle substance of the body contains only about 20 per cent., and often even less, dry substance, and as the fat of the intestines and the skin has nearly vanished, the assertion that fully *one-third of all the firm substance of the body is, during the spawning season, found in the ovarium* makes the proportion too low rather than too high.

If the entire development of the ovarium, in fresh water, is going on while the fish is fasting, the body of the average spawning salmon, compared with the body of the average spring or summer salmon, must show a decrease of the matter in the other organs, at least sufficient for building the entire ovarium, and even (on account of the self-consumption) more than sufficient for that purpose. As during the few months, from the end of July to the beginning of November, when the ovarium increases from 4 to 25 per cent. of the total weight of the body, the vertebral column of the fasting fish will hardly grow much in length, and as there are no indications (hyperdermic) to be seen in cuts, with the naked eye, all that should be done would be to examine fish of equal length at different seasons.

Those salmon, however, which bring a three-fourths or entirely mature ovarium from the sea, produced by the ample and rich food found there, must, even if the muscle-flesh were somewhat leaner and reduced in weight, show a larger weight and a greater amount of substance (including the ovarium) than the spring and summer salmon of equal length and equal ovarium.

There would, moreover, be noticed a very decided difference between such spawning-salmon and those which (according to what has been said above) undoubtedly supply the substance for the entire ovarium from their own body. But this is certainly not the case. *There are not two categories* of spawning-salmon. Whenever a spawning-salmon is, exceptionally, somewhat stouter when compared with its length than the rest, its ovaria will certainly be found to be below the average size, and its eggs will in some cases be small, probably retarded in their growth.'

If, moreover, it could be shown that these salmon, which have reached their sexual maturity in the sea, constituted an anyway considerable fraction of all the salmon which ascend from the sea, it ought to be impossible to prove that the summer salmon, up to the spawning season, lose as much flesh as they gain in ovarium substance; there certainly ought to be a deficit on the side of the summer salmon.

On account of the extraordinary scientific importance attaching to a certain proof of such a change of substance in the animal kingdom, I have for two and a half years (since November, 1877), as long as the salmon fisheries lasted, with hardly any interruptions, daily weighed and measured salmon, and portions of salmon, on the most extensive scale; the rich material on which I could operate being very kindly furnished by Mr. Glaser. In weighing I used altogether an admirably constructed pair of English spring scales, which through many years showed no sign of variance, and which in 10 kilograms distinctly indicated a difference of 20 grams. The measurements were made with a very simple apparatus, consisting of a board with a scale marked upon it, and another piece of board attached to it at a right angle, which could be moved up and down until it reached the back point of measuring (now recognized as the most reliable)—the point where the body tapers off and where it again begins to spread a little to form the caudal fin. From September, 1878, I also invariably determined the length of the nose (respectively, its horizontal projection, when the head is fixed in a horizontal position). In the male fish I considered as the "length of the fish" only the distance from the nostril to the root of the tail. The observations were taken very carefully every morning by Mr. *Jacob Weidmann*, the assistant of our Physiological Institute, generally in Mr. Glaser's presence, and were tested by frequent observations of my own, which were entirely satisfactory. No error of any consequence was discovered among a hundred figures thus examined; and if ever statistical data deserve to be called reliable, this term must certainly apply to the data obtained in the manner described.

From among the female fish of one and the same year (1878), beginning with May or June, when the sex could be distinctly recognized, I selected specimens as nearly as possible of equal length, the greatest difference of length not amounting to more than 10 to 12 millimeters. The total number was divided into 2 to 4 groups, arranged in chronological order, and for every group the average date was calculated. The comparison of the averages of the groups furnished the average change of weight of the fish in the periods included in the average dates. The same operation was gone through with six groups of as many different lengths, comprising in all 470 fish, all belonging to the same year (1878), and all caught between Basel and Laufenburg. From the changes of weight (in per cent.) of the six groups—the weight on the 1st of November being counted as 100—the average weights of different periods were calculated, and from these data a curved line was constructed, showing the average changes of weight.

The large figures are by no means superfluous; for from June to November the individual differences are very considerable, and salmon of the same length, the same date, and the same state of maturity frequently differ 25 and even 30 per cent. The question is not one of degrees of emaciation, but of differences in the build of the skeleton. There are thick-set and slender figures among salmon as well as among men. Not until we compare all six groups are the differences sufficiently equalized, and do we realize the change of weight, which in its almost mathematical regularity bears the undoubted impress of absolute truth.

TABLE IV.—*Average change of weight of female Rhine salmon caught between Basel and Laufenburg during the summer and autumn of 1878, six groups, all the fish of one and the same group being of equal length, 470 fish in all.*

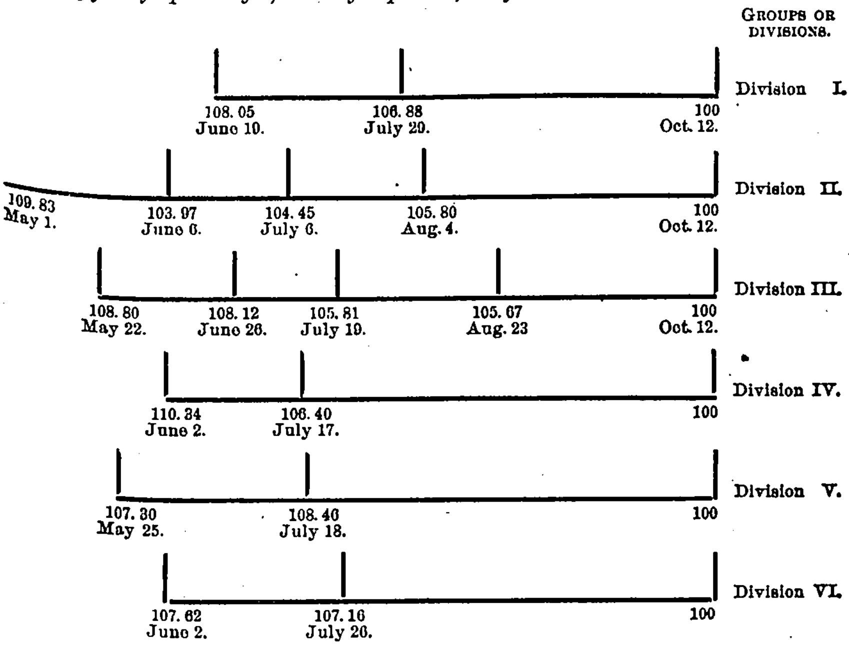
Number of group.	Maximum and minimum length; weight of body calculated October 12.	Limits of date when the fish were handed in for examination.	Average date of the group.	Average difference of time.	Number of fish in the group.	Average length of the group.	Average weight of the body of the group.	Average decrease of weight of body from group to group.			
								Total decrease in grams.	Daily decrease in grams.	Daily decrease in per cent. of the final weight (October 12).	
				Days.		*Mm.*	*Grams.*				
I.....	Length, 840 to 851; Weight, 7426	May 27 to July 1	June 19		19	845.3	8028				
				39.6				+87	+2.20	+0.296	....
		July 6 to August 28	July 29		18	847.2	7941				
				65.0				+440	+6.77	+0.911	....
		September 9 to November 4	Oct. 12		16	845.6	7501				
II....	Length, 855 to 865; Weight, 8073	April 5 to May 6	May 1		18	859.8	8810				
				46.6				+473	+10.15	+1.258	....
		May 21 to June 22	June 16		18	860.2	8337				
				20.1				−68	−3.38	....	−0.419
		June 24 to July 14	July 6		20	859.7	8405				
				30.9				−109	−3.52	....	−0.436
		July 16 to September 3	Aug. 4		17	860.8	8514				
				66.6				+455	+6.83	+0.846	....
		September 8 to November 11	Oct. 12		17	859.0	8059				
III ..	Length, 873 to 884; Weight, 8447	April 16 to June 4	May 22		22	877.8	9190				
				36.7				+57	+1.55	+0.184	....
		June 11 to July 4	June 26		18	878.2	9133				
				22.6				+195	+8.63	+1.022	....
		July 6 to August 3	July 19		20	877.3	8938				
				34.7				+12	+0.34	+0.040	....
		August 5 to September 13	Aug. 23		18	879.2	8926				
				50.3				+479	+9.52	+1.127	....
		September 23 to November 11	Oct. 12		23	878.5	8447				
IV...	Length, 885 to 895; Weight, 8886	May 2 to June 25	June 2		23	889.7	9790				
				45.1				+343	+7.61	+0.857	....
		July 3 to August 26	July 17		38	790.4	9447				
				86.1				+568	+6.60	+0.743	....
		September 7 to November 11	Oct. 12		26	890.3	8879				

TABLE IV.—*Average change of weight of female Rhine salmon caught between Basel and Laufenburg, &c.*—Continued.

Number of group.	Maximum and minimum length; weight of body calculated October 12.	Limits of date when the fish were handed in for examination.	Average date of the group.	Average difference of time.	Number of fish in the group.	Average length of the group.	Average weight of the body of the group.	Average decrease of weight of body from group to group. Total decrease in grams.	Daily decrease in grams.	Daily decrease in per cent. of the final weight (October 12).	
				Days.		*Mm.*	*Grams.*				
V....	Length, 896 to 906........ Weight, 9233........	April 20 to June 25........	May 25		27	900.3	9937				
				53.5				−107	− 2.00	....	−0.217
		June 28 to August 30........	July 18		33	901.3	10044				
				85.7				+781	+ 9.11	+0.987	....
		September 14 to November 19........	Oct. 12		19	900.8	9263				
VI...	Length, 907 to 917........ Weight, 9491........	April 13 to June 29........	June 2		18	910.0	10233				
				54.1				+ 44	+ 0.81	+0.085	....
		July 2 to August 26........	July 26		21	912.0	10189				
				79.1				+688	+ 8.70	+0.917	....
		September 21 to November 6........	Oct. 12		21	912.0	9501				

The following table, with its different horizontal lines, will give a still clearer view of the subject. On these lines, counting from the starting points of the six groups, placed perpendicularly, the figures of the excess of weight (in per cents) over the final weight (=100), reduced for the 12th October, are given in intervals proportionate to the differences of time:

TABLE V.—*Average change of weight of female Rhine salmon, caught between Basel and Laufenburg, from the beginning of June till the 12th of October, six divisions, each containing fish of equal length, in 3-5 groups each, 470 fish in all.*



The figures show the weights of the respective average date of a group when the weight on October 12 was 100.

If, supposing that the change of weight between two average dates took place in a straight line, we calculate approximately the average proportion to the final weight (October 12 =100) for a number of suitably-selected periods of time, of all the six divisions, we obtain the following course of changes of weight, in which the individual differences are very well equalized; so that, in spite of the retarding influence of later immigrants on the emaciation (as indicated in figures) of the earlier ones, a slight decrease in weight may be perceived from the very beginning, which, resembling a parabola, describes a curved line convex towards the top.* If nothing else, this form, instead of the line (at first concave towards the top and then straight, indicating the emaciation by hunger), points to a connection of an organ growing in geometrical progression, with the demand for subsistence.

* The large tables of curves have not been reproduced.—EDITOR.

TABLE VI.—*Average change of weight of female Rhine salmon.*

Date.	May 22.	June 4.	June 19.	July 4.	July 19.	Aug 3.	Aug 23.	Oct. 12.
Days from May 22....	0	15	30	45	60	75	95	140
Weight..............	108.17	107.74	107.39	107.08	106.66	106.7	104.61	100

d=0.0287=0.0233=0.0207 0.0280=0.0393=0.0730=0.0922

The principal result, which is apparent in all six divisions, obtained from Tables IV to VI, is this, that from the end of July or the beginning of August, when the ovarium weighs on an average one-fifth of its mature weight, till the spawning season, there is, in spite of the growth of the ovarium, not only *no* increase of weight, but even up to October 12 a *decrease* of weight of 6 per cent. (weight on the 12th October =100); for every pound of ovarium more than a pound of flesh has vanished. As the intestinal fat has mostly disappeared about the beginning of August, and as the changes of the intestines (as has been proved by numerous observations of weight) are of very little consequence, the muscle flesh alone must be the source from which the substances come.

The quantity of albumen contained in the large side-muscle of the body was, therefore, determined by observations taken on a number of July and August salmon and compared with a series of similar observations taken on November salmon (*i. e.*, the quantity of the dry residue which, at a temperature of 110°, remained, after complete exhaustion by means of hot alcohol, ether, and water).

TABLE VII.—*Decrease of the quantity of dry substance and albumen in the large side-muscle of the female Rhine salmon from July and August till November and December.*

	Length.	Weight of body.	Ovarium in per cents of weight of body.	Contents of the side-muscle. Albumen, per cent. of.	Contents of the side-muscle. Dry substance, per cent. of.
	Millimeters.	*Grams.*			
Dutch salmon, March 18, 1880	885	9,580	0.045	18.8	34.0
Basel salmon, March 30, 1880	860	9,030	0.077	18.1	82.6
Average				18.45	33.6
July 9, 1877	865	8,700	4.04	17.2	24.2
9, 1879	874	8,560	3.40	18.2	27.5
21, 1879	908	10,270	3.82	17.7	28.9
Aug. 1, 1879	940	11,130	7.21	18.7	29.0
4, 1879	858	7,840	4.20	17.3	26.6
7, 1879	878	8,930	3.13	16.7	29.7
25, 1879	883	7,740	6.52	16.5	21.8
Average of the Basel salmon during July and August			4.78	17.5	20.8

TABLE VII.—*Decrease of the quantity of dry substance and albumen, &c.*—Continued.

	Length.	Weight of body.	Ovarium in per cents of weight of body.	Contents of the side-muscle.	
				Albumen, per cent. of.	Dry substance, per cent. of.
	Milli-meters.	*Grams.*			
Dec. 8, 1876	....	5,530	Empty, ovar. 80 grs.	13.5	19.3
Nov. 3, 1879	877	7,740	26.37	13.6	19.8
4, 1879	932	9,620	18.90	15.2	21.4
8, 1879	912	8,900	19.21	13.0	18.3
10, 1879	820	7,650	26.72	13.4	18.4
22, 1879	891	7,290	*Empty..	13.4	20.2
25, 1879	874	5,865	Empty. 135 grs.	12.7	16.8
27, 1879	846	4,930	Empty, 55 grs.	11.0	14.1
Average of the salmon of November and December				13.2	18.5

Considering all the circumstances, viz: (1) the positive decrease in the weight of the flesh, and (2.) the decrease of the remaining flesh of the body by 4.3 per cent. of its contents of albumen, we find, from a comparison with the composition of the ovarium, that *the loss of albumen from the side-muscle is sufficient to meet the entire consumption of albumen by the last four-fifths of the growing ovarium.*

In order to determine this matter more accurately, the weight of the side-muscle of two fish of average size† was ascertained, its substance analyzed, and the decrease of its albuminous matter compared with the increase of albumen in the ovarium.

Of these two fish the second may certainly be considered as an absolutely normal fish, weighing 8,930 grams. It had almost the average weight (8,926), and, measuring 878 millimeters, it had the average length of the group to which it would have been assigned according to Table IV, if it had been weighed and measured on the same day of the year 1878. This coincidence, though intended, had been reached only by an accident.

The head, vertebral column, the bones of the shoulder, and the ventral fins of this fish were prepared, and freed from all the portions of the side-muscle attached to them, whilst the other muscles were left. To this must be added the heart, liver, spleen, and kidneys (according to the determination of another and very similar fish). The surface of the skin, apart from that adhering to the head, tail, and fins, was care-

* The empty females had yielded their eggs a few days previous, for piscicultural purposes.

† For these and other experiments Mr. *Schneider-Wirz*, dealer in table luxuries, has very kindly furnished the fish during those seasons when Mr. Glaser only sold fish at wholesale.

fully measured on the split fish, by laying a thick sheet of paper over it and cutting this sheet so as to fit exactly. The skin, from a cross-cut of the body, measuring 8 or 9 centimeters in breadth, was prepared and weighed; and, by comparing the weight of a piece of paper of equal size with that of the large piece of paper mentioned before, the approximate weight of the entire skin was determined.

	Grams.
The weight of the fish was	89.30
Subtract the above mentioned portions (the blood which had run out being estimated at 47 grams, and the mature ovarium at 280 grams)	25.90
And there remains for the muscle	63.40

We will now endeavor to find whether the probable loss of substance which, according to our average figures, will be sustained by the muscle, is sufficient for building up the ovarium. The decrease of weight of the entire animal, with the exception of the loss of some intestinal fat and part of the liver, will almost exclusively be a decrease of muscle, as the skin does not show any visible layer of fat, and, as is well known, the head and fin muscles hardly decrease at all.

Table VI shows us a possible way of calculating the probable decrease in weight, at any rate till the 12th of October. From the 7th of August to the 12th of October its weight would probably decrease from 105.78 to 100 grams. The spawning season, however, does not commence till the middle of November, and the fish which we had before fore us (with an ovarium weighing 279.5 grams=3.13 per cent. of the entire weight of the body) would be classed among his cotemporaries which had been examined (see Table I), among the less advanced as to its sexual maturity, and would probably not have spawned till the end of November or the beginning of December. We may therefore, further calculate the decrease of weight on the basis of the last period till the 11th of November = 30 days, all the more as just as many fish after the 12th October, as before that date, have been used for calculating the final weight. Going on this supposition, 2.77 per cent. will yet have to be subtracted from 100, and the final weight sought will be to the weight of the 7th of August (8,930) as $\frac{97.23}{105.78}=\frac{91.92}{100}$. The probable loss of weight 8.08 per cent. of 8,930, would be 722 grams; the final weight at the spawning-period would be 8,930 − 722 = 8,208 grams. The probable weight of the ovarium will be 23 per cent. of this final weight (Group V, Table I), 1,888 grams.

The loss of weight of liver and intestines should also be taken into account:

	Liver.	Intestines.
	Grams.	*Grams.*
Weight of these organs, August 7	119	125.5
This makes, calculated in per cent. of the final weight, November 11	1.46%	1.53%
From this subtract the average weight of the organ of mature female fish in November	1.06	0.70
Loss of weight of the body, in per cent	0.40%	0.83%

In building up the ovarium the following muscle substance has disappeared entirely:

(1.) Weight of the ovarium 1,880
(2.) Decrease of weight apart from liver and intestines (722—92). 630

Total........ 2710

With 16 per cent. albuminous matter 452.6
(3.) The remainder of the muscle (6,340—2,710) = 3,630 must, from 16.7 per cent. albumen, go down to 13.2 per cent. Loss 3.5 per cent of 3,630 .... 127.1

Total loss of albumen 579.7

This *quantity of albumen* would very nearly correspond to the *nourishing matter* contained in 6 *pounds* (3,000 grams) of beef of medium quality.

Of its total quantity of nourishing albumen (6,340 × 16.7) = 1,058.8 grams, the muscle has lost 54.74 per cent., or more than one-half; a result which will be interesting in many respects.

Of 100 parts muscle ("salmon-flesh," as understood by cooks) 43 per cent. have entirely disappeared; the remaining portion has sustained a loss of albumen, and has therefore lost 21 per cent.

Still greater is the relative loss of fat, whilst the loss of phosphoric acid is about equal to the loss of albumen.

From *this material* there had to be formed the ovarium, calculated at 1,880 grams, less that part of the ovarium already in existence (the contents of which, in firm substances, is almost equal to the mature ovarium) 280 grams, leaving 1,608 grams to be added to the ovarium.

Indeed, the demands made by the ovarium are very great! The clear, yellowish fluid, which forms by far its greater portion, is so concentrated that it dries very soon, and forms a sort of amber-like substance, which possesses such a strong refraction that the firm portions (little pellets and pieces floating about in it) look like holes (*vacuolen*).

Chemically considered, this fluid is nothing but "liquid caviar"—an intensely concentrated solution of a substance entirely analogous to the little yolk-disks of the sturgeon and other fish; it produces the reactions of albuminous bodies; by boiling it in alcohol about 20 per cent.

of a phosphoric fat (*Lecithin*) is produced, and by digesting it with artificial gastric juice, another phosphoric substance is obtained, viz, the *nuclein*, otherwise known to form the nucleus of the cells. This is of interest, in as far as both these substances, especially the last-mentioned one, are only found in the muscles in very small quantities. The formation of the liquid part of the egg can, therefore, not only be accomplished when muscle substance is taken from the flesh and is deposited in the egg, but the new combinations peculiar to the egg need to be produced from the albumen, the fat and the salts of the muscles containing phosphoric acid, by means of the most radical chemical changes.

I do not, at the present time, possess a sufficient number of albumen calculations from the ovarium, which would be useful in this connection. Taking from the figures at my command (which are probably somewhat too high) 30.0 per cent. of substance not soluble in boiling alcohol, ether, and water, I reach the following result:

Probable loss of the muscle	579.7
Probable amount of albumen consumed by the ovarium	482.4
Albumen left	97.3

to be used either as food, or for increasing the ovarium beyond its average size, or for spawning flesh containing more than 13.2 per cent. of albumen, not counting the loss sustained by the liver and the intestines.

The *other* fish to be examined was a decidedly lean one (we had purposely selected such an one). It was caught August 4, 1879, its length was 858 millimeters, and its weight 7,340 grams; therefore almost 700 grams less than the average weight of the division to which it belonged, according to its date (8,028). If in this case, where the conditions were less favorable, we could also succeed in showing a sufficient loss of substance, our proof would be doubly sure. The results obtained in the same manner as with the first fish are given in the following table in a tabulated form. As the development of the ovarium was farther advanced, I calculated the decrease of weight only to the 1st November.

TABLE VIII.—*Albumen balance-sheet—Growth of the ovarium at the expense of the muscle in a salmon caught near Basel, August 4, 1879.*

MUSCLE, *Dr.* MUSCLE, *Cr.*

Albumen.	Ovarium.					Albumen.	Albumen.
Grams.	*Grams.*		*Grams.*		*Grams.*	*Per ct.*	*Grams.*
		Weight of body August 4			7,340		
		Final weight, calculated for November 1: $\frac{7,340 \times 100}{107.84} =$			6,806		
		Total probable loss of weight of body up to November 1			534		
		Liver of 108 grams = 1.58 per cent. of weight of body, November 1, less 1.06 average liver of the mature fish in per cent. of weight of body		0.42			

TABLE VIII.—*Albumen balance-sheet—Growth of the ovarium, &c.*—Continued.

MUSCLE, *Dr.* MUSCLE, *Cr.*

Albumen.	Ovarium.					Albumen.	Albumen.
Grams.	*Grams.*		*Grams.*		*Grams.*	*Per ct.*	*Grams.*
		Stomach, intestines, &c. = 1.21 − 0.70 per cent. of weight of body	....	0.50			
		Loss of liver intestines in per cent. of weight of body	....	0.92	63		
		There remains, as share of the muscle, in decrease of weight of body	....	....	471	@17.3	81.4
	1,579	Probable weight of mature ovarium = 0.23 × 6,864.					
	− 430	Subtract from this: Ovarium in existence August 4.					
344.7	1,149	*Ovarium still to be formed*, @ 30 per cent. albumen (maximum).					
		Loss of muscle	....	....	1,149	@17.3	198.9
		Determination of the remainder of muscle November 1:					
		Weight of body August 4	....	*7,340			
		Subtract from this: Heads, fins, ovarian skin, various intestines + 30 cc. blood	2,400				
		Subtract from this: Reduced decrease in weight of body up to November 1	413				
		Subtract from this: Replaced by ovarium	1,149				
		Total amount subtracted from weight of body	....	3,962			
74.1	....	There remains as remainder of muscle, November 1, with probable decrease of the albumen from 17.3 to 13.27 per cent. Balance in favor of muscle.	....	....	3,378	@4.1	138.5
418.8		Total loss of muscle	....	....	....	....	418.8

In spite of the unfavorable selection of the fish used for the experiment, and an improbably high figure of the quantity of albumen in the ovarium, we also get in this case more than sufficient to cover the loss.

As regards the fat, the relative decrease of the quantity thereof can be approximately determined from the difference between the quantity of albumen and solid substance, under certain highly probable conditions. If this difference is made the basis of calculation in very lean fish, we shall get very near the absolute truth by either making this difference greater in proportion to the quantity of albumen, or by subtracting it from the total difference.

	Difference between the percentage of albumen and solid substance.	Calculated from the last difference (2.7) for ashes, &c.	Probable percentage of fat.
Average of two female March salmon (see Table V), one of them a Dutch fish	15.1	4.4	10.7
Average of female salmon during July and August (Table V)	9.3	4.1	5.2
Salmon of August 7, weight of body 8,930	13.0	4.0	9.0
Salmon of August 4, weight of body 7,340	9.3	4.1	5.2
Average of female salmon during November (Table V)	5.3	3.1	2.2
Average of two exceedingly emaciated female salmon, in whose flesh, even under the microscope, no trace of fat could be discovered	2.7	2.7	0.0

In the lean salmon (Table VIII) there is, therefore, the following quantity (approximated) of fat:

	Grams.		Decrease of percentage.		
Probable decrease in weight of body	413	at	9.3	=	38.4
Replaced by ovarium	1,149	at	9.3	=	106.9
Remainder of muscle, November 1	3,378	at	4.0	=	135.1
Probable total loss of fat					280.4
Subtract consumption of fat of 1,149 ovarium, at 9 per cent. (maximum)					103.4
And there remains for self-consumption					177.0

We cannot form an opinion as to the use made of the excess of albumen and fat, or as to the formation of phosphoric fat from one source or the other, until we have reliable average figures showing the quantity of albumen contained in the ovarium.

There is no doubt that the muscle contains more than enough *phosphoric acid* to supply all necessary phosphorus for the ovarium, at 1.1 per cent. phosphoric acid in the fresh ovarium against 2, 3–2, 6 per cent. of the firm substance in the muscle.

By the agreement of all these figures with my hypotheses, I consider it proved *beyond a doubt* that our salmon of the beginning of August are identical with the November salmon, and that, with few exceptions, there is no addition to their number of more mature fish with more substance in their bodies.

The microscopical examination fully corroborates the opinion that the side-muscle is really the most important source from which the food of the fish is derived, and which aids in advancing sexual maturity. Even the winter and spring salmon (especially the thin ones) show more or less distinct rows of little drops of fat between the fine elementary fibrils of the considerably thicker muscle-fibers, such as are known as indications of so-called deterioration of the muscular tissue. About midsummer, the very time when the ovarium commences to grow more rapidly, the number of these drops of fat increases considerably, and even goes so far as to make some of the fibers quite opaque. The most prominent example of degeneration is in a separate thin muscle plate, which lies on the side of the body directly under the skin (the skin-muscle). There remain, however, almost *intact* and *free from fat*, all the other muscles, pectoral fin, neutral fin, dorsal fin, caudal fin, the muscles of the jaw and tongue, the upper and lower long muscle, and the tail muscles proper. Only the ventral fin showed in some places faint indications of degeneration.

With this, I find there agree the numerous figures obtained by me in weighing the fin-muscles, of which I will give, as a single example, the data relating to the pectoral fins.

TABLE X.—*Proportion of weight of the muscles of the pectoral fin (of one side) to the weight of body of female summer salmon and spawning salmon.*

	Weight of body—		Weight of muscles of the pectoral fin.	1,000 parts contain pectoral fin calculated on weight of body—	
	With ovarium.	Without ovarium.		With ovarium.	Without ovarium.
DUTCH FISH.					
May 31, 1879, ovarium 31	6,800	6,760	19.1	2,808	2,825
SALMON CAUGHT BETWEEN BASLE AND LAUFENBURG.					
July 1, 1879, ovarium 198	9,750	9,550	34.23	3,511	3,584
July 2, 1879, ovarium 300	9,700	9,400	32.41	3,341	3,448
July 9, 1879, ovarium 291	8,560	8,270	30.45	3,557	3,682
July 21, 1879, ovarium 341	10,270	9,930	35.30	3,437	3,555
July 28, 1879, ovarium 394	7,440	7,050	26.14	3,513	3,708
August 1, 1879, ovarium 802	11,130	10,330	32.72	2,940	3,167
August 4, 1879, ovarium 429	7,340	6,910	25.10	3,420	3,632
August 7, 1879, ovarium 279.5	8,930	8,650	30.03	3,363	3,472
August 25, 1879, ovarium 505	7,745	7,240	26.69	3,446	3,686
Average	....	....	....	3,392	3,548
November 3, 1879, ovarium 20.40	7,740	5,700	25.99	3,358	4,560
November 4, 1879, ovarium 18.18	9,620	7,800	34.30	3,565	4,397
November 8, 1879, ovarium 20.44	8,900	7,190	34.02	3,822	4,732
November 10, 1879, ovarium 20.44	7,650	5,610	24.85	3,248	4,429
November 15, 1879, ovarium 16.10	6,750	5,130	24.71	3,661	4,817
November 22, 1879, ovarium 85	7,510	7,420	33.11	....	4,462
November 22, 1879, 117.5	7,290	7,170	32.22	....	4,494
November 25	5,730	....	28.20	....	4,967
Average	....	....	....	3,531	4,607

It will be seen from Table X that the muscles of the pectoral fin maintain the same proportion to the weight of the body from summer till November, or even—corresponding to the decrease of weight of the fish—increase somewhat, thus furnishing proof that the ovarium takes the place of muscle-substance which has been used up.

The decrease of albumen in the fin-muscles is either very small or there is no decrease at all. The very muscles, therefore, which are most necessary to the fish for its motions, remain singularly free from emaciation, and are even built up at the expense of substances furnished by the muscle of the body. On the other hand, the fact that the fins remain the same—in spite of the increase of the ovarium—furnishes another convincing proof that the ovarium cannot be considered merely as an addition to the existing body, but is really a substitute for substance (belonging to the body) which has been lost.

All the above facts prove, with *absolute certainty*, that (with very few exceptions) all the *Rhine salmon caught between Basel and Laufenburg go through their entire sexual development, and the entire growth of the ovarium, at the expense of the body, whilst in the Rhine.*

As regards the *male* fish I have not such full and accurate calculations. The few given below will show, however, beyond a doubt, that from midsummer to October there is a very noticeable decrease of weight.

TABLE XI.—*Average change of weight of male Rhine salmon, from summer till autumn, 1878; two divisions of equal length, 79 fish in all.*

Number of division.	Length from nostril to root of tail.	Limits of dates between which the fish were caught.	Average date of group.	Average difference of time, days.	Number of fish in group.	Average length of group.	Average weight of body.	Difference of weight of group.	Proportion of weights, calculating the final weight at 100.	Daily decrease of weight.	
										In grams, +.	Calculating final weight at 1,000 grams.
I.	844–855	June 4 to July 18..	June 26	81.0	22	850.4	9723	632	106.95	7.80	0.858
		July 22 to Nov. 4..	Sept. 15		18	849.1	9091		100.00		
II.	803–874	June 1 to Aug. 10..	July 4	91.7	19	867.8	10657	673	106.74	7.34	0.735
		Sept. 5 to Nov. 4..	Oct. 4		20	868.1	9984		100.00		

The average decrease of weight of the male fish would be still more striking if there did not arrive in the Upper Rhine (late in summer) a good many male stragglers, not quite as emaciated, and which somewhat covered the decrease in older immigrants. But even in these fish a considerable decrease of albumen can be noticed in the muscle of the body. The flesh of two March salmon, caught near *Basel*, showed 17.9 and 19 per cent. of albumen, just like the female fish of the same period; a September salmon (caught September 19) which certainly belonged to a later batch of immigrants, and whose testicles were one-third formed, showed 16.6 per cent. albumen, and 25.7 per cent. dry substance. Three salmon of January, 1880, which had ejected their milt, showed (in their muscle) 13.0, 14.3, 13.3 per cent. albumen, respectively. The decrease might, therefore, well be compared with that of the female fish; possibly it was somewhat smaller. But, as the sexual glands need much less albumen for their growth than the ovaria, it seems that the male fish, corresponding to their greater animation and excitability, consume more albumen than the female fish.

The influence—just referred to—of these stragglers on the figures showing the degrees of emaciation makes itself felt with the female fish also, but at an earlier period. Whilst those groups which were composed of April and May salmon showed considerably greater average weights than summer salmon of the same length, there was almost a stand-still in the average weights from June till the end of July or the beginning of August; in some groups there was even a slight increase (seemingly accidental); but from that time on a constant and considerable increase was noticed. In fact there is among the salmon from these months—middle of July till beginning of August—a very distinct difference between the older salmon (older as to the time of their arrival) and those recently arrived, such as is not found among early spring salmon. These last-mentioned fish have dark red and the former pale red flesh; the latter have considerable, and the former very little fat; the duodenum of the latter is enveloped in fat, while that of the former shows but little fat. When the ovarium has reached one-fifth of its nature weight by far the larger mass of this fat has disappeared. This difference is often, but not always, caused by the differences in the degree of development of the ovaria; for the July salmon, which contained the smallest quantity of fat (of all those examined by me July 9, 1877), had an ovarium which was only developed one-half of that of a very fat salmon of August 1.

This difference gradually vanishes from the beginning of August; the female September salmon, but still more the October salmon, are, apart from individual differences of bodily build, equally lean as to flesh and intestines.

To follow up these data, as regards the male fish, the measure of the length of nose, which, since September 1, 1878, was taken in fish of both sexes, is important. While in the female fish the average length of nose remains the same, an elongation of the jaw can be noticed in most male fish at an early date, and makes it possible to determine the sex (with the exception of a small percentage of doubtful individuals) as early as April and May.

Whilst in the male June salmon (length—exclusive of nose—800 to 910 centimeters) the length of the nose, in nine cases out of ten, varied between 5.4 and 6.4 per cent. of the weight of the body, and once in an exceptional case rose as high as 7.0 per cent., the same or very nearly the same minimum figures occur during the whole of July and August, although not very frequently, while the maximum figures become higher and more frequent. From September on, and all through October, both the minimum and the maximum figures increase, whilst the difference of the extremes decreases to some extent. But even in November there is a very considerable difference of length of nose in fully matured fish, whose size and shape are otherwise very nearly equal; and I am inclined to consider these differences as indications of different dates of arrival.

This will be the proper place to make use of the data relating to the *numerical proportion* between the two sexes, which I obtained from the weighing-lists I had kept without regard to individual differences. For 1879 I have made my calculations with the aid of the length of nose from June 1 whilst for 1878 I did not do this until July 1, at which time the sex may easily be determined, even without this aid. The average of both years shows as the average proportion of the sexes: 62.6 per cent. females, and 37.4 per cent. males.

TABLE XII.—*Numerical proportion of sexes among the Rhine salmon caught semi-monthly between Basel and Laufenburg.*

	1878.				1879.			
	Number of females.	Number of males.	Of 100 salmon there are—		Number of females.	Number of males.	Of 100 salmon there are—	
			Females.	Males.			Females.	Males.
July 1 to 15	97	44	68.8	31.2	4	23	85.2	14.8
July 16 to 31	104	41	71.7	28.3	12	38	76.0	24.0
August 1 to 15	78	22	78.0	22.0	15	46	75.3	24.6
August 16 to 31	37	13	74.0	26.0	29	71	71.0	29.0
September 1 to 15	52	29	64.2	35.8	17	37	68.5	31.5
September 16 to 30	37	42	46.8	53.2	34	41	54.7	45.3
October 1 to 15	64	33	66.0	34.0	79	79	50.0	50.0
October 16 to 31	53	55	49.0	50.9	45	37	45.1	54.9
November 1 to 30	47	19	71.2	28.8	52	63	54.8	45.2
	569	298	65.6	34.4	311	460	59.5	40.5

From the above table a corresponding change will be observed in both years in the numerical proportion of the sexes. Till the end of August the female fish are in the majority; during September the males gradually increase so that the numbers become almost equal, and in October the relative proportions are about the same. As there is nothing in the quality of the fish, in their color, length of nose, and quality of the flesh, to point to such a late immigration in great masses; as the October figures show great irregularities, and as, moreover, the females are again more numerous in November, I consider it probable that the females during the last stage of the ovarian development keep much quieter than the males, and are therefore not caught as frequently. Mr. *Glaser* shares this view. It is not impossible, however, that a larger number of such males as have hitherto roamed about in the Central and Lower Rhine immigrate into our region at so late a period.

There are instances of direct immigration of fresh fish. In 1877 and 1879 I observed (as an entirely exceptional case, however) male fish which undoubtedly were late immigrants. They had the appearance of summer salmon; their skin showed red spots, but was not quite as thick and dark as that of summer salmon; the nose was short (5 to 6 per cent. of the length of the body, instead of 8 to 11), the hook was less developed; there was a considerable quantity of intestinal fat, and the flesh was still red. But these fish, of which I took note during the period, November to January, were *never (sexually) mature.* (Notices regarding the testicles of 4 fish, among them 2 by Prof. *His*, 1870).* The weights and the degrees of maturity, ascertained by microscopical observations, differed very much, and corresponded to the normal organs from August till the beginning of October. The question here was by

*Mr. *Glaser* remembers only two cases in 19 years where he succeeded in squeezing a little semen from such late-comers, during a late spawning season.

no means one of barrenness, but one of retarded formation of normal elements. These fish are, as a rule, called winter salmon, and fetch prices like these; but they must by no means be confounded with the *genuine winter salmon* described above, which do not spawn till November and December of the following year.

The observations which I made relative to these late-comers are, in my opinion, a certain proof that for the male fish the short migration-period from the sea to *Basel* does not suffice to complete the entire sexual development up to the point of maturity, much as the rate at which this development goes on may vary between individual fish. The probability, therefore, becomes still greater than would appear from what has been said above, that the entire spawning generation of one year consists of fish which have staid in the Rhine several months longer than the shortest period occupied by the migration from the sea.

Neither during the spawning season nor later have I seen female fish whose general appearance stamped them as fresh immigrants; it is a matter of doubt with me whether the very rare, full-ripe female fish which occurred in January 1879 and (in 1880) even as late as February 20 belong to this category. I had my suspicions regarding a very lean fish, of the middle of November, 1879, which had a clear skin, and an ovarium only weighing 16.5 per cent. of the weight of the body, and containing comparatively small eggs; all this, however, might have been caused by the unusually small quantity of flesh.

The different links of the long series of internal and external changes, by which the spring salmon is transformed into the spawning salmon, run, as a general rule, parallel, but not with mathematical accuracy. The gristle of the nose and chin begins to grow before there is any sign of development in the testicles; and before the testicles have reached one-eighth of their mature weight the skin often shows very distinct red spots. It would also frequently lead to mistakes if one were to determine—say in August or September—the stage of development of the sexual glands by the degree of development to which the hook formation has attained. On the one hand we see the influence of the different seasons of migration, and on the other hand we see the effort (notwithstanding this difference) to finish the sexual development for the same time of spawning. In short, the development of the sexual organs is not the direct cause of external influences, but is only indirectly connected with them.

Finally, I have to make brief mention of an internal organ which exhibits some very curious phenomena. The *spleen*, which is now generally considered as a gland forming blood, appears in the winter salmon as a tough, brown, insignificant organ, weighing about $\frac{1}{1000}$ to $\frac{1}{2000}$ of the weight of the body. In May a swelling is observed to commence in the female fish, in the shape of dark-red raised knots, which increase in size and number, and combine, till, about the end of June or sometime in July, the organ has reached 15 to 20 times of the weight of the spleen, then at its smallest, and has become smooth, shining, dark-red, tender, and resembling coagulated blood. From that time on it shrivels again, and at the beginning of September is smaller than it ever was before, weighing now $\frac{1}{2000}$ to $\frac{1}{2800}$ of the entire weight of the body. In this condition it remains till the spawning season, and begins to increase shortly before the fish return to the sea. The volume of the spleen likewise changes in the male fish, but not in as regular a manner as in the female; it decreases and increases several times during the summer, until the largest size is reached, in the beginning of October (as much as $\frac{1}{120}$ of the weight of the body). During the spawning season it again decreases in size and weight.

This swelling is nothing else than a filling up with liquid blood. Under the microscope we see a net-work of beams, which, combined, form a sort of sponge. The outermost branches of the arteries open (as has been proved by injections) into the meshes of this sponge, and from this very same sponge the capillary vessels of the veins receive their supply. But these meshes may be either nearly empty or filled to repletion, according to the degree of contraction of the muscles of the arteries. This blood (as has been shown by comparing the coloring quality of the watery extract from the spleen with blood from the heart) is much richer in blood-particles than the circulating blood from the heart; the sponge acts upon the blood like an imperfect filter, partly retaining or keeping back the blood-particles, and at the same time, acts like a basin in the sea, in which the rapid current becomes slower, and drops its heavy accumulations. The whole mass of blood which is retained may, under different mechanical conditions, again join in the general circulation. As is shown by numerous comparisons between the veinous blood from the spleen and the blood from the heart, colorless blood-cells are formed in this stagnant blood, but, as it seems to me, not in such a degree as to thereby exhaust the significance of so remarkable an occurrence. Weighty reasons lead me to the opinion that such a temporary retaining of one-fourth to one-third of the entire quantity of blood, during certain phases of the sexual development, forms an important link in the chain of causes by which the great change in the internal economy of the entire body, described above, is introduced. This is not the place to enter more fully upon the discussion of this question. I only mention these curious phenomena of the spleen as further proof that the most radical changes in the formation of the salmon go on during its stay in fresh water.

STATISTICS RELATIVE TO THE MIGRATIONS OF THE RHINE SALMON.

The question of age.—At what age do the salmon, for the first time, migrate and spawn? Do they spawn every year or at greater intervals? Do they perhaps only spawn once in their life, and die soon after?

Such and similar questions have often been asked from a scientific and from a practical point of view; and I feel it my duty to examine whether the facts at my disposal—especially the numerous measurements—will throw any light on these questions.

For this purpose I divided the salmon caught between *Basel* and *Laufenburg*, keeping the males separate from the females, and also separating the fish of 1878 from those of 1879 into groups of 20 millimeters difference, accepting as a constant their *length* (counting this with the males from the nostril, and with the females from the front part of the head, to the root of the tail), and from these groups constructed curves, the abscissas of which corresponded to the lengths of the fish, and the ordinates to the figures indicating the dates of occurrence of these lengths. The regularity of these curves* shows that they rest on a reliable basis, and at the same time proves the accuracy of the measurements.

The first thing to strike us, with both sexes, is, that certain sizes are either entirely or almost lacking. If any further proof were required that not a single salmon goes through its entire development while in the Rhine, this fact would furnish it. From the line indicating 0, or from a slight elevation above this line, the curves showing the periods of migration rise like finely-shaped mountains with a maximum height and slopes on both sides. With the males, three elevations may be recognized in both years, resembling each other. The first gives the small salmon, the so-called St. Jacob's salmon, weighing 1,500 to 3,000 grams. As will be seen from the Dutch market reports, these are mostly late immigrants, which do not occur on the price-lists until July and August, and which, though in comparatively small numbers, reach us in September or October. The height of this curve, therefore, does not furnish an exact standard for estimating the numerical proportion of the immigration of these young fish. The second elevation contains such sizes as are found with us in September and October, with an average weight of 3,800 to 6,600; the third elevation shows the fish for the same months, but with an average weight of 6,600 to 13,000. If we had more data we would probably be able to construct a fourth elevation. Before proceeding any further we give the statistics in tabulated form:

* These curves are not reproduced in the translation.—EDITOR.

TABLE XIII.—*Showing the relative frequency of the different sizes of Rhine salmon between Basel and Laufenburg.*

Males.

Limits of length (nostril to root of tail).	Number of males. 1878.	1879.	Total.	Weight (Sept. and Oct.).
Below 500	1	19	20	Supplemented by St. Jacob's salmon, from Wesel.
501-520	4	11	15	
521-540	2	16	**18**	
541-560	3	12	15	
561-580	......	11	11	
581-600	......	3	3	
601-620	**1**	......	**1**	
				621-650.
621-640	1	6	7	Maximum 4,100
641-660	8	9	17	Minimum 3,200
661-680	14	13	27	Average **3,793**
				681-700.
681-700	**23**	**24**	**47**	Maximum 5,410
701-720	22	15	37	Minimum 3,900
721-740	14	15	29	Average **4,892**
				751-780.
741-760	11	8	19	Maximum 7,320
761-780	**11**	**5**	**16**	Minimum 5,620
				Average **6,601**
				781-810.
781-800	14	8	22	Maximum 9,450
801-820	24	23	47	Minimum 5,300
				Average **6,614**
				831-850.
821-840	38	36	74	Maximum 10,140
841-860	**53**	**27**	**80**	Minimum 7,350
861-880	52	25	77	Average **8,633**
881-900	23	17	40	
901-920	23	12	35	
				921-950.
921-940	10	3	13	Maximum 10,200

Females.

Limits of length (tip of nose to root of tail).	Number of females. 1878.	1879.	Total.	Weight (June and Aug.).
461-480	......	......	......	
481-500	St. Jacob's salmon, from Wesel, Sept. and Oct.	2	......	
501-520		2	......	
521-540		2	......	
541-560		5	......	
561-580		3	......	
581-600		3	......	
601-620	......	......	......	
621-640	......	......	......	
641-660	......	......	......	
				661-710.
661-680	3	1	4	Maximum 5,710
681-700	8	1	9	Minimum 3,350
701-720	13	8	21	Average **4,221**
721-740	15	15	30	
741-760	18	19	37	
761-780	22	14	36	
				781-800.
781-800	15	12	27	Maximum 7,870
801-820	34	18	52	Minimum 5,680
821-840	45	26	71	Average **6,687**
841-860	102	45	147	
861-880	138	61	199	
				881-900.
881-900	139	86	225	Maximum 11,560
901-920	106	69	175	Minimum 7,580
921-940	38	31	69	Average **9,549**
				941-960.
941-960	20	7	27	Maximum 12,400
961-980	9	4	13	Minimum 11,010
981-1,000	4	3	7	Average **11,533**
1,001-1,020	1	2	3	
1,021-1,040	......	1	1	

941–960	*1*	*3*	*4*	**Minimum** *10, 900*	*1041*	....	*2*	*2*
961–980	*2*	*4*	*6*	**Average** ***13,040***				
981–1, 000	....	*1*	*1*			....	....	....
1, 001–1, 020	*2*	*1*	*3*					
1, 021–1, 040	*1*	....	*1*					
1, 041–1, 060	....	....	....					
1, 061–1, 103	*2*	....	*2*					
	728	418	....					

In examining the three elevations we are, first of all, struck by their very considerable breadth. This points either to very great individual differences of growth, especially in youth, or—which appears far more plausible—to an *unequal age of the fish* when they first immigrate. Persons who have raised trout will be better able to decide than I whether differences of 20 to 30 per cent. of length and 80 to 100 per cent. of weight occur in fish of equal age, or in younger fish of otherwise normal conditions of life. It is improbable that these differences are merely produced by differences of food, because (according to Mr. Glaser's and my own observations) the smaller St. Jacob's salmon appear to be well fed, to judge from their shape and the condition of their flesh.

Is it, moreover, merely accidental that both the starting points and the maxima of the first curve are at an exactly equal distance from the second as the second from the third, and, therefore, show *exactly the same increase in length?* As it can only be a question of whole years, either the vertebral column grows between the first and second period *exactly* two or three times quicker or slower than between the second and third, or (which seems to me more probable) the increase of length of the vertebral column takes place at the same periods, and to the same amounts; and this equal distance would then be an indication of equal differences of time between the three fresh-water periods.

The heights of the curves likewise deserve some attention. The small St. Jacob's salmon of the first curve are of no account in this calculation, as they do not come in our neighborhood. On the other hand, it is surprising that the third curve corresponds to twice as many fish as the second, whilst (by fishing and mortality) one would expect the older fish to be much less numerous than the younger ones. Is this caused by the greater ease with which they can escape from the net? In that case the St. Jacob's salmon must be still more rare. Do not these male fish of average size migrate to the Upper Rhine as frequently as the larger fish, or does only the smaller portion of the St. Jacob's salmon of one year which have returned to the sea again appear during the next season? and does the greater portion come a year later, and perhaps make their appearance in the Rhine for the first time? Nothing but further observations as to the relative frequency of the different sizes, made on the Lower Rhine, can solve this problem.

As regards the difference of time (always supposing that the *same* fish occur in two successive curves), it will not be proper to class all fish under one and the same category. As, for instance, the male fish of the spawning season 1878 (middle of November till middle of December) could hardly have again reached the Rhine before the beginning or middle of January, it is self evident that the exceedingly fat winter and spring salmon, with very short nose, which immigrate into Holland as early as November, 1878, to March, 1879, and reach Basel from January to May, must have skipped the spawning season of 1878. This possibly also applies to one or two later months. On the other hand, I do not consider it impossible that among the later immigrants of 1879 there are many male fish which have still gone through the spawning period of 1878. This supposition would be the easiest explanation of the fact that—the length being equal—the winter and spring salmon are so much fatter and heavier than those among the August and September male fish (near Basel) which show indications of recent immigration in their color and nose, because the former have had more time to fatten in the sea. The same proportion would also apply to early and late salmon if the recent immigration of male fish from the spawning period 1878 would be placed in the year 1880. Supposing that the majority of the male salmon returns every year, there results a lowest possible *minimum age* for a male salmon begotten on the 1st December, 1874, and hatched on the 1st February, 1875, which participated in all three migrations, viz:

First migration (as young salmon) to the sea, spring of 1876	About 1 year.
First spawning season (as St. Jacob's salmon), near Basel, partly in December, 1877, and partly in 1878.	$2\frac{3}{4}$ to $3\frac{3}{4}$ years.
Second spawning season (as salmon proper), weighing $3\frac{1}{2}$ to $6\frac{1}{2}$ kilograms, December, 1878, and 1879	$3\frac{3}{4}$ to $4\frac{3}{4}$ years.
Third spawning season (as salmon proper), weighing $6\frac{1}{2}$ to 13 kilograms, December, 1879, and 1880	$4\frac{3}{4}$ to $5\frac{3}{4}$ years.

I must, however, consider it just as probable that every interval between the three last stages is one year longer; for I must confess that I cannot willingly accustom myself to think that so fine a fish as the salmon should be destined to starve throughout the greater portion of its adult stage, and should only eat with feverish voracity during short intervals between the starving periods, and yet grow during such periods at an enormous rate.

I think, moreover, that the influence of the feeding-process is rather overestimated, by supposing that, in $1\frac{1}{4}$ years, the small migrating salmon, weighing only 20 to 25 grams and measuring 7 to 9 centimeters,* should be transformed into the St. Jacob's salmon, which returns in June or July, and is seven times as long and 100 to 150 times as heavy, whilst the two-year old salmon of our waters which has remained with us, and which I occasionally observed, weighs about 80 to 100 grams.† We would, therefore, certainly have to allow $2\frac{1}{4}$ years for development from the small migrating salmon to the St. Jacob's salmon, and for the large St. Jacob's salmon probably one year more.

But why should we trouble ourselves with suppositions regarding a size which can be accurately determined according to our methods?

*As I did not have an opportunity to personally examine any specimens, I make use of an estimate by Mr. Glaser, which may have to be corrected.

†A very successful experiment was made to produce impregnation with the semen of such a salmon weighing about 100 grams. I have never seen mature females of this kind.

About 100 or 200 small salmon should be measured in the sea, and near the mouths of the Rhine, at a certain season of the year, if possible in one certain month (as the length does not always remain the same). These fish would certainly—as to their length—be classed among those the catching of which is forbidden by law; but the result would justify an exception; as the arrival of the great mass of the young fish is limited to a certain season of the year, the different migrations would show on the curves constructed from such measurements, like annual rings. So far all attempts to obtain such a determination of the age by the marking of young salmon have been in vain. But even supposing that fish thus marked are caught again, the result of the statistical method is much more valuable, because it alone can select from among the numerous exceptions and variations which doubtless occur in the conditions of life of these fish with absolute certainty, those *fundamental rules* on which everything depends.

From these and other reasons, to be considered later, I prefer to designate the time which elapses till the young salmon had been transformed from a small fish into the St. Jacob's salmon simply by t; and by introducing this unknown quantity to designate the following determination of the age of the fish as the more probable one in most cases in as far as fish which participate in all migrations are concerned:

Migration of the young salmon to the sea	1 year.
First spawning period of the St. Jacob's salmon:	
Small specimens	$1+t$ years.
Large specimens	$2+t$ years.
Second spawning period	$3+t$ and $4+t$ years.
Third spawning period	$5+t$ and $6+t$ years.

The curve indicating the sizes of the *females* is much easier to understand than that of the males. Here, likewise, three elevations may be noticed. Female salmon of the first migration are very rare near Basel, and the data had to be supplemented by measuring St. Jacob's salmon from *Wesel* (September 23 to October 13, 1879). Here the females are likewise in the minority; the *Wesel* salmon referred to (which were distinguished by the length of their nose) showed one-fourth females and three-fourths males.

The curves of the second and third immigration are very distinctly shown in the Basel salmon of both years. I am inclined to ascribe the considerable breadth of all three curves, just as with the male fish, first of all to differences of age in the first immigration which return at every succeeding migration, and to other differences of the intervals between the years of migration; and only in the second place to individual differences of growth. Attention should also be directed to the circumstance that the maxima of the three curves are not, as with the males, equidistant from each other, but that the proportion of the first distance to the second is as 10 or 11 to 7, or 3 to 2. Its proportion to the distance between maximum I and II, with the males of 1879, is neither 1:1 nor 2:1, but nearer 3:2 than either of the two former proportions. This decidedly favors the supposition that, with most males, the interval between the first and second spawning period is two, and with most females three years; the interval between the second and third spawning period being two years. It is also probable that the age at which the first immigration takes place differs greatly.

With the females the numerical majority of the third immigration over the second, and—considering the small number of female St. Jacob's salmon—probably also over the first, is very marked:

	Number of fish of the—		To every 100 of the second curve the third curve contains—
	Second curve.	Third curve.	
1878	642	86	748.0
1879	353	64	552.0

In 1878 not less than 277 fish, or 38 per cent. of all the fish of that season, are found included in the narrow limits of length of 861 to 900 millimeters (average weight on the 12th October about 8.0 to 9.3 kilograms).

Is this only caused by the circumstance that the majority of these medium-sized fish do not go as far up the Rhine as Basel? My numerous measurements of Dutch salmon, taken at different seasons of the year during three years, do not seem to favor such a supposition. Although on two different occasions I found a small number of Dutch salmon measuring 700 and 800 millimeters, the large females were, next to the St. Jacob's salmon, decidedly in the majority. Mr. Glaser, whose experience as an old importer of Dutch salmon gives considerable weight to his opinion on this subject, is prepared to corroborate my view. Until we obtain more exact data regarding the salmon of the Lower Rhine, therefore, I consider it highly probable that many of the females of the third curve (measuring 800 to 960 millimeters in length) had only migrated once before, or even were now visiting *the Rhine for the first time.* Such fish will, of course, grow into the limits of the third curve at an earlier age, because they escaped the disturbing influence (to their growth) of one or both of the former migrations. What they gain thereby will not, however, be sufficient in many cases. Some of them stop at this intermediary stage, and thus the lack of a deep depression between Curves II and III (making it almost appear as if the sharp lines between the two main curves were obliterated by the interpolation of a third and smaller curve) is explained by the supposition of such an immigration which has been retarded one year. If these same fish immigrate once more, we shall find them in the right lower portion of Curve III.

I therefore consider it probable that the spawning period of the salmon of the second curve (length, without tail, 680 to 790 millimeters) is for the majority three and for the minority four years later, and with the salmon of the third curve (from 791 millimeters on), four, five, and six years later than the spawning period of the St. Jacob's salmon, to determine the age of which I feel utterly incompetent. On the other hand, it seems strange that everything comes to an abrupt close with this powerful third curve and its steep slopes. Females of exceptionally heavy weight, weighing more than 12 kilograms (during the spawning period), are very rare. I consider this as a proof of the truth of the assertion that the salmon fisheries certainly interfere with the keeping up of the species. I believe that but very few of those female salmon which have not gone through a spawning period as St. Jacob's salmon spawn three times during their lives. *The circumstance that most fish do not participate in every spawning period to which their age would entitle them is perhaps the only cause which has saved the salmon fisheries in the Rhine from complete decadence*, and which has kept the average weight of the Basel Rhine salmon at about 8 kilograms.

In reviewing this whole subject I feel compelled to warn people not to apply the experiences gained in other rivers to the Rhine salmon, and *vice versa*. Among many imported river salmon (with empty intestines) which I had occasion to observe in the course of many years, and which, according to Mr. Glaser's statement, came partly from the Oder and partly from the Elbe, the fish of the *second curve* were decidedly in the majority; and this could hardly have been brought about by the character of the orders for these fish. The Swedish salmon, on the other hand, were very much mixed, and among them I found more exceptionally large fish, weighing 16 to 21 kilograms, than among any other kind.

The habits of migration, therefore, seem to vary in the different rivers, perhaps according to the length of the route traveled and the extent of *distribution in the sea* within which certain kinds are found.

From what is known relative to the salmon fisheries of Scotland and Norway, the habits of life of the fish, even, seem to vary. Very probably the flesh does in all cases furnish building material for the ovarium, but doubtless in greatly varying degree.

WINTER SALMON.

After the curves, showing the length of the fish, have led us to the view that the conditions of migration of the Rhine salmon can show various exceptions from the general rule (supposing, of course, that any such rule can be laid down), we shall feel justified in using this circumstance in explanation of various striking phenomena. The appearance of the so-called winter salmon has always been considered as a mysterious problem in the biology of the salmon. These winter salmon immigrate from the sea simultaneously with the last spawning salmon, from September on, in small numbers (Dutch market reports), and from

October on in larger numbers, and are nearly every year caught in small numbers near Basel in November; they are fat fish, with red flesh, and fetch $2\frac{1}{2}$ to 3 times as high a price as the spawning salmon. These fish, with their diminutive testicles and ovaria, have by many people been considered as a sort of barren variety of the salmon. But I have said before, that already during the first spring months, March and April (when the salmon increase in number), the ovaria increase arithmetically slow, but in a very considerable geometrical progression, until the large schools of summer salmon, which appear from May till July, show themselves as the undoubted candidates of the next spawning season. Soon, however, no former winter salmon can be distinguished from the summer salmon, at least not by any less development of the sexual organs.

If we observe these winter salmon closer—from November to March—we are first of all struck with the fact that, with few exceptions, they are very large fish, belonging as to length to the fish of maximum length, and to the second half of the third curve (length exceeding 860 millimeters). Also the Dutch fish—January and beginning of March—of which I have measurements, were, with few exceptions, within the same limits of size (861 to 970).* Among 99 Rhine salmon, the sex of most of which had not been determined (there being no decided difference of nose between males and females), from the months of January to March, 1878 to 1880, only five measured between 835 and 860 millimeters, whilst all the others measured more (as much as 975, and one even 990 millimeters); whilst during May and June, 1878 (just as in 1879), the salmon of the second curve came in large numbers, the St. Jacob's salmon making their appearance from July on.

By comparing nine winter salmon, which (by opening them) have been found to be females, and which are all of one and the same size, with the highest average weight (of a group) of the next division or group, comprising salmon of the same size, I found (although there are of course slight differences of shape) an excess of average weight over the summer salmon (June, July, and August) amounting to 990 grams, or 10 to 11 per cent.

That this cannot merely be ascribed to differences of "shape," but to an accumulation of reserve matter will be seen by a determination of the muscles of the pectoral fin of a *Basel* female salmon, made on the 5th April, which show these muscles to weigh 3.06 per cent. of the weight of the entire body (these same muscles in a Dutch salmon of March 18, weighing very nearly the same, viz, 3.03 per cent.), whilst otherwise the weight of these same muscles in eight *Basel* salmon (excepting, however, the strange fish caught August 1, 1879)† varied between 3.34 and

* As higher prices are paid in the Dutch markets for large salmon than for small salmon, while in the Basel market there is no such difference, no mercantile interests can here come into play.

† Could this fish (length 940 millimeters, entire weight 11,130, and weight of ovarium 808 grams) be an individual which was intended for a winter salmon, but which immigrated too late?

3.56 per cent. And still the great increase of the salmon fisheries in Holland during March and April, and near Basel from May to July, shows, without a doubt, that among the July and August salmon there must be many new immigrants, which is also indicated by the differences in the degree of maturity.

TABLE XIV.—*Female winter salmon from the Rhine, near Basel.*

Date.	Length (without tail).	Weight in grams.	Highest average weight of the corresponding group in table.	Differences in grams.
December 10, 1877	875	10, 200	9, 100	1, 010
January 30, 1878	878	11, 200	9, 190	2, 010
November 9, 1879	907	11, 210	10, 233	977
November 16, 1879	870	10, 140	9, 190	950
November 25, 1879	888	10, 880	9, 790	1, 000
March 13, 1880	885	10, 360	9, 790	570
March 20, 1880	884	9, 620	9, 190	430
March 20, 1880	897	10, 000	10, 044	46
April 5, 1880	885	10, 950	9, 190	1, 860
Average difference	....	....	....	994

In other words, the winter salmon and the early spring salmon are fish which, to begin with, have brought a larger *amount of fat* from the *sea* than the summer salmon. They need not, therefore, as *Barfurth* thinks, return to the sea, but their condition permits them to starve half a year longer. In view of these differences, the similarity (as to leanness) of the spawning salmon is very singular, as is (ignoring the rare latecomers) the relative constant difference between the amount of albumen and fat as compared with the greatly varying differences of the summer salmon. The lowest figures correspond to those fish which have already spawned, and which in consequence begin to grow lean very rapidly. I therefore agree with *Barfurth* that a certain degree of emaciation is, from causes regarding which we can as yet hardly venture a supposition, in both sexes a necessary, or at least profitable or favorable, condition of the complete development of the sexual organs, or of the act of copulation. And the different conditions of migration aim at reaching a comparatively normal spawning condition at the right time, and at the same time for all fish, no matter from what different points they have started in the race for life. The fat fish, therefore, as a general rule, immigrate earlier than the lean fish.

As the causes, to which the constantly recurring typical differences of natural phenomena may be traced, become simpler as the statistical data, which show them, become numerically larger, I consider *the different length of the fattening-period, viz, of the sojourn in the sea*, as the simplest cause of the varying quantity of fat found in the immigrating salmon.

The winter salmon are, in my opinion, therefore, fish which *have been in the sea for a longer period of time*, compared with the majority of their future companions in spawning, either—

(1.) By having skipped the entire spawning period by a period of more than one year; or,

(2.) By letting one more years intervene between two spawning periods. Possibly both cases occur.

The fish have thereby become longer than the majority of their future companions in spawning; they consequently belong to the right half of the third curve (showing size), but they have also become fatter, and therefore immigrate earlier, in order to reach their normal spawning condition. The gain in time which they have made is divided into an increasing and a decreasing phase, whereby they again reach the level of the rest.*

There may also be smaller fish, which go through the same course, because during the normal period they had an opportunity to fatten to an extraordinary degree. It is also possible that some fish which, as to age, correspond to the winter salmon,† on account of not having ready access to suitable food, join the later immigrants.

In reviewing this whole question one should not be led astray by differencs of shape, which may occasion great differences of weight in fish whose length is the same. I would therefore recommend not only an analysis of the flesh of the body, but more especially the proportion of the muscles of the pectoral fins to the weight of the body, as a standard by which to measure the amount of reserve substance contained in the body.

It will also appear from the above remarks that it would be a mistake to determine the emaciation by two series of data showing the weights of fish at any two periods differing about two months. The influence of great masses of salmon coming in July would disarrange the curve still more, if the new immigrants were not somewhat leaner to begin with. We therefore (possibly) owe the plausible result, in part at least, to the fact that various mistakes neutralize each other. Not till the middle or end of July, when from other causes I must consider the immigration of females into our waters as almost finished, can I pay closer attention to the figures indicating emaciation; in my opinion it is only from that time that the actual change of substance (*Stoffwechsel*) commences.

I have finally to direct attention to a sort of counterpart of the fat winter salmon. In reviewing the six groups (or divisions) of female salmon, each containing fish of equal length, considerable variations

*Some exceptionally lean spring salmon had fallen off very much owing to an invasion of leeches; they had gatherings in various parts of the body, and the rays of the fins had begun to fester. Not every lean spring salmon can, therefore, be adduced as proof against the truth of my view.

†Only those muscles which form the bones of the extremities extend to the basis of the rays of the fins.

must be looked upon as perfectly natural, but in some groups (not till July, however) some individuals attract attention by their exceptionally small weight, whilst there is no difference of length. Such fish, (some of which I myself have seen) occur only in isolated instances, one or two being found in a group, and they differ from the next smallest by 500 to 1,000 grams. We evidently have here extremes not produced by natural causes, but by some extraordinary cause. I have sometimes thought that these fish are possibly the counterparts of the winter salmon—impatient fish, which, after their return to the sea, do not skip the spawning period, but which immigrate as early as the summer of the same year, though their quantity of substance is as yet incomplete. Against this, however, speaks the very small weight of the pectoral fins (3.26 per cent. of the body) in a November salmon which I examined. If, moreover, we take those fish from all groups which differ very considerably from the average weight, and place them in groups, each varying from the other by 100 grams, we find no tendency whatever in these figures to form an independent curve; they are and remain scattered and disconnected figures. I therefore consider it probable, at least for the present, that these are pathological cases—fish which, during an invasion of leeches (much feared in early summer, especially when the water is low), or owing to some disease, have lost some of their substance. Supposing this to be the case, I have excluded these scattered figures from the calculation of the averages. Their number is very small (about 15 among 470).

The emaciation of the Rhine salmon in fresh water, which is really the main point of our entire investigation, has now been viewed by us from two standpoints, viz, as self-consumption, in its relation to the length of the starving condition, and as a yielding of substance for the building up of the ovarium. Both these processes require albumen and fat; both draw albumen and fat from the muscle of the trunk, which in March salmon, and even in winter (December) salmon, shows distinct traces of fatty degeneration. But whilst the self-consumption uses much fat, but very little albumen, as is shown conclusively by a comparison of the spring salmon with the midsummer salmon, the growing demand of the ovarium for substance makes considerable inroads on the albumen of the muscle of the trunk in a progression which is not quite regular, and has the same effect as a wasting disease, no matter whether there is much fat or not. Where, therefore, are we to look for the analogy, and where for the difference of these two processes?

The solution of this problem is, in my opinion, found in the condition of the muscles of the fins and of the head, regarding which I have numerous data, showing weights and quantities of albumen; these muscles but rarely share in the fatty degeneration, and they decrease but little, if any, in weight and albumen. What can be the cause? That it cannot be a so-called "morphological cause" (which, to me, is an entirely vague idea, though some other people may be able to fathom it) is clearly shown by the circumstance that the muscles of the ventral fins, which most assuredly are not homologous with the muscles of the trunk, form an exception to the rule. The muscles of the ventral fins degenerate in a moderate degree; and, though they show a marked decrease of albumen, it is by no means as striking as that of the muscles of the trunk.

At first sight one would feel inclined to think of the nerves on which the condition of the muscles depends to a large degree. But in vain have I sought for degenerated nervous fibers; and, moreover, how can it be possible that primitive bundles, some of which are greatly and others but little or not at all degenerated, should be found close together, as—considering the very small number of nerve-fibers entering from the spinal marrow—large masses of muscle are supplied by branches of a primitive fiber?

It therefore seems necessary to turn in another direction for the desired explanation. In soaking portions of different muscles of a salmon (which have been carefully weighed), such as those of the pectoral, ventral, dorsal, and anal fins, and those of the tail and the tongue, in equal quantities of water, we find—as the result of numberless experiments—that, *without exception*, the muscle of the trunk produces the extract having *the least color of blood*. Next to it comes the ventral fin, whilst the reddest extract, often possessing a threefold coloring power, is producedfrom the pectoral fin.* The same result is obtained with sea salmon, whose trunk muscle shows no signs of degeneration. It is the expression of the varying wealth of blood-vessels, which is also noticed in preparing fish.

As the fish in question is a starving fish, the blood cannot be considered as a food-giving liquid, but can only come into play in as far as it is of importance for breathing.

Here the accepted axioms of physiology leave us in the lurch. Whenever it was reported that the organs of a famishing animal decreased in varying degrees, these were principally supposed to be differences in the self-consumption of the organs. In view of this, the grand effort of the Rhine salmon—the building-up of its ovarium from the muscle of the trunk, will hardly be considered by any one as an isolated biological curiosity. Essentially analogous occurrences probably take place a thousand times under circumstances which are far more difficult to understand. In my opinion the experience which we have gathered with regard to the Rhine salmon is destined to extend our knowledge of the dependence of the life of the cells on external causes, by adding another fundamental principle, in which, possibly, one of the most important laws of nature as to the formation of portions of the animal body may lie concealed.

There is a period in the life of the cells of active animal tissue in

*The muscle of the skin cannot be considered in this connection, because its fibers contain the coloring matter of blood.

which this tissue decreases in quantity, not only by self-disintegration, but by protoplasm (organized albumen), being transformed to not organized, soluble albumen, which is absorbed by the juices of the body ('liquidation').

The same tissue may to-morrow absorb, under different circumstances, the same substances which it has given up to day, and grow at their expense.

The conditions of *the giving up of albumen* are *insufficient breathing*, insufficient in proportion to the energy displayed in the dividing processes (*Spaltungs-vorgänge*), and, more than anything else, an insufficient supply of oxygen; this supply must not, however, go below a certain minimum for any length of time.* If this is not the case, the decrease continues until the equilibrium has again been restored between the demand of the decreased quantity of tissue and the conditions of breathing.

The conditions of growth and absorption of substances are, amongst the rest, an ample supply of oxygen and the proper evacuation of the products of disintegration.

The substance which is formed is, besides salts containing phosphoric acid, principally albumen, for I have never found *pepton* either in the muscle of the trunk or in the blood of the summer or autumn salmon; whilst I have found in the serum of the blood more globuline than could in any way be supposed to come from the colorless blood-particles. This albumen may play the same part in the organism as the albumen contained in food which is absorbed by the intestines. Wherever the conditions favor disintegration it becomes disintegrated, and wherever the conditions favor new formation it forms new tissue.

The former (disintegration) is more frequent in male salmon, especially late in summer and in autumn, when the products of disintegration (protamine, guanine, sarkine) gather in considerable quantities in the seminal ducts.

The latter (formation), *i. e.*, the economical use of albumen from the muscle of the trunk for building a new organ, is more frequent in female salmon, as their absolutely necessary consumption of albumen is very small.

We, therefore, have here "stock-albumen," as Voit terms it, containing substances which became disintegrated, if there are no organs which quickly absorb them and draw them away from the current of juices. I have always favored the distinction which Voit makes in this respect. It only became open to objection when, more through Voit's pupils than through himself, they became unnecessarily mixed with rude mechanical hypothesis, relative to the "current of juices rushing through the cells," &c. Whenever this "stock-albumen" becomes rapidly disintegrated

*The insufficient evacuation of carbonic acid or of other products may possibly be one of the principal causes of sudden death. Tissues with strongly alkaline reaction, such as the immature testicles of the Rhine salmon, can at certain periods stand an extraordinary loss of blood, which continues for some time as a normal phenomenon.

we cannot tell whether this process takes place in the liver or in the colorless blood-particles. It is not at all necessary that the bulk of it should circulate through the blood, if only it is capable, when required, of being rapidly absorbed by the blood, like the "glycogen" of the liver or the fat of the fatty tissue. However this may be, there is in the body, independent of nutrition, a certain quantity of albumen which, owing to the locality where it is found, becomes quickly disintegrated, unless there are organs which rapidly assimilate and, so to speak, save it. Similar in its course to nutrition is the "liquidation" of a large organ containing plenty of albumen, if this process can be carried on in such a manner as not to affect the vegetative functions of the heart, nerves, and breathing apparatus.

In the salmon, therefore, it is not only the growing sexual glands which derive advantage from "liquidation" of the muscle of the trunk, but even the gristle of the nose grows, large wounds become cicatrized and all the muscles of the fins which are necessary for moderate motion and proper steering decrease hardly at all; they seem to live on substances from the muscle of the trunk. In short, apart from the muscle of the trunk, the fish lives like an animal which is scantily fed. The cause of this is that it has in its body genuine "stock-albumen."

And still we cannot speak of it as of a "reserve substance," for there is in the muscle of the trunk hardly any intermediate tissue. It is the excitable and contractile fibril of the muscle which, from its protoplasm, supplies substance. It is not a falling to pieces of entire elements of tissue and an absorption of their broken remnants, but the fibers of the muscle remain alive. With the exception of a few places (the convex portion of the tail-part of the vertebral column) I have, even in cases where degeneration had far advanced, never found entirely empty muscle fibers. Nor have I ever found in large sea-salmon—even when, by the length of their nose, or by the ovarium, they showed traces of having recently passed through a spawning period—any signs of the new formation of entire muscle fibers. Perhaps not a single fibril is completely assimilated with the muscle of the trunk.

I do not think it has been proved beyond a doubt that the fatty degeneration and the "liquidation" of an organ always go together, even if, according to the weight of the fins, this seems to be the case with the Rhine salmon.

We may well ask here: What is the principal cause which, when the starving period commences, compels the muscle of the trunk to act as a feeder?

I am here reminded of the technical rule laid down by physiologists, that frogs should be fed on meat if the circulation through their various organs was to be clearly demonstrated. What is the faint pulse of sick people, accompanied by serious disturbances of the process of nutrition, but an indication that, insufficiently elastic, owing to the tension of the vessels, but little blood flows into the heart before every pulsation, and is expelled by contraction, so that the entire quantity of blood requires a longer time to pass through the heart?

I am, therefore, of opinion that when the starving period commences, circulation first of all becomes less energetic, and continues in this course until in some organ or other, owing to insufficient respiration of the tissues, a state of "liquidation" is produced. As soon as vital organs are attacked in this way, death takes place. But if there is a solid organ which does not contain many vessels, but is rich in albumen, and may, comparatively speaking, be easily spared, it serves as a feeder, first of all to the vegetative central organs, and in the second place to the rest of the body, thus making it possible to maintain life. Besides the innate energy of the dividing processes, which is dependent on the temperature, conditions like the ones described above are, in my opinion, mainly instrumental in imparting to animals the greatly varying ability to stand hunger.

Such nutrition, however, must never reach a degree which would again render the energy of circulation normal, for in that case the state of "liquidation" would come to an end, and the food-supplying source would cease.

We thus find in the spring salmon, and more especially interspersed with the thin muscle fibers, rows of fine grains of fat, until in the early part of summer the growth of the ovarium in geometrical progression leads to a positive monthly consumption of substance, the demands of which, in addition to the self-consumption proper, become very urgent. If indications do not deceive, the swelling of the spleen, the extension of its arteries, the filling up of its net-work with blood, are powerful aids in causing the pressure of the blood to sink further, of increasing the state of "liquidation," and extending it to a constantly-growing number of muscle fibers, even such as are in a relatively favorable position with regard to the blood-vessels. At the time, therefore, when the monthly growth of the ovarium has risen from the thousandths to the hundredths per cent. of the weight of the body—from the middle of June till the end of July—we notice that the filling up with grains of fat becomes more intense, some of the fibers becoming almost opaque; and we see those black, shining, jelly-like spleen, resembling large clots of blood, which cause a decreased circulation of blood, less abundant in blood particles.

Meanwhile the ovarium is growing steadily, and the capillary nets of the follicle, numbering 10,000 to 20,000, begin to make such an abundant collateral blood-channel that its influence on the pressure of the blood renders the spleen superfluous. We thus see the spleen gradually diminish again, beginning in August, and remain at its minimum size from September till the spawning period. The ovarium, owing to its changing quantity of blood, is now able to regulate the intensity of the process of "liquidation." This seeming change of the phenomena, however, has this rule in common, that, in some way or other, the pressure of blood sinks till the consumption of matter and the loss of matter are equalized, still leaving something for self-consumption.

Sometimes, however, circulation sinks very low, like fish which in spring have been entirely sucked out by leeches. Some salmon show shortly before and during the spawning period small and large ulcers, with limber undermined bands and adhesive yellow scabs, at the bottom of which muscles and bones are laid bare. Such ulcers are not only, as in former times, found back of the lower jaw (where they may have been caused by constant rubbing against rocks or stones), but more particularly at the basis of the rays of the fins, at the tail, and sometimes on the operculum. Sometimes an entire ray becomes gangrened and falls off. In other parts of the body, especially on the jaws, there may be seen raised, yellow, opaque spots, void of blood, which are probably the forerunners of the ulcers. Fish in this condition are positively sick, and the epithelium, gradually tearing to shreds, indicating a disturbance of its process of nutrition, may well be compared to the tongue of a patient who is very low with a fever. The flesh of the trunk is entirely opaque, whitish, and full of little grains of fat. Even the heart, which has long remained intact, shows in many cases numberless fibers filled with little grains of fat, and to the naked eye shows a brownish color, whilst the inner layers of its flesh are quite tender.

What a different appearance is presented by fish which have passed the spawning period ten days, or, better still, some weeks (empty female fish, caught at the end of December or in January; but also one specimen from Mr. Glaser's fish-boxes, which certainly had lost its eggs not longer than ten days ago). The skin is again bluish, clear, and shining; the ulcers have become cicatrized or are healing; the flesh is transparent, entirely or nearly free from grains of fat; even the fibers of the heart are beginning to be purified, and in the intestines there is no trace of food. The ovarium contains more or less eggs, which, imbedded in a serous and occasionally somewhat suppurated secretion of the follicle skin, shrivel in the most manifest manner, and become absorbed. It is, therefore, a sort of nutrition, as it were—a little pocket-money for the return voyage. The greatest importance, however, I am inclined to ascribe to the pale, shriveled-up follicle skins. The collateral blood-channels of the ovarium have become closed (by contraction of the vessels). The salmon resembles a patient who, after *Esmarch's* bandage has been placed on his leg, has had that limb amputated. Its blood circulates within narrower limits, therefore with a higher pressure, and supplies a smaller quantity of substance than ever before with oxygen; the circulation again satisfies all demands upon it, and the muscle of the trunk again becomes normal. But the difference of color of the extracts with water, between the greatly reduced muscle of the trunk and the muscles of the fins which have remained intact, has become alarmingly small. Vital organs are now attacked, and what little nutritive matter is furnished by the ovarium is partly consumed by the convalescent muscle of the trunk. To all appearances hunger, in its most threatening aspect, does not make itself felt *till this time*, and compels the fish to enter upon its return trip. These late travelers, on their return to the sea, often show little knots in the spleen again, sometimes even considerable swellings. We know now what this means; some organic albumen has to be "liquidated."

Mr. Glaser is inclined to consider the period of this return journey as very short (shorter than I have estimated it), because these fish, in their haste, dash against the sand-banks near *Ste in*, and there run aground, which at other times does not occur. We must also remember that nearly the same weight of fin-muscles has to move a much smaller mass of body, and, what is also in its favor, *down* the stream.

As regards the male fish, the spleen, owing to their greater self-consumption, seems to be drawn upon as early as May and June, when not much weight can be attached to the increase of the testicles. During the summer, and up to September, there are many changes; we sometimes find small, and at other times average-sized spleen, with various intermediate sizes, as it seems to me, in some way corresponding to the varying quantity of blood in the sexual glands; but my investigations of this matter are not far enough advanced to lay down any certain rule regarding it. It seems somewhat singular, especially when we compare with it the striking regularity of this change from small to large spleen in the female fish; which regularity remains the same, no matter whether some of the female fish are more belated than others. Could varying conditions of sexual excitement have an influence on the consumption of matter? One thing, however, is certain: in October, generally early in the month, we find as a rule large (and the largest) spleen. All the maximum weights (as high as 0.86 per cent. of the weight of the body, or sixteen times the smallest weight observed in males) belong to this period. During the spawning period the weight of the spleen again decreases gradually.

The maturing of the sexual gland of the male fish does not require as large quantities of albumen and fat as the ovaruim of the females, but as far as my experience goes,* the sexual gland needs all the more phosphoric acid salts to form the various substances of the semen which contain phosphorus. Taking the weight of the mature testicles as 5 per cent. of the weight of the body, with 25 per cent. dry substance of 11.3 per cent. phosphoric acid,† we find that the growing testicles must take away from the blood 0.141 per cent. phosphoric acid; a larger quantity than is contained in one-half of the mature ovarium of a female fish of equal size. Why should not the hunger for phosphorus with the male fish produce similar effects as the hunger for albumen with the female?

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* *Die spermatozoen einiger Wirbelthiere* (The spermatozoa of some vertebrates), in the Transactions of the Basel Society of Natural History, vol. vi, part 1, p. 147.

† The same work.

This demand can only be met by the "liquidation" of muscle-substance containing phosphorus.

The falling off and the degeneration of the heart of the females described above I have also occasionally noticed in males, but not nearly as frequently. The purification of the skin, however, and especially the disappearance of the little grains of fat from the muscle of the trunk, I have often met with in a more or less advanced stage. One of the fish made an exception from the rule (as has been mentioned before), and had taken food. Though to a less extent, similar conditions may have to be taken into account, as with the females. I am inclined to lay considerable weight, as regards the improvement of the respiration of the tissue, on the reaction and consequent *decrease in the consumption of oxygen and substance*, which certainly follows the strong excitement of the spawning period.* The low temperature of the months of December and January, following close upon the spawning period, may also do its share of the work. It may safely be asserted, moreover, that when the season of extraordinary excitement is over, the blood-vessels of these lean fish have to supply only about two-thirds or even only one-half the original quantity of muscle, and that the demand and supply of oxygen have become nearly equalized.

The proof of the "*liquidation*" *of organs* and the description of the conditions under which this process takes place, which have been furnished by the investigations relative to the Rhine salmon, will, I think, very soon bear fruit on a more extended physiological and pathological field. Many interesting facts are scattered all through the literature of the salmon, but they were disjointed, and there seemed to be no proper connection between them, because the important element of "*liquidation*" was wanting; and because whenever there was a question of the dissolution of dead elements of tissue, the positive *loss of matter* by an organ was erroneously considered identical with a *change of matter*. I will here only remind the reader of the intensification of the disintegration of albumen by phosphorus, as shown by *J. Bauer*,† which fact has been corroborated by the investigations of *O. Frànkel*.‡ *Bauer* attempts an explanation by speaking in a somewhat vague manner of "an equilibrium between organs and juices." *Frànkel* quotes an attempt at an explanation by *L. Traube*, which very correctly lays stress on the difference in

*An observation made by Mr. Glaser, about 15 years ago, shows how high the passions of these fish run during the spawning period. He had placed a trap containing a male fish in the Rhine, directly above Basel, near to a spawning female salmon. A male salmon of medium size, prompted by jealousy, made violent attacks on the fish in the trap, and was caught, the iron prongs piercing his body. But as the trap was old and did not work very well, he succeeded in getting loose. He returned three times, however, and tore himself loose as many times, until a new trap was set, in which he was finally caught, his whole body being torn and bleeding from twenty wounds.

† *Zeitschrift für Biologie*, vii, viii.

‡ *Virchow's Archiv.*, lxvii.

the disintegration of living and dead albumen, but only supposes that there is an increased mortification of elements of tissue. How much easier can these and other phenomena be explained, as soon as we know for certain that it is not a question of life or death, but only one of disturbance of the equilibrium of normal conditions of life; and as soon as we take into consideration the circumstance that even organs like the obliquely-striped fibers of the muscle, without losing their excitability, and without—so to speak—making much stir, throw enormous quantities of albumen into the juices delivering them to disintegrating processes, under conditions which can at any time be fulfilled through the system of the vascular nerves? Is it certain that the few milligrams of phosphorus really produce the well-known and extensive fatty degenertion by exercising a direct influence on every fiber and cell of a mass of muscles and glands weighing many kilograms? May not this influence be exercised by means of the system of vascular nerves, and by a radical disturbance of the circulation? And, finally, we should seriously inquire if this same anomaly in the distribution of the blood—caused by a feverish process and in a nervous way affecting the retention of heat in the body—does not also produce the state of liquidation of the muscles, the consequent intensified disintegration of the albumen, the diminished desire for food, and the consumption, which no feeding can check.

These hints will sufficiently explain why I have made the conditions of life of the Rhine salmon the subject of exhaustive investigations. We are here confronted with the strongest and most effectual tendency to starvation known to physiology; owing to the supremacy exercised by the mass of *one* organ over all the rest, we are favored with a clear view of the internal economy of the substances of the animal body, such as we shall rarely find in any of the other animals which are generally made the subjects of such experiments. To find such objects as will aid in solving the different dark problems of life is, in my opinion, the proper aim of comparative biology.

APPENDIX F.

PROPAGATION OF FOOD-FISHES.

GENERAL CONSIDERATIONS.

XV.—REPORT ON THE CONDITION OF PISCICULTURE IN FOREIGN COUNTRIES FROM DOCUMENTS COLLECTED AT THE INTERNATIONAL FISHERY EXPOSITION AT BERLIN, 1880.

By M. C. Raveret-Wattel.*

THE UNITED STATES.

To this day pisciculture has nowhere produced results which can be compared to those obtained in the United States. In no other country has this industry attained to the same degree of development, perfection, and success. But it must also be said that perhaps no other nation has so fully understood the great importance of pisciculture, and that in no other country have such great efforts been made. Nowhere, certainly, has so much been accomplished by private enterprise; nowhere has the government given so much enlightened care to the rational cultivation of the waters, and afforded such efficient protection and generous encouragement.

At present thirty-six States or Territories of the Union have each an official piscicultural organization, called a State Fish Commission, generally composed of three members, whose services are, in nearly all cases, given gratuitously,[1] and whose authority is generally limited to a period of three or four years. These Commissioners may, however, at the expiration of their term, be reappointed for another term; and their official position somewhat resembles that of the commissioned Inspectors of Fisheries of Great Britain. Their authority, however, is in no case very great. It is their duty to instruct fishermen, to stock the waters with young fish from the State piscicultural establishments,[2] to act as experts for the government, to point out desirable changes in legislation, to repress abuses, to adopt protective measures,[3] introduce

*_Rapport | sur la | situation de la pisciculture à l'étranger, | d'après les documents recueillis à l'Exposition internationale | de produits et engins de pêche de Berlin_ | en 1880, | par M. C. Raveret-Wattel. | Bulletin mensuel | de la | Société nationale | d'acclimatation | de France, | 3e série, tome ix, | No. 2, February, 1882, | p. 69.—Translated from the French by Herman Jacobson.

[1] They are only reimbursed for their traveling expenses, and for expenses incurred during scientific researches or technical labors performed by them.

[2] The management of each establishment is generally confided to a superintendent, who draws a salary, and who is responsible for his administration.

[3] In the United States legislation affecting fishing differs in the different States. In the Northern States it generally resembles, more or less, the English legislation. Nearly

improvements, &c. Every year they submit to the legislature a statistical report, showing the work done during the year, the progress attained, and the observations made respecting pisciculture or fishing industries, the quantity of eggs or young fish distributed, &c.

Twenty-one States have State-hatcheries for the production of young fish, destined to restock the public waters. Some States, like Michigan, possess as many as three of these hatcheries. There are, therefore, in operation thirty-eight of these establishments, not counting those created for the piscicultural work undertaken by the Federal Government, besides that done by the States on their own account. In Connecticut the commission, which does not yet possess a hatchery, has made a contract with two private establishments for producing the young fish which it needs annually, and pays to the owners of these establishments a dollar for every thousand eggs which it hatches.

To the State of Massachusetts belongs the honor of having officially introduced pisciculture in the United States. This State was the first to intrust to a commission "the duty of studying facts relative to the artificial propagation of fish, and the ways and means of causing this industry to contribute, under the protection of the law, to the wealth of the State." Various experiments were made (in 1856) by this commission, which published a report on the condition of pisciculture in foreign countries, including a translation of the remarkable article published by M. Jules Haime in the *Revue des deux mondes* in 1854.

But the idea was not yet fully matured;[4] the public did not fathom the full importance of these experiments, which passed almost unobserved; and it was only in 1865 that Massachusetts definitely constituted her Fish Commission on the present basis.

Vermont and New Hampshire, and later, Connecticut and Pennsylvania followed the example set by Massachusetts, and created Fish Commissions whose duty it should be to restock the public waters. In 1864 Mr. Seth Green founded, near New York, the first American piscicultural establishment, on thorough business principles, and he soon found many imitators.

The results obtained by private enterprise proved the importance of similar establishments for rapidly restocking water-courses, and, in 1867, the State of Massachusetts established at South Hadley Falls, on the Connecticut River, a hatchery for the artificial propagation of shad.

In the same place and the same year Mr. Seth Green, who had also occupied himself with the propagation of shad, invented his hatching apparatus, consisting of inclined boxes floating in the water. These

everywhere, even in the largest rivers, such as the Mississippi, the right of fishing belongs to the inhabitants of the banks, but only to the point where the tide makes itself felt, and where the maritime domain commences. In the Southern States, on the contrary, the right of fishing in the great water-courses belongs to the State.

[4] It is only three years since Mr. Theodotus Garlich and Prof. H. B. Ackley of Cleveland, Ohio, the two pioneers of American pisciculture, made their first attempts at artificial fecundation.

boxes bear his name, and are as simple as they are ingenious, easy to manage, and inexpensive, and have in a very short time been adopted throughout the whole of the United States.[5]

A beginning had been made. The States of Maine (1867), New York (1868), California, New Jersey, and Rhode Island (1870), Alabama, (1871), Ohio and Wisconsin (1873), &c., soon possessed their official piscicultural service.

The year 1871 marks an important era in the history of pisciculture in the United States; from this year date two institutions, which have exercised a very beneficial influence on piscicultural industry throughout the entire territory of the Union, viz., *The American Fishculturists' Association*, and *The United States Fish Commission*.

William Clift, A. S. Collins, Fred. Mather, Dr. J. H. Slack, and Livingston Stone, all distinguished pisciculturists, well known by their writings and their practical labors, were the founders of the association, which has rendered such enormous service by influencing public opinion, and by giving a powerful impetus to piscicultural enterprise.

The useful character of the work accomplished in many States by the Fish Commission had not escaped the attention of the Federal Government, which, advised of the decrease of the results of both river and sea fisheries in all parts of the Union, did not hesitate to institute investigations as to the causes and remedies of this evil. A law passed by Congress on the 9th of February, 1871, authorized the appointment of a "United States Commissioner of Fish and Fisheries." The law empowered the President of the Republic to appoint said Commissioner with the sanction of the Senate, and stipulated that his services should be rendered gratuitously.

The President appointed to this important position Prof. Spencer F. Baird, then Assistant Secretary of the Smithsonian Institution, well known by his valuable works on zoology. No better selection could have been made; a vast knowledge, a prodigious capacity for work, great perseverance, enlightened zeal, indefatigable activity, a devotedness to his purpose bordering on self-denial, such are the eminent qualities which Professor Baird has brought to the exercise of those useful and absorbing duties which have been confided to him, and by the fulfillment of which he has justly become entitled to public gratitude, not only in the United States, but also in foreign countries benefited by the investigations and labors of the United States Commission of Fish and Fisheries.[6]

As soon as Professor Baird was appointed, he began work by conducting on the coast of New England for several months during the year

[5] A description of these boxes, and of other apparatus employed in America, will be found farther on.

[6] We will here only recall the large number of embryonated eggs of various kinds of salmonoids (*Salmo quinnat, S. fontinalis, S. sebago, Coregonus albus, &c.*) which so frequently and liberally have been sent to France, Germany, England, Austria, the Netherlands, Russia, Canada, Australia, New Zealand, &c.

1871 exhaustive investigations relative to the condition of the fishing industries, and the causes which influence the development thereof.

In 1872, Congress added to the duties of the Commissioner of Fisheries that of restocking the waters, and his labor was henceforth divided into two distinct branches, viz:

(1.) Investigations relative to the fisheries: Statistics, zoological researches, dredging, sounding, &c.

(2.) Piscicultural operations. Artificial increase and propagation of the principal kinds of food fish[7] throughout the whole extent of the Union.

Each of these two branches of work has its special appropriation, the total amount of which, in 1872, amounted to $20,000, and has been gradually increased, so that at present the annual appropriation exceeds $80,000.[8]

The strictest economy is constantly practised in the expenditures. The Commissioner receives no salary whatever. Only a few assistants, charged with special duties (voyages of exploration, superintendents of the hatcheries, stocking operations, &c.), receive salaries. Specialists, who are occasionally employed, receive some remuneration, but only temporarily. Three or four clerks constitute the entire force of the Commission, which every day receives and dispatches a considerable amount of correspondence.

The establishments founded by the Commission are liberally supplied with all the necessary material, but no concessions are made to luxury and elegance.

Since 1872 eight zoological stations have been successively organized on the coast of the Atlantic for the purpose of carrying on researches in the interest of the fishing industries.[9] These investigations have been carried on in different localities each year, and the arrangements are

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[7] A report on the work accomplished and the results obtained is every year made to Congress by the Commissioner. This annual report is always accompanied by appendices (various treatises concerning the fisheries and pisciculture), which are generally documents of exceedingly great value both from a scientific and practical point of view. Six large octavo volumes of these reports have, so far, been published.

[8] For the period 1871 to 1880 the total expenditure of the Fish Commission has been $476,200.

[9] During the same period sounding and dredging operations have been carried on in more than 2,000 different localities by government vessels placed at the disposal of the Commission. These investigations have been productive of many good results. Besides a large number of very interesting observations respecting the temperature of the water, the currents, the nature of the bottom, &c., very important collections have been made and numerous species of crustaceans, mollusks, annelides, &c., have been studied and described. Two new kinds of food fish have been discovered in depths to which the fishermen had not yet extended their researches, viz, the *Lopholatilus chamæleonticeps* and the *Glyptocephalus cynoglossus*. The first mentioned is found in considerable quantity on a bank where its presence was not even suspected; the second, which belongs to the family of the *Pleuronectes*, had so far been entirely unknown, because the small size of its mouth did not permit of its being caught with lines, and because, owing to the great depth at which it lives, it can only be taken with very strong nets.

essentially of a temporary character. Some of the establishments are specially devoted to various experiments in pisciculture, such as the artificial propagation of the shad, of the codfish, the herring, and some other fish. But there are, besides, some permanent establishments, nearly all of which are each devoted to one special kind of fish, producing the embryonated eggs or the young fish needed for stocking the waters. Four of these establishments are of special importance; these are the one at Bucksport, Me., for common salmon; the one on the McCloud River, California, for California salmon; Grand Lake Stream, Maine, for lake salmon, called "land locked salmon"; and Northville, Mich., for fish of the Coregonus species.

The first of these establishments is in charge of Mr. Charles G. Atkins, formerly Commissioner of Fisheries of the State of Maine, who has made the raising of salmon the subject of special studies. We are indebted to him for treatises and observations of great practical utility, of which we shall have occasion to speak below. The establishment, located on the Penobscot River,[10] is entirely constructed of wood, with double walls, the space between being filled with sawdust, which shelters the interior equally well from the heat and cold. The large incubating room, 23 meters long and 9 meters broad, is occupied by 40 long wooden troughs, placed parallel with each other and lengthwise of the room, in groups of four, and furnished with wire frames for receiving the eggs to be hatched; 4,500 liters of water every 24 hours feed these troughs. This hatching establishment annually produces 6,000,000 to 7,000,000 of embryonated eggs, and hatches 4,000,000 to 5,000,000 young fish.

Two interesting facts must be mentioned respecting the Bucksport establishment, viz, (1) the application of the so-called "dry method," which its director, Mr. Atkins, has applied from the very beginning to artificial fecundation; (2) the system of "parking" salmon, also practiced by the director, so as to insure, at the proper time, a sufficient quantity of eggs and milt.

According to Mr. James W. Milner,[11] an assistant in the Fish Commission, a note on pisciculture in Russia, published in 1870 in the *Bulletin de la Société d'acclimatation*[12] had at the time drawn the attention of American pisciculturists to the happy results obtained by Mr. Vrassky with his method of fecundation, which consists in placing the eggs *dry* in a vessel, and moistening them with milt diluted in water. This is the so-called "Russian" method. Mr. Atkins conceived the idea of pushing the application of this system still further by moistening the dry eggs with undiluted milt, and adding the water afterwards. The

[10] This establishment is not maintained entirely at the expense of the Federal Government; several States generally subscribe a certain sum for the annual expenditure, and receive a number of embryonated eggs proportioned to the sum subscribed by them.

[11] J. W. MILNER: *The progress of Fish-culture in the United States.*

[12] PAUL VŒLKEL: *L'établissement de Nikolsk pour l'éducation des poissons de luxe.* Bulletin 1870, p. 508.

result was excellent, as very few eggs failed to be fecundated. This mode of procedure, which constitutes the so-called "dry" method *par excellence*, is at the present day generally employed throughout the United States.[13] Its advantage over the "*moist*" method will easily be understood when one calls to mind the rapidity with which the spermatozoa of the milt lose their vitality when diluted with water.[14]

In operating on so large a scale Mr. Atkins occasionally found it difficult to procure the number of male and female fish, ready to spawn, which he needed for his artificial fecundation. He therefore took care to "park" in advance (according to the necessity of the case five or six months, and according to the number of fish caught in the Penobscot River) a large number of salmon.[15] These salmon are kept imprisoned till the moment they begin to spawn, when they are caught again for the purpose of gathering eggs and milt. At first they were placed free in a pond of an area of 24 hectares, but with this extent of water it became very difficult to catch them at the exact time when they were needed. It therefore became necessary to "park" them in a more limited space. A wire barrier extended across the pond only left them about 4 hectares; but as this barrier was not strong enough to offer resistance to powerful fish, which always found means of forcing a passage, it had to be replaced by a permanent barrier or wall of clay.

More recently, a small water course, a tributary of the Penobscot River, the Dead Brook, has been used for "parking" these reproducing fish. In this water-course an inclosure has been made by means of two barriers across the stream, formed of poles, placed in such a manner as to keep the salmon imprisoned whilst leaving a free passage for the water. In this inclosure are placed all the live salmon which can be procured during the season when fishing is permitted. These salmon are bought

[13] It is, as we have seen before, also very generally employed in Germany, and is the only method actually followed at Hüningen.

It should be mentioned that several practical pisciculturists have by their experiments been led to identical results. Mr. Seth Green one of the veterans of American pisciculture, has followed the "*dry*" method for a long time, the process of which he has for several years kept secret. The employment of this method gave him a decided advantage over other pisciculturists who followed the "*moist*" method, and invariably sustained losses by large numbers of their eggs not becoming fecundated.

[14] From experiments made by our eminent vice-president, M. *de Quatrefages*, it appears that the vitality of the spermatozoa only lasts—

In the milt of the barbel	2′ 10″
In the milt of the perch	2′ 40″
In the milt of the carp	3′
In the milt of the roach	3′ 10″
In the milt of the pike	8′ 10″

The above figures, however, must be considered as maxima, which are not always attained. (Memoir read at the Academy of Sciences May, 1853.)

[15] In Switzerland live salmon are sometimes brought in close proximity to the places where they were to spawn; or salmon ready to spawn have been kept "parked" for a few days so as to procure eggs or milt for artificial fecundation; but nowhere, as far as we know, have grown salmon been kept captive as long as at Bucksport for the purpose of procuring a sufficient number of reproducers.

from the owners of the weirs or permanent fisheries, and are taken to the inclosure in boats furnished with fish boxes. The depth of water in this "park" varies from 70 centimeters to 5 meters. An abundance of aquatic plants and shrubs on the banks, whose branches overhang the stream, furnish ample shelter and protection from the rays of the sun, for even in places where the water is deepest the temperature at the surface during the hot summer days only reaches 75 to 80 degrees Fahrenheit.

Throughout the whole extent of the inclosure the bottom is covered with a thick layer of mud, so as to prevent the salmon from spawning, which many of them would undoubtedly do if they found a sandy bottom.

The upper barrier is located in a place where the stream is shallow and only 4 meters broad. A small shed, close by, holds the necessary material for gathering the eggs and transporting them to the incubating establishment, which is located at a distance of about 5 kilometers.

When, in October, the days begin to grow cold, the instinct of reproduction makes itself felt in the salmon, which begin to seek favorable places for depositing their eggs. They leave the deep places where they have spent all summer and go up the stream until they reach the upper barrier, near the shed or pavilion above referred to. Twenty meters below this barrier a solid net stretched across the stream only leaves in the middle a narrow passage, on the principle of the fish-pot, permitting the salmon to enter without difficulty, but preventing their getting out again. They are thus kept prisoners within a very small space where they can be caught without the least trouble.

They are thereupon distributed, according to sex, in floating boxes, from which they are gradually taken by the operators whenever they are needed for artificial fecundation. These fish generally number five to six hundred and are capable of furnishing five to nine million eggs.

The fecundated eggs are immediately placed on wire frames and carried to the hatching establishment, where, without delay, they are immersed in the incubating troughs. At the end of sixty days they are embryonated and may be sent to any distance.[16]

[16] Eggs have thus been sent as far as Australia, where, at the present day, there are several water-courses which have salmon that originated in the Penobscot River. When all the eggs have been gathered, the total number is ascertained, which is an easy matter, as every incubating frame having a single layer of eggs contains about 2,000; so you have only to count the frames. According to the total expenditure of the establishment during the current year the retail price per 10,000 eggs is fixed, and this price serves to determine the quantity of eggs to be given to each subscriber in proportion to the amount of his subscription. In 1881 the subscription and the proportionate quantities of eggs were as follows:

	Subscription.	Proportionate quantities of eggs.
Federal Government	$1,757	950,000
State of Maine	2,000	1,080,000
State of Massachusetts	590	270,000
State of Connecticut	300	162,000

At first, tin boxes of various sizes were employed for transportation, but the high price of these boxes caused them to be very soon replaced by boxes made of light wood, where the eggs are kept wrapped up in cloths and moist moss, according to the method generally adopted in Europe. For long distances a double box is used, with an intermediary and isolating layer of sawdust between the two walls which protects the fish both against heat and cold.

The results of the experiments in stocking water-courses with fish by means of eggs from the Bucksport establishment soon became evident. While the common salmon (*Salmo salar*) were formerly unknown in most of the streams of the United States (only being found in some rivers in Maine, the Penobscot, the Kennebec, &c.) they are, at the present day, found in many rivers and streams where they have been artificially introduced. In fact they are found in nearly every water-course from the river Denny in Eastern Maine to the Susquehanna in Maryland. The Merrimac, the Delaware, and the Pemigewasset are particularly rich in salmon. The same applies to the Connecticut River, where fish weighing 10 to 20 pounds are caught by hundreds and are sent to the New York markets. Such are the results which have been attained within the short space of six years.

The introduction of the common salmon, however, cannot be accomplished everywhere; for only in sufficiently fresh and clear water will there be any chance of success. The Fish Commission has, therefore, endeavored to find a species of fish which is less exacting as to the nature of the water; and its attention has been directed to a species of salmon (*Salmo quinnat*) found in a number of streams flowing into the Pacific Ocean,[17] and particularly abundant in California streams, notably the Sacramento and McCloud Rivers. This species of fish is robust and endowed with a remarkable power of resistance to heat, and seems specially designed for introduction into those water-courses where the *Salmo salar* could not live, either on account of the temperature of the water or on account of its being muddy.

We have in a former article[18] pointed out the great interest which attaches to the propagation of the California salmon, and given some information regarding the labors of the Fish Commission to spread this valuable kind of fish as much as possible. We think, however, that we must add some details calculated to give an idea of the gigantic scale on which the labors of the Fish Commission are carried on.

The first experiments were made in 1872, at the suggestion of Mr. Robert B. Roosevelt, Member of Congress. Mr. Livingston Stone, who

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[17] The so-called "California salmon" is considered to be absolutely identical with the Sacramento salmon (*Salmo quinnat*, Richard), one of the largest members of the salmon family. The salmon caught in the Sacramento River generally weigh 20 pounds; but there are some weighing 100 pounds. The flesh of this fish is equal in quality to that of the *Salmo salar*.

[18] RAVERET-WATTEL: *Le saumon de Californie.* Bulletin de la Société d'acclimatation, January, 1878.

was placed in charge of these experiments, went to California during September of that year, thinking that he would arrive before the beginning of the spawning season, but he was too late, and it was only possible to gather a few thousand eggs, because the California salmon spawns much earlier than the common salmon, towards the end of August.

Mr. Stone, however, did not make his first journey entirely in vain, as he gathered much valuable information which enabled him to repeat the experiment during the following year under more favorable circumstances. The river McCloud was selected as the center of operations. This river, fed by the melting snow of Mount Shasta, has plenty of very cold water; which is not, like many other California rivers, made turbid by the washing of auriferous minerals. The hatching places are therefore always visited by numerous salmon.

On the banks of this river, and surrounded by Indian tribes, who, if not openly hostile, are at any rate not very kindly disposed towards the "pale faces," Mr. Livingston Stone pitched his tent, and laid the foundation of a fishing and piscicultural station,[19] whither he goes every year for four or five months, to gather salmon eggs, to fecundate them artificially, and to submit them to the beginning of the incubating process' because only when the eggs have become embryonated can they be sent to great distances without much difficulty.

On account of the large number of fish operated upon,[20] and the equally large number of eggs harvested (often nearly 10,000,000) these different operations represent a considerable amount of labor. A barrier stretched across the river stops the salmon in their ascent, and permits their being captured by means of immense seines. It is necessary that this barrier—a sort of palisade composed of poles placed close to each other—should be very solid, for the legions of salmon, often of enormous size, which throw themselves against it sometimes force a breach and succeed in making their escape. The labor of repairing such breaches, which of course ought to be done just as quickly as possible, is very difficult, obliging men to stand in the water, sometimes up to their neck; and this water, produced by the melting snow, is always very cold, even in summer resembling ice-water.

For the purpose of storing the captured fish, a "park" or corral has also been constructed here, by means of a row of palisades in the bed of the river. From this "corral", containing the direct products of the fisheries, the men in charge of the fecundation, draw the salmon which they need. But it is no easy matter to free these fish from their

[19] The encampment has been called *Baird*, in honor of the distinguished Commissioner of Fisheries.

[20] The eggs and milt which are harvested are all furnished by 5,000 or 6,000 salmon; but, in order to procure that number of fish ready to spawn immediately, forty or fifty times as many have to be caught. It is not a rare occurrence at Camp Baird, that from 7,000 to 9,000 salmon are caught a day; for a single haul of the seine often brings up 1,200 to 1,400; but it likewise often happens that, among several thousand, only a few hundred are able to furnish spawn immediately.

eggs or their milt; for they nearly all weigh from 15 to 20 pounds (often more) and are not easily managed. A veritable struggle with the fish has to be gone through; a struggle all the more fatiguing, as the back has to be bent in order to be able to gather the spawn.[21] Frequently the men have their hands lacerated by the rays of the fins or by the hard teeth of the male fish, which inflict painful and slow-healing wounds.

It should, moreover, be remembered that this operation has frequently to be carried on during the night, when the air is quite cool; for in this mountainous region the nights are, during the summer season, as cold as the days are hot. The station men who have often, during day time, to do hard work in a broiling sun, at a temperature of 54° C., are frequently at night while engaged in fishing or in artificial fecundation subjected to a cold air of +11° C., and, moreover, with their clothes constantly soaked in ice-water. Very few of them escape the consequences of such fatigues and exposure to a rapidly changing temperature; and this generally shows itself even during the first week by attacks of fever and rheumatic pains. Only men possessed of very strong constitutions can stand this work and carry it on without interruption.

In spite of all these difficulties the number of eggs gathered and fecundated every day generally exceeds 300,000, and often goes as high as 800,000 or 900,000. The gathering, that is the spawning, commences generally about the 20th of August, and comes to a close about the 15th or 18th of September.

The incubating process takes place in wooden troughs arranged parallel to each other on a scaffolding about breast high, and sheltered by a vast tent 20 meters long and 10 meters broad. These troughs, to the number of ten, are grouped two by two, leaving sufficient space between them to allow the watchful care and the manipulations which the eggs require. Each large trough is formed of three smaller ones, five meters long, placed end to end, with a difference of level of a few centimeters, to give fall to the water which is necessary to keep it fresh. In spite of the rapidity of the current and a sufficient quantity of water, the eggs at the end of the troughs are sometimes exposed to a lack of oxygen, the water having yielded to the eggs higher up the greater portion of the air which it contained.[22]

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[21] But as the object is not to keep the fish, and as it consequently does not matter even if the fish are a little hurt, skillful operators often manipulate only small salmon. They hold the head of the fish tightly between their knees, hold the tail in the left hand, and with the right extract the eggs or the milt. Large fish often require two or three men to manage them. The salmon which have thus been operated upon are abandoned to the Indians of the neighborhood, whose friendship and even aid in this difficult work is thus gained, at least to a certain point.

[22] Mr. Livingston Stone states that, especially towards the last period of the embryonic evolution, the eggs need plenty of oxygen in the water. At the beginning of the hatching process, the eggs may, without any detriment, be heaped up in the apparatus and exposed to a feeble current; but from the time the embryo becomes distinctly visible, great care should be taken to spread the eggs on the frames, and to make the current as rapid as possible.

In each trough the eggs are arranged on wire frames fixed in an ingenious manner (the Williamson apparatus) which we shall describe below. This method economizes much space (which is particularly useful when large quantities of eggs are to be operated on), and thoroughly aërates the water by keeping it constantly in motion.

Long boards, forming covers, should be placed over the troughs; for the light which, by daytime, penetrates the canvas of the tent would be sufficient to destroy the eggs.

The water which feeds these hatching troughs comes from the river. It is raised to a height of 3 meters and led into the apparatus by means of a hydraulic wheel, supported by two boats in the middle of the river, and furnished at its circumference with large buckets which at each revolution pour their contents into a wooden aqueduct raised on poles. This wheel, placed in the midst of the rapids, is thus driven by a very strong current, and is sufficient to raise and supply the apparatus with about 300,000 liters of water per hour.

The water of the river McCloud, which is almost always limpid during the fine season of the year, becomes generally turbid during the spawning season of the salmon, as these fish root in the sand to make their nests. In order to serve for the incubating process, this water must be considerably filtered. The filter used consists of three wooden boxes, the one of which, larger than the others, forms a first receptacle. The water flows through it, first through a vertical wall of coarse cloth or canvas, doubled, and firmly extended on a frame, and afterwards through four similar walls of flannel or some woolen fabric; each wall presenting a filtering surface of 1 square meter. In the two other boxes it flows through a triple canvas and seven flannel filters.

As the temperature of the water in the hatching troughs averages 12 to 14 degrees C., the eggs are generally embryonated at the end of sixteen days; when they have reached that degree of development desired for their transportation, they are packed in damp moss and placed in boxes measuring 60 by 15 centimeters. This packing in itself involves considerable work, considering that 10,000,000 eggs represent a volume of about a hundred decaliters. More than 200 decaliters of moss are required for packing these eggs in an almost equal number of boxes, which are packed two by two in hay in open cases, having an upper compartment destined for the ice which is supplied during the journey. The whole thus packed makes a hundred packages, weighing in all more than 20 tons. On account of the heat the packing must be done very rapidly, and requires a great degree of activity.

At last everything is ready, and nothing remains to be done but to forward the packages to their destination. They are (care being taken to shake them as little as possible) by a rather rough road of 35 kilometers, taken to Redding, Cal., the nearest station on one of the branch lines of that gigantic railroad (the Central Pacific Railroad) which unites the coasts of the Pacific and Atlantic, climbing the solitary heights of the Rocky Mountains and crossing the immense prairies of the "Far

West." After a journey of almost 4,500 miles the eggs arrive in the Eastern States, where they are distributed in accordance with the demands made by the various State commissions. Those destined for Europe are sent to New York, where, under the care of Mr. Fred. Mather, assistant of the U. S. Fish Commission, they receive, before being shipped, a new, special packing according to the method invented by that skillful pisciculturist. They are placed in thin layers on a sort of rectangular tray formed of light wooden frames, over which a kind of cotton fabric is extended. These frames are thick enough to allow of a number of them being placed one above the other without crushing or pressing the eggs. A solid box incloses the whole, leaving at the top, and sometimes also at the sides, an empty space sufficiently large to hold the ice needed for keeping the temperature low and retarding the embryonic evolution. Thanks to this ingenious arrangement, and by taking the precaution to have the ice renewed as soon as it is melted, eggs could safely be sent longer distances than across the Atlantic.

In spite of the very large and constantly increasing number of eggs annually distributed, this number is still insufficient to supply the steadily increasing demand for them, which is caused by a growing recognition of the merits of the California salmon.[23]

Of all the salmonoids this one is certainly best adapted to artificial propagation. When properly packed and kept at a sufficiently low temperature, eggs may be transported with hardly any loss. The loss in the hatching apparatus during the period of incubation is generally very small. As regards the young fish they are exceedingly vigorous and grow rapidly, and the mortality which takes off so many young fish of other kinds is hardly noticed among them. Every one who has raised them has been struck with the robustness and vigor of these young fish, and particularly with their excellent appetite, all of which are very favorable symptoms in young fish. When grown these fish easily adapt themselves to the most varied conditions of life. They ascend the Sacramento when the waters of this river have become muddy from frequent rains and the washing of minerals. In July and August they enter the San Joaquin River in large numbers, and ascend that stream a distance of 150 kilometers, thus traversing the hottest valley in California, where the temperature of the air, rarely lower than 26° C. at noon, often rises to 40° C. The temperature of the water of the river varies from 28° C. at the surface to 27° C. at the bottom. Leaving the hot and turbid waters of the San Joaquin, these fish full of vigor will enter, for the purpose of spawning, the tributaries of that river, the Merced, the Stanislaus, &c., which are principally fed by the melting snow among the mountains.

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[23] The total number of eggs gathered and distributed up to date is about 80,000,000. In order not to exhaust the McCloud River by thus constantly drawing upon the products of its spawning places, the establishment annually hatches from 1,000,000 to 1,500,000 eggs to supply the river with young fish, which is therefore always full of salmon, though possibly not to the same degree as in former times.

To judge from the nature of the waters which are continually inhabited by the California salmon, it seems certain that these fish could be successfully introduced in a large number of water-courses. In the United States these salmon seem to spread very successfully in the Eastern States, where few rivers have as turbid waters as the Sacramento, or as hot water as the San Joaquin. Furthermore, the long journeys annually undertaken by the California salmon, the strength and energy exhibited by these fish during their migrations in the waters of the Sacramento and McCloud Rivers, all prove that no other kind of fish equals them in the capacity of ascending the rivers for a considerable distance from the sea for the purpose of spawning.

The Shoshone Falls on the Snake River, one of the tributaries of the Columbia River, is the point where the salmon stop and where large numbers of them spawn; and these falls are more than 700 miles from the sea. It does not seem impossible, therefore, that the California salmon might live and flourish in the Mississippi, the tributaries of which river would afford spawning-places at a shorter distance from the ocean. As for waters of the Gulf of Mexico, where its annual migrations would take this fish, they are not any hotter at a certain distance from the mouth of the Mississippi than the waters of the sea along the coasts of New England. These considerations have induced the Fish Commission to make vigorous efforts to propagate the California salmon in the Southern States, where a special establishment will soon be created for the artificial propagation of these fish.

So far this salmon has been introduced into a large number of water-courses; and also into several lakes having no communication with the sea, where they have nevertheless begun to increase. It will hardly be necessary to point out the great importance of acquiring for our own waters a species of fish so remarkable and valuable in every respect.

XVI.—THE ARTIFICIAL PROPAGATION OF FISH.

By J. P. J. Koltz.

Chapter I.

§ 1.—*The artificial fecundation of fish-eggs.*

Whoever desires to engage in the artificial propagation of fish should endeavor to take nature for his guide in his manipulations. In the present work we shall do everything in our power to explain every principle by an example from nature, and shall refer to the results of experiments made in other places, without, however, entering into a useless and detailed examination of the different methods which so far have been recommended. We shall above everything else limit ourselves to indicating those methods which, after repeated experiments, promise certain success, directing attention at the same time to those points which are still somewhat dark and on which positive observations must throw further light.

When the spawning season has commenced one procures some males and females of that kind of fish which he desires to propagate artificially or to cross with other breeds. These fish are placed in tanks of sufficient size, keeping if possible each kind of fish separate, and taking care to give to all kinds those conditions of life which their nature demands. Thus trout, salmon, barbel, &c., which live in running or cold water, and propagate in it, should be placed in basins or tanks fed from springs, or by clear water which is renewed from time to time; whilst the carp, tench, &c., which spawn in stagnant waters, should be placed in such water. These tanks have a double bottom, the upper one being of open wicker-work, whilst the lower one is a movable hair sieve. The young fish can then be taken out by means of a fine net shaped like a dipper and furnished with a long handle (Fig. 1). If it is impossible to obtain tanks like those above described, the female fish are placed either in a fish-box (a kind of per-

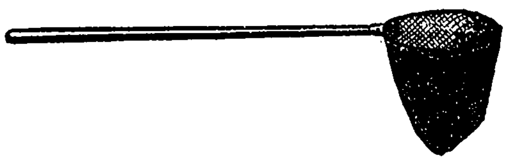


Fig. 1.

* *Traité de la multiplication artificielle des poissons.* Brussels, 1858.—Translated from the French by Herman Jacobson.

forated box), placed in the water, or in a large cage furnished with floats* (Fig. 2), which is so placed as to insure all the conditions necessary for the health of the fish. One may also use the box depicted in Figure 17 after having taken out the hatching frames, which are no longer needed.

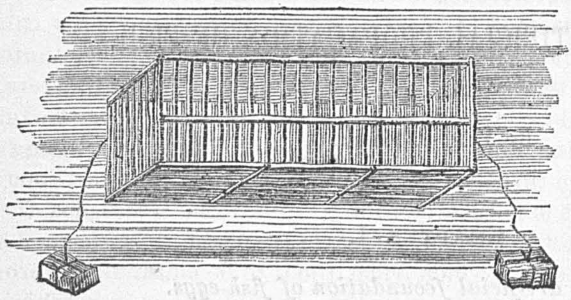


FIG. 2.

In case it should be impossible to procure live fish for the purposes of propagation, it will be necessary to operate with fish which have been dead for two or three hours or more. It is well known that the milt contained in the genital organs retains its fecundating property for a long time, and does not even lose it through frost; but we still lack positive and exact data as to the length of time in which eggs will retain the faculty of being impregnated by spermatozoa with regard to changes of temperature and to the different kinds of fish. Nothing but continued observations will lead to the solution of this problem.†

Towards the time when it may be assumed that the fish which are to be propagated are ready to lay their eggs, they must be watched so as to take them in the exact moment when the eggs are about to be laid. The following external signs indicate the near approach of this moment: The belly of the female is slightly distended, the anal opening is very moist and swollen and protrudes like a hemorrhoidal tubercle; the eggs, surrounded by an abundant ovarian secretion, are free from all connection and may by the slightest pressure be moved about in the cavity in which they have fallen. These eggs do not change color until they have come in contact with the water.

These symptoms are less pronounced in the male, but the slightest pressure on the abdominal walls provokes the emission of the milt and leaves no doubt as to the approach of the spawning period. One can now proceed with the fecundating process, which may take place in two different ways, according to the distinction made between fish laying *free* eggs, such as the trout, salmon, &c., and those whose eggs adhere to other bodies, such as the tench, carp, gudgeon, &c.‡

* J. Lamy: *Éléments de pisciculture*, Paris, 1855.

† It has been stated that eggs extracted from dead female trout and salmon, although beginning to show a change, were still endowed with the faculty of being fecundated by the milt from a male fish in the same condition; and the Munich piscicultural establishment frequently works with eggs bought in hotels or from fishermen. The result, however, is never as complete as with eggs from live fish.

‡ COSTE: *Comptes-Rendus*, 1852, i, 985.

§ 2.—*Artificial fecundation of free eggs.*

For this purpose one may use any vessel of glazed clay, porcelain, stone, wood, &c.; the circumference of the upper edge should almost be equal to that of the bottom, which ought to be flat, so the eggs can spread over a certain surface and not be crowded. Water is poured into this vessel so as to cover the bottom to the depth of about 10 centimeters. This water, which should be clear, may be taken either from the stream or pond where the hatching apparatus is to be placed, and where the eggs ought to develop, or from those waters where the fish about to be propagated generally live. It is necessary to ascertain if the water has the temperature observed at the time of the natural spawning. When the water of those rivers is used in which a fish about to be manipulated propagates naturally, its primitive temperature should above everything else be preserved. For this purpose, and if one operates in the open air, as near a trout-brook, it will be preferable, in order to accelerate the manipulations, to operate only on small quantities and to use fresh water every time.

As soon as these preliminaries are finished, one takes up a female fish with the left hand and holds it perpendicularly by the fins of the head over and as close as possible to the vessel. When the fish is in this position the eggs which are near the anal orifice are emitted through their own weight. If this is not the case, the belly of the fish ought to be pressed very gently by moving the thumb and forefinger up and down. (Fig. 3.)

FIG. 3.

As soon as the eggs, which have been extracted in the above manner, form a thin layer at the bottom of the vessel, one takes a male fish, treating him in exactly the same manner as the female, until the water becomes slightly turbid, or assumes the appearance of milk which has been violently stirred. This mixture is thereupon stirred either with the tail of the male fish, held in the water during the operation, or with the hand, or with the beard of a brush or a feather. After letting it stand for 5 or 10 minutes fecundation is accomplished.

If the strength of the tail of the fish operated upon necessitates the employment of an assistant, the above manipulations are modified; the assistant holding the tail of the fish whose convulsive and irregular motions inconvenience the operator. The fish is then, necessarily, in an almost horizontal position, and the pressure on the belly is exercised in the manner indicated in Fig. 4.

The following are invariably the essential conditions of success in the above-described operation: Perfect maturity of the eggs, suitable temperature of the water, and rapid execution of all the manipulations.

We have above given the signs by which the near approach of the spawning season may be recognized. The degree of resistance met with in the operation of expelling the eggs furnishes the most certain indication in this respect. If a first attempt should be without result it will be necessary to return the fish to the water or to their basins and to renew the experiment one or several days later. The experiment will not succeed if one has waited too long in freeing the females from their burden. This may be recognized by the simultaneous emission of a purulent yellowish matter, among which may be seen some eggs, which, when brought in contact with the water, first become opaque and then turn white.

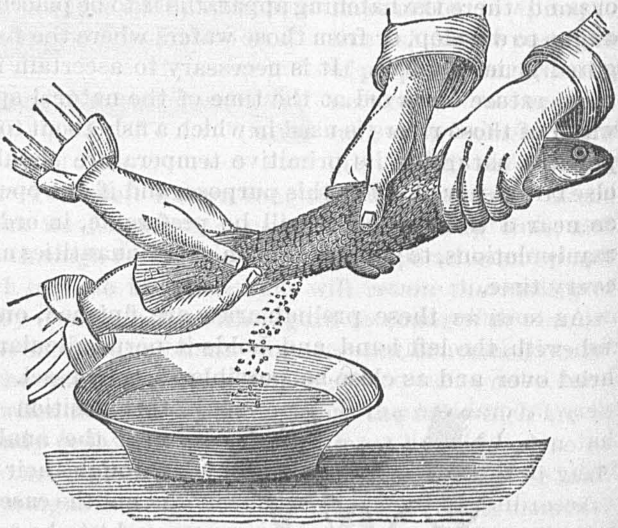


FIG. 4.

The habitual spawning period can, in the present case, only afford very little aid, as it not only differs in the varieties of one and the same family, but also, according to circumstances, in the individuals of one and the same variety. To this peculiarity must be ascribed the great difference between the data relative to the time of spawning of one and the same species of fish. As an instance of such differences in the data which we possess, we will mention the common trout (*Salmo fario*), which, according to the location and temperature of its different stations, spawns from September to March. The Netherlands Commission of Pisciculture* gives as the spawning season of this salmonoid the months of September and October, whilst M. Coste† gives the time from November to February. In the streams of the Vogelberg, in Germany, spawning commences about the end of September and seems to come to a close about the 1st November, as about that time no more trout containing eggs are caught. In the Grand Duchy of Luxemburg spawning generally com-

**Handleiding tot de kunstmatige vermenigvulding van vischen*, p. 22.

†M. COSTE: *Comptes-Rendus*, 1852, p. 139.

mences about the end of November and is finished about Christmas. The spawning season for Southern Germany is during the months of November and December, and during these months the greater number of experiments in fecundation have been made by Mr. Detzem. J. Lamy* says that trout spawn from the 15th of December to the 30th of January, and Grand Forester Wagener of Detmold† reports that in 1853 he succeeded in the artificial fecundation of the fish in question as late as March.‡ These facts prove sufficiently how necessary it is to have strict regard to the above-mentioned indications for recognizing the maturity of the spawn, as it is not safe to be exclusively guided by the indications as to the time when spawning takes place.

The preservation of a suitable temperature during the process of artificial fecundation is just as important as the perfect maturity of the eggs. Although we still lack complete and positive data relative to the extremes of temperature between which the fecundation of the different kinds of fish can be more or less successfully accomplished, it may be considered as definitely settled that the success of the experiment depends essentially on the temperature of the water, and that, owing to differences of temperature, it is often retarded or accelerated, and even in certain cases does not take place at all. Every pisciculturist knows that fish never fail to spawn in certain waters presenting every favorable condition but that of the temperature of the water, but that not the slightest trace of young fry could be discovered, simply owing to the absence of a suitable temperature.

According to the average period when fish spawn they are divided in "*winter fish*,"—the trout, salmon, burbot, &c.; "*early spring fish*,"—the pike, &c.; "*late spring fish*,"—the perch, &c.; "*summer fish*,"—the tench, the carp, &c. From experiments made in France by M. *de Quatrefages* it appears that the temperature most favorable for fecundation is, for fish spawning in winter from 4° to 6°, for early spring fish from 8° to 10°, for late spring fish 14° to 16°, and for summer fish 20° to 25° Celsius. A difference of 4° to 5° in the above temperatures may thwart the success of fecundation. We will not attempt to disprove this assertion so far as the winter and early spring fish are concerned, although we have successfully fecundated trout eggs at a temperature of 4° to 8°. As regards the other two classes of fish, we take the liberty to entertain doubts, whilst maintaining that the determining of the extremes of temperature should be made the subject of continued and careful observations.

The necessity for executing the different manipulations of the process of fecundation as rapidly as possible is already explained by what we said above regarding the temperature of the water. But this rapid

* J. LAMY: *Éléments de pisciculture*, Paris, 1855.

† DR. FRAAS: *Ueber künstliche Fischerzeugung*, p. 59.

‡ The ordinance of 1669 fixes the spawning season of the trout from February 1st till the middle of May.

manipulation is also necessitated by the circumstance that the milt of most fish loses its fecundating property very soon when brought in contact with the water. The same applies to the eggs, which when first laid are united and surrounded by an almost invisible mucilaginous covering. When brought in contact with the water this covering becomes bloated in a few seconds; the fecundating spermatozoa can no longer reach the egg, and are thus, by the sheer force of circumstances, prevented from performing successfully the process of fecundation. It appears that the substance which unites and envelopes the eggs acts in the same manner as the spawn of frogs which, according to experiments made by Messrs. *Prévost* and *Dumas*, cannot be fecundated as soon as the glutinous matter which envelopes it has become bloated by water.

§ 3.—*Artificial fecundation of eggs which adhere to neighboring objects.*

In order to accomplish the fecundation of eggs of fish like the carp, gudgeon, barbel, &c., which, by means of a glutinous matter, attach their eggs to any objects near them, the above-described practice must be somewhat modified. One takes a small quantity (a few handfuls) of well-washed aquatic plants, such as the water ranunculus, vessels of the form and size above described, and a trough. Three persons must assist at this experiment; one takes the female fish and relieves it of its eggs in the manner described above, another takes the male fish and extracts the milt, whilst the third stirs the water with a small bunch of herbs and thus facilitates impregnation. The eggs, which are of a viscous nature, adhere to the plants, and when these are sufficiently charged with them, one lets them lie in the spermatized water for three or four minutes in order to give them time to absorb the fecundating molecules. In order that the eggs adhering to the bunches of plants may not dry, these bunches are gathered in a trough, where they are covered with pieces of wet cloth. This manipulation does not offer as many difficulties as the preceding one, but it nevertheless requires considerable attention. Thus it is essential to allow only a quantity of eggs proportioned to the surface which one desires to cover with eggs to fall in the vessel; otherwise they would become conglomerated on the plants, which would be very detrimental to their development.

If there is no other way, two persons may go through this operation. In that case one will extract the eggs whilst the other gathers them on the bunches of herbs. When the eggs have become attached to the plants they are placed in a vessel to be subjected to the influence of the milt of the male fish. The water is gently stirred with the plants in order to subject all the eggs to the influence of the fecundating liquid. After the bunches of plants with the eggs have remained in the water impregnated with milt for 5 or 6 minutes the operation is finished, and the eggs are put away for the purpose of being hatched, either in an apparatus especially prepared for this object or in a tank or basin having the desired conditions of safety and temperature.

Natural spawning places may suffice for everything which has been recommended in the above.

§ 4.—*Artificial spawning places.*

As has been indicated at the end of the last paragraph, the simplest means of multiplying those species of fish whose eggs adhere to foreign bodies is to make the fish deposit their eggs in a place provided for them in a pond or water-course, &c. This may be done by means of very simple and inexpensive apparatus which are generally composed of wooden frames (Fig. 5) of different shapes and sizes, covered with aquatic

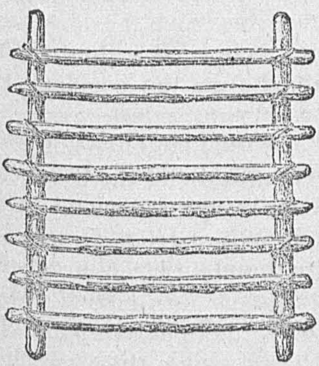


FIG. 5.

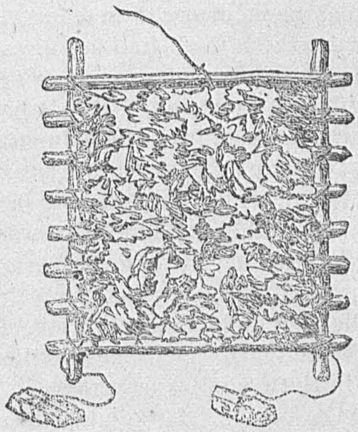


FIG. 6.

plants, brush-wood, &c., arranged in such a manner as to resemble a small roof for sheltering things (Fig. 6). Their size, which varies from 1 to 2 meters, their distribution and position, of course, depend on the different localities. It is always necessary that one end of the apparatus should be weighed down by a sufficiently heavy weight to have about three-fourths of the apparatus under the water (Fig. 7).

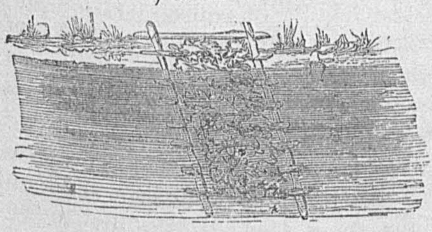


FIG. 7.

One or two months before the presumed time of spawning, these apparatus are placed on the banks of the water where the fish live, and are taken out again after spawning is over. The bunches of herbs are then carefully taken off, and are, in order to insure the hatching, placed under the same conditions as the products of artificial fecundation.

For those fish which deposit their eggs free on the gravel, or hide them in the spaces between the stones, as is the habit of the salmonoids, it will be best to select brooks with clear and not very deep water, and to cover the bed with a thick layer of stones, gravel, and sand, so as to induce the females to come and hide their eggs there.

These measures cannot in all cases replace artificial fecundation unless there is no danger of the spawn being destroyed in its free condition, and thus there is no ground for the objections raised against the natural restocking of our rivers.

§ 5.—*Crossing of different breeds.*

It rarely occurs in nature that different breeds of fish will cross, which is easily explained by the circumstance that the milt soon loses its fecundating property. Guided by their instinct the male fish deposit their milt in close proximity to the eggs laid by the females of their kind. The short duration of the fecundating faculty of the spermatozoa, when brought in contact with the water, does not allow the milt to attach itself to other eggs than those for which it is destined.

The possibility of producing cross-breeds is beyond a doubt. Thus at *Hüningen* a cross-breed has been obtained from the common trout and the salmon, from the salmon-trout and salmon, and *vice versa.* Attempts made in Bavaria to cross the trout and the pike have not proved successful, whilst the crossing of the common trout and the blay (therefore two different families) was successfully accomplished.† Cross-breeds have been produced from different species of trout among themselves, and specimens of these crosses are found in large numbers in the fish-ponds of the veterinary school at Munich. In crossing different breeds of fish, especially salmon, the object is to obtain fish able to live in those shallower waters in which those among them which live near the bottom of the lakes do not prosper.

We only mention these facts briefly, as our experience so far does not justify us in passing a final verdict as to their absolute reliability, and as to the profit which might be derived from crossing different kinds of fish. We have very good reasons for this; the majority of these cross-breeds are deprived of the faculty of reproduction, and if this is not the case they gradually return to their original types. The alleged fact of the sterility of certain cross-breeds is beyond a doubt; it is proven by the hybrid products of various kinds of salmonoids often met with. These cross-breeds, in which Dr. Fraas of Munich invariably found only a few sickly-looking eggs, can never spawn. But there are cross-breeds which can do it, as the cross between the carp and the crucian. Future experiments must show what are the species between which a cross can be effected and the conditions under which this can be done successfully. The objections raised against the production of cross-breeds is well founded, and in order to overcome it

* We occasionally meet with a cross-breed of the crucian and the common carp, and of the latter with the Chinese gold-fish. These cross-breeds may be recognized by having smaller scales and a shorter and thicker head.

† Dr. Fraas: *Die künstliche Fischerzeugung,* p. 57.

one ought to endeavor to confine the crossings to their reasonable limits, and to repeat them through several generations, always crossing the primitive kind with cross-breeds.

CHAPTER II.

HATCHING APPARATUS.

After the eggs have become fecundated they are placed in the hatching apparatus. For this purpose perforated boxes, resembling sieves, baskets of different shapes, boxes of wood, stone, earth, metal; sieves of every kind &c., have been proposed, and the only trouble is which to select among so many different kinds.

The long, open boxes described by Jacobi have for a long time been successfully employed in Germany, and have been replaced by the circular boxes of tinned iron, perforated like sieves, of Messrs. Gehin and Remy, which are still used in Germany, owing to the high praise bestowed upon them by Dr. Fraas, of Munich. He explains his preference for the apparatus of the two fishermen of *La Bresse* by stating the inconveniences presented by wire sieves, which easily rust and favor the generation of parasitical confervæ. The experience of all ages, however, has demonstrated that perforated boxes can only be successfully employed in very pure running water, as the holes easily become stopped up and are rendered useless by the oxidation of the tin of which they are made. The open wicker baskets recommend themselves by their cheapness, but they offer too little resistance to the enemies of the spawn; boxes made of coarse hair present the same inconveniences without even the advantage of being cheap.

These considerations have induced Mr. Coste* to find some method which would always enable him, whenever he deemed it useful, to manipulate the products inclosed in his apparatus and to pass them from the hatching-brooks to the fish-ponds. The incubating apparatus, consisting of artificial streams of continually-running water, were the result of Mr. Coste's researches. Their simplicity and their evident usefulness were immediately recognized, and facilitated the adoption of this system in a more or less modified form. We will first describe the apparatus in use in the piscicultural establishments in the Netherlands.

At the bottom of a common spring, with a capacity of 30 to 35 liters, beds are prepared of gravel, sand, and charcoal. The water, after having passed through the filter, flows through a faucet into a wooden tank, clothed on the inside with zinc or lead (a vessel of glazed clay is preferable); at the end of this tank there is an opening through which the water flows out into a small pond or tank.

The fecundated eggs are placed on hair frames and immersed in the

* COSTE: *Comptes-Rendus*, pp. 43 and 46.

water of the vessels to a depth of one or several centimeters, according to the different kinds of fish. These frames have raised edges which rest on the sides of the apparatus. Their dimensions are as follows: Length, 1 meter; breadth, 0.10 to 0.20 centimeters; depth, 0.05 to 0.10 centimeters.

Fig. 8 represents the incubating apparatus and Fig. 9 the hair frame.

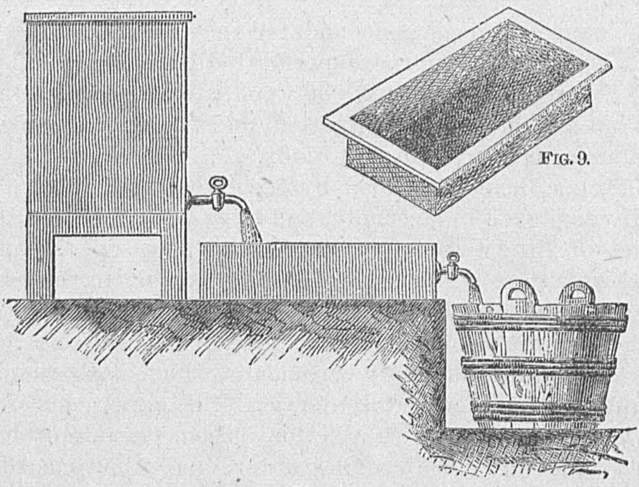


FIG. 9.

FIG. 8.

This apparatus may be considerably enlarged by adding more vessels, or by placing them one below the other in the shape of steps, as indicated in Fig. 10.

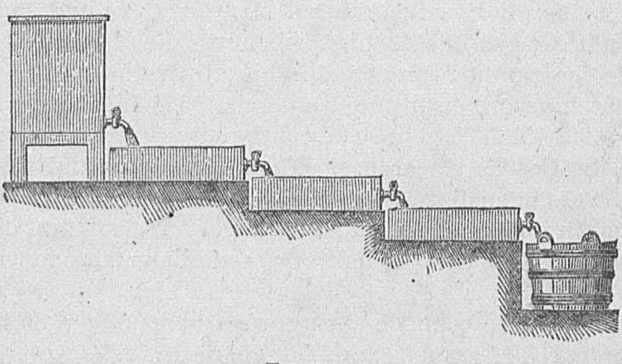


FIG. 10.

At one end or in the bottom there is an opening for a tube to let out the water, with a stop-cock, so that the water can be let out at any time.

For the incubation of trout eggs M. Coste uses an equally excellent apparatus, which is shown in Fig. 11, and therefore needs no further description. The outer portion, which is necessary to support the frames with glass-sticks (which here take the place of the hair-frames), is not seen in the drawing. The dimensions of the different troughs or vessels which compose this apparatus are as follows: Length, 0.52 meters; breadth, 0.15 meters; depth, 0.10 meters.

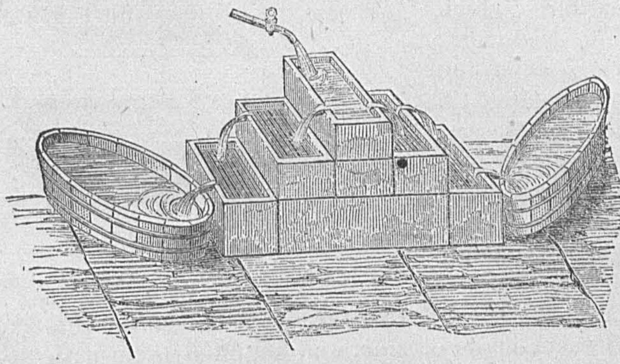


FIG. 11.

These troughs, which have been in use for a long time in Detmold, Germany, are placed in different ways according to the fancy of the operator. The hatching apparatus of the College of France, represented in Fig. 12, will show the utmost use to which this apparatus has been put.

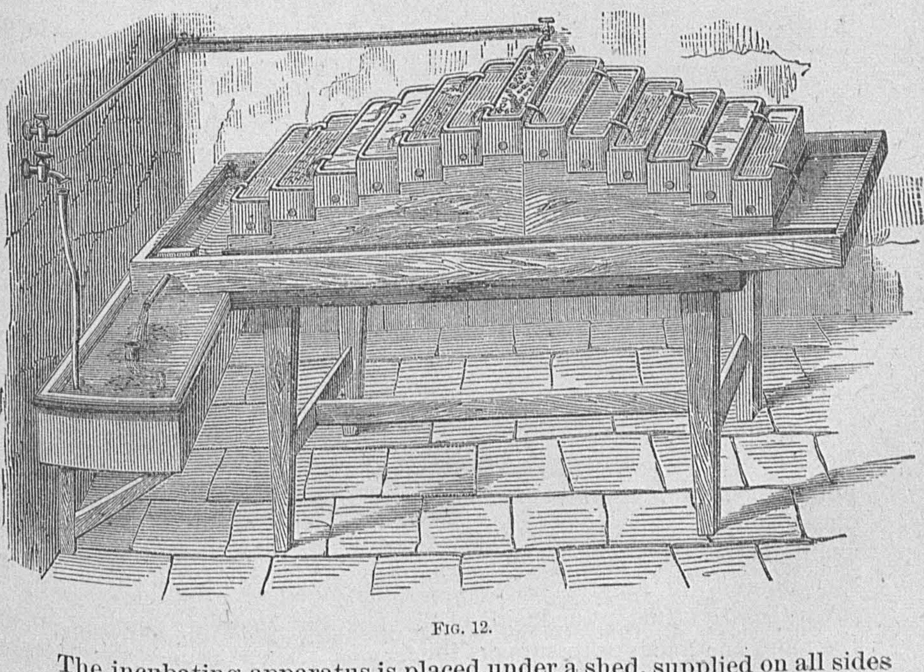


FIG. 12.

The incubating apparatus is placed under a shed, supplied on all sides with hatches opening outward. These openings are intended to let air pass through and to admit heat and light, all of which are necessary for the development of the eggs.

In case it should be impossible to construct any of the apparatus described above, and to carry on the incubating process in water-courses, one may, in pure running water which leaves no sediment, employ boxes like the one shown in Fig. 13, or the boxes of Messrs. Gehin and Remy. These last-mentioned boxes are used at *Scharnhouse*. In order to avoid the dangers threatening the spawn from the oxidation of the tin, Professor Rueff has had them made of zinc, and supplied them with floats. Vessels of glazed terra cotta are also employed, which have all the advantages of the Rueff boxes, and are less expensive (Fig. 14). Some pisciculturists prefer, in spite of the disadvantages mentioned above, flat wicker baskets, with or without floats (Figs. 15 and 16), according to the habits of the fish whose eggs are to be incubated.

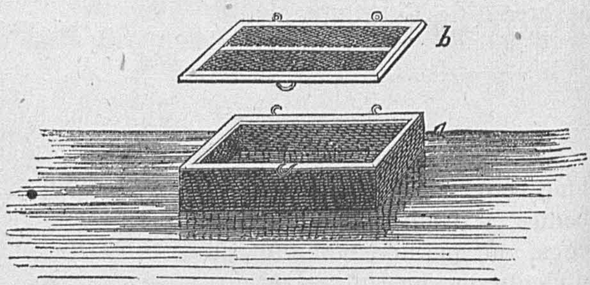


FIG. 13.

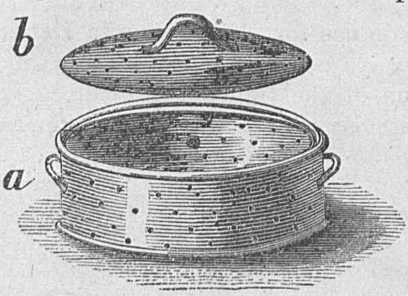


FIG. 14.

Coste* has also constructed an incubating-box which will remedy all the defects of the other boxes. This box (Fig. 17), which is an improvement on the Jacobi box, measures about 1 meter and one-half meter breadth and depth. Its sides and bottom are of solid wood. Its top is formed of a lid in two parts, in the center of which there is a grating of metal wire; and each end is closed by a door, whose opening is larger than that of the lids, and is also supplied with a grating. Both doors and lids move on hinges, open outward, and are closed simply by means of two small bolts fastened with strings, and, for greater safety's sake, supplied with padlocks. There are no subdivisions in the inside of this box, but there are running along the sides small ledges to support the frames. These frames are of wood

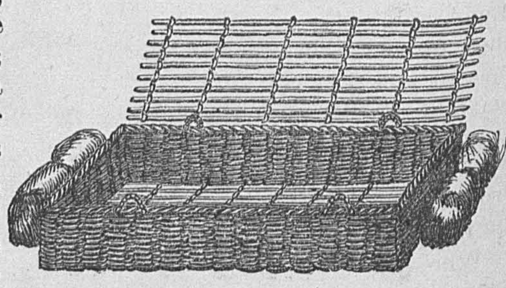


FIG. 15.

*COSTE: *Comptes-Rendus*, p. 55 et seq.

and glass sticks. But as these frames are intended to be put one over the other, the box must be somewhat higher than in the trough apparatus, and at the ends there must be large notches for the free passage of the water. To render the process easier, their surface must not (if the box has the length mentioned above) represent more than one-fourth of its capacity, so that four of them may be on the same floor.

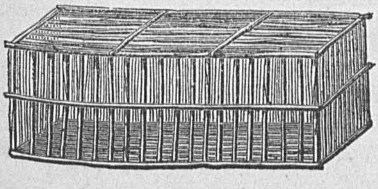


FIG. 16.

This box, which should be used in running water, can be used for free eggs and for eggs adhering to foreign bodies. In spite of its small size, it can hatch a very large quantity of eggs, and permits manipulations, which in the "sieve apparatus" are difficult or hurtful. For the purpose of observing what is going on inside, and to clean the gratings when they have become obstructed by sediments, the lids and doors can be opened as often as desired, without taking the apparatus out of the water and without disturbing the frames and the eggs. Whether attached to a floating frame by clamps or by strings attached to pegs driven in the ground, it must present to the current one of its extremities when the current is moderate and one of its angles when it is very rapid. A bed of pebbles and fine sand placed at the bottom receives the young fish, which either fall or descend on it as they are hatched, and offers them favorable conditions for their further development, till the time arrives when the gates can be opened and they can be set at liberty in some river or pond. Fish of small size will escape through the meshes of the wire grating and disperse through the water.

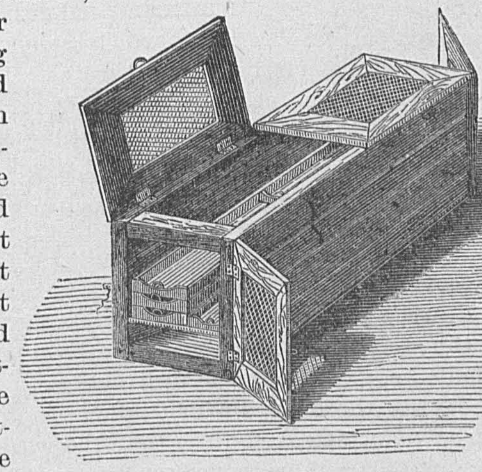


FIG. 17

When the hatching process is finished, all the frames are removed from the box, so that it can be cleaned, and better care can be bestowed on the young fish imprisoned in it.

Whenever it becomes necessary to place one or the other of the above-mentioned apparatus in stagnant water, the bottom should be covered with aquatic plants, to prevent this water, which of course is not renewed, from spoiling, and form an inexhaustible source of oxygen, which is so useful for the development of the embryo.

Wherever propagation is to be carried on on a large scale, it will be preferable to have hatching-canals, which should have solid walls, so as to exclude water-rats, as well as the *Disticus marginalis* and *Hydrophilus piceus* (both as larvæ and in their perfect state), and a good covering, and be provided with wire gratings, both to protect the fish from the voracity of other inhabitants of the water and to prevent their dispersion.

These coverings also prevent the appearance of the greenish mold which generally forms on the stones at the bottom, and which is composed of diatoms and other small algæ.

CHAPTER III.

§ 1.—*Hatching eggs in incubating apparatus.*

After the eggs have been fecundated either near or in water having the same temperature as that in which the hatching apparatus is placed, they are carefully put in this apparatus. By observing these conditions no disturbance need be feared from any sudden change in the temperature of the water. For incubating the free eggs of salmon and other winter fish, the specific weight of which is much greater than that of the water, and which consequently descend to the bottom of the apparatus, it will be necessary to furnish the apparatus with a layer of gravel several centimeters thick, and to see to it that this layer is uniformly covered with the eggs. Mr. Detzem and several other practical pisciculturists put a layer of fine sand on these eggs; others again avoid doing this, so as to be able to constantly watch the eggs, and to remove any spoiled eggs or causes of destruction.

As regards those eggs which adhere to foreign bodies, like those of the carp, &c., which are lighter than the water in which they float, it is necessary to place them in the apparatus with the plants on which they have been deposited, as has been described in Chapter I, § 3, of this treatise. It is necessary to avoid currents which would carry the eggs to one single part of the apparatus. It will, therefore, be best to select the stagnant and tranquil waters of ponds or canals where the effect of strong currents can be mitigated by using apparatus with very close wire gratings. In this case the apparatus must not be entirely submerged but should be placed in such a position that there is an empty space between the water and the lid. A few centimeters of water suffice for apparatus in which the water is easily and regularly renewed.

It should be mentioned that with Coste's apparatus and the one used in Holland, the eggs are deposited on glass or wire frames, and that no gravel is required; whilst the ingenious system of artificial brooks with constantly running water, invented by Coste,* regulates the distribution of the water in the most suitable manner.

It should also be observed that eggs which have been transported, or which come from a distance, should be gradually accustomed to the

* *Comptes-Rendus*, 1852, p. 301.

temperature of the water in which they are to be hatched, and that in that case it becomes necessary to place them for 24 hours with the boxes in water which has the same temperature as that which feeds the apparatus.

We must finally direct attention to the practice introduced by some German pisciculturists, to place the eggs, immediately after they have been fecundated, in those waters where they are to stay during the period that elapses between the two extremes of their life. The only precaution they take is to place the eggs in the most suitable location and to shelter them as much as possible from hurtful influences.*

§ 2.—*Rules to be observed during incubation; maladies and enemies of the eggs.*

During the entire period of their development the eggs require constant and watchful care. In the first place care should be taken, as has already been recommended above, that the eggs, no matter in what apparatus they are kept, are not piled up too high, but are evenly spread over the whole surface. If this is not observed, it would not only be impossible to constantly watch the eggs, but they would not develop evenly and their development may be indefinitely delayed. Piling up the eggs too high is also apt to produce those maladies which attack fecundated spawn. Confervæ and parasitical plants (Fig. 18) produced by the constant moisture in which the eggs are kept are particularly injurious to the spawn. They first attack the spoiled eggs, which may be recognized by their yellowish color, and by being opaque, and cover them with filaments of different colors.

FIG. 18.

A small alga (*Leptomitus clavatus*, Fig. 19) is particularly active in carrying on this work of destruction. It is true it can only grow on spoiled or dead eggs; but it will envelop healthy eggs in a thick and fuzzy net, and will thus choke them. The only remedy against these parasites, the propagation of which would be diminished or hindered if the eggs had been evenly spread, or if the apparatus had been cleaned at the proper time, consists in immediately removing, by means of a pair of pincers, (Fig. 20) all the eggs which show the slightest trace of infection. It would not only be a useless trouble, but the evil would only be increased, if, instead of removing the infected eggs, one would endeavor to save them by attempts to destroy with the pincers the parasitical plants which

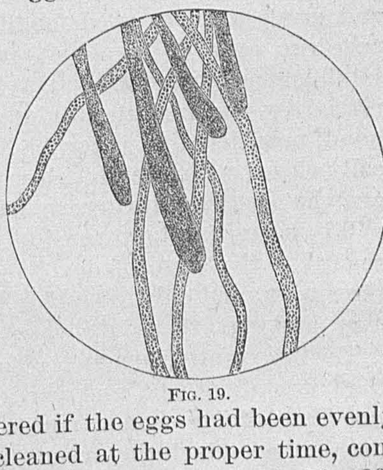


FIG. 19.

*VON SCHEWEN: *Zeitschrift des landwirthschaftlichen. Vereins für Rheinpreussen* 1857, No. 1.

cover them. Infected eggs are hopelessly lost, and in the attempt to clean them detached germs of these parasites might transfer the malady to eggs which so far have been spared.

Another very dangerous enemy of the spawn is found in the family of the *diatoms*, some of which attach themselves in enormous quantities to the stones and gravel at the bottom of the apparatus and cover it with a brownish or yellowish-green covering; they thereupon attack the eggs, exclude them from the air, and thus cause the death of the spawn, no matter to what degree of development it has attained. The species most to be feared are (Fig. 21) *Meridion circulare* (*f*), *Synedra angustata* (*a*), *parvula* (*b*), *acicularis* (*c*), VAUCHERIÆ, *palea* (*d*), *mucida*, and the *diatoma pectinale.* We possess two very excellent remedies against these plagues of the pisciculturist. These are: rapidly running water and the exclusion of light; but whilst the first can only be applied to fish of the salmonoid species, the second will, under all circumstances, prove effective, is not at all hurtful to the spawn, and can be applied anywhere. The exclusion of light hinders the propagation of the diatoms and confervæ, whilst the eggs can be successfully hatched even in the densest darkness.* Several authors also recommend in such cases to transfer the eggs to other vessels. The crooked and straight pipes used for this purpose can only be employed in small establishments, and they may be replaced by the first glass tube near at hand, provided that it can be hermetically closed with the thumb when the eggs have entered its lower portion. It will be necessary, however, to have due regard to the state of development of the spawn, and only to employ this remedy when it is absolutely necessary, and even then only when the eyes of the embryo are visible.

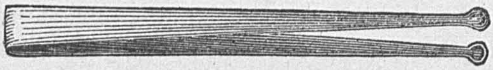


FIG. 20.

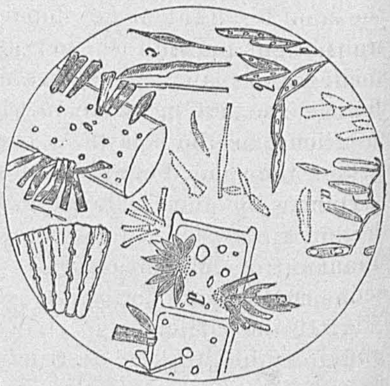


FIG. 21.

The intervention of man is also required when the eggs are attacked by the larvæ of insects, and particularly by those of *Disticus marginalis* and *Hydrophilus pisceus ;* nothing but constant watchfulness can prevent the ravages which they would cause. Another small insect, probably in its larva state (*Ascarides minor?*), and which probably comes from fish used in the operation, is very dangerous to the eggs at the time when the embryo has almost reached its full development. It pierces the outer shell of the egg and devours its contents. As the presence of this animalcula can only be recognized by the shells of the eggs floating near the surface, there is no time to think of its destruction.

* This observation is based on positive and repeated experiments. The hatching process takes place in a regular manner, but is somewhat delayed.

Water rats are also extremely dangerous to the embryo. They may be destroyed (though with considerable difficulty) by means of wire traps. In order to prevent as much as possible the approach of these unwelcome guests one should be careful not to destroy the damaged eggs near to the hatching apparatus, as thus the odor of putrefying animal matter which attracts the rats will be avoided.

We must once more direct attention to what has been said above regarding the temperature of the water. We believe that, if the water in the incubating apparatus is kept at the temperature which we have given above as being most suitable for fecundation, the first condition for a natural and rapid development is fulfilled. The person in charge of the apparatus should always watch the thermometer; by opening or closing the apparatus, or by adding cold or hot water, an even degree of temperature may be maintained.

§ 3.—*Transformation and development of the egg.*

There are various changes in the appearance of eggs which have been fecundated; one might almost say that their contents become turbid and that they become less transparent than when they left the opening near the anal fin; they again, and almost imperceptibly, assume their first transparent appearance, whilst in the inside there may be observed a small circular spot which was not seen there at first* (Fig. 22, 1). This change has erroneously been considered *a certain sign of fecundation;* it takes place both in fecundated and non-fecundated eggs, but it develops more slowly and irregularly in the latter (Fig. 22, 2).

During the first moments and even during the first days it is (with certain kinds of fish) impossible to distinguish with the naked eye fecundated from non-fecundated eggs, but when examined under the microscope there can no longer be any doubt.

After a certain time an arched line makes its appearance in the fecundated eggs (Fig. 22; 3, 4, 5). This time differs not only according to the different species of fish to which the eggs belong, but also according to the temperature of the water in which they are placed. Farther down we shall point out the causes of this (Fig. 22).

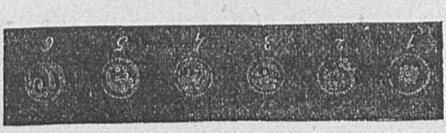


FIG. 22.

This line increases in size with the gradual development of the eggs; whilst one of its ends is prolonged in the shape of a tail, the other assumes the form of a spoon. This latter part is the future head of the young fish; the eyes, which now appear like two brown points† (Fig. 22, 6), prove this sufficiently.

The motions, particularly of the tail, of the young fish become more

*This fact has already been observed by ARISTOTLE. *Hist. anim.*, lib. 6, cap. 14.
†Also noticed by Aristotle.

and more noticeable according to the degree of its development. These motions, which cause the bursting of the shell which incloses the embryo, increase in violence till the moment when the young fish leaves the egg.

Finally, there is formed in the shell of the egg a small opening which allows the young fish to slip out of his place of imprisonment.

Either the tail or the head generally appear first; sometimes the umbilical bladder makes its appearance before either of the above-mentioned members. But whatever part of the body emerges from the shell first, the young fish is not yet master of all its motions. It remains partly inclosed in its shell, and only gradually and by repeated efforts does it succeed in enlarging the opening of its prison; after a few hours it is entirely free (Fig. 23), and can divest itself of a membrane which was only intended to protect it during the early stages of its development, and which was of no use whatever in forming any of the organs of the body.

FIG. 23.

The space of time which elapses from the moment of fecundation till the fish is freed from its protecting cover is different with the different kinds of fish. With the pike, it is eight, ten, or fifteen days; with others, like the salmon, it is one or two months.

The development of the fish progresses slower or quicker according to the temperature in which incubation takes place. Pike eggs placed in water exposed to the rays of the sun, and which has not been renewed, are hatched after nine days, whilst other eggs which have remained in the shade in water which has been constantly renewed would require eighteen to twenty days for their entire development.

CHAPTER IV.

RAISING YOUNG FISH, AND THE CARE WHICH SHOULD BE BESTOWED ON THEM.

§ 1.—*Dissemination.*

During the first period after the fish has torn its protecting membrane, it is useless to give it any food, as the umbilical sack, which in certain fish, like the carp, is found in the abdominal cavity (whilst in others, like the trout and salmon, is outside this cavity and can be plainly seen) furnishes it with food until it is entirely absorbed. The time required for this differs in the different species of fish; thus the carp goes without food for two or three weeks. Salmon remain one or two months after being hatched in the incubating apparatus without taking any other food but that furnished by the umbilical sack, or perhaps by microscopic animalculæ found in the water.

The necessity for other food asserts itself with the disappearance of this sack; and the further preservation and raising of young fish will have to follow one of the two methods described below, until further experience has shown which of the two is positively to be preferred.

(1.) Some pisciculturists begin to disseminate the fish in the water which is to be stocked with them as soon as the umbilical sack has been absorbed; they maintain that the young fish, which at that time is particularly lively and active, can escape dangers better than when it has grown larger.

The fish, moreover, becomes accustomed to the water in which it is to grow, and will not have to undergo a change of water and food, nor be subject to transportation, the expenses and difficulties of which increase as the fish grows older.

(2.) Other pisciculturists feed the fish for some time, and place them in special basins of different size, among which we would choose those of the piscicultural establishment of *Enghien-les-Baines*, as modified by the Netherlands Fish Commission (Fig. 24), which combines all the advantages of salubrity and easy management.

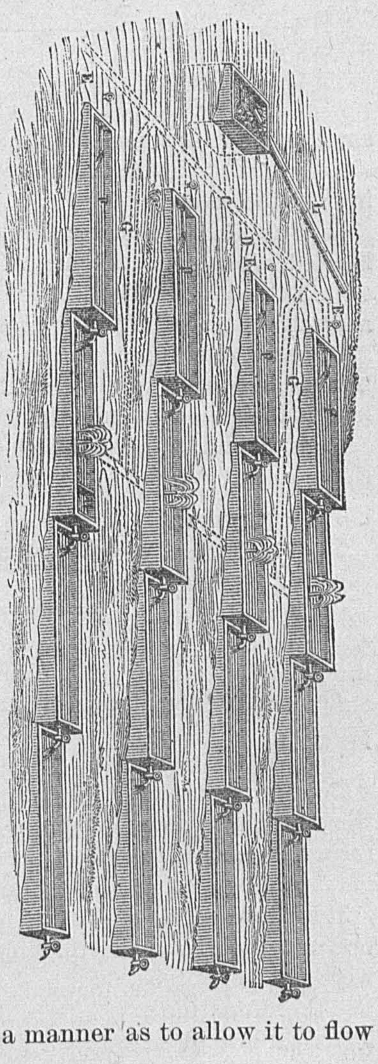


FIG. 24.

We give only those explanations which are absolutely necessary for understanding our sketch. The wooden sluice or the lead pipe A leads the water into the square basin B, which serves to filter the water; it is filled with stones and has a lid.

On the opposite side of this basin there is the lead pipe C, which opens into the transverse pipe D, of the same metal; the four tubes E lead the water from the tube D to the upper basin F, whence, by means of faucets, it can be conducted into four lower basins, and even further, in such a manner as to allow it to flow with ease.

Between the tubes F there are joined to the transverse tubes D the longer tubes G, which empty into discharging tubes; on these latter there are placed perpendicularly other tubes destined to form little fountains. These fountains may be provided with stop-cocks. The fish are placed in these basins, the water of which is continually renewed, until they have reached a certain size.

In order to prevent the little fish from getting into the faucets by which the different basins communicate—which, of course, would very seriously interfere with such communication—small wooden boxes are used, which are partly filled with stones, and which are placed in the basins at some little distance from the faucets (Fig 25).

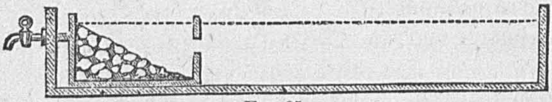


Fig. 25.

The faucets are placed in the walls of the large basins, which are put in communication with the small basins by means of a discharge pipe; one or several holes opposite to that of the discharge pipe serve to prevent the water from flowing out too freely.

In Fig. 24, H indicates the place where one of these small boxes is located, whilst Fig. 25 gives the profile of the two basins placed one within the other. The little fish would have to pass through the entire mass of stones before they could reach the stop-cocks.

In case the rising of the water should fill the basins too much, it will become necessary to draw off the surplus water by means of tube L, and lead it to some convenient place.

Figs. 26 and 27 give the elevation and ground plan of these basins rising one above the other like steps. The scale is 1 to 600.

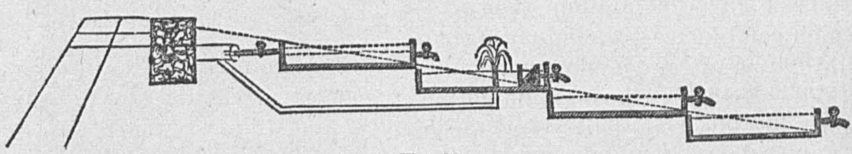


Fig. 26.

The dotted line indicates that part of the apparatus which is under ground.

In case the level of the water is not high enough above the ground on which the basins are to be constructed, it will become necessary to lead the water, by means of pumps or other contrivances, into a common reservoir destined to feed the entire establishment. The basin B can very well be replaced by a filter placed in the common reservoir.

It is probably not necessary to demonstrate that the young fish should be fed as nearly as possible in the same way as they would feed if they were entirely free. We therefore think it advisable to plant some aquatic plants in the basins where those fish are which feed on plants and insects; they ought also to have all the worms and larvæ that can be procured, as well as insects of the species *Cyclops*, *Cypris*, and *Cythera*, which in spring are plentiful in fresh water; boiled peas, hemp cakes, bread, &c., may also be given to them.

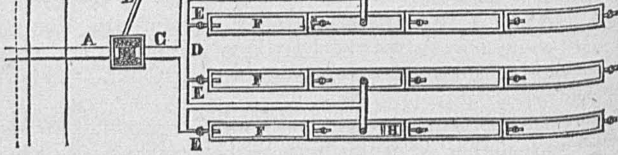


Fig. 27.

Those fish which live on their congeners may be fed with the spawn and young fish which they have produced. If it is not possible to do this, the following articles may be used to advantage: whiting, reduced to a paste; frog meat, cut, dried, and made into a very fine powder; veal or beef cooked and chopped up fine, or blood dried and pulverized. If this kind of food is used, the basins should be well cleaned from time to time, so as to prevent any accumulation of decaying animal matter.

As soon as the fish are large and strong enough to encourage the hope that they will not fall a prey to their worst enemies, they are let loose in the water which is to be stocked with them, or they are forwarded to those places where that particular kind of fish is desired, in kegs filled with water.

We are not in favor of any prolonged stay in the piscicultural establishments, except where foreign breeds of fish are to be acclimatized, where rare species are to be multiplied, or where continued stocking of waters necessitates the constant production of young fish; and even in this case it will be necessary to consider whether it is not preferable to place the young fish in basins specially set aside for that purpose.

§ 2. *Sickness of young fish.*

When fish-ponds are established in much frequented localities, it often happens that dead fish are found at the bottom. They generally sink to the bottom with their mouths wide open, and when examined the entire buccal cavity is found to be filled with blackish flakes. These are produced by small atoms floating in the air, which fall into the water and gather into small flakes, which the movements of the fish scatter throughout the whole pond. This detritus, which is too light to be swallowed, enters the respiratory organs, obstructs them, and finally causes asphyxia.

This evil may be remedied by supplying the apparatus with a double bottom, either by means of a wicker frame, or some tissue with large meshes, which is placed between the bottom of the basin and the space reserved for the fish.

§ 3. *Acclimatization.*

The possibility of acclimatizing fish was demonstrated a long time ago. Among the ancients, the Chinese* and the Romans hatched the

* Several authors tell us that the Chinese have from time immemorial pursued a method which only now begins to be known in Europe. Inquiries relative to this subject show that their whole merit consists in having transplanted eggs from one water to the other. For this purpose they gather spawn which has been fecundated in a natural manner on mats, which answer the same purpose as our artificial spawning-boxes, and which are sold by measure. No one will seriously consider the method recommended by their authors, to put spawn in egg shells, to seal these up hermetically, and have them hatched by a bird!!

spawn of salt-water fish in fresh water, and succeeded in acclimatizing them. In the sixteenth century Marshall imported carp into England.

A hundred years later the gold carp (*Cyprinus auratus*) was introduced into Europe from China, and at the present time is a frequent ornament of our ponds and of glass globes in our parlors. Towards the end of the last century the celebrated Dr. Franklin† gathered fecundated spawn of the Norfolk herring on marine plants, and successfully transplanted these fish to the inland waters of America, &c., &c. *M. de Lacépède*, in his *Traité des effets de l'art de l'homme sur la nature des poissons*;‡ and Backwell in his *Travels in Tarentaise* and in the *Edinburgh Review* of 1822, demonstrated the usefulnesss and possibility of such acclimatizing experiments, and directed special attention to the salmon family, which also at the present day forms the principal subject of our experiments. It was reserved for our modern pisciculturists to make this question the order of the day, and to hasten its solution by the facility and certainty which the artificial methods have brought to the propagation of fish. This facility of multiplying rare or foreign species of fish opens out a wide field of profitable speculation. No one will deny the great benefit which agriculture has derived from the introduction and the crossing of foreign breeds of domestic animals, and which horticulture has derived from the acclimatization, cultivation, and hybridization of rare and exotic fruits and plants. These facts show what we may justly expect from pisciculture; and the experiments which have been made of late years prove that these expectations have not been disappointed. The large quantities of fecundated eggs which have been transported in France and in foreign countries by Coste, Fraas, and by the *Hüningen* establishment, and the satisfactory results of all these experiments, are as many guarantees for the practicability of this method.

CHAPTER V.

MEANS USED FOR TRANSPORTING EGGS AND FISH.

Our knowledge of the methods of preserving and transporting fecundated eggs of fish is based on observations made in France in connection with the practical experiments in artificial propagation. Although it has been known for some time that aquatic birds, and particularly ducks, often become the propagators of fish, the fecundated spawn of which had become attached to their feet, no conclusion had been drawn from this circumstance relative to the subject of this chapter, nor to the solution of the question how long eggs can remain out of the water without endangering their ulterior development.

* LACÉPÈDE: *Œuvres.* Paris, Duménil, 1836, ii, 255.
† VON EHRENKREUTZ: *Das Ganze der Angelfischerei.* Quedlinburg, 1856, 6th ed.
‡ LACÉPÈDE: *Œuvres*, ii, 253.

The means which have been recommended for transporting fish-eggs are very numerous. The one which recommends itself on account of its simplicity, and which is invariably successful, is to use flat boxes, measuring 10 to 12 centimeters in height, which have been previously furnished with a piece of moist linen or muslin, to spread the *free* eggs on them, and to cover them well. These pieces of cloth are moistened from time to time. Of late years cloth has been replaced by aquatic mosses (*Sphagnum*), between which the eggs are placed in layers. This way of transporting eggs will invariably prove successful if the eggs do not touch each other, and if the pressure of the upper or the lower layers of moss is not too great.

As regards *glutinous eggs*, like those of the perch, it is recommended to place them with some bunches of aquatic plants in glass globes about three-fourths full of water. *Eggs adhering to foreign bodies*, like those of the carp, should be wrapped with the bodies to which they adhere in moist cloths and be placed in a box or basket, on a layer of moist plants, in such a manner as not to bring any great pressure to bear on them.

The forwarding of spawn in glass globes filled with water, which has lately been recommended by some, is fraught with great danger to the life of the embryo, and this method should, therefore, only be employed in the cases indicated above. The shell of the egg is easily broken by the motion of the water in the globe, and the germ is thereby destroyed.

In all cases, and whatever means of transportation are employed, it is essential not to pack the eggs immediately after their fecundation. Experience has shown that the most favorable time for transporting spawn is *the period when the embryo is far enough developed to show the eyes like two black spots on the membrane of the shell.**

The forwarding of fish is regulated by the age of the fish which are to be transported. *The younger the fish, the easier it is to transport them a great distance.*† Fish which have been recently hatched are inclosed in vessels filled with water, in which a few aquatic plants are placed. When still in the state of young fry they are placed in large buckets three-fourths filled with water, the motion of which is deadened by means of a board or a wreath of straw placed in the water. Spring or autumn are the seasons most favorable for transporting fish.

In summer the heat and thunder-storms may kill the fish. If they have to be transported during this season, they should be forwarded by night, and fewer fish should be put in the vessels. Care should be taken to keep the water constantly in motion, even when the vehicle conveying the fish stops.

During long journeys it is necessary to renew the water from time to time, in such a manner as not to produce too great a difference of temperature between the old and new water. It is also necessary that air should enter the tubs at all times.

*M. COSTE: *Comptes-Rendus*, p. 109. †M. COSTE: *Comptes-Rendus*, p. 110.

CHAPTER VI.

EXPENSES OF THE ESTABLISHMENT AND OF RUNNING IT.

The cost of the first establishment of piscicultural apparatus, and of their maintenance, will depend on the object for which they were established and on the extent to which the work is to be carried on. If the operator wants to have recourse to artificial means of propagation only for stocking small sheets of water, for which he would only need 30,000 to 40,000 eggs, the expenses will be very small.

An intelligent workman can, even during a very severe winter, take care of an enormous quantity of successfully hatched eggs, whilst his work will be greatly simplified in spring and during summer, because the fish belonging to these seasons are very prolific. These expenses may, on the other hand, amount to a considerable sum, according to the greater or less extent of the operations and the degree of development to which the fish are to be brought.

The expenses will, in all cases, comprise the ground, sheds, canals, water-courses, and will be regulated according to the location.

The establishment should comprise the following: (1) Fecundating vessels; (2) hatching apparatus; (3) pincers; (4) thermometer; (5) nets, &c.; (6) different vessels.

The principal and regular expenses of the establishment comprise: (1) Wages of the persons in charge of the propagation and the surveillance of the spawn; (2) cost of spawn and its transportation, fish, &c. These expenses are, comparatively speaking, very small, so that for 4,000 to 5,000 francs a year one would have an establishment which would be able to supply on the most liberal scale all the fish needed for stocking the waters of a country like Belgium. With this sum several millions of eggs of the finest kinds of fish could be produced every year.

The operation becomes expensive only when one wishes to raise young fish of a certain age, instead of placing them as soon as possible in those waters where they are to live. In that case a sufficient quantity of the proper food should be procured, their development should be watched, they should be regularly fed, and protected against the attacks of their enemies. All this would in the end amount to more than the value of the fish in its *wild state;* for it should be remembered that pisciculture will only yield a certain profit, proportionate to the capital invested, if the means employed are simple and follow nature. It would therefore be profitable to scatter the young fish throughout the open waters immediately after the umbilical sack has been absorbed, and to consign propositions for the permanent and prolonged maintenance of fish to the domain of laboratory experiment.

CONCLUSION.

All the above regulations are based on the principle that small piscicultural establishments, founded in those localities where the need of restocking the rivers makes itself felt, are preferable to establishments on as large a scale as the one founded by the French Government at *Hüningen*. In order to justify this assertion, it will suffice to state that one is very apt to make a miscalculation in concentrating all the means for stocking water-courses at his command on a single point. Fish are subject to many contagious diseases. Parasitical confervæ, which attack both the eggs and the young fish, and even at times tolerably large fish, may at a single stroke destroy all that which has been prepared at great expense.

Small establishments will also occasion smaller losses, and can easier be removed to some new locality; one can, moreover, hatch the eggs in water which suits the species, and the expenses incidental to the transportation of fish are saved.

The art of propagating fish artificially is of too recent date to expect that the rules and hints given above are not to be modified or changed in many respects, and that they may not possibly be entirely replaced by other rules based on more recent experiments.

We have indicated those methods which, in our opinion, are the best, and which agree most with those principles which practice and nature have, so far, pointed out to us. The possibility, or rather the certainty, of changes and improvements which may considerably modify these principles, is still another reason in favor of cheap establishments.

In conclusion, we must make the following remarks: A somewhat lively imagination may see in the artificial propagation of fish an unlimited source of production, which may render applicable to our rivers and lakes what is said of the river Theiss in Hungary, that it contains one-third water and two-thirds fish. We consider artificial propagation of fish simply as the means of bringing the finny population of our rivers and water-courses back to that degree of prosperity which they enjoyed before steam navigation, various industries, and other causes of destruction threatened our fisheries with slow but gradual ruin. We look upon the artificial propagation of fish simply as a means of stocking our rivers with fish quicker than nature can do it; but this object can only be attained if sufficient care is bestowed upon the preservation of the young fish, thus artificially produced, after they have been placed in the water. It should not be forgotten that it would be useless to stock our waters with choice kinds of fish if these were left to the mercy of the ignorant and indolent inhabitants of the river banks.

The artificial propagation of fish, is not, and cannot be, a substitute for a well-regulated management of the water courses and their fisheries, but should only be considered as a powerful aid to pisciculture; it cannot, therefore, render unnecessary legislative provisions protecting and restricting the fisheries. Establishments for propagating fish artificially are to pisciculture what nurseries are to forest culture; and as forest culture would be useless if the irregular and destructive management of forests continues, thus the artificial propagation of fish would not aid in restocking the water-course if the young fish are not protected by every means within reach of the law. It will, therefore, not only be necessary to see to it that the existing fishery laws are carefully observed, but that the production, catching, transportation, and sale of fish should be properly regulated.

It will hardly be necessary to observe, in conclusion, that the species of fish which are to be propagated artificially should be carefully selected. This is very important, for if, as an example, one should stock waters with pike, all the other fish would soon disappear.

XVII.—THE TRANSFORMATION OF SALT MARSHES INTO FISH PONDS.

By M. DUCASTEL.

[From "*Bulletin mensuel de la Société d'acclimatation*," iii series, vol. vi, No. 2, February, 1879.]*

SALT MARSHES.

The waters of the sea on several points of our western and southern coasts are left to evaporate in a natural way in vast basins which are called salt marshes (*les marais salants*). These basins vary in shape and depth, and the water of the sea passes successively from one to the other. In the last basins (those nearest shore), where the water is only a few centimeters deep, the salt is deposited under conditions which vary in the different localities. Thus, in the salt-pits of the west the first deposit of salt is gray, and in order to give it a white color it is necessary to subject it to a refining process, whilst in the south the salt obtained from the salt-pits is white and pure.

The salt harvest depends altogether on atmospheric influences, such as the heat of the sun and the winds which more or less favor the evaporation of the water. In many places, especially in the West, the salt harvest will be almost an entire failure when the season is rainy or cool.

Vast pieces of ground, on which considerable sums of money have been spent, therefore become almost entirely unproductive. For this reason, and in view of the constantly-increasing demands for food for the masses, people have in many places been led to abandon the manufacture of salt by the spontaneous evaporation of the sea-water, and have begun to utilize to greater advantage the grounds once devoted to this industry by transforming in them into fish-ponds.

The ponds of this kind which have been constructed on the coast of the basin of Arcachon, in the department of Gironde, are excellent models of such fish ponds, and cannot be too highly recommended to the attention of the owners of salt marshes.

THE PONDS OF THE ARCACHON BASIN.

By ministerial order of August 6, 1852, Mr. Coste was commissioned

* *Transformation des marais salants en réservoirs à poissons.* Translated by HERMAN JACOBSON.

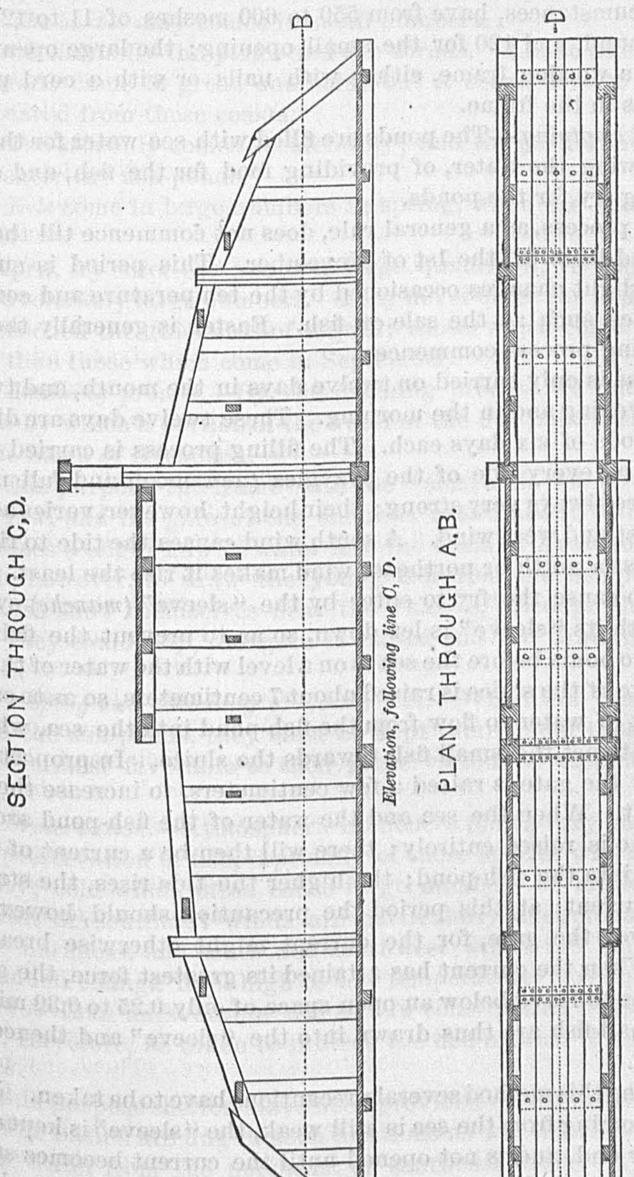
to visit the coast of Italy and ascertain under what conditions experiments might be made, on a large scale, in the way of propagating marine animals.

The result of Coste's visit to Italy was his interesting work on *Comacchio*. *Comacchio*, a colony of fishermen located in the midst of the lagoons of the Adriatic, has solved the interesting problem of cultivating the domai of the sea, "the fruits of which," says Coste, "are gathered, ripened, and multiplied in vast fish-ponds, and somewhat later harvested with as much profit and less labor than those of the soil."

Does not this way of characterizing the industry of *Comacchio* apply in almost every particular to the ponds of the Arcachon Basin? Whilst, therefore, the famous scientist envied Italy on account of her piscicultural industry, this very industry flourished in our own country, in the Arcachon fish-ponds, where, on a smaller scale, it is true, and under other, but no less favorable conditions, the fruits of the sea ripen and are harvested with as much profit and less labor than those of the soil.

It would be difficult to mark the exact time when these ponds were constructed, or to trace to any one man the invention of this ingenious system of cultivating the sea. The Marquis *de Cirac* was the first person who conceived the idea of utilizing the vast alluvial grounds of his domain. He inclosed them with dikes, and thus constructed salt marshes. The salters soon noticed that with the water destined to supply their salt-pits there came young fish; they saw them grow and flourish. The fisheries, at first only carried on to supply the wants of the family, soon became a business which extended from the hamlet to the city. The manufacture of salt was abandoned for the new industry, and people studied how to improve the apparatus which was to assure its success. Every year some progress was made, and the fish-ponds have now arrived at that state which, without being the height of perfection that might be attained, nevertheless justifies us in designating their arrangement as a model to all who desire to devote themselves to marine pisciculture. And it is of this arrangement that we now intend to give a brief description.

The fish-ponds were, as we have already remarked, originally salt marshes. They may still be recognized by their general appearance, there being vast sheets of water, separated from each other by pieces of ground equally large and devoted to agriculture. These last-mentioned pieces of ground are called "*bosses*" (protuberances), and have been formed by soil taken from the diggings which constitute the deeper portions and have been assigned to the fish. By means of sluices constructed in convenient places in the dikes which separate the fish-ponds from the basin of Arcachon, the water in the ponds is renewed, and the young fish, when still in the condition of small fry, are introduced into the ponds. These sluices are generally constructed of wood, and consist of four principal parts, viz: In the middle the bridge, which is placed at the higher part of the dike, and which serves as a passage-way; towards the right, and adjoining the bridge, a post, with slides for a large sluice-gate; farther on, another post with slides for the



Ground-plan, following the line A, B.

ELEVATION AND GROUND-PLAN OF A SLUICE.

"sleeve"; and on the left, towards the Arcachon basin, a third post, with slides for a net.

The "sleeve" is a net in the shape of a truncated cone, 7 meters long; its opening is underneath the frame to which it is fastened; it must, under all circumstances, have from 550 to 600 meshes of 11 to 12 millimeters all round, and 120 for the small opening; the large opening is fastened on a wooden frame, either with nails or with a cord passed through holes in the frame.

Filling and emptying.—The ponds are filled with sea-water for the purpose of renewing the water, of providing food for the fish, and of obtaining young fry for the ponds.

The filling process, as a general rule, does not commence till the 15th of March, and lasts till the 1st of November. This period is subject, however, to slight changes occasioned by the temperature and commercial necessities, such as the sale of fish. Easter is generally the time when the filling process commences.

This process is only carried on twelve days in the month, and twice a day, in the evening and in the morning. These twelve days are divided into two periods of six days each. The filling process is carried on for six days during every tide of the syzygies (new moon and full moon). These tides are always very strong; their height, however, varies according to the east and west wind. A south wind causes the tide to rise the highest, whilst a north or northeast wind makes it rise the least.

In order to cause the fry to enter by the "sleeve" (*manche*) system, the frame with its "sleeve" is let down, so as to prevent the fish from escaping; two hours before the sea is on a level with the water of the fish-pond, the gate of the sluice is raised about 7 centimeters, so as to cause a small current of water to flow from the fish-pond into the sea, which is intended to attract the small fish towards the sluice. In proportion as the tide rises the gate is raised a few centimeters, to increase the force of the current. When the sea and the water of the fish-pond are on a level, the gate is raised entirely; there will then be a current of water from the sea into the fish-pond; the higher the tide rises, the stronger will be the current; at this period the precaution should, however, be taken to lower the gate, for the current might otherwise break the "sleeve." When the current has attained its greatest force, the gate is lowered, so as to leave below an open space of only 0.25 to 0.30 millimeter. The small fish are thus drawn into the "sleeve" and thence into the fish-pond.

In employing this method several precautions have to be taken. When the current coming from the sea is still weak, the "sleeve" is kept closed at the narrow end, and is not opened until the current becomes strong, or when the level of the sea, raised by the tide, is 30 centimeters higher than that of the water of the fish-pond; because, if this is the case, the fish in the pond cannot rise with the current or escape.

Species of fish which enter the sluices.—The species of fish which, by means of this contrivance, enter the fish-ponds are as follows:

(1.) *The mullet* (black mullet, white mullet, and "land-jumper"—*saut-curi du pays*); the black mullet is much more frequent than the others.

(2.) *The barbel* only comes in small numbers.

(3.) Occasionally the *plaice* and the *dorado*. About fifteen years ago the dorado came in great numbers; but it seems now to have almost disappeared from these coasts.

(4.) The *sole* only comes accidentally; and the *gurnet* and *turbot*, &c., never enter the fish-ponds.

(5.) *Eels* come in large numbers in spring, when the sluices are first opened.

In April, fry enter the ponds in large quantities; in September they come in tolerably large numbers. They never enter the ponds until they have reached the thickness of a quill; those which come in April are larger than those which come in September.

The draining process.—By the draining process we understand the process by which a portion of the water of the fish-pond is caused to flow into the basin of Arcachon.

For this purpose the frame with the "sleeve" is let down when the tide is low, and the gate of the sluice is raised about 0.07 centimeter; this causes a slight flow of water into the basin of Arcachon not strong enough, however, to draw the young fish from the fish-pond. When young fish show themselves near the "sleeve," through the meshes of which they could slip, the gate is closed and the draining process is stopped.

The keeping and fattening of young fish.—When the young fish have entered the fish-ponds, they must be kept there under those conditions which are most favorable to their preservation, development, and fattening.

(1.) *Preservation.*—Atmospheric influences play a very important part in the preservation of fish, especially of those species which are kept in captivity; cold winds often cause large numbers of mullet to perish. Northeast or southeast winds are particularly dangerous; northwest wind is harmless, and south and southwest winds are very favorable. Any sudden change from high to low temperature, frost or ice is less dangerous than unfavorable winds. In constructing a fish-pond, care should, therefore, be taken to protect the fish against these hurtful influences.

For this purpose shelters have been provided in the following manner:

(1.) The basins are dug in such locations as will afford shelter to the sheet of water from the northeast or southeast winds. This object is attained by having regard to the natural configuration of the ground, by artificial shelters or by trees.

(2.) If these conditions do not exist, the dikes are made as high as possible, so as to form ramparts against the northeast and southeast winds, and in every case trees are planted on the banks of the fish-ponds; the tamarind is the only tree capable of resisting the force of the wind on the shores of the basin of Arcachon.

(3.) Pits are dug in the shape of holes or trenches, thus creating depressions in the ground, 1.30 to 2 meters (and more) deep, where the mullet can take refuge either during great heat or severe frost. These pits are particularly beneficial to the fish when they cause fresh water to flow into the ponds. The temperature of this subterranean water, which is nearly always the same, 8 to 12 degrees, has a very salutary effect, by cooling off the water of the fish-ponds in summer, by keeping up a suitable degree of saltness, and by preventing the sheets of water from freezing in winter. When the surface is frozen, care should be taken to break the ice at regular intervals, so as to establish the proper circulation of air. For this purpose holes are made in the ice, and fagots or bundles of sticks whose ends are mixed with straw, either in small quantity or in sheaves, are stuck in the holes. Without these precautions one would run the risk of losing a large number of mullet, which often gather in the pits in dense masses, and there die from asphyxia.

(4.) Fresh water is brought into the ponds from neighboring water-courses, or from ponds or wells dug in the neighborhood. Such water, by reason of its composition and temperature, produces the same result as subterranean water obtained by digging.

Raising and fattening.—The deep places of a pond are specially intended to afford shelter to the fish, but they would not answer the purpose of raising fish, the rapid development of the fry and the fattening of the grown fish, especially the herbivorous kinds, like the mullet.

With the view of supplying the necessary conditions for raising fish, pastures are provided for them—shallow portions of the pond where those plants will grow which serve as food for the fish. These pasture-lands generally occupy vast plains on the bottom of the pond, where the fish can rest and feed, and where they are exposed to the direct influences of air, light, and sun. The best pasture-lands are those portions of the pond which present an extensive plain, very deep, and with scanty vegetation.

On these pasture-lands the fish might be surprised by cold winds, and might perish in large numbers. In order to protect them, and prevent them from straying away, the water of the fish-pond is lowered from the 1st November to about the 15th March. This causes the fish to seek the deep and sheltered places, where they are protected from hurtful winds, and where they can easily be caught, whenever there is any demand for fish.

The vegetation of the pasture-land and that of the pond in general is of great importance for raising fish.

Aquatic plants not only afford shelter to the fish, but also supply them with food, both in a fresh condition and when decayed. These plants also contribute indirectly to the food of fish by serving as shelter and nourishment to a very large number of small aquatic animals, especially larvæ and shells, which certain kinds of fish will eagerly devour.

For raising mullet, and particularly for fattening them, the *Ruppia spiralis* and *Ruppia rustellata* are the plants which should be particularly cultivated in fish-ponds; for by observing the mullet when on the pasture-lands and by examining its entrails one will find that this fish consumes a large quantity of *ruppias* and a large number of microscopic shells adhering to this plant. This food gives to the mullets from most fish-ponds a peculiar flavor, which can be specially noticed when one takes care to preserve the detritus of this plant in the body of the fish.

Another plant has also been noticed, called by the country people "*lége*"; it is really an agglomeration of confervæ, which makes its appearance in loose threads, forming a sort of green moss on the surface of the water. When this plant grows too extensively it has a hurtful effect; but otherwise it contributes to the nourishment of several kinds of fish, for it nearly always contains a large number of small bivalves and diminutive crustaceans.

For raising and fattening mullet, old fish-ponds are preferable to new ones or to those which have been but recently constructed. In these last-mentioned ponds the fish grow very little during the first three years; after that time they develop in proportion as the pond becomes older. The yield of a pond, which is very small during the first few years, increases in proportion as the fish-pond is filled with ooze, plants, shells, &c. Careful observations have taught men the method which should be adopted to increase the productiveness of a pond during the first years and to aid the action of time, which is never very rapid. It will be sufficient in most cases to introduce and propagate suitable plants which the mullet likes, such as the *ruppia*, also those marine shells which live on these plants, and which are found in great abundance in old fish-ponds. It might also be advisable to raise only carnivorous kinds of fish during the first year, such as the barbel, the dorado, the plaice, the sole, &c., providing them with the food necessary for their development by propagating small crustaceans, shells, &c.

After some years have elapsed, when the time appears to have arrived for substituting mullet for carnivorous fish, these latter must all be caught, because their presence, at least in large numbers, would cause serious ravages among the mullet.

In order to obtain fish of good size and possess a tolerable degree of fatness, the quantity of fry and young fish of different ages should be proportioned to the size of the pond and its ability to supply a suitable quantity of food. Without observing these precautions it will be difficult to obtain fish of the size and quality which are in demand in the market.

THE FISHERIES AND PRODUCTS OF THE FISH-PONDS.

(1.) *Sluice-fishing.*—Sluice-fishing is carried on when the level of the sea is higher than that of the water in the fish-ponds; at the extreme end of the sluice, towards the sea, there is placed a frame made of wire, with meshes 11 millimeters in width, and when this has been done the gate is raised entirely. The water of the sea rushes into the sluice, and creates a current. The fish which are in the pond are drawn towards the sluice by the movement of the water and by its freshness, and as it is always their tendency to go against the stream, they enter the sluice. When a sufficient number of fish have entered, the gate of the sluice is quickly closed, so as to prevent the fish from returning to the pond. They may then be caught in the water with a line, or one can wait till the water of the sea has receded, when the fish can easily be taken out. Fish of small dimensions are thrown back into the pond. This method of fishing is generally employed only in September and October. It is employed particularly for catching eels, called "*mouregains*" by the country people, by proceeding in the following manner:

Beginning in October, and all during winter, when the weather is bad and there is much wind and rain, one drains off the water for three to six hours during the early part of the night, especially during very dark, moonless nights (these are the times and conditions when the eel is liveliest), in order to attract the eels towards the sluice.

When the sea has completely receded, generally after two hours, the wire frame is placed outside the sluice, as I have described above, and the gate of the sluice is raised about 1½ centimeters; a strong current is thereby established from the fish-pond to the sea, and the eels pass with this current underneath the gate and gather in the sluice. At daybreak the gate is let down again to prevent the eels from returning to the fish-pond. Generally about 500 kilograms of eels are in this way caught in one sluice. This is a very excellent method of fishing, as it does not involve any expense. As a general rule, only full-grown eels are caught. Care should be taken not to drain off the water from the pond, or to catch full-grown eels during the month of March, for during that month the young eels would escape from the pond and would pass through the wire grating. During the other months the young eel is very quiet; it remains in the pond and shows no desire to escape.

(2.) *Trammel-fishing.*—For trammel-fishing one uses an ordinary trammel with lead and cork. The fishermen who manage it are in a boat, and row about, describing circuits or labyrinths, all the while making a noise, in order to frighten the fish which become entangled in the meshes of the net. On account of the large size of the meshes, one only catches large or medium-sized fish. This method of fishing is only employed during the day, from the end of August till Easter.

Pond-mullets are only caught from the end of August, for the following reasons:

During the hot season the fish grow most rapidly; if, therefore, they were caught during this period of the year, this would occasion a considerable loss, not only in weight, but also in quality; for fish, transported during the hot season, often undergo a change; they lose much of their freshness, and cannot be sold to advantage. The fisheries of the basin of Arcachon are, moreover, very abundant during summer, and the sale of fresh vegetables interferes considerably with the sale of pond-fish. These are the reasons which have determined the owners or farmers of fish-ponds not to commence fishing until the weather gets colder. The fisheries generally extend till Easter, because the Holy Week is very favorable for the sale of fish.

Fishing with the fish-gig.—This method is exclusively employed in catching the various kinds of eels, from February till Easter. The reasons for this are as follows:

In order to use the fish-gig advantageously, the water in the ponds must be very low, so that the eels may be gathered in larger or smaller groups. The fish-gig should only be used when frosts need no longer be feared, for, on account of its troubling the water, the fish-gig would, in case of a severe frost, increase the danger to the mullet. The ooze is carefully gone over in all directions with the fish-gig, and its five prongs are inserted in innumerable places. The eels which are caught in this manner are, therefore, partly lacerated.

Fishing with the fish-gig has this advantage, that in this way even the bottom of the pond is made to yield a profit; but, on the other hand, it involves considerable expense in the way of wages to the fishermen; and, after all, it only yields dead or torn eels, which cannot in that condition be sold to advantage, and which cannot be kept alive.

Production of fish-ponds.—In its present condition pond-culture only occupies itself with eels and mullet, called "*mules*" in this part of the country. The mullet constitute the more important object of these fisheries.

Pond-mullet belong mainly to three different kinds:

(1.) The "*negrott*," or black mullet.

(2.) The "*saoultott*," or sand-jumper (the golden mullet—*Mugil auratus*).

(3.) The "*blancheou*," or white mullet (the "*ramado*" or *Mugil capito*).

Of these three kinds the black mullet, or the "mullet with thick lips," is found more frequently than the two other kinds. It enters the sluices in very large numbers, and seems to flourish better in the ponds than the other kinds. Its size is, generally, one-third greater than that of the other two kinds, more especially than the white mullet (*Mugil capito*).

The average annual yield from the mullet and eel fisheries may be estimated at 300 kilograms per hectare.

The establishment of fish-ponds, therefore, offers positive advantages, not only by increasing the quantity of food for the people, but also by being more profitable than the cultivation of the soil; for in these parts the average annual yield of a hectare of ground, set out in wheat or beans, is 100 francs; of meadow-lands which are not irrigated, 120 francs; of meadow-lands irrigated by fresh water, 250 francs; and of salt marshes, 150 francs; whilst fish-ponds, when properly cultivated, will yield as much as 300 francs per month.

It must be borne in mind that this result is obtained in a perfectly natural manner, without using any artificial food. The fish are actually left to themselves in the ponds, where the *ruppia*, which grows spontaneously, is sufficient for their nourishment.

The construction and cultivation of fish-ponds cannot, therefore, be too highly recommended. Our population is constantly increasing, and its luxuries and actual needs increase still more rapidly. All classes of society eagerly seek enjoyment of every kind, and the scarcity (every day greater) of delicate meats, such as fish, threatens at no distant future to make many articles of food almost unattainable, food which is eagerly sought by all classes, absolutely necessary for weak and sick people, that it becomes a matter of great importance to place it within the reach of those (especially the last mentioned) who are not favored with a superabundance of this world's goods.

Two objections, however, have been raised against the fish-ponds. It has been said that they are a cause of insalubrity because their waters are often stagnant; and, secondly, the objection has been raised that they create a competition which endangers the privileged fisheries of the enrolled mariners.

Insalubrity.—The first of these objections shows an entire ignorance of the manner in which fish-ponds are managed, for their water is renewed twenty-four times per month; for example, during the three days which precede and the three days which succeed the new and the full moon, during the double day and night tide. Can water be called stagnant when it is renewed twenty-four times per month?

It has also been said that the mingling of fresh and salt water is productive of insalubrity, whilst this mingling is certainly recognized as favorable to the development of fish, improving the flavor and quality of their flesh.

Without entering into a scientific discussion of this assertion, we will confine ourselves, by way of refutal, to presenting the sanitary statistics of the country—statistics taken among those classes of people which are most exposed to the alleged fever-breeding miasmas of the fish-ponds; I mean the salters, lock-keepers, and the customs officers, the last mentioned being often compelled by their duties to pass their nights near the marshes. It must be granted that the salters are the most robust people in that part of the country; and as far as the customs officers are concerned, we point to the report of the inspector of customs, which says that of all the customs officers scattered along the coast of the basin, those of the district of Aude had the smallest number of sick, even less than the healthy district of Arcachon.

The fact that the mingling of fresh and salt waters, when the latter are not stagnant, is perfectly harmless, has been fully corroborated by Mr. Coste's observations in the lagoons of *Comacchio*. This famous author says: "Intermittent fevers to which people living in a marshy country are generally exposed are not frequent at *Comacchio;* and whenever there are in the neighboring country any young people with a feeble constitution or threatened with consumption, they are sent into the marshes for the purpose of gaining strength, and are made to share the work and food of the fishermen."

Competition.—In a petition addressed to the minister of marine, the proprietors of fisheries, especially those of the district of La Teste, have thus expressed their grievances:

"During winter, when the scarcity of fish would allow us to realize some profit, we are deprived of this advantage by the number of fish from the fish-ponds which are brought to the Bordeaux market."

This was followed by a request to have the fish-ponds abolished, so that with them all competition might disappear, and the greater scarcity of fish bring about a corresponding rise in prices.

To expose such pretensions means to denounce them. Without seeking to refute them, we feel nevertheless constrained to say that this competition which has been denounced in such a manner does not exist at all, neither in the fish-market nor in the fisheries.

As regards the fish-market, it must be said that the ponds only furnish fish during winter, therefore at a time when bad weather has rendered fishing impossible, or at least prevents the fisheries from fully supplying the demand.

As regards the fisheries, it must be said that when the mullet enters the fish-ponds it measures, generally, only 6 centimeters in length and 8 millimeters in breadth. If caught by the fishermen these young fish would uselessly perish on their hands; it has, therefore, been found necessary to prohibit the fishing of young mullet. In the fish-ponds, on the other hand, the mullet is left in peace, and finds all those conditions which favor its preservation and development. Left to itself in the basin of Arcachon, the young mullet is often thrown by the tide on the shore, where it invariably perishes, and in nearly every case falls a prey to voracious animals, most of which are of no use whatever to man.

The fish-ponds, therefore, tend to utilize for the food of man products which otherwise would, to a great extent, be lost.

The young fry of the mullet, during the first stages of their development, remain in the basin of Arcachon. As soon as frost sets in, they leave this basin and seek deep and sheltered places farther out at sea. Their migration commences in November, and at that very time a large number of fish of prey are observed, notably hake, which, by their instinct, are led to the entrance of the Arcachon Basin, where they find an enormous number of young fry, especially of the mullet kind. On opening these hake their stomachs are found filled to repletion with young fry, particularly with young mullet. Before the migration of the mullet, the hake were thin, but after a few weeks they have grown very fat.

There seems no way of counteracting these powerful causes of destruction but to place a certain quantity of fry in the fish-ponds. This destruction of the fry is very much to be regretted, for actual observations regarding the growth of fish of prey in the coast-waters, and that of mullet in the fish-ponds, show the following result: A thousand young mullet left in the basin of Arcachon are, when quite small, devoured by fish, whose flesh may be used as food, but which at best only furnishes half a kilogram of flesh fit to eat; whilst the same number of young mullet, placed in fish-ponds and raised there, furnish, when grown, more than 1,000 kilograms of the most delicious food.

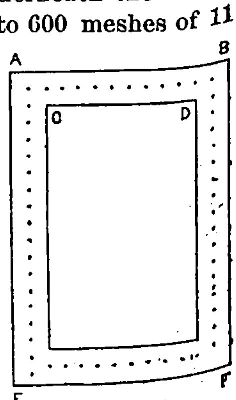
Under these conditions, and in view of the constantly rising prices of all articles of food, especially animal food, we must say once more, and in the most emphatic manner, that the development and cultivation of fish-ponds cannot be too highly recommended, and that whereever they do not yet exist they should certainly be established.

SLUICES.

Introduction of young fish.—By means of sluices, constructed in convenient places in the dikes which separate the fish-ponds from the Arcachon Basin, the water of these ponds is renewed, and the fish, when still quite young, are introduced into the ponds.

The sluices are constructed of wood, and consist of four principal parts, viz: In the middle, the bridge which is placed against the high part of the dike, and which serves as a passage-way; to the right, towards the fish-pond and leaning against the bridge, there is a post with grooves for a large gate; farther on, another post with grooves for the "sleeve"; to the left, towards the basin of Arcachon, a third post with grooves for a fishing-net.

Use of the "sleeve."—The "sleeve" is a net in the shape of a truncated cone, 7 meters in length; its opening is exactly underneath the frame to which it is attached; it must always have 550 to 600 meshes of 11 millimeters' width, on its sides, and about 120 for the small opening. The net-makers are permitted to make the meshes larger for a portion of the net, measuring about 3 meters from the small opening; but they must gradually decrease in size until they have reached 11 millimeters; the small opening measures about 30 centimeters in circumference.



The large opening is attached to a wooden frame, either by nails or by a cord which is passed through holes made in the frame.

A B=1.10 to 1.30 millimeter.

C D=1 to 1.20 millmeters.

A E=The legth or height is proportioned to the depth of the sluice.

In all cases, however, the line E F must touch the bottom, and the line A B must rise 0.50 millimeter above the level of the water, so as to prevent the mullet from leaping over the frame and escaping in that manner. The frame runs in two posts with grooves.

Manufacture and preparation of "sleeves."—At Bordeaux "sleeves" are prepared by the process employed for preserving awnings and sails. This process imparts to the the twine a greenish color. It costs, per "sleeve," from 1 franc 75 centimes (34 cents) to 2 francs (39 cents), according to the weight, and makes a "sleeve" last one-third as long again as it would have lasted otherwise. A "sleeve" without preparation costs 25 francs.

This apparatus is made at *Bassens* (12 kilometers from Bordeaux) by women and children; the twine is manufactured at Tonneins (Department of Lot et Garonne); in making a "sleeve" 10 francs' worth ($1.93) of twine is used; the maker gets 10 francs, and theprofit of the merchant is 5 francs (96.5 cents).

If a "sleeve" has been well prepared it will last one year; this will greatly depend on the quantity of detritus, refuse, and plants floating in the sea and drifted towards the "sleeve"; sometimes a "sleeve" will last eighteen months; but as a general rule a "sleeve" without preparation becomes worn out in about eight months.

It will be good to immerse the "sleeve" from time to time in tan (an infusion of the bark of oak), which gives to the twine a reddish color.

STOCKING THE FISH-PONDS.

Process of stocking.—The following kinds of fish when quite young are made to pass from the sea into the fish-ponds by means of sluices:

Mullets, commonly known as "*mules*," enter in large numbers and form the most important part of the population of the ponds.

Barbels, commonly known as "*brignes*," only enter in small numbers.

Eels enter in large numbers in spring, when the sluices are opened.

The introduction of young fry into the ponds by means of a net ("sleeve") placed in the sluice often causes too large a quantity of barbels and eels to enter at the same time, which is not desirable, as these fish are exceedingly voracious, and are apt to devour all the young fry of the mullet. The only means of warding off this danger is to gather but few young mullet in the "sleeve," and to raise young mullet by *artificially impregnating* their eggs, which are generally emitted by the spawning process at the end of June or the beginning of July. By replacing the "sleeve" with a metallic frame (not letting any sea-water enter), and by hatching fecundated eggs only of the better kinds of mullet, the pond will be exclusively stocked with these fish, the cultivation of which is far more profitable than that of the barbels and eels. It may be well to state, in this connection, that the mullets, more especially the black ones, can easily stand saltness varying from zero to 8 degrees of Baumé's areometer, and a degree of heat and cold which would cause most other fish to perish.

Rules to be observed in transforming salt marshes into fish-ponds.—In transforming salt marshes into fish-ponds the following rules should be observed:

A request should be addressed to the minister of marine asking for the privilege of converting into fish-ponds the whole or part of a salt marsh. Such a request is never refused.

The water of the sea should be allowed to flow off by means of trenches.

The saltness should be taken out of the ground by rain-water, either by allowing the rain to fall on it, or by gathering the rain-water on the neighboring land.

Whenever there is a sufficient quantity of water from wells or water-courses, it is used for watering the ground and for freeing it from the greater portion of the sea-salt with which it is impregnated.

The ground should be allowed to dry until it has reached a degree of consistency sufficient to permit of its being worked with a spade.

The soil gained by digging is used for constructing large and solid dikes intended to retain the water in the fish-pond and to prevent the water of the sea from flowing into it.

In these dikes sluices should be constructed for renewing the water of the ponds, and for introducing the young and fry of fish.

By all possible means the growth of *Ruppia spiralis* in the ponds should be encouraged.

Deep places should be dug in certain portions of the pond, pastures should be established, and shelters should be constructed. Rain-water, wells, and water-courses should be utilized for the purpose of rendering the water of the ponds brackish.

Regulating the fish-ponds.—These fish-ponds, being fed from the basin of Arcachon by means of sluices, were classed among the coast-fisheries; and, although they are located on private property (they were formerly salt marshes), they come under the general law of January 9, 1852, for regulating such fisheries.

Before the regulation of July 4, 1853, went into effect, the sluices were at their inner opening furnished with a "sleeve" or bag-shaped net, 7 meters in length, the meshes of which each formed a square of 11 to 12 millimeters; the fry that came with the tide were drawn into this net and thus carried into the reservoir. The "sleeve" was used for preventing both the fry and the young fish, fattened in the ponds, from leaving the ponds; and the size of the meshes was arranged accordingly.

The above-mentioned regulation has raised these dimensions to 25 and 18 millimeters: "The sluice or way of communication will be closed at its inner opening by a wire grating or by a net, the meshes of which shall each measure at least 18 millimeters square from the 1st of October till the 31st of March, and 25 millimeters from the 1st of April till the 30th of November.

"At the moment when the sea-water enters the ponds there may be substituted for this grating a bag-shaped 'sleeve,' or net, the meshes of which, throughout its whole length, shall measure at least 18 millimeters from the 1st of October till the 1st of March, and 25 millimeters from the 1st of April till the 30th of November." (See Article 27 of the above-mentioned regulation.)

This provision might cause the ruin of the ponds. When the fry enter the inner basin, they generally measure only 6 centimeters in length and 8 millimeters in breadth; meshes of 25, and even of 18, millimeters would therefore not only *allow the fry to escape*, but also, as has been observed repeatedly and under different circumstances, *liberate those fish which have been raised in the ponds*, and which have reached the size of 20 centimeters.

For ordinary fishing, as in those fisheries which are carried on in the sea and in the basin of Arcachon, the prohibition of apparatus with narrow meshes is perfectly justified. Narrow meshes, in fact, would either injure or capture the fry, which would thus *perish uselessly* in the hands of the fishermen; the use of nets with narrow meshes has therefore been prohibited.

The ponds, on the other hand, which are guarded by apparatus with narrow meshes, *keep* the fry, and furnish them *with all the conditions which are essential for their preservation and development.*

These facts have been taken into serious consideration by the minister of marine. Article 9 of the decree of May 10, 1862, contains the following: "Fish-pits or fish-ponds may, after proper authority has been granted, be constructed on private property which receives water from the sea. The licenses granted by our minister of marine and the colonies will determine, according to the character and extent of the ground, the conditions upon which these ponds are to be managed."

At this day the size of the meshes of the nets ("sleeves") placed at the opening of the sluices is no longer regulated by law, but the owners of fish-ponds adopt the size which suits them best. Only one condition is imposed on them, viz, not to bring to market fish which do not have the regulation size—barbels 0.10 millimeter in length, mullets 0.14, and eels 0.25.

Under these conditions, the transformation of salt marshes into fish-ponds has steadily increased; at the end of 1876, there were 1,022.50 hectares of such ponds; and there is every reason to hope that this number will be increased tenfold.

XVIII.—POND-CULTIVATION ON THE KANIÓW ESTATE (DISTRICT OF BIALA, GALICIA), THE PROPERTY OF HIS IMPERIAL HIGHNESS, ARCHDUKE ALBRECHT OF AUSTRIA.

Paper prepared for the International Fishery Exposition at Berlin, 1881.

By ADOLF GASCH, *the present farmer of Kaniów.**

It is not my present intention to write a manual of pond-cultivation. The sole object of the following monograph is to present a sketch of pond-cultivation at *Kaniów* as it is actually carried on, with all its defects and excellencies, for exhibition, criticism, and, possibly, imitation; and, in presenting this sketch, I shall treat the subject principally from an agricultural point of view, as the Berlin Agricultural Club will mainly view the subject from that stand-point.

The special data relative to pisciculture have reference only to carp, as the principal object of fresh-water fisheries, although they will apply more or less to all fresh-water fish, at least to all those fish which form objects of special cultivation.

The domain of *Kaniów* (and *Mirowec*) which belongs to His Imperial Highness Arch Duke Albrecht of Austria, lies north of the *Beskiden* range in the lowlands of the Vistula, on the right bank of the river Bialka, which forms the boundary line between Galicia and Austrian Silesia, and near its confluence with the Vistula. On its territory, comprising 1,000 Austrian acres (575.46 hectares,) it shows all the characteristics of old alluvia of a large river and a mountain stream combined; clay alternates with occasional rocky strata, sand, loam, and humus in this bottom land, from which the water has receded. Fully one-half of the estate has a heavy clay soil, one-fourth is composed of peat-bogs and sand, and the rest has a light loamy humus-like soil. With the exception of the sand all these soils contain iron. They are damp, and, in some places, even marshy, but show a rich vegetation of grass and clover, probably owing to their strong alkaline qualities caused by the decay of the carpathian sandstone; and this peculiarity is still more favored by the exceedingly moist climate. Till within four years the estate was frequently subject to inundations. Since, moreover, the water of the Bialka, which passes the manufacturing towns of

*"*Die | Teichwirthschaft | auf dem | Sr. Kaiserlichen Hoheit dem Herrn Erzherzog Albrecht von Oesterreich | gehörigen Gute | Kaniów, | Bezirk Biala, Galizien. | Zur internationalen Fischereiausstellung in Berlin | im Jahre* 1880, | *dargestellt vom gegenwärtigen Pächter | Adolf Gasch.*"—Translated by HERMAN JACOBSON.

Bielitz and *Biala*, often contains a considerable quantity of fertilizing matter, nature has very clearly indicated that stock raising and pisciculture must be the principal objects to which attention should be paid at *Kaniów* and *Mirowec*.

From time immemorial the *Kaniów* estate had large but badly watered ponds, which, in former times, occupied almost the entire territory, and which, even now, after having been regulated, occupy 450 acres, or 45 per cent. of the total area. Of this pond area, 250 acres are on the heavy clay soil, 50 on the marshy soil, and 150 on the light loamy soil. In many cases, however, two of these soils are found in one pond. All the ponds are fed by the Bialka water which, especially during seasons of violent rain-storms, carries with it a great deal of fertile mud, so that the ponds actually serve as mud reservoirs. But as pond cultivation is carried on in these parts on an extensive scale, the Bialka water is often insufficient, especially in midsummer, when there is so much evaporation from the large sheets of water. This, of course, injures pisciculture, and does not allow it to be carried to its highest perfection. Nearly all the ponds in this part of the country are shallow, and invariably incline towards the Vistula. In former times they were badly watered, and a system of regulating was inaugurated by my predecessor, Herr Potyka (who deserves great credit for his energy and perseverance), and has been completed by me at my own expense, so that at present nearly the entire pond area is covered with water. All the ponds can be drained so thoroughly as to allow of their being plowed and planted throughout their entire extent. In these parts it has, fortunately, long been known that it is not sufficient to provide the ponds with an ample supply of good water, and to keep their soil fertile, but that it is absolutely essential that the ponds can be entirely drained at any time for the purpose of fishing or planting. Wherever this cannot be done, there can be no systematic and profitable pond cultivation, but merely irregular lake fishing. The most profitable part of pond cultivation, viz, their agricultural utilization by planting, is thus entirely lost.

Of the 450 Austrian acres of our pond area, 400 acres are occupied by nine main ponds, one of which has twice the average size; 3 acres by five spawning ponds, and finally 47 acres by eight ponds for the young fry, to which, since 1877, there must be added 22 acres occupied by three ponds for young fry which were rented from a neighboring farm, so that the total pond area of this estate is 472 acres.

Of the above-mentioned nine main ponds, which are equal to ten medium-sized ponds, Mr. Potyka, who deserves great credit for his zeal in carp culture, only had the smaller half under the water, the remainder being either planted by himself or rented out for the same purpose. The young carp were always left in the main ponds two full years, which produced a very fine marketable fish of about 1½ kilogram average weight. The average yield per acre was, according to the official reports, 103 kilograms of fish, each fish weighing on an average 1.394 kilograms. These fish even at that time enjoyed the reputation of being the finest carp in the whole neighborhood, and were nearly all shipped on the Vistula to *Cracow* and *Warsaw*. After a pond had been under water for 4 years, it was entirely drained, and served agricultural purposes for 5 or 6 years.

When in August, 1873, I took *Kaniów* and *Mirowec* on a lease of twelve years, the ponds contained a fine well formed species of carp, and pond cultivation had been carried on systematically though perhaps not as vigorously as it might have been. I immediately took steps to extend the pond cultivation, by allowing one year to pass, and then, in 1875, planting or renting out for the same purpose one-half, and fishing in the other half after the first summer. From that time on one pond was plowed and planted every autumn, whilst at the same time one pond was freshly watered. This system I have maintained ever since, in spite of the difficulty experienced in the beginning, of obtaining the very large quantity of young fish required, because it offers many and great advantages. At present the greater half of all my ponds are under water, and I confine myself to plowing and planting one pond, either main pond or pond for young fry, a year, with the view of providing a sufficient quantity of fodder of the very best quality for my valuable herd of cattle. All the ponds are of course at present managed by myself, and none are rented out.

It is well known that the carp grows most rapidly during the first year of its life, and slower as it grows older. If the main ponds are, therefore, drained of their fish *annually* the most favorable result will be obtained. By avoiding one wintering the risk is greatly decreased and the stock of fish is under more frequent and better control. This system, moreover, offers the advantage that one has a certain regular annual income, which will vary but little; and thereby that point is reached which, owing to the slowness of all agricultural processes, is after all mainly to be aimed at, viz, to decrease the working capital and to obtain a rapid sale for the products of the farm.

I did not rest satisfied with this change, but aimed at a further improvement of our breed of carp by selecting the breeders very carefully, having special regard to their build and to rapid growth (if this can be considered a peculiarity of any breed of fish). Herein I was guided by the view that a fish possessing a well-shaped body is apt to develop a larger quantity of flesh, thus obtaining not only a greater total weight, but also a more even proportion between the valuable and valueless portions of the body, which of course increases the worth of the fish. I therefore principally look for a comparatively small head, a well-arched full back, and a broad and well-rounded body. In other words, a good carp of pure breed is to be among the fish what shorthorns are among cattle, particularly as, in all probability, the carp will, for a long time to come, remain the principal fish bred and raised in our ponds.

I begin to select my future breeders among the one-year-old fish, and continue to select some from the two-year-old fish, as well as from those which have reached a marketable age, 3 years, so as to have on hand a considerable number of breeders from among which I then select the best.

Following *Dubisch's* method, I only place one spawner and two milters in one and the same pond. These are fully able to supply my demand for young fish, which at present amounts to 60,000, for stocking the original *Kaniów* ponds and those I have rented from *Prince Pless.*

It is not necessary, but even injurious, to place a larger number of breeders in one pond, because they are apt to produce too large a number of young fish, which might suffer from want of food; and if carp are to grow rapidly, it is very essential that the growth of the young fish should be favored as much as possible by supplying them with ample food, which can be done even without having recourse to artificial food; so that by merely furnishing a sufficient supply of natural food one can, during the first summer, obtain fish 5, 8, and even, in exceptional cases, 10 inches. With these young fish I stock my ponds for young fish during the second summer, allowing 240 to 360 per acre (about 420 to 630 per hectare) according to the size of the fish and the nature of the pond. In this manner I obtain carp weighing ½ to ¾ kilogram, and even reaching in some cases the weight of 1 kilogram. Of these I place 90 to 120 in the main ponds during the third summer, and thus obtain carp weighing 1 to 2 kilograms a piece, when ready for market.

I have not always been able to supply the necessary number of carp for raising, and as there are no spare ponds for young fish near *Kaniów*, and as unfortunate accidents will sometimes occur, even in the best piscicultural establishments, I have repeatedly been obliged to supply the places of the lacking fish by placing selected fry of unusually large size in the main ponds, and in these cases I have invariably obtained fish weighing about 1 kilogram each and having particularly fine and tender flesh. I have also observed that young fry, which have grown rapidly, will continue to grow fast till they are ready for the market, and actually grow faster than young fish of the same age which have been somewhat retarded in their growth; but that the latter, although of equal size, will weigh heavier, when they have reached a marketable age, than fish raised from young fry, because their flesh has a greater consistency.

It should therefore be the aim to accelerate the growth of the fry and the young fish as much as possible, because fish which have grown rapidly are apt to continue this rapid growth; and it would be very bad policy to be stingy with the extent of water allowed for the raising of fish, because the final result will amply compensate for this.

As regards the stocking of the main ponds, it is an old experience that in stocking a certain extent of water with a small number of fish, finer and more valuable specimens will be obtained; whilst the stocking of the ponds with a larger number of fish, if kept within reasonable bounds, will result in a greater total weight, but in an inferior quality of fish. Stocking ponds with a small number of fish is therefore to be recommended, but, like everything else, it should be kept within proper bounds, and a correct calculation will herein form the safest guide. No more than 90, and never more than 120, fish per acre are placed in the *Kaniów* ponds. The result has been that our breed of carp has steadily improved, and the number of kilograms of fish caught per year and per acre has been as follows:

	Kilograms.
Up to 1873	51.5
1876*	76.76
1877 and 1878†	83.00
1879	104.50

thus, the yield of the ponds has more than doubled in six years, and regarding the quality of our fish I can state that in one year we raise very fine carp, weighing 1½ kilograms and more, which enjoy an excellent reputation in the Breslau and Hamburg markets.

In favoring the growth of carp from their earliest youth, one has the special advantage that the fish, in spite of their size, remain slender in figure (that is, do not have those monstrous stomachs which are seen in some fish), and that they begin to grow fat at an early age, whereby, as in all animals, the development of the sexual organs is often entirely stopped, and the favorite fish of all gourmands, the "barren carp," is obtained.

With the view of increasing the natural food in the ponds, they are allowed to lie dry during the winter, in order that the frost may deprive the mud of its acidity, thus making it, by atmospheric influences, a suitable breeding-place for insects and infusoria. For the same reason I never allow the bottom of a fresh pond to be hoed before its first watering. This method has stood the test of a number of years. It seems best, however, if during winter the larger portion of the pond is exposed to the frost, leaving a small portion under water to serve as a place of refuge for valuable aquatic animalculæ, where they may be sheltered from the destructive cold, so that with the beginning of spring they can breed all the more rapidly and numerously in the freshly filled pond, and in this way be of great benefit to the carp. I have demonstrated with two of my ponds, which were treated in this manner, that by wintering some of the fish in the deepest places the result will be a steadily increasing number of fish during the fishing season, which is not the case when ponds have been under water for a long time.

* The years 1874 and 1875 being transition years, have not been taken into account.

† The greater portion of the fish of the year 1877 were not sold, but were kept in tanks. They were recently placed in ponds with the other stock of fish of 1878, and were finally sold with these.

In order to dispel the erroneous idea that I obtain the above-mentioned results only by going to a great expense, I will mention that for tending the *Kaniów* ponds of 450 acres I only employ one assistant, and that for the 22 acres of ponds which I rent I only employ one person as a watchman. During autumn, when there is more danger from fish thieves, and during winter, when holes have to be cut in the ice, I generally employ an extra assistant for the *Kaniów* ponds.

Even while under water the ponds do not merely serve piscicultural purposes, but also, in a narrower sense, assist agricultural objects.

As soon as spring sets in, and the ponds are released from their icy yoke, varied life begins to stir in the water; manifold aquatic birds begin to make their appearance with the first warm rays of the sun; insect-life begins to awaken, and a grand and mysterious activity is developed in the ponds. Long before the land casts off its wintry mantle, the ponds as far as the water reaches are clothed with verdure, as a welcome indication to the farmer that the time is near, when after a hard winter he will, as stock-raiser, derive advantage from his ponds, in the cheap, profitable and ample pastures they will furnish. As soon as the water has lost its icy temperature, which does not agree with cattle, they may be allowed to go into the ponds, where, wading about, they seek their food. They are thus not only benefited themselves, but through their excrements, dropped here and there, they indirectly benefit the fish. By treading about in the muddy bottom they stir it up, and thus enable the fish to catch more readily worms and other aquatic animalcula which serve as fish-food. Cows generally become accustomed to these pond-pastures very quickly, and actually show eagerness to go into the water, which from a sanitary point of view, also, is beneficial to them. No one, who has not seen it himself, would believe with what delight cows take their bath, eagerly eating all the while, until they are satisfied and seek a place of rest in the higher portions of the pond. Even if the number of cattle is very large, they are not able to destroy the luxuriant growth of grass and reeds; and the farmer will soon have to place them in another pond where the grass is younger and more tender. As soon as cows enter a new pond, they will act like boys just let out of school. The new pond, a veritable *terra incognita* for them, is eagerly explored in every direction, until they seem to have taken all its bearings, when their appetite returns and they begin to graze. The wild ducks, scared away by the first noisy approach of the cattle, again enter the pond and boldly swim about close to the grazing animals, whilst the carp peacefully seeks its food, without being in the least frightened by either ducks or cattle. Such a pond therefore resembles a small but harmonious and happy community, where every one is doing well and feels contented, and lives on the most friendly footing with his neighbor, much as he may differ from him in nature and habits. Below the surface, however, and hidden from the eyes of the humam observer, a terrible war for existence is waged among the diminutive animalcula which fill the water of the pond.

These pond-pastures not only supply the cattle with pleasant and healthy food, but actually become a source of profit to the farmer. My cows, always well fed, give better milk when grazing in the ponds, than when they are stable-fed with fresh clover. There is no fear that the reed-grass (Polish, "*odymka*") will make the cattle bloated; for this quality of the reed-grass—which it undoubtedly possesses—is entirely lost when it grows in the water. Altuough my cattle have pastured in ponds for seven years, I have not had a single case of the kind. Whoever has time and opportunity to mow the reed-grass before it blossoms, and dry it, will thus obtain excellent hay for the winter. On account of the large quantity of nitrogen it probably contains, of its fine texture, and finally, on account of its tough character, it easily becomes heated and to some extent begins to ferment; great care should be taken to avoid this. The same applies to the remnants of grass, &c., which are left after a pond has served as pasture. The best way is to let this grass lie for a considerable time, and then to put it up in stacks or small heaps, only using it mixed with harder winter straw, when it will make a good and effective fertilizer.

It would doubtless be profitable to make experiments with feeding cattle on hay from the ponds, mixed with winter-straw and rape-stalks, for this would in all probability furnish excellent food for the young cattle during winter. Unfortunately I cannot speak in this matter from personal experience; but it would be very gratifying to me, if my remarks would encourage others to make the attempt.

I need not dwell on the utilization of the mud from the ponds, as being too well known. This manner of utilizing ponds will only be profitable in cases where the mud can during winter be taken direct to a neighboring field, to be used as manure, such as for clover, or for making the hot manure from the cattle-yard somewhat milder; for if the mud is to be transported any great distance, the expense will exceed the profit, as is often the case when heavy manure is sent any distance.

All these small profits yielded by a pond whilst still under water are insignificant if compared with the vast benefit to accrue from a pond which, after having served piscicultural purposes for a number of years, furnishes the farmer with a rich and well-manured soil, fit for almost any kind of plants.

A farmer who is able to drain his pond entirely and plow it thoroughly before winter sets in, will find it easy work in spring to plant the muddy bottom of the pond, transformed by the frost into the very best of soil. If he does his work carefully, he may confidently look forward to a rich harvest, which will fully repay him for the considerable trouble involved in the first plowing, and which will prove beneficial to his entire farming operations. Let no one say that it is too difficult, or even impossible, to plow large ponds in autumn, after the fishing season has come to a close; for if it is possible to plow the large *Rosenberg* pond near *Wittingau*, in Bohemia, measuring 1,500 acres, where fishing does not commence till the beginning of October, it will be an easy matter in small ponds, especially if one takes care to get a number of extra oxen for this extra work, to be employed, of course, only temporarily for this specific purpose. It will be found most profitable to employ for this work oxen which, being well fed during the season of labor, may often be sold with advantage, after the work is done, to butchers for fattening. The capital invested will thus be profitably reduced.

Possibly it would be found advantageous to use a steam-plow in very large ponds, but this will of course depend on the locality, the means at the farmer's disposal, &c.

Under all circumstances it is not only a short-sighted policy, but actually an injury to the national wealth, if any farmer, who has the means, does not drain at least those of his ponds where this can be done easily, and periodically devote them to agricultural purposes, thus deriving the greatest possible benefit from every part of his property. There are many farmers who are unfortunately compelled to obtain their manure from abroad, partly on account of insufficient harvests from poor fields, partly because industrial enterprises necessitate a greater production. Many farmers who possess arable ponds, unfortunately have recourse to the comparatively easy system of buying artificial concentrated fertilizers, before they have made careful and repeated experiments, to determine whether these fertilizers will suit their peculiar soil, and the consequence is that they soon become convinced by bitter experience of the mistakes they have made, which, moreover, in most cases has proved a considerable expense.

In my opinion it would be far more practical, and, at least as long as agricultural chemistry, owing to the great and general ignorance of the nature of soils is not able to give absolutely reliable advice as to the application of fertilizers, much more rational, to make use of those advantages furnished by every locality, *i. e.*, to use that fertilizer which, so to speak, has grown on the same soil (the mud of ponds is nothing but a portion of the soil), and will, therefore, be particularly suitable, can easily be assimilated, and with very little trouble can be transferred from the ponds to the neighboring fields. No harm will be done, even if in some cases this fertilizer is mixed with other substances not having such strong fertilizing qualities. In using mud from the ponds as manure, the plants growing on fields, whose soil has thus been improved will of course draw from the ground only those substances needed for their growth. In this manner a circulation, on a small scale, of the most valuable mineral substances serving as food for plants, is inaugurated, atmospheric influences uniting with these during the growth of the plant; whilst the mineral substances above referred to, during this process, again return to the inexhaustible source whence they came, of course excepting that small portion which was taken away in the fish, of which, during the flooding of the upper portions of the pond, does not return to it.

What wealth of excellent food for plants may eventually be secured by the pond-harvest, may be gathered from the observation that the water of the ponds is, even in its original condition, the bearer of dissolved fertilizers, which become a portion of the mud at the bottom and increase its existing wealth of food for plants, to which are added the valuable refuse, &c., from the manifold animal life of the water. The correctness of this view is proved beyond doubt by the exceedingly luxuriant vegetation of the ponds.

As long as the ponds are not plowed and regularly planted, a greater or smaller quantity of plant-food lies almost idle in the mud of the ponds, as only a very small portion of it is utilized as pasture, hay, &c. Every farmer, therefore, who has the opportunity, should aim at the greatest possible utilization of the mud in his ponds, by regulary plowing and planting their bottoms. For my part I do not hesitate in the least to derive the greatest possible profit from my ponds, by benefiting my other fields through them, and I feel convinced that even *Justus von Liebig* would have sanctioned this system, because during the very next period of flooding or filling the ponds, all those substances which were removed with the mud, would gradually be replaced by fresh accessions thereof.

As to the manner in which the hidden treasures of the mud may best be secured in various localities, *i. e.*, what kind of cultivation will best suit the different ponds, we must say that no doubt every intelligent farmer will find this out for himself, and all that is necessary is to give a few hints.

The following method has, after a number of timid experiments, proved eminently successful in the *Kaniów* estate: in poor ponds I plant, the first year after the pond has been drained, oats, the second year again oats, or, applying a small quantity of manure, wheat mixed with clover, followed in the third and fourth year by clover which, mixed with grass, furnishes excellent pasture during the fifth year, unless I prefer to fill the pond after the fourth year. I do not hesitate to apply some manure to such ponds, especially in the higher places which have not been thoroughly flooded by water, which I can easily do, as I have always some manure to spare. Whatever I have planted in such ponds has thriven better than, or at least as well, as on the best fields on my farm, and moreover, I thereby furnish a suitable breeding-place for the insects and infusoria which, when the pond is again full of water, will have their home there.

In better ponds, however, all other agricultural plants may be successfully cultivated, with the exception of barley, which in *Kaniów* (though reaching a relatively heavy weight per standard measure) only gives a medium harvest, and does not furnish a fine quality of malt. As regards wheat and clover, my ponds often produce richer harvests than my fields. In these better ponds I hardly ever use any manure. I find that the following method will yield the greatest profit, both in money and in additional fodder for my numerous cattle: the first year I plant peas (a small early variety of green peas); the second year, rape, and in exceptional cases, potatoes; the third year, wheat (on heavy soil, Galician wheat, and on loamy humus soil, Frankenstein wheat) mixed with clover, so that during the fourth and fifth years clover finishes the agricultural period of the pond. I take the special precaution to add some grass-seed to the clover for those portions of the wheat-fields which lie on the higher portions of the ponds, with the view of furnishing better pasture for my cattle when at some future time they will seek their food in the ponds.

I prefer to close the agricultural period of my ponds with clover, because the remnants of clover will furnish a very large quantity of vegetable food for insects, and will thereby supply a large amount of food for the fish, which eventually will benefit me by producing larger and finer fish.

After all my experience I can say that my safest harvests have always been those gathered from my ponds, and that I have found pond-cultivation productive of a decided addition to my annual income.

Although I cannot but highly recommend to all farmers the plowing and planting of their ponds, I must caution them to be careful not to plow too close to the dikes, because by doing so they run the risk of destroying the reeds, which are of primary importance to the safety of the dike. I always leave about 2 to 4 meters from the base of the dike, which the plow never touches, and whereI do not even mow, because in stormy weather the waves will be broken by the reeds, especially if by the growth of years they have become very dense. It is, under all circumstances, a much cheaper way of saving the dikes and keeping them in repair, than to erect stone dikes or walls (as in the *Rosenberg* pond). Where no reeds are growing below the base of the dike they can easily be supplied by cutting some reeds in the pond deep under the water and laying these in the water near the dike, where they will soon send out water-roots towards the bottom and thus grow and flourish near the dike.

I will also mention here that localities which, probably owing to the lack of forests, suffer from aridity, may have their climate changed in a very cheap and profitable manner, by the filling with water of a number of large ponds.

I will here close my communication, which has come from the unpracticed pen of a practical farmer, and which does not in the least claim the merits of a literary production. Nor will this be required of a work like the present, because it simply intends to add another contribution to the experience of those who have given some attention to fresh-water fisheries (pond-fisheries) and the farming operations connected therewith. I know very well that I am still far from the limit of the possible in this line, but I honestly claim that, as far as my experiments go, they have been very successful. I shall of course not rest contented on my laurels. I would, in conclusion, direct attention to the circumstance that most practical farmers have, as a general rule, been but little benefited by the grand results of scientific investigation, and that, unfortunately, they lack a thorough knowledge of the aquatic fauna which is of such great importance for the feeding of fish. In the interest of pisciculture I herewith express the justified wish that scientists may give us still more practical advice. By carefully raising the respective aquatic animalculæ for fish-food, we should, perhaps, succeed in favoring the growth of the fish during the second and third year in a similar way as is done during the first year.

I cannot too strongly urge all farmers who take an interest in pond-cultivation to make—in their respective localities—further observations and experiments relative thereto, and I sincerely hope that their experience will be published for the general good. It is one of the beauties of agriculture, that it knows no professional envy, and dare not know any, for even if the greater experience of one man benefits another, the first one will not deem his interests endangered thereby, since a larger production, by creating a greater demand and better markets, will in the end again prove a benefit to him.

As far as I am concerned, I shall also in the future gladly make known to the general public the results of any further experiments in pond-cultivation. I shall rejoice at every success obtained by other farmers and pisciculturists, and in anticipation of such happy results I herewith bid them, from the depth of my heart, a sincere *God-speed.*

XIX.—THE INJURIOUS INFLUENCE ON PISCICULTURE OF THE RETTING* WATER OF FLAX AND HEMP.†

By E. REICHARDT.

The question of the injurious character of the refuse water from the retting of flax is still an open one, inasmuch as opinions differ widely. Flax and hemp retting aims at a partial decomposition of the vegetable substances, during which process especially the outer parts of the plant (the bark or rind) soon become brittle, whilst the inner (glutinous or easily solvable) vegetable substances begin to ferment, whereby decomposition is furthered, but which, however, must not extend to the firm tissue of the plant. This tissue offers stronger resistance to the process of decomposition; but the action of the so-called retting process must be interrupted, as soon as repeated tests show that the outer (brittle) parts can be removed by simple rubbing, and that there is danger of the inner (firm) tissue being torn asunder. To continue the retting process any longer would injure the fibers of the tissue by likewise rendering these brittle and tender, and would therefore frustrate the object in view.

Retting is carried on differently in different parts of the country, either by the *dry* or by the *moist method*. If the *dry method* is employed, the plants, after having been pulled, are in the beginning of autumn spread over the empty fields and exposed to the alternating atmospheric influences of moisture and heat, to the dew of the night and the glaring rays of the sun by day, these natural influences being artificially assisted by occasionally sprinkling the plants with water. Whatever substances are dissolved and withdrawn from the plants assimilate with the soil on which they lie, and the whole process may be termed *decay*.

In the *moist method* of retting, the plants are soaked in water which is stagnant, or which is agitated as little as possible. Stones are placed on the bundles of flax or hemp, in order to keep them under water, and the process of *putrefaction* very soon commences, and is indicated by the solution of various vegetable substances, which imparts a dark color to

* [The literal meaning of the German verb "*rösten*," "*to ret*," is retained in the translation. The word is exclusively applied to the process of heating and fermentation produced in flax and hemp by laying these plants, after being cut, either on the fields, exposed to the dew and the sun, or in water.—EDITOR.]

† *Mittheilungen zur Gesundheitspflege. Von E. Reichardt in Jena. Schädliche Wirkung des Röstwassers von Flachs und Hanf für die Fischzucht. Archiv der Pharmacie*, vol. 219, part 1, Halle, 1881.—Translated by HERMAN JACOBSON.

the water; and by the development of gases, whose presence may be perceived by the smell. As soon as the necessary degree of brittleness has been reached, the plants are taken out of the water and dried in the air, during which process these decaying vegetable substances fill the entire neighborhood with miasmatic exhalations to such a degree as to cause animals to refuse to pass by. The impure water is frequently poured into the nearest running water, and the sanitary authorities have in most cases vigorously opposed this method.

The Thüringian Fishery Association therefore passed a resolution at its last annual meeting to cause an investigation of the disputed question of the injurious character of this retting water, and commissioned me to conduct this investigation. This fact had hardly been mentioned by several of our papers when I received from Chief Forester Mr. Wilke, of Waltershausen, a report on the subject, which he voluntarily placed at my disposal, portions of which I shall, with his consent, embody in this article, as communications of this kind are exceedingly acceptable in giving a practical insight into the matter.

Mr. Wilke was for a considerable time stationed near the River *Nesse*, along the banks of which flax is cultivated on a large scale, and where the moist method of retting is universally employed. Mr. Wilke says:

"Although it is prohibited by law to ret flax in rivers, I have every year seen large masses of flax, both in the bed of the *Nesse* and more especially in its small tributaries, where the water has been dammed for the purpose of retting flax. In these tributaries pestiferous pools are created. When such pools have been used for retting for any length of time, they are opened, and the whole mass of foul and putrid water is emptied into the river, and every living being coming within its reach is doomed.

"As soon as the retting of the flax commences, the water begins to assume a brownish color and to emit an offensive odor. This color and odor increase in intensity from day to day, till the water has the color of coffee, and the odor becomes so repulsive that I have often gone one-half league out of my way so as not to be obliged to pass near such water, especially in the morning and evening. The drier and warmer the temperature the more intense will be the odor and the infection of the water.

"Whenever the water has attained a certain degree of putridity all the fish will strive to reach the bank, gasping for air, and in such a state of torpor that they can easily be caught with the hand. If they do not speedily get fresh, pure water, they die, and remain lying on the bank, where they serve as food for birds, or are caught in the grates of mills, from which they are gathered, only to be thrown away.

"At one station I have known years when fish of all kinds were picked off the mill-grates by the hundred weight, some dead and some alive. The dead fish were immediately thrown away, and the live ones were eaten. I myself once partook of such fish, which had been allowed to lie in fresh water for several hours before they were killed. But even after they were cooked they still smelled and tasted of the retting water, and all who ate of this dish felt the bad consequences.

"The inhaling of this pestiferous air for weeks and weeks certainly requires the attention of the health authorities.

"Mortification of the spleen, which is so frequent in the valley of the *Nesse* among sheep, cattle, and hogs, and which is exceedingly contagious, is quite probably produced by the drinking of retting water."

The above valuable communication by Mr. Wilke directs attention to the injurious influence of retting water on public health, and very justly, for we know now that putrefying substances are most effective in spreading contagious diseases. I have personally convinced myself of the very disagreeable impurities with which the air is tainted by the retting of flax, and which became especially noticeable during the slow drying process of the decaying flax.

In order to subject this matter to chemical tests, I obtained a considerable quantity of retting water, which, however, was tolerably clear and odorless, so that it could hardly possess many injurious qualities. These are not developed till the last stage of decomposition. Experiments made on a large scale to obtain vegetable poisons from this water led to no result. This determined me to obtain fresh flax-plants and, on a small scale, to go through the whole retting process.

For this purpose I laid a bunch of flax in water; after a few days gases began to develop, the water began to assume a brownish color, and finally complete decay set in, accompanied by the development of offensive gases, &c. As soon as the flax had reached this stage of decomposition, and the fiber could easily be separated from the outer (brittle) portions of the plant, I made the following experiments:

1.—WITH LIVE FISH.

In these experiments I used both kinds of whiting, such as are found in the river Saale, and which on the whole are an exceedingly tender fish, and bastard carp, weighing about 3-500 grams. The last-mentioned kind of fish is better able to stand a change of water. These fish had been living in running water of a temperature of 7° to 9° C., which is the usual temperature of water in spring time. In these experiments I therefore endeavored to keep the water at exactly the same temperature as that from which the fish had been taken. Some of the fish were put aside in the water in which they had been living, and some were placed in water mixed with retting water. In the fresh water the fish kept for several days without undergoing any change, so that they could again be transferred to the running water. The retting water was obtained by soaking flax for five days.

One part retting water and three parts running water mixed.—The fish placed in this water immediately showed signs of uneasiness, gasped uninterruptedly for air, and were found dead the next morning. The experiment had commenced towards evening of the preceding day.

The second experiment, made the following day in exactly the same manner, led to exactly the same result. The fish died within three hours.

One of the large bastard carp lived in this mixture of fresh water and retting water for two days, but soon began to lose its color, gradually grew weaker, and, although again placed in running water, died after eight days.

One part retting water and nine parts running water mixed.—The fish immediately began to be sick, showing this by their motions and their gasping for air; lived for twenty-four hours in the mixture, and began to recover when again placed in fresh running water, but finally died after a few days.

One part retting water and two parts running water.—Small fish died very soon. A large bastard carp kept alive for one and three-fourths days, but was on the point of death when at that period again transferred to pure running water, from which time it began to recover, but only to die within two weeks.

Retting water fourteen days old.—In a mixture of one part of this retting water and four parts fresh water the fish died after one and one-half days.

The same retting water three weeks old.—Fish placed in it (one part retting water and four parts fresh water) grew sick immediately, gasped for air and changed their color, but managed to keep alive for several days, so that they could again be transferred to fresh running water.

As all these experiments led to the same expected result, they were brought to a close. The conclusion was as follows:

Retting water, when in a putrid condition, kills fish within a few hours, even when mixed with three to four parts of running water which is otherwise well adapted to pisciculture. When mixed with a larger proportion of fresh water the fish can stand it better, but are nevertheless considerably injured.

Retting water which is allowed to stand for some time, and which thereby loses its strongly putrid character, does not therefore hurt the fish so much.

These experiments fully corroborate the facts observed in rivers on a larger scale. Wherever actually putrid retting water mingles with pure water, a poisonous juice, which is positively injurious to fish, exists in the water, and shows its destructive character in proportion to the degree of putrefaction and its quantity.

I was not able to obtain water in which hemp had been retted; in such water one might have looked for positive vegetable poisons, as such substances have been shown to exist in hemp. Repeated experiments with water in which I had laid hemp and allowed it to putrefy did not show any substances of an alkaloid or acid nature in the water. The usual offensive decaying process took place, developing substances whose composition is well known. My attention was, therefore, directed to the gaseous matter developed during the process of decomposition, and as these gases withdraw the oxygen from the water they are highly injurious to the life of fish.

II.—TO DETERMINE THE GASES.

Frequent experiments as to the gases contained in spring and running water (see this Journal, vol. 202, p. 238) showed the proportion found by Regnault, Bunsen, and others, viz, oxygen and nitrogen as 1 : 2, whilst the proportion of oxygen to nitrogen in the air is 1 : 4; *i. e.*, the solution of these two gases in water corresponds to these fully established proportions.

In 1,000 cubic centimeters of water taken from the river Saale during spring (see this Journal, vol. 206, p. 206) I found 30 to 31 cubic centimeters gas; these contained, at a temperature of 3° C., 6.2 per cent. carbonic acid; this percentage rose, when the temperature of the room grew warmer, to 16.5, without any noticeable change in the total quantity of the gas. One experiment showed that the water of the river Saale, at a temperature of 3° C., contained one part oxygen to 4.78 parts nitrogen, whilst a second experiment showed the proportion of these two gases to be 1 : 1.91. After the water had become somewhat warmer in the room the proportion was 1 part oxygen to 2.2 parts nitrogen; therefore the same as the one given above.

Water in which hemp had been retted, and which had attained a considerable degree of putridity, was found to contain in 554.3 cubic centimeters of water, 35.5 cubic centimeters gases, which might be expelled by boiling; this would make about 64 cubic centimeters gases in 1,000 cubic centimeters water. Calculating the percentage I obtained the following result:

Oxygen	4.2	= 1
Nitrogen	29.9	= 7.0
Carbonic acid	65.9	
	100.0	

While river water mixed correspondingly shows a proportion of 1 : 2, this mixture shows a proportion of 1 : 7.

Carbureted-hydrogen gas, hydrogen or carbonic-acid gas could not be discovered, which may possibly be owing to the degree of putridity and to the difficulty of solving these gases in water. But these proportions must also be considered in connection with carbonic acid, which is just as hurtful to fish as nitrogen.

The percentage of gases in two different specimens of water from the river Saale (the temperature of the room being 20° C.), was that given under No. I and No. II, whilst retting water, at the same temperature, showed a different percentage:

	Saale water. I.		*Saale water.* II.		*Retting water.*	
Oxygen	29.5	=1	25.9	=1	4.2	=1
Nitrogen	65.1	=2.4	57.6	=2.86	29.9	=22.8
Carbonic acid	5.4		16.5		65.9	

The proportion of oxygen to the other gases which can be expelled by boiling and which produce suffocation, has therefore been decreased *ten* fold. Taking finally into consideration the fact that 1,000 cubic centimeters retting water contained 64 cubic centimeters gases, whilst repeated experiments with river water showed that the same contained only 30.32 cubic centimeters, the fatal character of the mixture will become still more apparent in its relation to the breathing and life of fish.

It cannot be doubted, therefore, that retting water will kill fish by its lack of oxygen, if from no other cause. In this all observations made on a large and small scale will agree. The fish immediately gasp for air until they become tired, and finally suffocate. Even leaving this hurtful mixture of gases out of our calculation, it must be granted that putrefying substances must exercise a hurtful influence, both directly by producing changes which are injurious to life, and indirectly by rapidly absorbing oxygen and thereby depriving the surrounding objects of this gas which is so essential to all life.

If only small quantities of retting water are mixed with large quantities of running water there may be no immediate evil consequences, whilst if this proportion is reversed the injurious consequences will make themselves felt very soon; in either case, however, poisonous substances are introduced in the water which had better be kept out of it.

The introduction of retting water into fishing waters should therefore be strictly prohibited, and has actually been prohibited in many places. The retting water may be employed much more suitably in irrigating meadows, where, owing to the loose soil, it loses its putrid character very soon, and aids in forming good food for plants. It would be still better if the moist method of retting could be altogether abandoned, and the dry method adopted in all cases, or if other and less injurious methods could be discovered and come into general use.

APPENDIX G.

PROPAGATION OF FOOD-FISHES.

SPECIAL APPLICATIONS.

XX.—REPORT OF OPERATIONS CONNECTED WITH THE PROPAGATION OF WHITEFISH (COREGONUS ALBUS) AT THE NORTHVILLE STATION, NORTHVILLE, MICH., FOR SEASON OF 1880-'81.

By FRANK N. CLARK, *in charge*.

PREFACE.

A brief notice of the hatchery, together with its immediate surroundings and facilities for the work under consideration, may properly precede an account of the work of the season.

The Northville hatchery was built by the late N. W. Clark, its nucleus being collected from a similar establishment formerly located at Clarkston, Mich., thirty miles distant. The latter building was torn down and removed, together with the appurtenances of fish-hatching contained therein, to its present site during the summer of 1874, and the erection of a building double the size and capacity of its predecessor immediately begun.

A description of the hatchery as then completed and of its surroundings will suffice in the present instance, as no material changes were made until August, 1880, at which time the United States Fish Commission assumed control. Under their direction many needed improvements have been made and some new features added, which will be noticed in the proper place. The hatchery as built and as it now remains, is a one-story frame structure, 80 feet in length by 30 in width, containing a 9 by 11 office in front, also an 8 by 30 tank-room in the rear. Its interior arrangements were designed more especially for the accommodation of the hatching appliances to be used therein, viz: hatching troughs and the "Clark" hatching box. No new apparatus was introduced, neither was its capacity increased previous to the present season. The main or hatching room was provided with three parallel tanks, each 50 feet in length and uniformly 9 inches in depth. One tank was 42 and either of the others 28 inches in width, the larger being divided into 96 and each of the others into 64 compartments for the reception of the boxes, making a total capacity of 224 hatching boxes. Although as many as 75,000 eggs of the whitefish can be brought forward successfully in each of these boxes, usually but 48,000 have been incubated therein, it being possible to hatch a greater percentage with less trouble and expense when the latter number is not exceeded. Of the eggs of *Salmo fontinalis* or *Salmo iridea* not more than 24,000 should be placed in each box to obtain the best possible results. A description of the "Clark" hatching-box is given in Report of United States Commissioner of Fish and Fisheries for 1872-'73, pages 583 and 584.

The hatchery is located at the foot of a gentle slope of land, and ascending this declivity about 200 feet we find issuing forth within a circle of a hundred feet numberless little springs which furnish in the aggregate about 175 gallons of water per minute. A public highway running directly in front of the hatchery and between it and the spring, by intercepting the flow of water from the latter, serves incidentally as a dam, thereby creating a pond having an area of one-eighth acre, averaging 4 feet in depth and extending back a few feet beyond the spring area, thus incorporating the whole of the latter. The surface of this spring pond is 7 feet above the level of the hatchery floor, which gives an ample fall of water. This spring, called the upper spring to distinguish it from a second one underneath the hatchery, is the sole feeder of the spring pond, and not only furnishes all the water used in the hatchery, but a considerable excess for which other avenues of escape have been provided; but the demand for water to develop eggs of the whitefish in the hatchery is not supplied directly from the spring pond, as the temperature of the latter during the hatching season is sufficiently warm to bring forth the fry earlier than is usually deemed desirable. The temperature of the water at its immediate source is 47°, never fluctuating more than a small fraction of a degree, while in the spring pond it is variable, depending, of course, on the temperature of the atmosphere; but, owing to the constant and abundant influx of spring water, is kept warmer than is desirable for incubating eggs of the whitefish, except during brief periods of extremely severe weather. The average temperature of the spring pond, then, through the winter season will approximate 43°, which would bring forth the fry in from 80 to 90 days, or about the 1st of February. Aside from the consideration of the existence of food for the young fishes at the period indicated, about which there may be no uncertainty, the advisability of allowing a too rapid development of the embryos may be considered questionable from the fact that when brought forward in this manner they suggest prematurity, shown by their vague and shadowy outlines, which present a decided contrast as compared with the fruit of 120 to 150 days' incubation, the latter having black and fully developed forms, evidently better fitted to survive or escape the vicissitudes necessarily attending their infantile period.

At the time of the construction of the hatchery no information concerning the temperature of the spring pond during the winters season could be obtained, no record having been made; however, as it was known to contain but little ice even in the most severe winters, steps were taken with a view to aid in securing the desired reduction in temperature. The water must be exposed still further to the influence of cold winter air; an artificial pond must be arranged, and into this must be drawn barely enough water to supply the actual necessities of the hatchery. Accordingly a pond 12 feet wide by 100 long was constructed on a narrow plateau situated across the road diagonally from the spring pond, and running nearly parallel with the hatchery. The surface of the plateau is nearly level with the spring pond, and thus the requisite fall of water is maintained. A trunk fitted at its mouth with an adjustable gate runs under the road and conveys the water to the cooling or ice water pond, as it is called.

With the limited amount of water used in the hatchery up to the present season, and consequently the comparatively small quantity of water to be cooled, this pond proved equal to the requirements. The first severe weather of November coated it with ice, which soon increased to several inches in thickness, and remained until the following March. Water which issued from the earth at a temperature of 47° was thus reduced to an average temperature of 35°. The good results obtained by the use of this cooling pond have been substantially the same each succeeding season up to the present, when, as operations were to be conducted on a much larger scale, and as the Chase jars, requiring a greater volume of water than the hatching-boxes, were to be introduced, it was thought to be inadequate. Subsequent events verified the prediction, and the additional measures adopted in the premises will be alluded to again.

The trout ponds at the station, six in number, and constituted in one series, are situated immediately in the rear of the hatchery, and are supported by a spring yielding 200 gallons of water per minute, located directly beneath the hatching room. They have contained at various times since their construction Brook trout (*Salmo fontinalis*), McCloud River trout (*Salmo iridea*), California salmon (*Salmo quinnat?*), Lake trout (*Salmo namaycush*), and Grayling (*Thymallus tricolor*), but at present are occupied exclusively by the first two varieties named, the latter being the property of the United States Fish Commission.

A feature of both the upper and lower springs, and which indicates that their origin and conducting strata are far beyond surface influences, is their uniformity of flow and temperature; even the "oldest inhabitant" failing to remember any perceptible increase or diminution in their yield. They are perpetual fountains, inasmuch as they are uninfluenced by protracted droughts, while the variance of temperature between the extremes of winter cold and summer heat is less than one degree.

The amount of water furnished by the lower spring, all of which now runs through the ponds in use, is abundantly ample to sustain a second series, while the waste from the upper spring could be utilized by supporting a third series of ponds.

It will be readily perceived, then, that these springs, both as to their relative position and fecundity, are peculiarly fitted for trout propagation and culture on an extensive scale; but for whitefish work of sufficient magnitude to demand the use of more than half the product of the upper spring, the reduction and maintenance of the temperature of the water to that degree of coldness necessary to delay the hatching until early spring is a work not easily accomplished, evidenced by the results of the season just closed. If it is considered immaterial whether white-fish are hatched and planted in February or in April, then a more suitable locality would be difficult to find; for with an adequate quantity of ova to consume the entire yield of the supplying spring the water would, even against the adverse influences of the ice-water pond as now used, be still warm enough to bring forth the fry as early as February, thereby shortening the season by two or three months, with its attendant expenses.

PREPARATORY WORK.

During the month of August, 1880, instructions were received from United States Fish Commissioner Prof. Spencer F. Baird for the prosecution of the work of propagating whitefish at the Northville station for the season of 1880–'81. As provisions were made for conducting operations quite extensively, preparations commensurate with the contemplated extent of the work were essential. Preliminary work, then, was immediately begun, and consisted for the most part of the following: Cleaning and enlarging the spring pond; devising and introducing some plan of drawing the surplus water immediately from its source at the head of the pond, instead of from the foot, as had previously been done; enlarging ice-water pond; providing increased facilities in the way of conducting pipes and trunks for conveying the water from the spring pond to the ice-water pond, and from thence to the tank room; repairs to the hatchery and a thorough overhauling of the appliances of the hatching and tank-rooms; providing increased facilities for carrying spawn; and, finally, the construction and arranging of feeding troughs and equipping the same with the Chase hatching jars.

The object, of course, of drawing all the waste water from that portion of the pond fed directly by the spring or springs was to obtain the minimum quantity of spring water to be cooled, allowing only enough of the latter to mingle with the pond to maintain it against the counter draught of the ice-water pond for consumption in the hatchery. The plan originally intended to secure these results contemplated a division of the spring pond into two sections by the erection of a wall or dam, thus separating the spring area from the remainder. With the springs thus cut off and confined within the smallest possible space, provisions for drawing from them the actual quantity needed and also for the disposition of the surplusage could be easily made. But a careful inspection of the premises and a complete investigation of the character of the bottom of the pond disclosed the fact that this plan could not be carried out save at an expense greatly in excess of the estimates, and it was, therefore, abandoned and substituted by a simple arrangement, the results of which proved quite satisfactory. An open trough, resting on stilts driven just beneath the surface of the water and drawing from the upper or spring-fed part of the pond, was laid the entire length of the pond. This being the only exit allowed for the discharge of the superfluous water, the entire waste was thus drawn from the immediate vicinity of the springs.

The dimensions of the ice-water pond were then increased to 150 feet in length by 18 feet in width, with its boundary maintained by a wall of masonry backed up on one side of the pond by the natural elevation of the ground, on the other by a layer of clay of sufficient thickness to prevent leakage. The trunk from the spring pond discharges into an open, shallow trough, which carries the water to the farther end of the ice-water pond for the purpose of cooling as much as possible by exposure to the air while in transit, the two conductors for the tank room tapping the opposite end of the pond. The additional precautionary measures adopted for cooling the water were thought to be sufficient, but, as a result of the increased work of the season, the demand of the hatchery required fully one-half of the product of the spring, and, notwithstanding the unusual severity of the winter, it was found necessary at times to use considerable quantities of ice in the tank room to keep the temperature of the water down to the desired point. The cooling-pond rendered efficient service, but did not fully meet anticipations.

The repairs to the hatchery included a new roof and new floors for the hatching and tank rooms. A small temporary apartment was arranged in one corner of the hatching room adjoining the office, which was occupied as a sleeping room by one of the employés during the hatching season. This precaution was adopted upon the supposition that the sleep of the occupant would be interrupted as quickly by the cessation of the noisy monotony of running water in the hatching room as by the sudden intrusion of noise under ordinary circumstances.

One double row of hatching boxes were removed, and replaced by a tier of tanks for feeding the hatching jars. These tanks, three in number, are placed one above the other, and consequently occupy but little more floor room than a single row of hatch boxes; they are uniform in size, viz, 40 feet long by 15 inches wide and 14 inches deep, the top one being fitted with 50 and the middle one with 56 No. 8 faucets, or 106 altogether. The jars rest on narrow shelves placed crosswise of the tanks, one shelf sufficing for two jars, one at either end, the water entering the top tank feeding the upper rows of jars, which, in turn, supply the middle tank, from which the lower rows of jars are fed, the water from these emptying into the bottom tank, which, at present, serves only as a conductor for the waste water. The five rows of hatching boxes remaining were thoroughly examined, and given the needed repairs, in the way of caulking &c. Some of the wire trays were repaired, while others were supplied with new screens entire, and all were given a coat of asphaltum varnish. The picking trough was lengthened to 50 feet.

For carrying the spawn, nine boxes, each containing 20 canton flannel trays 16 inches square, were made, also one large can for the same purpose. This can is 24 inches high by 16 in diameter, cylindrical in shape, and filled with a system of wire trays fitted around a central tube, funnel-shaped at its mouth, through which the water is introduced and conducted to the bottom of the can before being freed, the bottom of the tube having a conical flange attachment to diverge the water, which then flows upward through the trays of eggs (or fish) and out of the ventricle provided near the top of the can. It is undoubtedly superior to the boxes for carrying spawn, but is much more expensive, and, when in transit, requires extra attention as to frequent changes of water.

The Chase hatching jars, 100 of which had been ordered of the Dorflinger Glass Company, White Mills, Pa., had not yet arrived October 20, although advices of their shipment September 29 had been received. Considerable uneasiness was felt on account of their non-arrival, as the anticipated time for using them was near at hand, and steps were at once taken to locate their point of detention. They finally arrived October 28, without the loss of a single jar or tube by breakage, and were placed in position as soon as possible. A full head of water was turned on to search out any leaks or disclose any defects that might exist in the trunks, tanks, &c., and in time to make any needed repairs or changes before eggs were received. The preparatory work was now soon completed—none too soon, however, as subsequent events will show—and everything placed in readiness for the reception of spawn.

SPAWN-GATHERING OPERATIONS.

While the preceding operations were making, a visit to the "Bass" Islands of Lake Erie, viz, North Bass, Middle Bass, and Put-in-Bay was made in the early part of September for the purpose of arranging for the privilege of collecting whitefish eggs from the catch of the leading pound-net fishermen. Usually, it is "first come first served"; but, in the present instance, several net-owners were found who were quite unwilling to allow their eggs to be taken for the benefit of the United States Fish Commission, preferring to give them to the Ohio State commission, whose work, being more of a local character, would naturally include deposits of fry in their vicinity. A sufficient number, however, cheerfully offered to co-operate in the work.

While on this trip I engaged the services of Mr. P. Wiers and Mr. S. W. Downing, residents of North Bass Island, and experienced spawn-takers, to assist in that work during the season.

A second visit was made to the islands October 25 and 26, to complete the preliminaries and note the condition of the fish, which were then being caught in considerable numbers. Many of the large females showed indications of early spawning, while several ripe males were found—always reliable evidence that ripe fish of the opposite sex will soon appear. Instructions were left with Mr. Wiers to keep a close watch, and report by telegram the first appearance of mature spawners.

Meanwhile, correspondence with some of the leading fishermen of Alpena elicited information from which the conclusion was reached that large numbers of eggs of the whitefish could be secured at that point, although no precedent for this conclusion had been established by previous operations of private parties or State commissions. The fishermen, too, here, unlike many at the islands, were not only willing but anxious to render all reasonable aid to the State and United States commissions in their efforts to propagate the whitefish.

Large numbers of the lake trout (*Salmo namaycush*) are also caught at this point, but the fishermen, claiming they are a deadly enemy of the whitefish, a much more valuable fish, strenuously object to, and will not permit, so far as they have the power to prevent, the collection of their spawn for the purpose of perpetuating the species. But this claim of the fishermen is not supported by the investigations of the late Mr. J. W. Milner (Report of United States Commissioner of Fish and Fisheries, 1872-'73, pages 38 and 39), and it is altogether probable that the destruction of the young whitefishes to any great extent by the trout exists only in the imaginations of the fishermen. Nevertheless, the opposition of the latter, including the boat and net employés, as well as proprietors, is an element to be conciliated by the spawn-gatherer, as the net-lifters have it in their power, and with but little effort on their part, to greatly increase or decrease the numerous difficulties against which the operator must always contend under the most favorable circumstances, it being an easy matter to carelessly or accidentally (?) overturn the pans or pails of spawn when throwing the fish from the pound-nets into the small open pound-boats, or likewise equally as easy to assist by throwing the spawners near the operator and avoid covering the same with subsequent "dips" of other kinds of fish.

Notwithstanding the favorable outlook for collecting spawn of the whitefish at Alpena, it was thought best not to place too much confidence or reliance in this direction, as its remoteness and inaccessibility as compared with the Lake Erie islands were sufficient reasons for depending mainly on the latter to furnish the desired supply. Accordingly but one man was stationed at the former place, Mr. A. W. Root, who was instructed to engage the aid of one or more assistants, as circumstances might require.

At the time of the first visit to this place, November 3, the gill-netters were catching many whitefish, but no ripe spawners were found. Leaving operations here under the immediate supervision of Mr. Root, I returned to Northville, arriving November 6. Arrangements were made with the porters of the Bay City line of boats to receive the boxes of spawn of Mr. Root and deliver the same to messengers previously sent on to meet them at Bay City, who would of course bring them on to Northville with all possible dispatch. While at Alpena word came to Northville from Mr. Wires, at North Bass Island, that he had taken eggs from six fish October 31. On receipt of this Mr. Bower repaired to the islands as quickly as possible, equipped with pails, pans, dippers and four of the carrying cases for eggs, arriving November 3.

As will be seen by referring to the subjoined table, the number of eggs secured by Wires and Bower up to November 6 amounted to nearly two and one-half millions. They were then conveyed to the hatchery by boat and rail in charge of Mr. Bower, leaving the islands at 11 a. m. and arriving at Northville 7 p. m. same day. Eggs were in prime condition when deposited in the hatching boxes the following morning.

At 4 a. m., November 8, I started for the islands, accompanied by assistants Bower and Donnelly, arriving at 12 m. The results of each day's efforts for the season of procuring the ova at the islands will be found in the special table of spawn-taking operations. All eggs were taken by what is known as the dry method, wherein impregnation is accomplished by mixing the spermatic fluid undiluted with the eggs before water is added.

Notes and instructions to spawn-takers and those having the care of spawn included the following:

Take eggs only from ripe fish, *i. e.*, those yielding their eggs by a gentle pressure of the hand on the anterior of the abdomen, including, of course, those from which the eggs are oozing.

Reject the entire yield of any female when more than 3 to 5 per cent. of her eggs are spotted or milk-white when taken; likewise throw aside all females bearing broken eggs.

Do not try to force all the eggs from each female manipulated, but only those which can be extruded by a gentle pressure or stroking of the abdomen, each stroke commencing just forward of the pectoral fins and extending towards the ventricle, releasing the grasp about midway between these two points. This will, however, expel nearly all the eggs if the fish is in the proper condition.

The manipulation of the male is a pinching or stripping process, but the female should be neither pinched nor stripped, the process or operation consisting of a slow, gentle, and crowding movement upward and forward with the whole hand adapting itself to the natural curve of the belly.

Hold the vent of the female as near the bottom of the pan or receiving vessel as possible, as the eggs are very soft and tender when first taken, and may be injured by dropping.

Incline the fish to an angle of about 45 degrees; the eggs will then naturally settle towards the orifice and require less pressure for expulsion. The males, however, should not be held in this position, as in many instances the vital fluid will not stream directly into the pan, but cling to the fish and follow down to the end of the tail, mixing with slime and water before dropping, wasting the entire yield of the male sometimes, as many will furnish but a few drops, which may not find their way into the pan at all. This loss can be obviated to a certain extent by holding the male in a horizontal position, when the result of each titillation will usually be driven directly into the pan. When there is an abundance of ripe males the observance of this precaution is not material; but when there is a scarcity—frequently the case—the saving of every particle of this fluid is of great importance, as each drop may represent the future life of thousands of fishes.

If the first or any subsequent ejection of milt from any male is streaked with blood, cast him aside.

Not more than one large or two small females should be handled before using the males. It is a good plan to alternate one or more males with each female, adding milt to the eggs as soon as possible after they are taken, having a few of the former selected and placed within easy reach before manipulating the latter. No definite rule can be given as to the number of males to be used for each female, owing to the great variance of yield in both sexes; still it is evident that a sufficient quantity of the male principle has been mixed with the eggs if, when the pan is tilted, a milky coating is seen crawling on the bottom, for, when used as freely as this it seems impossible that any eggs could have escaped contact with the spermatic fluid, all that is necessary to accomplish impregnation. A feather or the tail of a fish—nothing harsher—should be used in mixing the milt and eggs. The same end may also be secured by swaying the pan, but the first plan is preferable, as a complete diffusion of the milt can be effected in much less time.

After thoroughly fertilizing the eggs allow them to stand three to five minutes before adding water; then add about a half dipperful and mix with a feather or by tilting and swaying the pan. But do not delay the addition of water much beyond the time specified, as a portion of the eggs will, if neglected but a short time, adhere to the pan and collect in twos, threes, and bunches, subsequently requiring considerable extra labor for their separation. Continue to add water as before at intervals of five minutes until the pan is nearly full; then pour off, rinse the eggs well through two or three waters, and transfer to one of the large pails previously filled with fresh water, filling no pail, however, more than half full of eggs, giving them an hourly change of water thereafter—oftener if practicable, the oftener the better—until removed to the floating boxes or carrying cases. As soon as water is given the eggs they immediately begin to absorb it with greater or less greed, depending on the temperature of the water—the warmer the water the more rapid the process—the impregnated eggs, also, absorbing water more readily than the unimpregnated. This absorption of water also causes them to swell proportionate to the quantity so imbibed, and harden gradually, growing firmer for several hours. They may be deposited in the floating boxes any time after being thoroughly washed, but should not be placed on trays for at least four to six hours, by which time they will become sufficiently hardened to spread in single layers. A greater depth than this would at this juncture distort many of the eggs on the bottom layer; but when they are eight or ten hours old, so to speak, they may be transferred from the water to the trays and arranged two or three layers in depth.

Spread with a feather and always tilt the tray for a moment or two to drain off any water that may remain. The eggs should be damp, but not saturated—in short, should never remain in contact with water not subjected to frequent changes or aëration.

Guard well your air temperature, never allowing eggs on trays to get below 30°; 28° will prove fatal to them. On the other hand, although they will live for several hours on trays at a temperature of 60°, they are imperiled at this point and should be removed to a cellar or some cool place, or surrounded by ice. If circumstances make any of these subterfuges impracticable, then return them to the floating boxes to remain until cooler weather. The nearer they can be kept down to 33°, in air or water, the better.

Of course strict compliance with some of these hints is not necessarily essential so far as the well-being of the eggs is concerned; for instance, changing the eggs from the pans to a pail or larger vessel is not necessary, although it is quite important that they should be taken in a pan or shallow dish for obvious reasons; but a considerable saving of time is effected by concentrating into fewer vessels, no more time being consumed in changing the water in a pail of 250,000 eggs than in a pan of 50,000, while the former will occupy less room and is less liable to be overturned by the fishermen in the prosecution of their work, and also to lose its contents by the lurching of the boat in a heavy sea.

Again, a fixed routine cannot always be observed in regard to the treatment of the eggs while on the pound or tug boat. For example, in fair weather, with the boat quiet, an active operator, with an abundance of fish, will often have six or seven pans containing eggs in different stages of progression scattered about; but in a heavy sea, with the boat tossing violently, only the pan receiving the eggs, and this held with the greatest difficulty while manipulating the fish, can be used. In such cases the eggs may be transferred at once to a pail or larger vessel, which may have to be secured to its place.

It will be seen, then, that no accurate or specific rules can be given (or observed) for every contingency likely to arise, for many times the operator will meet with annoyances and difficulties not anticipated, and which, to overcome, will require expedients his own ingenuity must suggest; while the extent to which any given instructions may be violated must be determined by his knowledge of the requirements of the case. It is well to bear in mind, however, that the sooner the fish are used after taken from the water, the greater the percentage of impregnation to be obtained; that the greater the care with which the eggs are handled and the more frequent the changes of water, the smaller the percentage of loss; and that the nearer the eggs are kept at a temperature of 33° in air or water, but not lower in air, the farther their removal from danger. Knowing that good results depend largely upon the near observance of these "first principles," the operator must be governed accordingly, remembering that the object of taking eggs is to *hatch fish*; that fish can be hatched only from *live, impregnated eggs*, and therefore it is better, under all circumstances, to strive not so much to see how *many* but how *well* they can be taken and taken care of. A half million eggs secured in this way will produce more fish than a million carelessly taken and indifferently cared for.

FLOATING BOXES.

The floating boxes referred to in the following tables are a simple contrivance for retaining the eggs for a short time at the spawning grounds, and are usually made of the following dimensions: Twenty-four inches in length by fifteen in width and twelve in depth, having a screen-wire bottom, and wide boards fastened edgewise to the ends to insure their floating. For the safety of the eggs they should be placed in harbors, or some suitable place protected from violent storms or heavy seas. In the present instance they were floated under the docks, whence they were not subjected to the force of sharp seas, and yet were sufficiently influenced by the smaller waves and tide-currents to give the eggs constant changes of water. As the presence of dead (or unimpregnated) eggs is not specially hazardous to the others, previous to fungus growth, and as this growth seldom, if ever, appears on eggs less than seven days old, and usually ten to twelve—depending, of course, on the temperature of the water—their removal during this period is not material, and for this reason the floating boxes are found very convenient for retaining the eggs until a sufficient number for shipment has accumulated, requiring no special care in the mean time.

Record of spawn-taking operations conducted at the Bass Islands, Lake Erie, from October 31, 1880, to November 20, 1880, in charge of Seymour Bower.

Date.	Temperature.		Wind.		No. pounds visited.	Owner of pounds.	Fish caught.			Ripe white-fish used.		No. eggs obtained.	By whom taken.
	Air.	Water.	Direction.	Intensity.			No. of white-fish.	No. pounds of herring.	No. pounds of other fish.	Males.	Females.		
	°	°											
October 31	48	47	W.	Gentle	4	Jasper Snide	170	1,800	150	15	6	120,000	Peter Weirs.
November 1	40	46	W.	High	2	do	50	500	75	3	2	40,000	Do.
November 2	45	46	S. E	Gentle	4	do	445	1,800	100	25	10	200,000	Do.
November 3 (a. m)	48	47	E.	do	3	Stone & Fox	170	1,500	50	15	10	200,000	Do.
November 3 (p. m)	48	47	E.	do	4	Jasper Snide	450	4,000	300	60	30	600,000	Weirs & Bower.
November 4	45	47	E.	do	4	do	360	1,500	200	45	21	420,000	Do.
November 5	50	47	S. E.	Fresh	4	do	225	1,600	225	100	45	900,000	Do.
November 6	40	45	N. W.	High	None.								
November 7	42	45	W.	do	None.								
November 8	45	46	S E.	Fresh	3	Jasper Snide	600	3,500	500	140	50	1,000,000	Weirs & Downing.
November 9	48	47	E.	Gentle	3	do	200	1,200	775	24	15	300,000	Do
November 9					4	Morrison & Delichy	650	4,000	500	80	31	620,000	F. N. Clark.
November 9					10	A. Dolar	1,000	6,000	1,000	52	15	300,000	F. L. Donnelly.
November 10	40	45	S. E.	High	3	Jasper Snide	100	1,400	300	15	10	200,000	Weirs & Bower.
November 10					2	Morrison & Delichy	300	1,500	250	45	25	500,000	F. N. Clark.
November 11	40	43	S. W.	High	2	do	200	1,000	150	18	10	200,000	F. L. Donnelly.
November 12	33	42½	N. W.	do	None.								
November 13	33	42	S W.	Fresh	3	Jasper Snide	400	7,600	600	44	30	600,000	Weirs & Bower.
November 13					4	Morrison & Delichy	200	1,500	300	20	9	180,000	F. L. Donnelly.
November 13					3	Wm. Brandow	175	1,200	200	21	16	320,000	S. W. Downing.
November 14	31	40	W. N. W.	High	2	Jasper Snide	150	5,400	200	15	8	160,000	Weirs & Bower.
November 14					4	Morrison & Delichy	200	1,000	150	16	9	180,000	F. L. Donnelly.
November 14					3	Wm. Brandow	150	800	100	12	5	100,000	S. W. Downing.
November 15	30	37	N. W.	High	3	Jasper Snide	130	3,100	75	13	10	200,000	Weirs & Bower.
November 15					4	Morrison & Delichy	220	2,000	150	17	12	240,000	F. L. Donnelly.
November 15					3	Wm. Brandow	180	1,600	300	18	11	220,000	S. W. Downing.
November 16	32	38	W.	High	None.								
November 17	21	35	W.	do	3	Jasper Snide	500	15,000	500	42	35	700,000	Weirs & Bower.
November 17					4	Morrison & Delichy	220	3,000	300	20	14	280,000	F. L. Donnelly.
November 17					3	Wm. Brandow	240	4,000	400	20	13	260,000	S. W. Downing.
November 17					1		75	1,200	100	14	10	200,000	L. Carpenter.
November 18	18	34	N. W.	High	None.								
November 19	16	32½	S. W.	do	3	Jasper Snide	800	17,000	200	18	15	300,000	P. Weirs.
November 19					4	Morrison & Delichy	225	6,500	125	7	5	100,000	F. L. Donnelly.
November 19					1	W. Brandow	50	1,400	110	6	4	80,000	S. W. Downing.
Total					100		8,335	103,600	8,385	940	486	9,720,000	

Diary in connection with the preceding table.

October 25.—Weirs examined fish at Snide's pounds. Ripe males numerous, but no ripe females.

October 26.—Fish handled as before. No appreciable difference to be seen.

October 27.—Examined about 1,000 whitefish, lifted from seven pounds. Milters plenty, and large females softening.

October 28.—Pounds not lifted; high winds.

October 29.—Abundance of ripe males, but no ripe spawners.

October 30.—Females getting quite soft.

October 31.—Six ripe females found. About two males caught to one female, and nearly half of them ripe. Eggs placed in floating boxes.

November 1.—High westerly winds, in consequence of which only two of Mr. Snide's pounds lifted. Eggs obtained were placed in floating boxes.

November 2.—Very pleasant day. About one in fifteen of the females ripe. Eggs deposited in floating boxes.

November 3.—Warm and pleasant. Three pounds visited in forenoon by Weirs, and four in afternoon by Weirs and Bower, the latter of whom arrived from Northville at 12 m. The best day of the season for operations, as lake was very calm. Eggs secured in good shape and well milted. Those taken in the forenoon were placed with those previously deposited in the two floating boxes on hand. Eggs obtained in the afternoon exceeding the numbers on hand, it was feared that injury might result from having them too deep in the floating boxes; accordingly two more boxes were hastily improvised, the eggs, however, being allowed to stand in the pails six hours, with changes of water every forty minutes, becoming almost perfectly hardened before being transferred thereto. But when all were taken up for shipment, no noticeable difference was apparent between these and the others that had been deposited in the boxes immediately on arrival of the pound boat at the dock, and while the eggs were yet quite soft.

November 4.—Eggs obtained to-day were retained in pails six hours—water changed ten times—and then spread in double layers on the flannel trays for shipment. A narrow margin of flannel was left unspread, so that eggs did not come in contact with the tray frames, and the trays were thoroughly sprinkled or immersed before receiving the eggs—precautions that were observed with all subsequent shipments from this point.

November 5.—Eggs taken to-day, after standing seven hours, with hourly changes of water, were, together with those in the floating boxes, transferred to the carrying cases, the next day being regular boat day for Detroit. Eggs were dipped from the floating boxes with a small tin strainer into a pail partially filled with water, then transferred in like manner to the trays, being held in the strainer until pretty well drained, and still further drained after spreading, by tilting the tray and inserting a knife blade between the flannel and frame at the converging corner—a routine adopted with all shipments.

November 6.—Lake so boisterous that no pounds were lifted. Eggs on hand, nearly two and one-half million, taken to Northville in charge of S. Bower, leaving the island (North Bass) at 11 a. m., and arriving at Northville at 7 p. m., without special incident.

November 7.—Still blowing too hard to lift pounds. Weirs made six floating boxes.

November 8.—Best day of the season thus far, as regards number of eggs taken. Plenty of ripe fish of both sexes. Eggs consigned to floating boxes. Clark and Donnelly arrived at Put-in Bay, and Bower returned to North Bass. Five floating boxes sent from latter place over to Put-in Bay.

November 9.—Large numbers of eggs obtained to-day. All placed in floating boxes. A few spent females found.

November 10.—Heavy wind and rain storm, nearly destroying one of Mr. Snide's pounds. Nevertheless, five pounds were visited at the two islands. Mr. Clark came over to North Bass on Sandusky boat, bringing with him in pails and cases all eggs that had been obtained at Put-in Bay, nearly a million and a half, those collected same day in pails, and remainder, gathered the day previous, in cases. The following morning the cases contained nearly three millions ready for shipment, those in pails and in the floating boxes at North Bass having been placed therein in the meantime.

November 11.—Blustering wind and heavy sea prevented Detroit boat from landing at North Bass, and the Sandusky boat ran no farther north than Put-in Bay, five miles distant, thus necessarily deferring the intended shipment of eggs. No pounds lifted at North Bass. At Put-in Bay Messrs. Morrison & Delichy lifted two pounds near shore, off the leeward side of the island, and Mr. Donnelly succeeded in gathering a few eggs, which were deposited in floating boxes.

November 12.—Very high wind; no boats to North Bass, nor no pounds lifted. The trays of eggs were removed from the cases, sprinkled by pouring water through the strainers previously alluded to, thoroughly drained, and then replaced in the cases; all in excellent condition, apparently, in the warehouse at dock. Temperature of room, 33°.

November 13.—Detroit boat stopped at North Bass and eggs were conveyed to Northville in charge of Mr. Clark. Ten pounds visited altogether to-day. At North Bass, Mr. Snide's pounds not having been lifted for three days, a heavy catch of fish was secured, the great bulk of which, however, were herring. About 100,000 eggs were taken after boat had reached dock, the fish used having been out of water about thirty minutes. From another pound boat a female and two males, out of water forty-five minutes, were used. The eggs in these instances swelled as rapidly as those known to be thoroughly fertilized, thus showing a good impregnation. The fish, though, were not yet dead, as the air was down to 33°, in which temperature they will hold their vitality much longer than in air at 45° to 60°. However, a good percentage of impregnation can be obtained with a live male, if female has been dead three or four hours; but, if the case is reversed, a very small percentage will be fertilized. All eggs gathered to-day were deposited in floating boxes.

November 14.—High wind and frequent squalls. Plenty of ripe females, although about one in four is spent; but males, not spent, are quite scarce. Probably about one in six of the females yet unripe. Eggs consigned to the floating boxes.

November 15.—As milters were in the minority, the experiment of using a less quantity of milt was tried. The eggs were crowded from one large and one small female and the milt from two small males immediately mixed with them; they were then set aside and treated the same as those known to be sufficiently milted; about 10 per cent. died within twelve hours. There were about 50,000 eggs to be impregnated with not more than six drops of milt—enough, perhaps, under favorable circumstances, but the males used in this instance had been dead a few moments, or long enough so that the milt, instead of being emitted in jets, as usual, had become sufficiently hardened to be expelled only in drops or clots, which required considerable stirring with the eggs to effect a complete solution and diffusion.

November 16.—Snow-squalls and cold westerly winds. Lake rough; no pounds lifted. Messenger arrived from Northville, via Sandusky, with empty egg cases.

November 17.—Best day of the season as regards number of eggs obtained; over one and one-half million secured from all sources. Eggs on hand at North Bass taken to Put-in Bay in the evening and placed in warehouse at dock; temperature of room 28°; cases covered with blankets.

November 18.—Temperature of room this morning 25°; temperature inside the cases, 31°; eggs unharmed, though many were incased in a thin shell of ice, which, upon being taken in the hand, would roll from the egg, leaving it moist and perfect in form. Mr. Bower proceeded to Northville, via Detroit, having in charge nearly three and one-half million eggs arranged in six cases. No pounds lifted to-day.

November 19.—Wind high and very cold. Boat and rigging coated with ice. Eggs in pans soon freeze; frequent changes of water and motion of boat prevented ice from forming in the pails.

November 20.—One pound lifted at North Bass, but lake was so rough and boat so icy that no eggs were taken.

November 21.—High winds, no pounds lifted. Ice forming in the lake.

November 22.—Fishing practically stopped; fishermen taking up nets as fast as possible and d—(enounc)—ing the weather and season in very vigorous language. Many nets destroyed. Navigation from islands, via Detroit, closed.

Eggs on hand, except those at Kelley's Island, brought on to Northville by Bower via Sandusky November 25. Eggs at Kelley's Island, taken by Carpenter, brought to Northville November 27, by F. L. Donnelly. Eight inches of ice in Sandusky Bay on November 24, and navigation suspended except with the Eagle, a boat designed especially for breaking ice, and which was making daily trips to the islands. It may be stated in this connection that fishing at the islands is confined almost entirely to pound nets, set within a mile of shore.

AT ALPENA.

No record of the spawn-gathering work at this place having been kept by Mr. Root, it is, of course, impossible to furnish a table or daily record of observations and operations. Suffice it to say, however, that Mr. Root, with but little assistance, obtained five million and sixty thousand eggs, a much greater number in proportion to the days of actual work than was secured at the islands of Lake Erie, a result due partly to the greater numbers of whitefish caught at Alpena, and partly to the eggs being taken mostly from gill-net fishing, by which method the fish are taken into the boat one at a time, thus affording the operator an opportunity to examine each fish as fast as taken from the net, a privilege necessarily inadmissible with the pound-net, where the fish are cornered and scooped in as rapidly as possible. However, although in the pound-boat many desirable fish may be lost sight of or covered up with the hundreds of smaller fish caught in a pound-net, and thereby escape examination, yet on the whole the pound-net is the best field for operations, as the fish are always alive, fresh, and uninjured, and consequently their eggs will invariably turn out better than those from gill-nets, in which the fish are found exhausted, frequently injured, and sometimes dead—all caused by their violent struggles to free themselves from the mesh of the net—and which is also a fruitful source of spent fish, the efforts causing many of the females to emit their eggs. But on the other hand, again, a greater number of eggs can usually be secured daily from gill-nets than from pound-nets; that is, when the former are set in gangs of two to five miles—many extend this length at Alpena—as it gives the operator from six to twelve consecutive hours' labor, whereas the pound-net is generally lifted in less than an hour, and one boat rarely visits more than four or five pounds daily.

CONCLUDING REMARKS IN CONNECTION WITH THE SPAWN-TAKING OPERATIONS.

The fishing industry of Alpena, a rapidly growing city now having population of seven thousand, is a very important one, second only to its lumbering interests. The bulk of the catch is secured by gill-nets, many gangs of which are set on the reefs from five to thirty miles out; a number of pound-nets, however, are located inshore and off the adjacent islands.

The eggs of the whitefish at this point, as also the fish themselves, present a decided contrast when compared with those from Lake Erie. Eggs from the former place are a bright orange color when first taken; from the latter a pale straw color.

The Alpena fish average larger in size than those from Lake Erie, while their difference in appearance is so marked that New York and Philadelphia dealers detect their source at sight, and make, as I am credibly informed, a difference of a cent a pound in favor of the latter. Just why this commercial discrimination is made against the Alpena fish is not easily understood, unless we charge it to the distinction in their external characteristics being taken advantage of for speculative purposes, for surely the Lake Erie whitefish in no wise excel their brethren from the deep waters of Lake Huron in firmness, flakiness, or delicacy of flavor; in fact, if any difference in their table qualities exists, the epicure must decide in favor of the latter.

The Huron whitefish have dark fins, very dark backs, almost black down the spinal column, shading to a dark green at the sides, the color line extending farther down than on the Lake Erie fish, while the latter are not so highly colored in any part of the body.

Many millions of eggs can be obtained at Alpena, but the railway facilities now wanting must be supplied before there can be any certainty of delivering them to hatcheries located elsewhere, and for the reason that navigation is liable to close early and abruptly, even before gill-netters are obliged to suspend operations, as witnessed the past season, thus cutting off all communication, so far as the transportation of whitefish eggs with safety and economy is concerned, the nearest railroad point being 48 hours distant by stage. But when the much-needed railroad facilities are secured, as they undoubtedly soon will be, Alpena will present inducements for spawn-gathering hardly equaled by any other point on the lakes.

The islands of Lake Erie also furnish whitefish spawn in large numbers, but must always be subject to the same restrictions in regard to boat communication, though in a much less degree, as they are but twenty-five miles from Sandusky and sixty from Detroit; consequently, trips to these points, although often irregular or delayed at this season of the year, are seldom discontinued for any length of time.

The season now under consideration was a very disastrous one to shipping as well as fishing interests. Ordinarily the same number of men employed in collecting spawn would have secured double the number of eggs; but bad weather compelled many idle days and necessitated an early suspension of operations by the fisherman, thus forcing the spawn-gatherer to discontinue operations when the meridian line of the spawning season had barely been passed. The result of their efforts, then, should not be the standard by which calculations for future work should be made. It must not be inferred, though, that the severity of the weather was so much responsible for the deficit in the number of eggs obtained as the brevity of the season, for it has been equaled in this respect by many of its predecessors, and probably will be by many successors. It should be understood that procuring eggs of the whitefish is invariably attended with labors, exposures, difficulties, and dangers not met with in similar work with any other kind of fish; but, owing to their great fecundity, large numbers of eggs can be obtained with adequate help. Local causes alone are responsible for the hardships frequently experienced in their procurance. The spawning season of the whitefish occurs at that time of the year when the great lakes, proverbially rough and treacherous, are seen at their worst; squalls are common, severe storms frequent, and high winds prevail. But the fisherman, as well as the spawn-gatherer, must "Make hay while the sun shines," and the little tug-boat or pound-boat often puts out in a heavy sea, the attempt appearing almost foolhardy to the ordinary landsman. Under these circumstances, with the boat tossing about so violently that equilibrium is maintained only with the greatest difficulty, spawn-taking is necessarily a slow and arduous work; but when the wind, that is strong enough to almost deluge the boat and its occupants with spray, is cold enough to convert the spray into ice, existing difficulties are magnified and multiplied, the situation becomes perilous, and the suffering from cold and exposure, from which there is no escape in the pound-boat, is intensified almost beyond physical endurance.

OPERATIONS AT THE HATCHERY.

As will be gathered from previous notes, the total number of eggs shipped to the hatchery was 14,780,000; all of which were received in prime condition with the exception of the last lot of 1,000,000 from Alpena, which were thrown away as soon as received, as but very few, if any, were free from the little white spot, the death mark. The actual number, then, deposited in the hatching boxes and jars was 13,780,000, and this is the number, of course, on which the hatching percentages are based. They were distributed as follows:

100 hatching-boxes, 6 trays each, 8,000 to the tray	4,800,000
40 hatching-jars, 150,000 to the jar	6,000,000
15 hatching-jars, 125,000 to the jar	1,875,000
10 hatching jars, 100,000 to the jar	1,000,000
1 hatching-jar, 105,000	105,000
	13,780,000

With the exception of five jars of mixed eggs, those from the Lake Huron fish were kept separate from the eggs of the Lake Erie fish, and none of the fry of the former were planted in Lake Erie or the Detroit River.

All the eggs taken at Kelley's Island (Lake Erie) were procured in one day, November 17, by Mr. L. Carpenter, who, having no floating boxes, spread them on flannel trays after keeping them eight hours with hourly changes of water. The trays were then removed to a cellar, where they remained until November 26, when they were brought on to the hatchery via Sandusky, arriving the next day at 11 a. m. Eggs looked well when received, but some doubts as to results were felt, no record of the temperature to which they had been exposed while in the cellar having been made. They were placed in two of the Chase jars, and watched with considerable interest. The percentage of loss was no greater than the average, and the fish began hatching at precisely the same time as other eggs of the same age. The length of time that whitefish eggs of this age may be retained on trays without material injury has not been fully determined, and experiments in this direction, as well as others in regard to their treatment at this, their most critical period, were intended to have been made, after having secured the complement of eggs for the hatchery, but the season terminated abruptly and before the desired numbers had been obtained.

The regular employés of the hatchery at this time were Mr. I. Slaght, Mr. A. W. Root, and Mr. S. Bower, and the respective duties assigned to each were well performed. Mr. Slaght was given the immediate supervision of the eggs in the hatching-boxes; Mr. Root was employed as carpenter and general assistant; and Mr. Bower was intrusted with the immediate care of the eggs in the jars, and also attended the office work.

The principal and most important of the work of the hatching-room from this time on, consisted in protecting the live eggs from the fatal presence of the dead egg of confervoid growth, and from the pernicious influences of slimy coatings and sediments. Other general work included a periodical cleaning of the tanks, troughs, trays, hatching-boxes and flannel screens, to remove slimy deposits and accumulations; making shipping cases and shipments of eggs; the construction and operation of a refrigerator; confining the temperature of the water to certain limits by the use of ice and snow when necessary; repairing old and constructing new tanks, and fitting them for the reception of the fry; and finally the general distribution of the young fishes.

In the artificial propagation of whitefish, if the eggs have been taken with a greater regard for quality than quantity, and are given special care and attention under favorable circumstances until received at the hatchery, 85 to 95 per cent. may be hatched. If the eggs have been secured under the conditions just indicated, nearly accurate calculations as to the number of young fishes to be shown at the end of the season can then be made; results can be anticipated with confidence. But approximate estimates cannot always be made from the appearance of the eggs on arrival at the hatchery, their aspect at this time generally giving no clew upon which to base computations, as the fruits of prior neglect or defective treatment may not yet be apparent; neither does the unimpregnated egg exhibit any distinguishing marks visible to the unaided eye, by which its presence may be detected. The lapse of a few days, however, will tell the story, for the greater part of the loss during the period of incubation, be it much or little, will occur within thirty days; the "good," "bad," or "indifferent" lots received at different times and from diverse sources, if kept separate, will soon be searched out. So it was in the present instance. The eggs from Alpena, although a good lot, were decimated in numbers within the time above noted, while those from the islands proved to be unexceptionably good, the loss within the time mentioned not exceeding 5 per cent. Of the total loss of a million and a half in round numbers, during the season, nearly one million died within twenty-five or thirty days.

THE HATCHING-BOXES.

There seems to be but one way to rid the hatching-boxes of the dead eggs, viz, pick them out one by one as they appear. For this purpose a shallow picking trough running parallel with the rows of hatching-boxes, and of the same length, is arranged along the side of the hatching-room facing a row of windows. The little nippers or tweezers for removing the eggs are spherical at the picking end, so that when closed they are just large enough to hold the egg without crushing it. Girls were employed for picking the eggs—as many as were needed to look over all the hatching-boxes at least once in two days.

The eggs, boxes, and trays received a weekly washing, a process accomplished with the eggs by simply agitating the tray in a tub or tank of water. The tray is then transferred to the picking trough, a clean tray fitted over it and the whole quickly overturned and immersed in a tank of clean water, when the eggs will be changed to the clean tray. The compartments containing the hatch-boxes are provided with plugs, which, being removed, the whole is quickly washed and cleansed, a waste trough underneath running the entire length of the rows of boxes.

It is of great importance that the dead egg should be removed very soon after the little white spot—the first positive evidence of its death visible to the naked eye—is apparent. This is rendered imperative from the rapidity with which confervoid growth develops on dead eggs lying motionless on the trays, and which, if undisturbed, soon reaches out from an individual egg and embraces within its deadly grasp the circle of eggs surrounding it, and these again in turn soon destroy another circle, and so on. This growth starts much quicker and creeps out faster from eggs of the whitefish than from any of the large eggs of the Salmonidæ, as *Salmo fontinalis*, *Salmo quinnat*, *Salmo iridea*, &c., and the same rule holds good with respect to eggs of the whitefish incubating in the jars, in which the morbid growth is usually delayed from five to ten days after the death of the egg, doubtless due to the constant motion imparted to the eggs by the upward current of water.

From about the tenth to the thirty-fifth day the eggs in the hatching-boxes require special attention, for not only does the greatest mortality occur during this period, but the contact of diseased growth is especially destructive to the live eggs at this time, it being the most critical period in the life of the egg, so far as the influence of confervaceous growth is concerned. During the period just mentioned, and with a temperature of water ranging from 40° to 45°, ten dead eggs scattered equidistant on a 7 by 12 tray containing 10,000 live eggs (in water) will soon accomplish the destruction of the remainder, if allowed to remain undisturbed. Eggs thus neglected are doomed.

From the thirty-fifth to the forty-fifth day the eyes of the embryo become plainly visible, and the egg from this time on may remain in contact with fungous growths much longer than previously without injury. From this time on, too, the work of caring for the eggs continually lessens.

THE HATCHING JARS.

With reference to bringing forward eggs of the whitefish in hatching boxes and applicable more particularly to the earlier stages of development, it may truthfully be said that "eternal vigilance" is the price of success. But this statement cannot be made concerning the development of embryos in the Chase hatching jar; for, while incubating in this manner, the eggs are not subjected to critical periods, and thus the necessity of a constant surveillance at certain times is obviated. Happily, too, the introduction of the jar does away with the primitive one-by-one-picking process with nippers, unavoidably a slow and tedious operation requiring the persistent patience of a Chinaman. The jar, then, greatly lessens and simplifies the work, thereby reducing the expense to a nominal figure. Safety and economy constitute its chief points of superiority over any hatching device in which the eggs are stationary, or, at best, have but very little movement; more economical, because one man having but little experience or instruction can readily care for 20,000,000 eggs; and safer because the dead eggs are separated by the natural operation of the jar as soon as confervoid growth begins. Previous to this growth, however, separation of the dead from the living eggs by any mechanical arrangement of currents or counter currents would seem to be impossible as there is no apparent difference in their specific gravity; but the spongy filaments of morbid growth, without materially increasing the weight of eggs thus affected, present a greater surface to the influence of the current which, having an upward tendency, carries and retains them either against the gate or just above the surface of the mass of eggs whence they are easily syphoned away. Unless great care, demanding considerable time, is observed, and which is not at all essential, the syphon will draw away many good eggs, and frequently good eggs will be found with the bad ones at the gate; but when all such are transferred to a separate jar, a solid layer of varying depth of the worst eggs will soon rise to the surface and can then be drawn away without disturbing the remainder.

During the early part of the season, the eggs collecting at the wire gate and those hovering over the mass of eggs were removed twice daily and placed in a separate jar or jars, conveniently named "hospital" or "post" jars; while later on only a daily treatment was needed, and during the last six weeks preceding the hatching season a weekly manipulation in this manner sufficed to keep the eggs in excellent shape. The "hospitals," of course, were relieved of their extraneous eggs whenever a sufficient number had collected in bunches or layers to be drawn away unaccompanied with good ones.

The wire gates were cleaned at least once a day throughout the season until the eggs began hatching, when they were removed to allow the fry and shells to float off, the supply of water for each jar being slightly decreased at this time to prevent eggs from being thrown overboard also. If the jars could be made exactly perfect, thereby compelling a uniform current of water to flow from all points of the base of the tube, the upward current might probably be so nicely adjusted as to throw off only fungoused eggs, in which event the gate and syphon could be dispensed with, thus making a complete self-picking apparatus; but the slightest imperfection in the jar or tube—found to exist in every one in use during the season—will create unequal currents, the stronger ones throwing good eggs against the gate, the weaker having strength barely sufficient to carry the light eggs to the surface but not enough to expel them; hence the necessity of a little assistance to complete the elimination, and which is undoubtedly accomplished more readily by the syphon than any other way.

NOTES, ETC.

One convenience, and probably the only one, of the hatching boxes over the jars is, that eggs in the former receiving a tri-weekly picking are nearly ready for shipment at all times, it being important of course in shipping eggs that all dead eggs should be removed; this the jar will not do; it separates only those made buoyant by confervoid growth, and the picking trough must be resorted to to complete the work; hence a few trays and nippers and the picking trough will be found almost indispensable accessories, and should be retained in the hatching room where jars have displaced the boxes.

Although the collection of eggs of the whitefish is attended with hardships seldom if ever experienced in gathering eggs from any other kind of fish, yet from the date of their introduction into the hatchery they can be brought forward with much less trouble and expense (when the jar is used) than the eggs of any other member of the salmonoids; and, furthermore, greater percentages can be hatched than from any other salmonoid, or from the shad. As compared with the latter, which are equally as well adapted to bulk methods of hatching, the difference in the temperature of water in which they are incubated must be charged with the difference in mortality, the rapidly growing fungous of the warmer water necessarily destroying a greater number of embryos. As compared with the former, over which they may have no advantage in water temperatures, the difference in favor of eggs of the whitefish must be credited to their ready adaptability to the bulk method of hatching; for not only can eggs be developed in this way at a greatly reduced outlay of labor and expense, but it is a safe assertion to make, susceptible of proof by any one who will make a fair trial, that the jar will hatch 5 per cent. more eggs than any hatching box now in use, other things being equal. The deficit with the latter method may be charged to the frequent handling of the eggs, changing from the boxes to the picking trough and return, but more than this, to the quick thrusts of the nippers amongst the eggs when picking, and which alone unavoidably injures or kills outright throughout the season nearly 5 per cent., at a low estimate.

The average yield of eggs from the whitefish may be computed at 20,000 for each female spawner, although as many as 75,000 were taken from single specimens in two instances at the Islands; but this was a very extraordinary yield, as such extreme fecundity is rarely found. Eggs on trays were estimated on a basis of 64 to the square inch and in bulk on a basis of 36,800 to the quart, this number being almost absolutely correct, having been determined by actual count of a fractional part of the quantity taken as the standard.

RETARDING EGGS.

For the purpose of experimenting with a view to retarding the development of eggs, about 10,000 taken October 31 were spread in double layers on flannel trays December 8, and the whole arranged in a small refrigerator previously charged with ice and placed in the corner of the hatching room farthest removed from the stove. No special care was given them other than to keep the chambers well filled with fine ice and to give the eggs a weekly picking and sprinkling, care being taken to thoroughly drain the trays before replacing, and also to avoid exposing the eggs to a greatly increased temperature while being picked, a work usually performed in the morning before the room had become too warm for the purpose. Very few eggs had died up to December 29, fewer probably than if they had remained in water, but of course this is simply a matter of conjecture. A record of the temperatures both inside and outside the refrigerator was made three times daily. The extremes previous to December 29 were: inside 30° and 31½°, and outside 30° and 46°. The eggs were in splendid condition on the date mentioned, when the temperature of 30° was recorded at 8 p. m.; but the next morning the temperature of the hatching room had fallen to 21°, 9° colder than the refrigerator had been subjected to, while inside, the thermometer marked 27° and the eggs were all dead. The fact that not a single live egg could be found, proves conclusively that eggs of the whitefish will not live in an atmosphere of 27°.

Meanwhile, a larger refrigerator was made, having seven chambers fitted with slides of the proper size to admit the flannel trays of the carrying cases, thus avoiding the expense of new trays by utilizing those on hand. This was completed December 22, and the following day 1,000,000 eggs from a lot received at the hatchery November 6, were placed in chambers 1 and 2; January 5, 1,500,000 from lot received November 13, were transferred to chambers 3, 4, and 5; and the remaining chambers were filled January 12, with 1,000,000 eggs from lot received November 13. The eggs were treated the same as those in the smaller refrigerator in regard to sprinkling and picking, but the temperature inside the larger one was maintained one degree higher on an average, while 29° was the lowest limit allowed the atmosphere surrounding it. The temperature inside ranged from 31° to 34°, averaging 32°. The eggs from section one, one-half million, were removed January 10, for shipment to Iowa. Section 3, containing the same number, was likewise emptied January 13, for Kentucky and Minnesota shipments. The two and one-half million remaining were retained in their respective sections (2, 4, 5, 6, and 7) until February 1, when all were transferred to the hatching jars. A jar of eggs from section 2 began and completed hatching almost simultaneously with eggs received at hatchery, November 18, showing a retardation of twelve days. By comparison with eggs of various ages continuously developed in water, sections 4 and 5 showed a detention of ten days, and sections 6 and 7 a retardation of 9¼ days. The fry from all these were equal in vigor and development to those brought forward in the usual manner. Previous experiments in retarding eggs of the whitefish have given substantial evidence that the eggs should be taken from the water earlier in the season to secure the longest possible postponement of the hatching period.

SHIPPING EGGS.

The following table includes all shipments of eggs made during the season, except a few sample lots to Prof. S. F. Baird, Washington, D. C., Prof. S. A. Forbes, Normal, Ill., and John A. Ryder, Philadelphia, Pa.:

Eggs shipped by express.

Date of shipment.	Number of eggs shipped.	Destination.
December 17, 1880	250,000	Fred. Mather, Newark, N. J.
December 22, 1880	500,000	E. M. Stilwell, Bangor, Me.
January 10, 1881	500,000	B. F. Shaw, Anamosa, Iowa.
January 13, 1881	250,000	R. O. Sweeney, Saint Paul, Minn.
January 13, 1881	250,000	Wm. Griffith, Louisville, Ky.
January 17, 1881	250,000	B. B. Redding, San Francisco, Cal.
January 19, 1881	500,000	E. M. Stilwell, Rangeley, Me.
January 22, 1881	250,000	Wm. Griffith, Louisville, Ky.
February 3, 1881	25,000	Mrs. H. C. Fenstermaker, Eureka, Nev.
February 5, 1881	250,000	B. B. Redding, San Francisco, Cal.
February 12, 1881	100,000	S. Weeks (for H. B. Wright), Corry, Pa.
Total	3,125,000	

All eggs prepared for shipment were subjected to a critical picking, and were spread and packed in an atmosphere ranging from 29° to 35°. The first lot, to Mr. Mather, were spread in double layers on trays of

Canton flannel with a piece of the same material corresponding in size to the insidé of the tray frames spread over the eggs; the trays were throroughly soaked in water before receiving the eggs, and a narrow margin left unspread so that no eggs came in contact with the frames; the flannel covers were similarly saturated in cold water and partially wrung out, but were allowed to retain all the moisture possible without dripping; the trays were then placed one above the other in two equal lots for the two cases in which they were to be shipped, each lot resting on an inch board on which was spread a piece of wet Canton flannel, and having a second board and flannel on top for a cover (the flannel, of course, being on the under side of the cover), and all held to position by strips on the ends and sides tacked to the top and bottom boards. The packages were then removed to their respective cases and entirely surrounded with a 6-inch coating of fine, dry, hard-wood shavings, quite firmly packed in by stamping with the feet. This consignment of eggs was repacked and shipped to Germany by Mr. Mather.

The following extract from a communication from Mr. von dem Borne to the *Forest and Stream* of February 17, 1881, concisely states the condition of the eggs on arrival: "The whitefish eggs recently sent over by favor of Professor Baird arrived almost without loss. They are very healthy, and are now developing in my hatching troughs."

MAINE.—Reports from the two shipments of one-half million each to Maine are not so favorable. The first was packed precisely the same as those sent to Mr. Mather, with the exception of using trays twice as large, to carry twice as many eggs in the same number of cases, the latter being made larger to correspond. Notwithstanding the fact that "whitefish eggs" was displayed in large letters on the covers of the cases, coupled with a special request to express messengers and employés to exercise great care in handling, and to "keep this side up under all circumstances and place the case as far as possible from the stove in the car," they were evidently subjected to rough treatment while *en route*, and were probably allowed to get too warm in the car.

Commissioner Stilwell wrote, January 12, in reference to their appearance when unpacked, that "the eggs had undoubtedly been roughly handled on the route, as they had been, apparently, rolled from one side to the other, and were piled together in the corners of the trays," and that they were looking so badly that less than 40 per cent. could be saved.

The second lot forwarded to Maine, packed in one large case, arrived in better shape than the first. The following letter addressed to F. C. Hervey, to whose care this shipment was made, shows the manner of packing:

"NORTHVILLE, MICH., *January* 19, 1881.

"DEAR SIR: In accordance with instructions from the United States Fish Commission, I ship you per express to-day 500,000 whitefish eggs, and trust they will reach you in better condition than the former lot. They are packed as follows: The first ten trays on top have the flannel coverings drawn down close to the eggs and secured by strips tacked to the tray frame. This ought to prevent rolling or accumulation of the eggs in case the box is overturned while in transit. The next five trays have moss in addition to the cloth covering; the next four are precisely the same as all were in the preceding lot sent you, and the last tray is covered with snow.

"Please note carefully the condition of the eggs in each method of covering and communicate the facts to me.

"Yours, very truly,

FRANK N. CLARK."

Unfortunately, the eggs preceded the arrival of the letter, which was forwarded the same day, and no accurate note of their precise condition was reported. It is fair to presume, however, that there was no marked difference in results, or the party opening the case doubtless would have noticed it.

The following extracts from letter of Commissioner Stanley, dated February 28, embrace the facts relative to their condition when received:

"In appearance they were in very good condition when they arrived at their destination, although they were considerably shaken up and had apparently received very rough usage on the route. After being placed in the hatching-boxes the loss has been large. I should judge by appearances now that if we can save 50 per cent. of them we will do well. * * * They must have been in good condition when packed, as I have examined them carefully and could find none but what were impregnated and well developed."

And, again, from letter of April 19, in reference to the disposition of the fry:

"Your favor inquiring about our whitefish eggs received this day. Would say we have just deposited the fry into the Mooslucmaguntic Lake, one of the Rangely chain of lakes. Both lots were placed in the same lake. Of the last lot, about 50 per cent. hatched; of the first, about 25."

IOWA.—The half million eggs to Iowa were prepared exactly the same as the first lot to Maine, except being placed in one large case instead of two smaller ones. The following from Commissioner Shaw shows their condition on arrival at destination:

"I found the whitefish eggs in fair condition on opening at Spirit Lake, except that some of them were a little matted with fungus. I was delayed two days by a very bad snow-storm, but kept the eggs in a cool place, however, and succeeded in getting them safely through. I was much surprised to see nearly 10,000 young fish hatched out the next morning after eggs were put into the water, all the more so as the water was only just above freezing. There were quite a number hatched in the box upon opening, and I am of the opinion that a portion of the eggs were a little too far advanced when shipped."

Some of the eggs being matted together with fungus indicates that they were exposed to a considerable warmth during their journey; for eggs in the refrigerators—arranged practically the same as those intended for shipment—although exhibiting fungous growth a few days after dying, in a temperature of 32° or 33°, exerted no baleful influence on the live eggs within a much longer period than that occupied in making this shipment—due to the very slow formation of fungous growths on dead eggs out of water, in the temperature above noted.

From the reports of the careless handling and treatment which the cases of eggs had evidently undergone at the hands of express employés, it was very obvious that but little heed was paid to the precautions conspicuously lettered on the cases; and concluding that a special order from the superintendent of the express company would be more effectual, a personal interview was held with that courteous official, Mr. J. S. Hubbard, with the result of receiving his indorsement to the following, which appeared on all subsequent shipments; and by his instructions the Northville agent was required to attach a duplicate to the way-bill accompanying each consignment:

"*To express messengers and employés:*

"You will observe the following regulations in regard to the care and handling of cases containing fish eggs:

"Place the case as far as possible from the stove in the car.

"The case must never, under any circumstances, be overturned, but kept right side up with care.

"Do not delay or detain, but forward as expeditiously as possible; but where detention for any length of time is unavoidable, as in case of accident or non-connection of trains, place the eggs in a room containing no fire.

"This order must be countersigned by Frank N. Clark, superintendent United States fish hatchery, Northville, Mich.

"J. S. HUBBARD,

"*Superintendent American Express Company.*"

"Countersigned:

——— ———,

"*Superintendent United States Hatchery.*"

Thereafter but one instance of carelessness in regard to rough handling of the cases was reported (second lot to Maine), but protection from too great a degree of warmth was not secured in every instance, for which, however, messengers could not be held accountable, their whole duty having been performed when the eggs were placed as "far as possible from the stove in the car," a point not necessarily removed from too great a degree of heat for the safety of the eggs.

MINNESOTA.—Eggs shipped in one case of ten trays, 25,000 to the tray, packed as usual. A communication from Commissioner Sweeney in reference to these eggs contains the following:

"The eggs came on the 15th instant and were, except two trays, in good order. These two trays were frozen, and we feared all the eggs were killed that were on them, but now they are hatching very freely, and the frosted ones seem as vigorous and forward as the others. The outer eggs on the two frozen trays were killed, but those in the center seem all right, notwithstanding they were frozen or caked together."

It will be seen from this that a little freezing is not so disastrous as overheating.

Later on, Superintendent Watkins reported on the disposition of the fry as follows:

"January 25, deposited in White Bear Lake, Ramsey and Washington Counties, 80,000 whitefish fry; January 29, deposited in Minnebonka Lake 100,000; February 8, deposited in Gervais Lake 50,000; total, 230,000. Some of the trays were frozen around the edges when received; loss, including the frozen ones, 20,000."

KENTUCKY.—First lot packed precisely the same as the one forwarded to Minnesota same day (January 13). The following is from letter, dated January 15, from Wm. Griffith, President of Kentucky Board of Fish Commissioners:

"The whitefish eggs arrived yesterday, and were placed in troughs at hatch-house yesterday evening. My man has just reported to me that the eggs opened in better condition than any lot he has ever before received. He reports 293 dead eggs, and the embryo moving, and thinks they will soon commence hatching."

Again, from same source, January 17:

"A messenger just in from hatch-house reports all the whitefish eggs dying. These eggs were received Friday, the 14th instant, at noon, and were placed in troughs at hatch-house late same evening; water, 38°. They appeared in splendid condition Saturday, but yesterday the weather moderated, with a drizzling rain, and the temperature of the water rose to 44°. The eggs commenced dying, and this morning about two-thirds of them were dead. * * * This misfortune is to be regretted, and is a matter of great surprise to me, as my man reported that he had never opened a lot of eggs in such apparent good condition."

Again, January 22, in which the daily loss is reported, as follows:

"I herewith annex a statement of condition of the eggs from date of receipt to present time: White-fish received and opened in apparent splindid condition.

White-fish eggs received and opened in apparent splendid condition.

	Dead eggs.
January 14, temperature of water 38°	183
15, temperature of water 38°	110
16, temperature of water 44°	5,000
17, temperature of water 40°	28,000
18, temperature of water 40°	39,000
19, temperature of water 42°	55,000
20, temperature of water 44°	12,000
21, temperature of water 40°	7,000
22, temperature of water 44°	3,400
Total to date	149,693

"The eggs commenced hatching January 16, and about 10,000 are now hatched. I think we will save about 75,000 of them."

Without attempting to assign a reason for this great mortality, or whatever the cause may have been, certainly the rise in temperature from 38° to 44° cannot be charged with the loss, for this change should have produced no decided effect, except perhaps to hatch them out very freely, the eggs being quite well advanced.

A second lot of a quarter of a million equally distributed on twenty trays was forwarded January 22. The first fifteen trays were covered as usual, *i. e.*, damp canton flannel spread loosely over the eggs: On tray No. 16 the covering was drawn down so closely as to exert some pressure on the eggs, and secured to its place by cleats tacked to the frame; No. 17 was covered with flannel as usual, and the intervening space between it and the next tray above—about one-half inch—filled with moss; No. 18 had nothing whatever over it, that is, in the way of a cover; No. 19 contained a compartment 2 inches square, which was filled with eggs to the level of the frame, or about six layers deep; and No. 20, the bottom tray, was covered with flannel and one-half inch of snow firmly packed in.

The following extract from letter of President Griffith, dated January 29, shows results:

"The last lot of white-fish eggs arrived in Louisville Tuesday the 25th instant, at 8½ a. m., and at hatch house 11 a. m., same morning. Temperature of air 26°, water 41°. Packing on top of trays dry, around trays damp. Temperature of trays 48°. Eggs all in troughs at 2 p. m. In trays from 1 to 15 inclusive were 17 dead fish and 183 dead eggs; in tray No. 16 were 2 dead fish and 12 dead eggs; in 17 were 2 dead fish and 12 dead eggs; in 18 were 2 dead fish and 12 dead eggs; in 19 were 3 dead fish and 14 dead eggs; and in No. 20 were 7 dead eggs."

The loss throughout the case being merely nominal—a small fraction of 1 per cent.—and so uniformly distributed, the inference might be drawn that the manner of covering, or, indeed, the presence or absence of any cover at all, has but little bearing on the successful transportation of eggs. The principal object of a damp cover being to supply additional moisture the evidence would clearly indicate that it might be dispensed with for shipments designed to reach consignees within three or four days, the damp trays on which the eggs are spread and the eggs themselves retaining all the moisture essential.

However, although in the present instance there was no manifest difference in results due to any special feature in the cover or between the several methods and the absence of any covering, except possibly tray No. 20, covered with snow, and on which there were no dead fish and only 7 dead eggs, or a trifle over half the average, still, the conclusion can hardly be drawn that the absence or presence of a damp covering of some kind would be immaterial for eggs conveyed long journeys; and, as it can do no harm under any circumstances, and makes provision for insuring the proper degree of moisture in the event of a delay, and as it would seem to be quite essential for the retention of requisite moisture for long journeys, it may be regarded as nominally indispensable. But snow, which in the present instance was dry and frosty when packed, and hence exercised a salutary influence by maintaining a low temperature, can hardly be considered a safe covering either for long or short journeys, for the chances are all in favor of its melting in transit, thereby completely saturating a portion of the trays and their contents, a condition which repeated experiments have shown to be deleterious or even fatal to eggs thus situated for any length of time.

Far better results were obtained from the second lot of eggs. Two hundred and sixty thousand fish were hatched from the two lots and planted as follows, according to report of President Griffith:

"White-fish fry deposited as follows: February 3, 1881, Barren River, tributary to Green River, tributary to Ohio River, near Bowling Green, Warren County, 100,000; March 5, same place, 160,000; total, 260,000."

CALIFORNIA.—The first case to San Francisco was started January 17, and contained ten trays, 25,000 to the tray, with the flannel spread securely fastened with strips same as in last shipment to Maine. They arrived in excellent shape as the following from Commissioner Redding indicates:

"The 250,000 whitefish eggs received in good condition, not to exceed 1 per cent. loss. After regulating the temperature of the water they were placed in it and within twelve hours commenced hatching out."

A second lot of 250,000 packed precisely the same as its predecessor, shipped February 5, arriving 9 days later, was almost a total loss, as the following from Commissioner Redding will show:

"The last lot of 250,000 whitefish eggs arrived a few days ago in a terrible condition. The top layers were entirely decayed, and there seemed to be hardly any life remaining in the lower eggs. All that appeared to have life have been put in the water. I do not know of any reason for this result except probably they were detained by the snow blockade and the car was kept too warm."

The following is from a subsequent communication from Mr. Redding in reference to these eggs:

"The eggs arrived on the 14th instant. * * * The messenger in the express car usually has two stoves, one in each end of the car, to keep himself warm, and the temperature is kept too high for the transportation of fish eggs."

Mr. Redding's supposition that the eggs were allowed to get too warm is undoubtedly correct.

The report of Superintendent J. G. Woodbury, San Leandro (where the State hatchery is located), contains some interesting notes, and is given in full:

"*Whitefish shipments.*—February 5, Tulare Lake, 125,000; February 10, Mountain Lake, 10,000; February 12, Merced Lake, 10,000; February 14, Tahoe Lake, 100,000; March 25, to Judge McShalter, Warm County, 2,500; total, 247,500.

"The temperature of the water in which the whitefish were hatched was about 54°, ranging from 51° to 56°. The first lot of 250,000 came in splendid order, better than any ever before received from the East. After being put into the water and during the hatching, also up to and including the last shipment, the loss did not exceed 1½ per cent. Most of them hatched out very soon after being put into the hatching baskets, but were vigorous and shy, and at the end of one week began to eat pounded-up crab which they were fed on. They appeared to be very fond of this, taking in their mouths pieces of the fiber a quarter of an inch long, swimming around trying to swallow it. The white meat of the crab could be seen in their stomachs through their transparent bodies.

"The last lot of 250,000 whitefish eggs arrived (being delayed, I suppose) in very bad condition, all the top layers rotten and smelling badly. Of those put into the water only a few hatched out (four or five thousand), and in a very sickly condition. These few would not eat, and at the end of three weeks they were quite attenuated, with their heads and gills covered with fungus. During the hatching and feeding time of the first lot the water was quite muddy, so much so that the little fish could hardly see their food."

NEVADA.—February 3, a case containing 25,000 eggs was forwarded to Mrs. H. C. Fenstermaker, a lady considerably interested in pisciculture, residing at Eureka, Nev.; but for some unaccountable reason no word has ever been received as to whether they reached their destination or not. Three letters of inquiry have failed to evoke any response.

PENNSYLVANIA.—One hundred thousand eggs, packed as usual, were shipped February 12 to Corry, Pa., with the following results, embraced in a communication from the Hon. Hendrick B. Wright:

"The eggs arrived safely at Corry and were hatched and the fry delivered to me on the 18th instant. I succeeded in putting some 70,000 of them in my lake in Luzerne County, Pennsylvania, so that the matter is, so far, a success. The lake where they were deposited is known as Harvey's Lake, containing about 1,000 acres, ten miles in circumference, and in places over a hundred feet deep; it is pure spring water, and about 1,000 feet above the sea level."

Two small packages, each containing about 500 eggs, were sent by mail to Mr. John Ryder, Academy of Sciences, Philadelphia, but eggs were all dead when received by Mr. Ryder.

The results of shipping eggs of the whitefish the present season, as well as of moving them much greater distances in previous seasons, have demonstrated beyond a doubt that they can be transported to the most distant points of the globe with almost absolute certainty of a successful issue, provided the proper limits of temperature are guarded, and the eggs are not too far advanced when shipped. The essential conditions as to the means of securing the maintenance of the proper degree of moisture and of the admittance of air, can be so completely satisfied in the preparation of packages of eggs for extended journeys as to render their inspection or repacking at intervening points entirely superfluous. But with many shipments, notably those by rail, it is not so easy to provide for guarding temperatures; that is, of course, when they are to be unaccompanied by a special messenger. Very rarely indeed will the eggs be exposed to a dangerous degree of coldness, and practically the opposite extreme is the only one to guard against. The clear, cold atmosphere produced by ice seems to be the best adapted to the preservation of the vitality of the embryos; hence, a roughly constructed refrigerator would answer every purpose, but would require special arrangements as to replenishing the ice at intermediate points along the route, and would also demand ample provisions for the disposition of the drips, otherwise the water slopping or draining in the car would doubtless subject the whole affair to extortionate express rates. The ice rooms of vessels, being uniformly cold, are especially suited to keep fish eggs in excellent condition; and for this reason foreign shipments can be made (from port to port) with a far greater degree of certainty of success than can those inland even for a short distance; in fact, the ordinary carrying cases used to convey eggs from the spawning ground to the hatchery, filled with eggs not too far advanced, and snugly ensconced in the ice room of a vessel, could safely be intrusted with a voyage across either ocean.

To obtain the best possible results, shipments should be made before the development of the embryo has proceeded too far, and therefore applications should be sent in earlier in the season.

DISPOSITION OF THE FRY.

The work of distributing the young fish was greatly facilitated and the expense materially lessened by the gratuitous assistance of several railroad companies, to whom acknowledgments are due, as follows: The Flint and Pere Marquette Railroad Company for special car from Northville to Bay City; special car, and round trip passes for messengers, from Northville to Ludington; hauling Michigan Central car from Detroit to Northville, and from the latter place to Wayne Junction, where connection is made with the Michigan Central Railroad; special car from Northville to Toledo (terminus of the line), and allowing car to go on to Sandusky; and conveying cans of fish in baggage car from Northville to Detroit. The Michigan Central Railroad for special car and round trip passes for messengers from Wayne Junction to Chicago. The Lake Shore and Michigan Southern for hauling Flint and Pere Marquette car from Toledo to Sandusky and return. The Chicago and Northwestern for transporting cans of fish in baggage cars from Chicago to Waukegan, and from Chicago to Milwaukee.

In addition to favors above noted all empty cans were returned gratis, and the first-named company carried all eggs over its line during spawn-gathering without charge.

Following is the table of distribution:

Date of removal from hatchery.	Hour.	Temperature of water in hatchery.	How transported.	Number of cans used.	Where deposited.	At what point.	Temperature of water in which fish were planted.	Number fish deposited.	Date of deposit.	Hour.	Messengers.	
1881.							°					
Mar. 1	8 to 10 a. m.	38°; reduced to 33° in the cans before starting.	Special car.	68	Saginaw Bay	Bay City	32	2,000,000	Mar. 1	5 to 6.30 p. m.	F. N. Clark and S. Bower.	
Mar. 8	...do	40°	...do	98	Lake Michigan.	Ludington	32½	2,000,000	Mar. 9	9 to 11.30 a. m.	Do.	
Mar. 15	10 p. m., the 14th, to 3 a. m.	41°	...do	33	...do	Michigan City	32½	1,000,000	Mar. 15	7 to 8.40 p. m.	Clark, Bower, Root, and Horton.	One trip; one car.
Mar. 15	...do	41°	...do	33	...do	Waukegan	32½	1,000,000	Mar. 16	11.05 a. m. to 1 p.m.	Clark, Bower, and Horton, from Michigan City to Chicago; S. Bower, from Chicago to Waukegan.	
Mar. 15	...do	41°	...do	33	...do	Milwaukee	32½	1,000,000	Mar. 16	12.15 to 2 p. m.	Clark, Bower, and Horton, from Michigan City to Chicago; Clark and Horton, from Chicago to Milwaukee.	
Mar. 21	7.45 to 9.45 a. m.	41°	...do	50	Lake Erie	North Bass and Put-in-Bay Islands.	33	1,250,000	Mar. 23	1.30 to 4 p. m.	Clark and Slaght.	
Mar. 30	8.30 to 9.30 a. m.	37°	Baggage car.	10	Detroit River	Detroit	33½	1,000,000	Mar. 30	12 to 1 p. m.	F. N. Clark.	
Mar. 24	8 p. m	45°; reduced to 33° in can before shipping.	Express.	1	Cedar Lake	Crown Point, Indiana.	33	15,000	Mar. 26	9 a. m	Water not changed or aërated on the route; a few dead fish reported.	
Total.								9,265,000				

FOOD OF THE YOUNG FISHES.

On December 31, a few hundred whitefish eggs taken November 1 were arranged in a perforated tin box, and placed in the spring pond in a temperature ranging from 43° to 45°. These began hatching January 15, and were all hatched out by January 24. The fry were then divided into two lots, one of which was removed to the lower spring near its source, where the water ranges from 45° to 47°. The others were set free in a tank in the hatchery, the water being quite variable, but averaging much colder than the spring. Those in the spring were offered no food, but those in the tank were given the privilege of partaking of shrimp (*Gammarus*) pounded to a pulp and diffused into the water two or three times daily. Specimens from both lots were, from time to time, sent to Prof. S. A. Forbes, Normal, Ill., who made a thorough microscopical examination of their stomach contents, and reported the results of his investigations as follows:

NORMAL, ILL., *March* 29, 1881.

F. N. CLARK, Esq.,
Northville, Mich.:

DEAR SIR: Having now finished work on the young whitefish sent me since February 1, I wish to make a connected statement of my observations and conclusions, to take the place of the rather confused memoranda I have sent you heretofore.

I have been carefully over the slides a second time, and think that there is little, if anything, more to be learned from them.

1. FRY FROM THE SPRING.

a. Received February 9.

One hundred specimens were examined from this lot. Only one had lately taken food, and this had eaten some filamentous algæ and a minute fragment of the parmchyma of some higher plant, with a few scattered diatoms.

b. Received February 17.

There were also one hundred in this lot of the fry. All were passed under the microscope, and food was found in but one. This consisted of a few particles of vegetable parmchyma, doubtless derived from the decaying plant structures in or about the water.

c. Received February 25.

In this lot there were but forty-two specimens. Six of these showed traces of food in the intestines, consisting almost entirely of filamentous algæ and a little vegetable parmchyma. Desmids and diatoms were observed in trivial number, associated with oscillatoria, &c., in a single specimen. Total from the spring, 242; containing vegetable food, 8; containing animal food, none.

2. FRY FROM THE HATCHERY.

a. Received February 9.

Ninety fishes were examined—all but four without result. In three, mere traces of dirt were seen in the intestine, and these were not dissected. In the fourth was a fragment of *Gammarus.*

b. Received February 17.

One hundred and eleven fry, of which seventeen had taken food. I dissected nine of these, and found fragments of *Gammarus* and nothing else.

c. Received February 25.

Ninety specimens examined. Food was found in fourteen. Four of these had eaten fragments of *Gammarus;* seven, small particles of the leaves and stems of vascular plants; two, larvæ of gnats; and one, a small *Entomostracan* (*Cypris*) entire.

d. Received March 15.

There were thirty-nine specimens in this lot, and food was visible in fourteen. I dissected nine of these, finding fragments of *Gammarus* in four, larvæ of gnats in three, and a minute vegetable fragment, a *Cyclops*, a *Cypris*, and some undetermined *Entomostracan* each in one.

Thus there were 340 fry in all examined from the hatching house, in 47 of which (14 per cent.) more or less food was discernible. Of the 35 dissected, 18 had eaten fragments of *Gammarus;* five, minute insect larvæ; four, *Entomostraca;* and eight, small particles of vegetation.

Taking these facts in connection with the appearance of teeth on the lower jaw at the time the egg-bag is entirely absorbed, I am very well satisfied that the earliest food of this fish consists of *Entomostraca*, with probably some admixture of filamentous algæ. As the gill-rakers are not developed at this early age, I don't think that any smaller objects could be separated from the water, except by accident.

The *Gammarus* "hash" evidently makes a very good substitute for the *Entomostraca.* It is, however, less nourishing, as much of the soft tissues of the *Gammari* must be lost in pulverizing the crust—a fact indicated also by the greater quantity of oil found in the intestines of those fishes which have taken *Entomostraca* entire.

Very truly, yours,

S. A. FORBES.

The following, from a previous letter from Professor Forbes, is very valuable and interesting in this connection:

"An observation made to-day practically settles to my mind the earliest food of the whitefish. As you are of course aware, the adult fish is quite toothless. The young are likewise without teeth until the egg-sack has nearly disappeared. At that time the lower jaw develops four strong, sharp canines, which curve backward and inward, forming stout hooks, two on the front of the jaw and two at the sides. It is evident that these hooks are for the seizure and retention of a living prey. Such a provision would be useless for protozoa or rotifers, or any other animals as minute as these, and the fish itself is too small to eat anything as large as an amphipod crustacean. The whole apparatus is, however, well adapted for the capture of *Entomostraca* and minute insect larvæ, and it is very probably upon these that the little fish depends for its principal food."

The egg-sac of the fry in the warmer spring water disappeared some faster than with those in the hatchery, the fish developing in size to correspond; but their growth, however, was very slight. But a few days after the absorption of the egg-sac the fish began dying, and by March 1 were all dead.

Those in the hatchery fared somewhat better. After the last lot were sent to Professor Forbes (March 14) about 40 or 50 remained, some of which lingered along until April 10, when the last one disappeared. The nourishment derived from the scant animal life found in the water, supplemented by the meager sustenance afforded by the few particles of *Gammarus* eaten, although prolonging their lives several days after the egg-sac was gone, was quite insufficient to sustain life for any length of time.

On March 18 about 200 young fish (hatched March 5), having their egg-sac nearly absorbed, were placed in a tank 2½ feet deep by 1½ in width and 4 in length, supplied with water from two one-inch spigots. These were offered *Gammarus*, as before; but as soon as the sac was entirely consumed they commenced dying quite rapidly, until only about 20 remained on the 25th of April. These had grown a trifle in length, but were quite attenuated. A change of diet was then tried with better results to date (May 25) and prospectively. Liver and kidney, chopped into very fine particles, was substituted for the *Gammari*. The chopping process of preparing the food seems to be much better than pounding (the only way practicable with the *Gammarus*), as a minute subdivision of the mass is obtained without destroying the nutritious value of the particles by pounding out the soft tissue, leaving nothing but fiber.

The fact that *fragments* of *Gammarus* were found in the stomachs of the fry dissected by Professor Forbes would indicate clearly that their food must not be too impalpable before the gill-rakers are developed. This is corroborated by the conduct of the little fellows when fed the *Gammarus* "hash." They would invariably attack the larger particles first—those quite too large to be swallowed; these would be held by the mouth of the fish for a second or two, then spewed out and almost immediately seized again—an operation that was repeated until the particle had subsided to the bottom of the tank; then the smaller particles, more perfectly held in suspension by the water, would be taken in the mouth as before, and many of these they succeeded in swallowing.

At the present writing (May 25) eight of the twenty specimens fed on liver and kidney since April 25 remain. Seven of these have attained lengths varying from ¾ to 1¼ inches, while one has grown to fully 1½ inches in length.

From the fact that the fry in the spring, being deprived of animal food, lived but a short time after the consumption of the sac, and also from the fact that a portion of those supplied with animal food are to-day alive and growing, the evidence is clearly established that animal life is absolutely essential for their subsistence in early life, whatever the adult fish may feed upon.

SUMMARY.

Number of eggs deposited in hatching boxes and jars		13, 780, 000
Number of eggs shipped	3, 125, 000	
Number of fish distributed	9, 265, 000	
Loss	1, 390, 000	
		13, 780, 000

Expenses of the work, including repairs to hatchery and ponds, and expenses of distribution of fry	$4, 003.35
Less inventory of property on hand paid from above amount	459.80
	$3, 543.55

Comparing the number of eggs shipped and fish distributed with the number of eggs procured, it will be seen that the average percentage brought forward was, approximately, 90, and the average cost per million, $286.

Record of temperature observations made at Northville, Mich., from November 1, 1880, to April 1, 1881, by S. Bower.

Date.		Temperature of—						Wind.						Condition of—			
Day of week.	Day of month.	Air, 8 a. m.	Water, 8 a. m.	Air, 1 p. m.	Water, 1 p. m.	Air, 5 p. m.	Water, 5 p. m.	Direction, 8 a. m.	Intensity, 8 a. m.	Direction, 1 p. m.	Intensity, 1 p. m.	Direction, 5 p. m.	Intensity, 5 p. m.	Sky, 8 a. m.	Sky, 1 p. m.	Sky, 5 p. m.	Water.*
		°F.	°F.	°F.	°F.	°F.	°F.										
Monday	Nov. 1	33	45	53	47½	42	45	S. W.	Gentle	W.	Strong	S.	Gentle	Clear	Lt. clouds.	Clear	....
Tuesday	Nov. 2	32	45	53	48	48	48	S. E.	do	S. E.	Gentle	S.	do	Lt. clouds.	Clear	do	....
Wednesday	Nov. 3	34	45	64	49	60	50	S.	Calm	S. E.	do	S.	do	do	Cloudy	Cloudy	....
Thursday	Nov. 4	50	48	56	50	60	50	S.	Gentle	S. E.	do	S.	do	Cloudy	Rain	do	....
Friday	Nov. 5	56	50	53	51	48	52	S. W.	do	S. W.	do	W.	Strong	do	Cloudy	do	....
Saturday	Nov. 6	34	46	32	44	32	44	N.	do	N. W.	Fresh	W.	do	do	do	do	....
Sunday	Nov. 7	28	38	34	40	33	42	W.	Strong	W.	do	W.	Gentle	Clear	Clear	Clear	....
Monday	Nov. 8	34	42	40	43	40	42	W.	Gentle	W.	Gentle	W.	do	do	do	do	....
Tuesday	Nov. 9	38	42	52	48	50	48	W.	Calm	S.	do	S.	do	do	Lt. clouds.	Lt. clouds.	....
Wednesday	Nov. 10	44	46	48	47	56	48	S.	Gentle	S. E.	do	S. E.	do	H'vy cl'ds.	Cloudy	Rain	....
Thursday	Nov. 11	38	46	38	45	40	44	S. W.	Fresh	W.	Strong	W.	Strong	Cloudy	do	Cloudy	....
Friday	Nov. 12	32	39	33	39	30	40	W.	Strong	W.	Fresh	W.	Very gentle	do	do	do	....
Saturday	Nov. 13	26	38	38	39	36	42	W.	Gentle	W.	Gentle	S. W.	Gentle	do	do	do	....
Sunday	Nov. 14	33	38	44	40	36	42	S. W.	do	S. W.	do	S. W.	do	do	do	do	....
Monday	Nov. 15	22	35	26	38	25	38	W.	do	W.	Fresh	W.	Fresh	do	do	do	....
Tuesday	Nov. 16	26	36	32	38	26	38	W.	Fresh	W.	do	W.	Gentle	do	do	do	....
Wednesday	Nov. 17	16	34	22	36	26	38	W.	do	W.	do	W.	Fresh	do	do	Clear	....
Thursday	Nov. 18	6	36	19	37	14	38	W.	Gentle	N. W.	do	W.	Strong	Clear	Clear	do	....
Friday	Nov. 19	0	36	22	38	13	38	W.	do	N. W.	Gentle	W.	Gentle	Lt. clouds.	do	Cloudy	....
Saturday	Nov. 20	7	36	20	38	18	38	W.	do	N. W.	Fresh	W.	Strong	Clear	Cloudy	Clear	....
Sunday	Nov. 21	6	34	10	34	1	35	W.	Strong	W.	Strong	W.	do	Cloudy	do	do	....
Monday	Nov. 22	−10	34	15	36	8	37	W.	Fresh	W.	do	W.	Fresh	Clear	do	Cloudy	....
Tuesday	Nov. 23	2	37	22	37	24	38	W.	Gentle	W.	Gentle	S. W.	Gentle	do	Clear	do	....
Wednesday	Nov. 24	15	37	22	38	21	38	S.	do	S. W.	do	S. W.	do	Cloudy	Cloudy	do	....
Thursday	Nov. 25	14	38	22	38	18	39	S. W.	do	N. E.	do	N. E.	do	do	Clear	do	....
Friday	Nov. 26	0	38	29	38	25	38	S. E.	do	S. E.	do	E.	do	Clear	do	do	....
Saturday	Nov. 27	16	38	32	39	26	39	S. W.	do	S. W.	do	E.	do	Cloudy	Cloudy	do	....
Sunday	Nov. 28	22	38	22	39	30	39	S. W.	do	S. W.	do	S. W.	do	do	do	do	....
Monday	Nov. 29	21	39	30	39	18	39	W.	Strong	W.	Strong	W.	Strong	Clear	do	do	....
Tuesday	Nov. 30	2	37	28	39	25	39	W.	Gentle	W.	Fresh	W.	do	do	do	do	....
Wednesday	Dec. 1	26	39	28	40	27	40	W.	do	N. W.	Gentle	W.	do	Lt. clouds.	do	do	....
Thursday	Dec. 2	29	39	29	39	26	39	N. W.	do	N. W.	do	N. W.	Gentle	do	do	do	....
Friday	Dec. 3	19	38½	30	40	28	39	S. W.	do	S. W.	do	S. W.	do	Cloudy	Clear	Clear	....
Saturday	Dec. 4	15	38½	36	40	31	38	W.	do	S. W.	do	S. W.	do	Clear	Cloudy	Cloudy	....

Sunday	Dec. 5	36	42	38	40	38	38	S. W.	Fresh	W.	Strong	W.	Strong	do	do	do	
Monday	Dec. 6	12	34½	28	35	15	35	N. W.	Strong	W.	Gentle	N. W.	Gentle	Cloudy	do	do	
Tuesday	Dec. 7	9	32	12	34	6	35	N. W.	do	N. W.	Fresh	N. W.	do	do	Clear	Clear	
Wednesday	Dec. 8	8	33½	16	36	6	37	N. W.	Gentle	N. W.	Gentle	N. W.	Fresh	do	do	do	
Thursday	Dec. 9	10	36	16	38	15	38	N. W.	do	N. W.	Fresh	N. W.	do	do	do	Cloudy	
Friday	Dec. 10	10	38	15	38½	20	38½	W.	do	W.	do	S. W.	do	do	do	do	
Saturday	Dec. 11	12	38	31	38½	30	39	N. W.	do	W.	do	W.	do	Clear	Lt. clouds	do	
Sunday	Dec. 12	34	39	36	40	32	41	W.	do	S. W.	do	S. W.	Gentle	Cloudy	Cloudy	do	
Monday	Dec. 13	30	40	33	40½	28	41	N. W	do	W.	do	W.	do	do	do	do	
Tuesday	Dec. 14	33	41	35	41	34	40	S. W.	do	W.	do	W.	Fresh	do	do	do	
Wednesday	Dec. 15	30	40	33	40	30	39	W.	Fresh.	W.	do	W.	do	Clear	do	do	
Thursday	Dec. 16	22	38	24	38	28	38	N W.	Gentle	N.	do	N.	do	Lt. clouds.	do	do	
Friday	Dec. 17	21	37	25	37	36	37	W.	do	N.	do	N.	do	H'vy cl'ds	do	do	
Saturday	Dec. 18	20	37	22	38	18	38	N. E.	do	N. E.	Gentle	N.	do	do	do	Clear	
Sunday	Dec. 19	20	37	20	38	24	38	N.	do	N. W.	do	N. W.	do	do	do	Cloudy	
Monday	Dec. 20	26	38	27	38	26	38	N. E	do	N. E.	do	N. E.	Gentle	Cloudy	do	do	
Tuesday	Dec. 21	23	36½	26	38	26	37	N. W.	do	N. E.	do	N. E.	do	Clear	do	do	
Wednesday	Dec. 22	20	38	27	38	27	37	N. E.	do	S. E.	Fresh	S. E.	do	Cloudy	do	do	
Thursday	Dec. 23	24	39	30	39	28	38	N. E.	do	S. E.	do	S. E.	do	do	do	do	
Friday	Dec. 24	26	38	27	38	27	38	S E.	do	S. W.	Gentle	S. W.	do	do	do	do	
Saturday	Dec. 25	23	37	28	38	27	37	S. E.	do	E.	do	E.	do	do	do	do	
Sunday	Dec. 26	28	37	20	38	30	38	S. E.	do	N. E.	do	N. E.	do	do	do	do	
Monday	Dec. 27	26	38	20	37	6	35	S. E.	Strong	W.	Strong	W.	Strong	do	Clear	Clear	
Tuesday	Dec. 28	– 4	32	6	32	0	32	N. E.	Gentle	W.	Gentle	W.	do	Clear	Cloudy	Cloudy	
Wednesday	Dec. 29	–15	33	– 8	34	–12	32	W.	Strong	S. W.	Strong	W.	do	do	Clear	Clear	
Thursday	Dec. 30	– 5	33	7	35	– 2	35	N. W.	Fresh	W.	do	W.	Fresh	do	do	Cloudy	
Friday	Dec. 31	–10	34	6	35	2	36	W.	do	N. W.	do	N. W.	do	do	do	Clear	
Saturday	Jan. 1	– 2	34	16	37	11	38	W.	Gentle	S. W.	Gentle	S. W.	Gentle	do	do	do	
Sunday	Jan. 2	– 4	36	14	37	10	37	S.	do	S. W.	do	S. W.	do	do	do	do	
Monday	Jan. 3	16	38	28	38	24	38	W.	Fresh	W.	Fresh.	W.	do	Cloudy	do	Cloudy	
Tuesday	Jan. 4	20	37½	27	38	23	37½	W.	do	S. W.	do	S. W.	do	do	do	do	
Wednesday	Jan. 5	7	37½	21	38	26	38	S. W.	Gentle	S. E.	do	S. E.	do	Clear	Cloudy	do	
Thursday	Jan. 6	21	37	30	38	36	38	S. W.	do	S. W.	do	S. E.	Fresh	Cloudy	do	do	
Friday	Jan. 7	16	37	24	37	15	36	S. E.	do	S. E.	Gentle	S. E.	Gentle	do	do	do	
Saturday	Jan. 8	–11	34	16	36	4	36	N. E.	Fresh	N. E.	Fresh	N. E.	do	Clear	Clear	Clear	
Sunday	Jan. 9	12	35	20	36	18	37	N. E.	Gentle	N. E.	do	N. E.	do	Cloudy	Cloudy	Cloudy	
Monday	Jan. 10	4	35	16	37	4	37	N. W.	do	N. W.	Light	N. W.		Clear	Clear	Clear	
Tuesday	Jan. 11	–12	34½	25	36	2	36	N. W.	do	E.	Gentle	N. W.		do	Cloudy	do	
Wednesday	Jan. 12	2	35	30	36	26	37	N. W.	do	N. E.	do	N. E.		Cloudy	do	Cloudy	
Thursday	Jan. 13	32	37	29	36	12	36	S. W.	do	S. E.	do	S. W.		do	do	do	
Friday	Jan. 14	– 9	32	2	33½	– 7	34	W.	do	S. W.	Fresh.	W.		Clear	Clear	Clear	
Saturday	Jan. 15	9	34	20	36	12	35	S. W.	do	S. W.	Gentle	S. W.		Lt. clouds	Lt. clouds.	Lt. clouds.	
Sunday	Jan. 16	12	36	24	36	22	36	S. W.	do	S. W.	do	S. W.		Cloudy	Cloudy	Cloudy	
Monday	Jan. 17	6	35	19	37	– 4	36	N. W.	do	N. W.	do	N. W.		Clear	Clear	Clear	
Tuesday	Jan. 18	3	35	10	35	4	35	S. E.	do	S. E.	Fresh	S. E.		Cloudy	Cloudy	do	
Wednesday	Jan. 19	–12	35½	26	37	10	36½	S. E.	do	S. W.	Gentle	S. W.		Clear	Clear	do	
Thursday	Jan. 20	6	36	14	37	20	37	N. E.	do	S. E.	do	S. E.		Cloudy	Cloudy	Cloudy	
Friday	Jan. 21	26	37	27	37	20	37	N. W.	Strong	N. W.	Strong	N. W.		do	do	do	
Saturday	Jan. 22.	26	37	40	38	32	38	S. W.	Gentle	S. W.	Gentle	W.		do	do	do	
Sunday	Jan. 23	20	37	29	38	22	38	N. E.	do	N. E	do	N.		Clear	do	do	
Monday	Jan. 24	16	37	26	38	21	38	N. E.	do	N. E.	do	N.		Cloudy	do	do	
Tuesday	Jan. 25	14	37	20	37½	16	37	N. W.	do	S. W.	do	W.		do	do	do	

Record of temperature observations made at Northville, Mich., &c.—Continued.

Date.		Temperature of—						Wind.						Condition of—			
Day of week.	Day of month.	Air, 8 a. m.	Water, 8 a. m.	Air, 1 p. m.	Water, 1 p. m.	Air, 5 p. m.	Water, 5 p. m.	Direction, 8 a. m.	Intensity, 8 a. m.	Direction, 1 p. m.	Intensity, 1 p. m.	Direction, 5 p. m.	Intensity, 5 p. m.	Sky, 8 a. m.	Sky, 1 p. m.	Sky, 5 p. m.	Water.
		°F.	°F.	°F.	°F.	°F.	°F.										
Wednesday	Jan. 26	12	34½	16	34½	10	34	W.	Strong	W.	Strong	W.		Cloudy	Cloudy	Cloudy	
Thursday	Jan. 27	6	34½	6	35½	8	36½	N. W.	Gentle	W.	Fresh	W.		do	do	Clear	
Friday	Jan. 28	−6	34	16	36	10	36½	S. W.	do	S. W.	do	S. W.		Clear	Clear	do	
Saturday	Jan. 29	14	37	21	37	19	26½	W.	do	S. W.	Gentle	S. W.		Cloudy	Cloudy	Cloudy	
Sunday	Jan. 30	34	37½	34	38	30	38	S.	do	S.	do	S.		do	do	do	
Monday	Jan. 31	17	37	20	37½	12	36½	E.	do	E.	do	E.		do	do	do	
Tuesday	Feb. 1	6	31¾	10	32	2	32½	N. E.	Strong	N. E.	Strong	N. E.		do	do	Clear	
Wednesday	Feb. 2	−24	33¾	6	35	− 2	35	N. E.	do	N. E.	Fresh	S. E.		Clear	Clear	do	
Thursday	Feb. 3	−10	35	7	36	6	36	N.	Gentle	N. W.	Gentle	N. W.		do	do	do	
Friday	Feb. 4	0	34½	22	36½	8	36½	N.	do	N. W.	do	N. W.		Cloudy	Cloudy	do	
Saturday	Feb. 5	−16	34½	17	36¼	2	36	W.	do	N. W.	do	N. W.		Clear	Clear	do	
Sunday	Feb. 6	4	35	26	36¼	16	35½	S. E.	do	S. E.	do	S. E.		do	do	do	
Monday	Feb. 7	16	36	40	35½	38	35	S. E.	do	S.	do	S.		Cloudy	do	Cloudy	
Tuesday	Feb. 8	35	36	37	36	36	32	S.	do	S.	do	S.		do	Cloudy	do	
Wednesday	Feb. 9	38	33	40	35	40	36	S.	do	S.	do	S.		do	do	do	
Thursday	Feb. 10	35	36	33	35	40	36	W.	Fresh	W.	Fresh	W.		do	do	do	
Friday	Feb. 11	30	35¾	36	37	32	37½	W.	Gentle	S. W.	Gentle	S. W.		do	do	do	
Saturday	Feb. 12	32	37	34	36	26	36	S. W.	do	S. W.	do	S. W.		do	do	do	
Sunday	Feb. 13	16	35	18	35	19	35	N. W.	Fresh	N. W.	Fresh	N. W.		do	do	do	
Monday	Feb. 14	2	34	16	37	14	38	N. W.	Gentle	N. W.	Gentle	N. W.	Gentle	Clear	Clear	Clear	
Tuesday	Feb. 15	12	36	31	36½	24	36	N. E.	do	N. E.	do	S. E.	do	Lt. clouds	Cloudy	Cloudy	
Wednesday	Feb. 16	20	36	22	37	22	37	W.	Strong	W.	Strong	W.	Strong	Cloudy	do	do	
Thursday	Feb. 17	8	34½	26	35	22	35	W.	Gentle	W.	Gentle	W.	Gentle	Clear	Clear	Clear	
Friday	Feb. 18	26	35	36	35	32	36	E.	do	E.	do	N. W.	do	Cloudy	Cloudy	Cloudy	
Saturday	Feb. 19	14	36	36	38	15	38	N. W.	do	N. W.	do	N. W.	do	Clear	Clear	Clear	
Sunday	Feb. 20	0	37	36	38	18	38	N. W.	do	N. W.	do	N. W.	do	do	do	do	
Monday	Feb. 21	26	38	31	38	24	39	W.	do	W.	do	W.	do	Cloudy	do	do	
Tuesday	Feb. 22	27	26	38	39	36	38	S. W.	Fresh	S. W.	Fresh	S. W.	Fresh	Clear	do	do	
Wednesday	Feb. 23	2	40	10	37	11	38	W.	do	W.	do	W.	do	do	do	Cloudy	
Thursday	Feb. 24	2	37	24	37	16	37	W.	Gentle	N. W.	Gentle	N. W.	Gentle	do	Cloudy	do	
Friday	Feb. 25	− 5	37½	20	37½	10	38	W.	do	N. W.	do	N. W.	do	do	do	do	
Saturday	Feb. 26	3	37	40	38	37	38	S. W.	Fresh	S.	do	S.	do	do	Clear	do	
Sunday	Feb. 27	40	37	43	38	42	39	S.	Gentle	S.	do	S.	do	Cloudy	Rain	Rain	
Monday	Feb. 28	20	42	26	39	18	38	W.	Fresh	W.	Fresh	W.	Fresh	do	Cloudy	Cloudy	

Tuesday	Mar. 1	− 8	38	18	37	10	37	S. W.	Gentle	W.	Gentle	W.	do	do	do	Clear	....
Wednesday	Mar. 2	12	33	30	36	25	38	S. E.	do	S. E.	do	S. E.	do	Clear	Clear	do	....
Thursday	Mar. 3	10	37	28	37	24	39	S.	Fresh	S.	do	S. E.	do	do	do	Cloudy	....
Friday	Mar. 4	14	36	34	39	30	40	S. W.	Gentle	S. W.	do	S. W.	Gentle	Cloudy	Cloudy	do	....
Saturday	Mar. 5	18	38	38	40	31	41	N. E.	do	N. E.	do	N. E.	do	Clear	Clear	Clear	....
Sunday	Mar. 6	8	41	31	42	36	42	S. E.	Fresh	S. E.	Fresh	S.	Fresh	Cloudy	Cloudy	Cloudy	....
Monday	Mar. 7	18	41	42	45	40	43	W.	Gentle	W.	do	W.	Gentle	Clear	Clear	Clear	....
Tuesday	Mar. 8	28	39½	38	45	40	44	E.	do	E.	Gentle	N. E.	do	Cloudy	do	do	....
Wednesday	Mar. 9	32	44	44	49	38	48	N.	do	N. W.	do	N. E.	do	Clear	do	do	....
Thursday	Mar. 10	31½	42	38	47	44	46	E.	do	N. E.	do	N. E.	Fresh	Cloudy	Cloudy	Cloudy	....
Friday	Mar. 11	18	45	29	45	32	45	N. E.	do	N. E.	do	N. E.	Gentle	Clear	Clear	do	....
Saturday	Mar. 12	20	39	28	40	34	40	S. E.	Strong	S. E.	Fresh	W.	Fresh	do	do	do	...
Sunday	Mar. 13	18	38	33	39	30	39	N. W.	Fresh	S. W.	Gentle	S. W.	Gentle	Cloudy	Cloudy	do	....
Monday	Mar. 14	33	40½	36	45	39	49	S. W.	do	W.	Fresh	W.	Fresh	Clear	do	do	....
Tuesday	Mar. 15	35	40	38	44	37	43	W.	Gentle	W.	Gentle	W.	Gentle	Cloudy	do	do	....
Wednesday	Mar. 16	29	39½	35	45	34	44	S. W.	do	S. W.	do	S. W.	do	do	do	Clear	....
Thursday	Mar. 17	32	40	40	44	38	42	S.	do	S.	do	S.	do	Clear	do	do	....
Friday	Mar. 18	40	41	44	46	42	44	S. W.	Fresh	S. W.	Fresh	S. W.	Fresh	do	do	do	....
Saturday	Mar. 19	45	41½	47	45	38	42	N. E.	Gentle	N. E.	Gentle	N. E.	Gentle	do	do	do	....
Sunday	Mar. 20	40	41	48	42	42	42	S.	do	S.	do	S.	do	do	do	do	....
Monday	Mar. 21	30	41	33	42	32	42	S.	do	S.	do	S.	do	Cloudy	Clear	do	....
Tuesday	Mar. 22	28	40	36	41	34	41	W.	do	W.	do	W.	do	Clear	do	do	....
Wednesday	Mar. 23	26	39	36	44	34	44	W.	do	W.	do	W.	do	do	do	do	....
Thursday	Mar. 24	33	42	40	48	37	47	S. W.	do	S. W.	Fresh	S. W.	Fresh	do	do	do	....
Friday	Mar. 25	28	44	40	50	36	46	S. W.	do	S. W.	Gentle	S. W.	Gentle	Cloudy	Cloudy	Cloudy	....
Saturday	Mar. 26	26	42	30	46	32	47	S.	do	S.	do	S.	do	Clear	Clear	Clear	....
Sunday	Mar. 27	20	38½	33	43	36	47	N. W.	Strong	N. W.	Strong	N. W.	Strong	do	do	do	....
Monday	Mar. 28	30	41	42	44	40	48	N.	do	N.	do	N.	do	do	do	Cloudy	....
Tuesday	Mar. 29	30	40	31	42	28	41	N.	Gentle	N. W.	Gentle	N. W.	Gentle	Cloudy	Cloudy	do	....
Wednesday	Mar. 30	24	37	26	37	28	38	N.	Fresh	N.	Fresh	N.	Fresh	do	do	do	....
Thursday	Mar. 31	30	38	38	40	36	40	W.	do	W.	do	W.	do	Clear	do	do	....

* Spring water; always clear.

INDEX

XXI.—REPORT OF OPERATIONS AT THE UNITED STATES SALMON-HATCHING STATION ON THE M'CLOUD RIVER, CALIFORNIA, DURING THE SEASON OF 1880.

By LIVINGSTON STONE.

CHARLESTOWN, N. H., *December* 31, 1880.

Prof. SPENCER F. BAIRD,
United States Commissioner:

SIR: I beg leave to report as follows: I reached the McCloud River this year on the 22d of June and found everything at the salmon fishery in as good condition as could be expected after eight months exposure to the heat and cold, rains, snows, and droughts of a California mountain climate. The country looked beautifully, owing to the late spring rains. The McCloud River was still 18 inches above the usual summer level, and the water was unusually cold for the season, being only 53° against 57° of last year at the same time.

The salmon were more abundant than ever, the river seeming to be full of them. As an illustration of their abundance I mention the fact that on the 21st of July, before the rack or any obstruction had been put in the river, we caught 150 salmon at one haul of a very small net.

The piers of the last year's bridge remained in position in the river, though in a somewhat damaged condition. The current wheel and the flat-boats on which it rests had been drawn inshore during the high water by Mr. James A. Richardson, who had charge of the salmon-hatching station through the winter. The wheel and boats had sustained very little damage.

Our first labors this season consisted in doing the necessary white-washing and painting, in caulking and pitching the flat-boats, and in putting the wheel in thorough repair. We next proceeded to build the usual rack and bridge across the McCloud River. My instructions being to take five or six million salmon this year, I did not hurry to get the bridge in as early as usual. For the last two or three years the river has been bridged by the 4th of July. This year I did not close up the river to the salmon till the 1st of August.

Another change in regard to the bridge and rack this year consisted in using stakes split out from old-growth fir instead of the small round pine poles used hitherto. Poles are getting so scarce now in the vicinity of the fishery that we have had to go several miles for them the last two or three years, which was of course a great disadvantage. Being saplings, also, the poles became weak and very brittle after one season's use, and could not be relied upon to do service more than one year, which was, of course, another disadvantage. By making the rack of fir stakes cut from old-growth trees we hope not only to save expense, but to make the rack wear a year or two longer than the former racks have done.

I cannot speak in too high terms of the character of the work which some of the Indians do for us. There are now nearly a dozen of them who have been with me, more or less, since I came to the McCloud River, who are splendid workers. They are faithful, steady, industrious, and very intelligent. During my first year here I gave all the Indians the same pay; now I discriminate between the best workers and the others, and give the higher class 25 or 50 cents a day more than the rest. This little addition to their pay, or probably the distinction which it implies, affects them perceptibly, and it becomes quite conspicuously a matter of pride with them to make their work correspond with their increased pay.

After the closing of the river to the ascending salmon was made secure beyond a doubt, we turned our attention more particularly to the special preparations for catching the salmon and putting everything about the place in satisfactory shape. The California climate is such that a great deal of whitewashing and painting, and that very often, is necessary to keep a place of this sort looking as it ought to. Then there are the necessary repairs incident upon keeping up a half a dozen buildings and the thousand and one things to be done to put flumes, hatching-troughs, trays, filtering tanks, &c., in order. Besides doing all these things we built a wagon road to the garden and another from the house to the stage road. The corrals were put in the river at the fishing ground, and the spawning-house built with its apparatus for taking salmon eggs. We also did a good deal of hard work on the river trail opposite the house. This narrow trail, which in the Eastern States, would be called a bridle-path, extends along a rough, rocky, and precipitous hillside for fifty rods or so, and was positively unsafe. I myself have seen a horse and rider fall headlong over the cliff just opposite our front door. The horse fell fifty feet down to the water's edge and was killed. The rider fell about 20 feet and was saved by being caught against a tree.

By some hard digging and by the free use of giant powder we converted the trail into a safe and easy path.

On the 20th of August we found the first ripe female salmon. To save the trouble of taking small lots at a time, I postponed the taking of eggs until a sufficient number of spawning salmon appeared to authorize the beginning of steady work. This occurred on Monday, August 30, when we began the season's regular fishing for spawning fish. We did not begin to take eggs, however, until the next day, when we inaugurated the spawning season by placing 130,000 salmon eggs in the hatching-house. From this time the taking of eggs proceeded with unusual steadiness until the night of the 14th of September, when we had taken 6,000,000 eggs, which was all that we wanted for the large hatching-house.

The men having worked for over two weeks, Sundays and all, we took a holiday on Thursday, September 16, which was passed in rifle-shooting, ball-playing, boating matches, and the like. On the morning of September 17 we began fishing again for the small hatching-house, but did not fish long, for we caught 167 spawning females at the first haul, and this being all that we wanted to keep in the corral through the day, we quit fishing until evening. In the evening we caught 108 more, and took a quarter of a million eggs. The next day we alternately fished and took spawn all day, taking three-quarters of a million eggs, which made one million in all for the supplementary hatching-house, which, being all that were needed for that house and making seven millions eggs in all as this year's harvest, we hung up our net and stopped fishing and taking eggs for this season.

I depended entirely this year upon horses for pulling in the lower rope of the seine, and have no hesitation in recommending their use for this work. After the season's regular fishing begins it requires nine men to pull in the lower rope properly, and even with this force it does not come in always as steadily or as quickly as it ought to. With two horses only two men are needed at this rope, so that the expense of employing seven men is saved, against which you have only to offset the use of two horses.

From this time till we began to pack eggs for distribution to their various destinations the time was taken up in making packing-boxes and crates, in washing and picking over the moss used for packing, in gathering ferns, and in attending to the maturing of the eggs. One other thing we did during this time which must not be forgotten. This was putting up the telephone, a memorable event in this unsettled Indian country. The telephone material arrived Tuesday evening, September 28, and the next evening we were talking between headquarters and the post-office building. The Indians were in great glee over it, and were soon talking to each other over the wires. They have been in the habit of calling our hydraulic ram "mame debbil" (water devil) They call the telephone "teen klesch" (talking spirit).

On Friday, October 1, we packed and crated 2,200,000 eggs, on Saturday 800,000, and on Sunday morning 800,000 more, making 3,800,000 in all, occupying 76 packing-boxes and 38 crates. These were taken in wagons to Redding, Cal., where our stage road connects with the California Pacific Railroad, and where I had a car waiting for them with several tons of ice. The crates of eggs having been safely stored away in the car and the ice chambers filled with ice, the balance of the ice was placed on the tops of the crates, and the car shackled on the train which left Redding for Sacramento and the East early Monday morning, October 4. I accompanied the car to Chicago, where I turned over the car and eggs in good order to Mr. Ellis and other representatives of the United States Fish Commission who were there to receive them.

Below will be found the following tables, viz:

I. Table showing the temperature of air and water at the McCloud River station during the season of 1880.

II. Table showing the number of fish, &c., caught at each haul of the seine during the season of 1880.

III. Table showing the daily number of salmon eggs taken.

IV. Table showing the distribution of the eggs.

V. Table showing the actual planting of young California salmon hatched from eggs taken in 1878.

TABLE I.—*Table of temperatures taken at the United States salmon-breeding station, McCloud River, California, during the season of* 1880.

Month.	Air.				Water.			Forest temperature.	Wind.	Weather.
	Shade.			Sun.						
	7 a.m.	3 p.m.	7 p.m.	3 p.m.	7 a.m.	3 p.m.	7 p.m.		3 p.m.	
	°	°	°	°	°	°	°	°		
June 1	......	......	......	......	......	......	......	......	......	
June 2	......	......	......	......	......	......	......	......	......	
June 3	......	......	......	......	......	......	......	......	......	
June 4	......	......	......	......	......	......	......	......	......	
June 5	......	......	......	......	......	......	......	......	......	
June 6	......	......	......	......	......	......	......	......	......	
June 7	......	......	......	......	......	......	......	......	......	
June 8	......	......	......	......	......	......	......	......	......	
June 9	......	......	......	......	......	......	......	......	......	
June 10	......	......	......	......	......	......	......	......	......	
June 11	......	......	......	......	......	......	......	......	......	
June 12	......	......	......	......	......	......	......	......	......	
June 13	......	......	......	......	......	......	......	......	......	
June 14	......	......	......	......	......	......	......	......	......	
June 15	......	......	......	......	......	......	......	......	......	
June 16	......	......	......	......	......	......	......	......	......	
June 17	......	......	......	......	......	......	......	......	......	
June 18	......	......	......	......	......	......	......	......	......	
June 19	......	......	......	......	......	......	......	......	......	
June 20	......	......	......	......	......	......	......	......	......	
June 21	......	......	......	......	......	......	......	......	......	
June 22	58	......	70	......	52	......	54	......	......	Clear.
June 23	58	90	......	112	52	53	......	......	......	Do.
June 24	57	87	70	112	54	54	56	......	......	Do.
June 25	58	88	70	114	53	54	56	......	......	Do.
June 26	62	94	76	116	54	55	56	......	......	Do.
June 27	64	95	......	118	54	56	......	......	......	Do.
June 28	62	90	72	115	54	54	56	......	......	Do.
June 29	54	92	71	116	54	53	56	......	......	Do.
June 30	56	96	79	119	54	56	56	......	......	Do.
July 1	......	96	79	122	......	56	56	......	......	Do.
July 2	......	98	75	122	......	56	56	......	......	Do.
July 3	63	100	77	124	54	57	56	......	......	Do.
July 4	69	94	79	120	54	56	57	......	......	Do.
July 5	56	94	75	118	55	57	57	......	......	Do.
July 6	58	93	75	114	54	58	57	......	......	Do.
July 7	58	93	79	118	55	58	58	......	......	Do.
July 8	......	91	76	117	......	58	58	......	......	Do.
July 9	62	93	......	116	55	57	......	......	......	Do.
July 10	......	81	......	116	......	56	......	......	......	Light clouds in p. m.
July 11	60	83	65	112	53	56	55	......	......	Clear.
July 12	65	94	72	116	53	50	56	......	......	Light clouds in a. m.
July 13	{7.30 70}	99	......	121	54	57	......	......	......	Clear.
July 14	......	104	......	126	......	58	......	......	......	150° in sun reflected heat.
July 15	......	107	......	132	......	58	......	......	......	Clear.
July 16	64	93	......	102	56	58	......	......	......	Decidedly cloudy nearly all day.
July 17	......	100	......	128	......	58	......	......	......	Clear.
July 18	......	97	......	122	......	59	......	......	......	Do.

TABLE I.—*Table of temperatures taken at the United States salmon-breeding station, &c.*—Continued.

Month.	Air.				Water.			Forest temperature.	Wind.	Weather.
	Shade.			Sun.						
	7 a.m.	3 p.m.	7 p.m.	3 p.m.	7 a.m.	3 p.m.	7 p.m.		3 p.m.	
	°	°	°	°	°	°	°	°		
July 10....	......	95	......	121	......	50	......	......	......	Do.
July 20....	......	93	57	119	......	58	57	......	......	Cloudy.
July 21....	......	99	58	122	......	58	58	......	......	Clear.
July 22....	62	103	59	123	56	59	59	......	......	Light rain at night.
July 23....	......	103	......	124	......	60	......	......	......	Clear.
July 24....	62	106	59	128	57	60	59	......	......	Do.
July 25....	62	105	59	123	58	60	59	......	......	Do.
July 26....	76	94	59	120	58	60	59	......	......	Do.
July 27....	60	93	......	110	56	58	......	......	......	Do.
July 28....	64	92	56	109	55	57	56	......	......	Do,
July 29....	......	96	57	119	......	58	57	......	......	Do.
July 30....	54	95	58	118	54	58	58	......	......	Do.
July 31....	56	92	......	112	56	59	......	......	......	Do.
Aug. 1....	55	92	74	110	56	59	57	......	W.	Do.
Aug. 2....	51	92	75	114	59	59	57	......	S.	Do.
Aug. 3....	51	92	78	115	55	58	57	......	W.	Do.
Aug. 4....	50	87	79	110	54	58	58	......	S.	Do.
Aug. 5....	50	87	75	109	54	57	56	......	S.	Do.
Aug. 6....	51	96	74	120	54	58	57	......	C.	Do.
Aug. 7....	55	98	76	118	54	58	58	......	S. W.	Do.
Aug. 8....	55	95	77	120	54	58	58	......	S.	Do,
Aug. 9....	57	95	78	115	54	59	57	......	W.	Do.
Aug. 10....	53	93	75	114	54	58	57	......	N.E.	Do.
Aug. 11....	54	90	75	112	54	58	56	......	S. E.	Do.
Aug. 12....	50	90	73	112	53	58	57	......	S.	Do.
Aug. 13....	45	93	72	116	52	57	57	......	W.	Do.
Aug. 14....	49	94	75	112	52	58	56	......	S.	Do.
Aug. 15....	54	96	80	117	52	58	57	......	S. W.	Do.
Aug. 16....	55	97	77	114	53	58	58	......	C.	Cloudy 5 p. m.
Aug. 17....	51	88	75	102	52	56	58	......	C.	Cloudy a. m.
Aug. 18....	49	93	71	112	52	57	57	......	S. W.	Do.
Aug. 19....	49	97	75	119	52	58	57	......	C.	Clear.
Aug. 20....	55	101	76	118	54	59	58	......	W.	Do.
Aug. 21....	54	97	75	117	53	58	57	......	C.	Do.
Aug. 22....	56	95	72	114	53	60	58	......	S. W.	Do.
Aug. 23....	54	86	74	104	53	58	57	......	S. W.	Do.
Aug. 24....	54	85	75	106	52	58	57	......	S.	Cloudy p. m.
Aug. 25....	50	85	56	105	50	56	55	......	N.	Clear.
Aug. 26....	60	90	72	107	51	56	55	......	C.	Do.
Aug. 27....	54	93	74	114	52	58	54	......	N.	Do.
Aug. 28....	50	79	75	96	52	55	55	......	C.	Cloudy a. m.
Aug. 29....	40	75	62	94	51	54	52	......	C.	Clear.
Aug. 30....	45	83	64	102	50	54	53	......	S.	Do.
Aug. 31....	46	84	64	100	50	54	54	......	W.	Do.
Sept. 1....	50	95	65	118	50	56	54	49	N.	Do.
Sept. 2....	50	90	69	120	50	56	55	50	N.	Do.
Sept. 3....	55	99	74	130	52	58	56	54	N.	Do.
Sept. 4....	52	100	72	120	52	58	57	52	N.	Do.
Sept. 5....	55	98	75	118	54	58	57	50	S.	Do.
Sept. 6....	48	97	72	116	53	58	56	46	N.	Do.
Sept. 7....	50	90	70	104	52	57	57	49	S.	Do.
Sept. 8....	46	94	67	106	52	57	56	45	E.	Do.
Sept. 9....	48	94	74	104	52	56	55	47	N.	Do.
Sept. 10....	50	97	73	112	52	57	56	49	C.	Do.
Sept. 11....	49	97	70	108	52	57	56	48	C.	Do.
Sept. 12....	46	93	72	99	52	57	55	45	S. E.	Cloudy.
Sept. 13....	48	88	66	98	52	57	56	47	S.E.	Clear.
Sept. 14....	50	91	68	108	53	56	55	49	N.E.	Do.
Sept. 15....	51	95	69	110	52	56	55	50	C.	Do.
Sept. 16....	50	89	65	99	52	56	56	49	S.E.	Cloudy.
Sept. 17....	45	81	63	96	52	56	56	44	C.	Do.
Sept. 18....	57	86	62	112	51	55	54	44	S.	Clear.
Sept. 19....	45	90	64	116	51	56	55	44	C.	Do.
Sept. 20....	44	85	64	100	50	54	54	43	E.	Do.
Sept. 21....	48	85	63	100	50	54	54	42	S.E.	Do.
Sept. 22....	46	78	62	93	50	54	54	44	C.	Cloudy.
Sept. 23....	39	76	58	100	48	58	52	57	S.	Clear.
Sept. 24....	54	78	58	110	49	58	52	53	N.	Do.
Sept. 25....	41	85	63	110	48	54	53	39	N.E.	Do.
Sept. 26....	41	88	62	114	48	58	52	40	C.	Do.
Sept. 27....	39	82	62	110	47	52	50	38	N.E.	Cloudy.
Sept. 28....	39	84	61	94	47	52	50	38	S.	Do.
Sept. 29....	42	75	61	......	47	52	50	49	C.	Do.
Sept. 30....	45	68	65	......	48	52	57	44	C.	Do.

TABLE II.—*Record of salmon-seining operations conducted at United States salmon-breeding establishment on the McCloud River, California, from July 2, 1880, to September 18, 1880, inclusive, on account of the United States Fish Commission, by Livingston Stone.*

Date.	Hour.	Temperature of—		Direction of wind.	Condition of sky.	Seine hauled (length).	Fish taken.		Ripe fish.	
		Air.	Water.				Males.	Females.	Males.	Females.
		°	°			Feet.				
July 2	4.30 p. m.	......	56	....	Clear	65	143	7	None.	None.
July 2	6.00 p. m.	......	55	....	do	65	8	......	None.	None.
July 6	4.00 p. m.	......	58	....	do	65	10	2	None.	None.
July 6	5.00 p. m.	......	57	....	do	65	2	......	None.	None.
July 6	6.00 p. m.	......	57	....	do	65	6	......	None.	None.
July 6	7.30 p. m.	......	57	....	do	65	46	4	None.	None.
July 8	3.00 p. m.	......	57	....	do	65	12	3	None.	None.
July 8	7.00 p. m.	......	57	....	do	65	20	3	None.	None.
July 9	5.30 a. m.	......	56	....	do	65	40	8	None.	None.
July 9	6.00 a. m.	......	56	....	do	65	3	......	None.	None.
July 9	7.00 a. m.	......	56	....	do	65	1	......	None.	None.
July 9	7.00 p. m.	......	56	....	do	65	20	3	None.	None.
July 10	7.00 a. m.	......	55	....	do	65	8	1	None.	None.
July 10	7.00 p. m.	......	56	....	do	65	40	8	None.	None.
July 12	7.00 p. m.	......	56	....	do	65	3	1	None.	None.
July 13	7.00 p. m.	......	56	....	do	65	20	8	None.	None.
July 14	7.00 p. m.	......	57	....	do	65	17	3	None.	None.
July 15	7.00 p. m.	......	57	....	do	150	40	6	None.	None.
July 15	7.30 p. m.	......	57	....	do	150	700	62	None.	None.
July 18	7.00 p. m.	......	58	....	do	150	70	8	None.	None.
July 18	7.30 p. m.	......	58	....	do	150	40	1	None	None.
July 23	7.00 p. m.	......	59	....	do	150	70	4	None.	None.
July 23	7.30 p. m.	......	58	....	do	150	100	2	None.	None.
July 26	6.00 p. m.	......	58	....	do	150	400	25	None.	None.
July 30	5.30 p. m.	......	57	....	do	150	18	2	None.	None.
July 31	7.00 p. m.	......	58	....	do	150	20	......	None.	None.
Aug. 1	7.30 p. m.	......	57	....	do	150	70	9	None.	None.
Aug. 2	7.00 p. m.	......	56	....	do	150	20	......	None.	None.
Aug. 3	7.30 p. m.	......	57	....	do	150	30	8	None.	None.
Aug. 4	7.00 p. m.	......	56	....	do	150	50	3	None.	None.
Aug. 4	7.30 p. m.	......	56	....	do	150	70	5	None.	None.
Aug. 5	7.00 p. m.	......	57	....	do	150	50	2	None.	None.
Aug. 5	7.30 p. m.	......	57	....	do	150	80	......	None.	None.
Aug. 9	7.30 p. m.	......	58	....	do	150	9	9	None.	None.
Aug. 28	7.25 p. m.	54	50	....	do	150	640	60	(*)	13
Aug. 28	8.30 p. m.	54	50	....	do	150	450	50	(*)	1
Aug. 28	9.30 p. m.	51	50	....	do	150	134	16	(*)	3
Aug. 28	10.10 p. m.	51	50	....	do	150	130	20	(*)	2
Aug. 28	11.00 p. m.	47	50	....	do	150	115	10	(*)	....
Aug. 28	11.45 p. m.	46	50	....	do	150	85	15	(*)	1
Aug. 30	5.30 p. m.	......	......	....	do	150	720	80	(*)	7
Aug. 30	6.30 p. m.	......	......	....	do	150	270	30	(*)	8
Aug. 30	7.15 p. m.	......	......	....	do	150	260	40	(*)	11
Aug. 30	8.00 p. m.	......	......	....	do	150	130	20	(*)	5
Aug. 30	8.45 p. m.	......	......	....	do	150	90	10	(*)	....
Aug. 30	9.45 p. m.	......	......	....	do	150	90	10	(*)	....
Aug. 31	4.00 a. m.	......	......	....	do	150	18	2	(†)	1
Aug. 31	4.45 a. m.	......	......	....	do	150	70	10	(†)	2
Aug. 31	5.45 a. m.	......	......	....	do	150	72	8	(†)	2
Aug. 31	6.15 a. m.	......	......	....	do	150	12	8	(†)	4
Aug. 31	7.00 a. m.	......	......	....	do	150	14	6	(†)	....
Aug. 31	8.15 a. m.	65	......	N.	do	150	13	2	(‡)	....
Aug. 31	8.45 a. m.	70	......	N.	do	150	10	2	(‡)	2
Aug. 31	10.15 a. m.	75	......	N.	do	150	52	5	(‡)	5
Aug. 31	5.30 p. m.	70	56	Calm.	do	150	374	22	(‡)	4
Aug. 31	7.30 p. m.	60	55	Calm.	do	150	10	....	(‡)	....
Aug. 31	8.00 p. m.	60	53	N.	do	150	125	25	(‡)	4
Aug. 31	8.45 p. m.	......	......	N.	do	150	65	10	(‡)	....
Aug. 31	9.45 p. m.	......	......	N.	do	150	50	10	(‡)	....
Sept. 1	5.00 a. m.	......	....	N.	do	150	267	33	(‡)	7
Sept. 1	5.45 a. m.	......	......	N.	do	150	185	15	(‡)	7
Sept. 1	6.30 a. m.	......	......	N.	do	150	54	6	(‡)	8
Sept. 1	8.15 a. m.	......	......	N.	do	150	28	2	(‡)	1
Sept. 1	5.30 p. m.	......	......	Calm.	do	150	267	33	(‡)	7
Sept. 1	6.00 p. m.	......	......	Calm.	do	150	236	10	(‡)	4
Sept. 1	6.30 p. m.	......	......	Calm.	do	150	283	17	(‡)	9
Sept. 1	7.00 p. m.	......	......	Calm.	do	150	324	16	(‡)	12
Sept. 1	8.30 p. m.	......	......	Calm.	do	150	266	9	(‡)	7
Sept. 1	9.00 p. m.	......	......	Calm.	do	150	144	6	(‡)	4
Sept. 1	9.50 p. m.	......	......	Calm.	do	150	39	9	(‡)	6
Sept. 2	4.45 a. m.	......	......	N.	do	150	270	30	(‡)	7
Sept. 2	5.30 a. m.	......	......	N.	do	150	230	20	(‡)	7

* A few ripe males. † Ripe males more numerous.
‡ Not counted, but usually much more numerous than the females.

TABLE II.—*Record of salmon-seining operations, &c.*—Continued

Date.	Hour.	Temperature of—		Direction of wind.	Condition of sky.	Seine hauled (length).	Fish taken.		Ripe fish.	
		Air.	Water.				Males.	Females.	Males.	Females.
		°	°			*Feet.*				
Sept. 2	6.00 a. m.			N.	Clear	150	225	25	(*)	6
Sept. 2	6.30 a. m.			N.	....do	150	230	20	(*)	7
Sept. 2	7.30 a. m.			N.	....do	150	85	15	(*)	1
Sept. 2	9.00 a. m.			N.	....do	150	275	25	(*)	5
Sept. 2	6.00 p. m.			C.	....do	150	139	11	(*)	4
Sept. 2	6.15 p. m.			C.	....do	150	110	18	(*)	2
Sept. 2	6.30 p. m.			C.	....do	150	116	7	(*)	2
Sept. 2	7.30 p. m.			C.	....do	150	244	31	(*)	11
Sept. 2	8.15 p. m.			C.	....do	150	183	17	(*)	2
Sept. 2	8.45 p. m.			C.	....do	150	112	18	(*)	3
Sept. 2	9.15 p. m.			C.	....do	150	90	10	(*)	1
Sept. 3	4.45 a. m.			N.	....do	150	185	15	(*)	5
Sept. 3	5.20 a. m.			N.	....do	150	350	50	(*)	21
Sept. 3	5.45 a. m.			N.	....do	150	180	20	(*)	6
Sept. 3	6.30 a. m.			N.	....do	150	180	20	(*)	4
Sept. 3	8.00 a. m.			N.	....do	150	178	20	(*)	7
Sept. 3	9.35 a. m.			N.	....do	150	264	25	(*)	11
Sept. 3	9.50 a. m.			Calm.	....do	150	48	5	(*)	2
Sept. 3	5.30 p. m.			Calm.	....do	150	53	7	(*)	4
Sept. 3	6.00 p. m.			Calm.	....do	150	12	8	(*)	3
Sept. 3	6.30 p. m.			Calm.	....do	150	30	5		
Sept. 3	7.00 p. m.			Calm.	....do	150	26	10	(*)	4
Sept. 3	7.30 p. m.			Calm.	....do	150	210	40	(*)	9
Sept. 3	8.00 p. m.			Calm.	....do	150	180	25	(†)	5
Sept. 3	9.15 p. m.			Calm.	....do	150	123	20	(†)	7
Sept. 3	10.00 p. m.			Calm.	....do	150	100	8	(†)	2
Sept. 4	5.20 a. m.			Calm.	....do	150	163	37	(†)	12
Sept. 4	6.00 a. m.			Calm.	....do	150	123	27	(†)	7
Sept. 4	6.30 a. m.			Calm.	....do	150	166	32	(†)	7
Sept. 4	7.00 a. m.			Calm.	....do	150	11	7	(†)	2
Sept. 4	9.30 a. m.			N.	....do	150	19	8	(†)	3
Sept. 4	5.45 p. m.	78	58	C.	....do	150	180	20	(†)	11
Sept. 4	6.15 p. m.	69	58	C.	....do	150	350	50	(†)	12
Sept. 4	7.00 p. m.	68	58	C.	....do	150	350	50	(†)	17
Sept. 4	8.45 p. m.	65	58	C.	....do	150	170	25	(†)	5
Sept. 4	9.15 p. m.	64	58	C.	....do	150	230	15	(†)	5
Sept. 5	4.45 a. m.	52	52	C.	....do	150	175	20	(†)	5
Sept. 5	5.10 a. m.	52	52	C.	....do	150	107	30	(†)	13
Sept. 5	5.35 a. m.	52	52	C.	....do	150	122	35	(†)	10
Sept. 5	7.00 a. m.	52	52	C.	....do	150	258	42	(†)	17
Sept. 5	7.15 a. m.	67	52	C.	....do	150	200	50	(†)	19
Sept. 5	9.45 a. m.	87	55	C.	....do	150	20			
Sept. 5	10.10 a. m.	87	55	N.	....do	150	180	20	(†)	1
Sept. 5	5.30 p. m.	83	58	N.	....do	150	350	50	(†)	11
Sept. 5	6.00 p. m.	80	58	N.	....do	150	175	25	(†)	5
Sept. 5	6.30 p. m.	73	57	N.	....do	150	86	3	(†)	1
Sept. 5	7.00 p. m.	69	57	N.	....do	150	229	50	(†)	19
Sept. 5	9.00 p. m.	68	56	N.	....do	150	222	25	(†)	8
Sept. 5	9.30 p. m.	67	56	N.	....do	150	181	8	(†)	4
Sept. 6	4.45 a. m.	52	56	N.	....do	150	181	44	(†)	14
Sept. 6	5.10 a. m.	52		N.	....do	150	86	14	(†)	4
Sept. 6	5.30 a. m.	50		N.	....do	150	96	52	(†)	12
Sept. 6	6.30 a. m.	51		N.	....do	150	84	5	(†)	1
Sept. 6	7.00 a. m.	61	54	N.	....do	150	180	10	(†)	10
Sept. 6	9.00 a. m.	74	58	C.	....do	150	76	25	(†)	10
Sept. 6	10.00 a. m.	77	60	C.	....do	150	95	30	(†)	12
Sept. 6	5.45 p. m.	78	57	C.	....do	150	630	70	(†)	38
Sept. 6	6.15 p. m.	66		C.	....do	150	430	70	(†)	20
Sept. 6	8.10 p. m.	64	56	C.	....do	150	318	82	(†)	21
Sept. 6	9.00 p. m.	62	56	C.	....do	150	293	7	(†)	5
Sept. 7	4.30 a. m.	55	52	N.	....do	150	360	40	(†)	12
Sept. 7	5.15 a. m.	53	52	N.	....do	150	200	40	(†)	16
Sept. 7	5.45 a. m.	53	54	N.	....do	150	215	35	(†)	16
Sept. 7	6.15 a. m.	53	54	N.	....do	150	175	25	(†)	10
Sept. 7	7.45 a. m.	54	55	N.	....do	150	150	50	(†)	21
Sept. 7	9.35 a. m.	81	55	N.	....do	150	133	17	(†)	8
Sept. 7	10.15 a. m.	85	56	N.	....do	150	117	23	(†)	11
Sept. 7	5.40 p. m.	76	58	N.	....do	150	367	33	(†)	13
Sept. 7	6.00 p. m.	65	58	C.	....do	150	250	50	(†)	19
Sept. 7	6.30 p. m.	65	58	C.	....do	150	260	40	(†)	15
Sept. 7	7.30 p. m.	64	58	C.	....do	150	260	40	(†)	12
Sept. 7	8.00 p. m.	64	58	C.	....do	150	175	25	(†)	6
Sept. 7	9.00 p. m.	62	58	C.	....do	150	180	20	(†)	7

* Not counted but usually much more numerous than the females.
† Not counted, but numerous.

TABLE II.—*Record of salmon-seining operations*—Continued.

Date.	Hour.	Temperature of— Air.	Temperature of— Water.	Direction of wind.	Condition of sky.	Seine hauled (length).	Fish taken. Males.	Fish taken. Females.	Ripe fish. Males.	Ripe fish. Females.
		°	°			*Feet.*				
Sept. 8	4.00 a. m.	48	58	C.	Clear	150	175	28	(*)	14
Sept. 8	4.30 a. m.	48	54	C.	...do	150	265	35	(*)	26
Sept. 8	5.25 a. m.	48	54	C.	...do	150	180	20	(*)	12
Sept. 8	6.00 a. m.	48	54	C.	...do	180	88	12	(*)	5
Sept. 8	8.30 a. m.	58	54	C.	...do	150	80	20	(*)	9
Sept. 8	9.40 a. m.	80	54	C.	...do	150	160	15	(*)	8
Sept. 8	10.30 a. m.	80	56	C.	...do	150	188	12	(*)	5
Sept. 8	5.50 p. m.	70	56	C.	...do	150	380	20	(*)	12
Sept. 8	6.05 p. m.	62	56	C.	...do	150	110	15	(*)	6
Sept. 8	6.50 p. m.	58	56	C.	...do	150	128	12	(*)	5
Sept. 8	7.30 p. m.	56	56	C.	...do	150	130	20	(*)	10
Sept. 8	8.50 p. m.	56	54	C.	...do	150	165	15	(*)	7
Sept. 8	9.30 p. m.	54	54	C.	...do	150	88	12	(*)	6
Sept. 9	4.30 a. m.	53	54	N. E.	...do	150	160	40	(*)	7
Sept. 9	5.15 a. m.	53	54	N. E.	...do	150	160	40	(*)	14
Sept. 9	6.00 a. m.	53	54	N. E.	...do	160	35	15	(*)	5
Sept. 9	6.30 a. m.	53	54	N. E.	...do	150	340	60	(*)	30
Sept. 9	8.00 a. m.	74	54	C.	...do	150	250	50	(*)	13
Sept. 9	8.30 a. m.	76	54	C.	...do	150	250	50	(*)	15
Sept. 9	10.15 a. m.	85	55	N. E.	...do	150	350	50	(*)	16
Sept. 9	11.00 a. m.	90	55	N. E.	...do	150	55	5	(*)	2
Sept. 9	5.50 p. m.	78	56	C.	...do	150	270	30	(*)	15
Sept. 9	6.10 p. m.	65	56	C.	...do	150	270	30	(*)	11
Sept. 9	6.25 p. m.	65	56	C.	...do	150	50	10	(*)	2
Sept. 9	7.15 p. m.	65	56	C.	...do	150	50	10	(*)	2
Sept. 9	8.15 p. m.	60	56	C.	...do	150	80	20	(*)	8
Sept. 9	9.00 p. m.	60	56	C.	...do	150	60	15	(*)	7
Sept. 9	9.35 p. m.	60	56	C.	...do	150	125	25	(*)	6
Sept. 10	5.15 a. m.	48	52	N.	...do	150	230	20	(*)	8
Sept. 10	5.55 a. m.	48	52	N.	...do	150	175	25	(*)	12
Sept. 10	6.25 a. m.	50	52	C.	...do	150	113	12	(*)	6
Sept. 10	6.55 a. m.	50	52	C.	...do	150	12	3	(*)	1
Sept. 10	8.50 a. m.	66	52	C.	...do	150	270	30	(*)	24
Sept. 10	9.10 a. m.	66	54	N.	...do	150	135	15	(*)	7
Sept 10	11.05 a. m.	84	54	N.	...do	150	180	20	(*)	11
Sept. 10	11.25 a. m.	84	56	N.	...do	150	150	25	(*)	18
Sept. 10	5.30 p. m.	77	56	C.	...do	150	250	50	(*)	10
Sept. 10	6.00 p. m.	77	56	C.	...do	150	220	30	(*)	9
Sept. 10	6.40 p. m.	70	56	C.	...do	150	125	25	(*)	6
Sept. 10	7.00 p. m.	64	56	C.	...do	150	125	25	(*)	8
Sept. 10	7.35 p. m.	64	56	C.	...do	150	140	10	(*)	5
Sept. 10	8.10 p. m.	64	56	C.	...do	150	95	5	(*)	8
Sept. 10	9.00 p. m.	58	56	C.	...do	150	69	6	(*)	8
Sept. 10	9.45 p. m.	56	54	C.	...do	150	90	10	(*)	6
Sept. 10	10.10 p. m.	56	54	C.	...do	150	45	5	(*)	2
Sept. 10	11.30 p. m.	54	54	C.	...do	150	22	8	(*)	1
Sept. 11	8.30 a. m.	76	54	N.	...do	150	450	50	(*)	40
Sept. 11	8.55 a. m.	76	54	N.	...do	150	138	12	(*)	7
Sept. 11	9.45 a. m.	79	54	N.	...do	150	135	15	(*)	8
Sept. 11	11.00 a. m.	86	56	N.	...do	150	117	8	(*)	4
Sept. 11	5.55 p. m.	76	56	N.	...do	150	175	25	(*)	18
Sept. 11	6.15 p. m.	76	56	N.	...do	150	70	5	(*)	8
Sept. 11	7.00 p. m.	62	56	C.	...do	150	85	15	(*)	10
Sept. 11	8.00 p. m.	60	56	C.	...do	150	80	20	(*)	11
Sept. 11	8.45 p. m.	60	56	C.	...do	150	80	20	(*)	7
Sept. 12	6.20 a. m.	48	52	C.	...do	150	215	35	(*)	28
Sept. 12	6.45 a. m.	48	52	C.	...do	150	175	15	(*)	9
Sept. 12	8.35 a. m.	64	53	C.	...do	150	355	45	(*)	39
Sept. 12	10.25 a. m.	82	53	C.	...do	150	270	30	(*)	28
Sept. 12	5.45 p. m.	80	54	W.	...do	150	180	20	(*)	12
Sept. 12	6.05 p. m.	76	54	W.	...do	150	140	10	(*)	5
Sept, 12	6.45 p. m.	64	54	W.	...do	150	90	10	(*)	6
Sept. 12	7.15 p. m.	64	54	C.	...do	150	100	50	(*)	22
Sept. 12	8.40 p. m.	62	54	C.	...do	150	96	12	(*)	8
Sept. 12	9.10 p. m.	60	54	C.	...do	150	85	15	(*)	9
Sept. 13	6.00 a. m.	50	52	N.	...do	150	265	35	(*)	28
Sept. 13	6.40 a. m.	50	52	N.	...do	150	450	50	(*)	46
Sept. 13	8.30 a. m.	58	52	C.	...do	150	270	30	(*)	27
Sept. 13	10.20 a. m.	78	54	C.	...do	150	185	15	(*)	10
Sept. 13	11.00 a. m.	78	54	C.	...do	150	85	15	(*)	12
Sept. 13	6.05 p. m.	72	54	C.	...do	150	135	15	(*)	12
Sept. 13	6.40 p. m.	60	54	C.	...do	150	88	12	(*)	9
Sept. 13	7.30 p. m.	58	54	C.	...do	150	170	30	(*)	25
Sept. 13	9.15 p. m.	58	54	C.	...do	150	550	50	(*)	34
Sept. 14	6.25 a. m.	52	52	N.	...do	150	275	25	(*)	20

* Almost all ripe.

TABLE II.—*Record of salmon-seining operations, &c.*—Continued

Date.	Hour.	Temperature of—		Direction of wind.	Condition of sky.	Seine hauled (length).	Fish taken.		Ripe fish.	
		Air.	Water.				Males.	Females.	Males.	Females.
		°	°			*Feet.*				
Sept. 14	6.50 a. m.	52	52	N.	Clear	150	185	15	(*)	12
Sept. 14	8.25 a. m.	74	52	C.	...do	150	270	30	(*)	26
Sept. 14	8.45 a. m.	76	52	C.	...do	150	265	35	(*)	27
Sept. 14	10.20 a. m.	80	54	N.	...do	150	142	8	(*)	5
Sept. 17	9.00 a. m.	68	54	C.	...do	150	825	175	(*)	167
Sept. 17	5.30 p. m.	80	56	C.	...do	150	350	50	(*)	40
Sept. 17	9.15 p. m.	60	52	C.	...do	150	425	75	(*)	68
Sept. 18	9.30 a. m.	68	52	N. E.	...do	150	860	140	(*)	85
Sept. 18	2.15 p. m.	80	54	N. E.	...do	150	420	80	(*)	50

* Almost all ripe.

EGGS OBTAINED.—As the eggs are not taken from the spawning salmon as they are caught in the seine, but as all the ripe fish of the whole day's catch are put together and the eggs taken from the whole the next day, it is not known how many eggs are obtained from each separate haul of the seine.

TABLE III.—*Table showing the daily number of salmon eggs taken at the United States salmon-hatching station on the McCloud River, California, during the season of* 1880.

Date.	No. of eggs.	No. of females spawned.	Date.	No. of eggs.	No. of females spawned.
August 31	156,600	38	August 11	270,000	84
August 1	286,800	70	August 12	570,000	171
August 2	192,600	58	August 13	519,000	167
August 3	358,800	98	August 14	403,200	126
August 4	356,400	89	August 15	....	....
August 5	420,000	107	August 16	....	....
August 6	532,200	137	August 17	291,000	92
August 7	406,800	117	August 18	909,600	291
August 8	513,600	141	August 19	286,800	89
August 9	386,400	115			
August 10	540,000	159	Total	7,396,800	2,164

TABLE IV.—*Table of distribution of salmon-eggs from the United States salmon-breeding station, McCloud River, California, during the season of* 1880.

State.	Commissioner.	No. asked.	No. assigned.	No. forwarded.	Destination.
Illinois	N. K. Fairbank	200,000	100,000	100,000	Geneva Lake, Wis.
Kansas	D. B. Long	100,000	100,000	100,000	D. B. Long, Ellsworth, Kans.
Maryland	T. B. Ferguson	300,000	200,000	200,000	Oakland, Md., Garret County.
Maryland	Thomas Hughlett	200,000	250,000	200,000	Druid Hill Park, Baltimore, Md.
Missouri	Silas Woodson	200,000	200,000	200,000	Silas Woodson, Saint Joseph, Mo.
Missouri	J. Ed. Humes	5,000	10.000	10,000	J. E. Humes, Versailles, Morgan County, Mo.
Minnesota	R. O. Sweeny	200,000	200,000	200,000	R. O. Sweeny, Saint Paul.
Nebraska	R. R. Livingston	750,000	400,000	400,000	"Nebraska Fish Commission," South Bend, Cass County, Nebr.
New York	James Amion, jr.	10,000	....	....	Mrs. J. H. Slack, Bloomsbury, N. J.
New Jersey	E. J. Anderson	300,000	300,000	300,000	James Annin, jr., Caledonia, N. Y.
North Carolina	S. G. Wortle	200,000	200,000	200,000	S. G. Worth, Morgantown, N. C.
South Carolina	A. P. Butler	200,000	200,000	200,000	Do.

TABLE IV.—*Table of distribution of salmon-eggs, &c.*—Continued.

State.	Commissioner.	No. asked.	No. assigned.	No. forwarded.	Destination.
West Virginia.	H. B. Miller	150,000	150,000	150,000	C. S. White, Romney, W. Va., care agent, Green Spring Run.
Canada	S. Wilmot	50,000	50,000	50,000	S. Wilmot, Newcastle, Ont.
France	R. Wattel	100,000	100,000	100,000	Fred Mather, for Societé d'Acclimation, Paris.
Germany	Von Behr..........	800,000	800,000	800,000	Fred Mather, for Deutsche Fischerei-Verein, Berlin.
Germany	F. Busse...........	50,000	50,000	50,000	Fred Mather, hatching ponds, Bremen.
Germany	Carl Schuster.....	30,000	30,000	30,000	Fred Mather, hatching ponds. Freiburg.
Holland	Von Pestel	100,000	100,000	100,000	Fred Mather, Government of the Netherlands, in charge of Zoological Society of Amsterdam.
Holland	C. J. Bottemann ..	100,000	100,000	100,000	Fred Mather, hatching ponds, Bergen-op-zoom.
U. S...........	....	....	810,000	810,000	William P. Sauerhoff, for Upper Potomac River.
			3,800,000	3,800,000	

TABLE V.—*Disposition of California salmon reared from eggs collected in 1878.*

States.	Where finally hatched.	Waters stocked.	Tributaries in which fish were placed.	Locality.	Date of transfer.	Number of fish.
California	United States hatchery	Sacramento River	McCloud and Little Sacramento Rivers.	McCloud and Sacramento, Cal	Nov. —, 1878	2,000,000
Illinois	Geneva Lake hatching-house	Fox River	Geneva Lake	Geneva, Wis	Nov. —, 1879	200,000
	do	Fox River	Crystal Lake	Crystal Lake, Ill	Nov. —, 1879	20,000
	do	Illinois River	Rock River	Rockford, Ill	Nov. —, 1879	50,000
	do	Illinois River	Fox River	Cacy, Ill	Nov. —, 1879	20,000
Iowa	Anamosa, Iowa	Missouri River	Sioux River		Jan. 27, 1879	4,000
	do	Mississippi River	Mud Lake		Jan. 31, 1879	10,000
	do	Mississippi River	Skunk River		Jan. 31, 1879	10,000
	do	Mississippi River	Wall Lake		Jan. 31, 1879	10,000
	do	Mississippi River	Towner's Lake		Jan. 31, 1879	7,000
	do	Mississippi River	Iowa River		Jan. 31, 1879	7,000
	do	Mississippi River	Des Moines River		Feb. 12, 1879	10,000
	do	Mississippi River	East Coon River		Feb. 12, 1879	10,000
	do	Mississippi River	Middle River		Feb. 12, 1879	10,000
	do	Mississippi River	Wall Lake		Feb. 12, 1879	20,000
	do	Mississippi River	Maple River		Feb. 12, 1879	10,000
	do	Mississippi River	Maquoketa River		Feb. 20, 1879	10,000
	do	Mississippi River	Turkey River		Mar. 20, 1879	3,000
	do	Mississippi River	Lisborn River		Mar. 24, 1879	4,000
	do	Mississippi River	Wapsee River		Mar. 10, 1879	10,000
	do	Mississippi River	Big Rock River		Mar. 17, 1879	3,000
	do	Mississippi River	Boone River		Mar. 22, 1879	10,000
	do	Mississippi River	Upper Des Moines River		Mar. 22, 1879	10,000
	do	Missouri River	Plymouth River		Mar. 22, 1879	15,000
	do	Mississippi River	Cedar River		Mar. 28, 1879	5,000
	do	Mississippi River	East Skunk River		April 1, 1879	2,500
	do	Mississippi River	West Skunk River		April 1, 1879	2,500
	do	Mississippi River	Maltby Kellogg		May 14, 1879	2,500
	do	Mississippi River	Streams along C., B. & Q. R. R.		May 19, 1879	12,000
	do	Mississippi River	Independence River		May 20, 1879	4,000
	do	Mississippi River	Volga River		May 20, 1879	5,000
	do	Mississippi River	Turkey River		May 20, 1879	5,000
	do	Mississippi River	Cedar River		May 30, 1879	10,000
	do	Mississippi River	Spring Branch		May 30, 1879	5,000
Kansas	Cedar Rapids, Iowa	Missouri River	Stranger River	Stranger, Kans	May —, 1879	2,500
	do	Missouri River	Verdigris River	Independence, Kans	May —, 1879	2,500
	do	Missouri River	Delaware River	Delaware, Kans	May —, 1879	3,000
	do	Kansas River	Red Vermillion River	Centralia, Kans	May —, 1879	2,000
	do	Kansas River	Spring Creek	Wetmore, Kans	May —, 1879	1,000
	do	Big Blue River	Mill Creek	Washington, Kans	May —, 1879	1,000
	do	Big Blue River	Black Vermillion	Frankford, Kans	May —, 1879	2,000

TABLE V.—*Disposition of California salmon reared from eggs collected in* 1878—Continued.

Date.	Where finally hatched.	Where stocked.	Tributaries in which fish were placed.	Locality.	Date of transfer.	Number of fish.
Kansas	Cedar Rapids, Iowa	Kansas River	Clear Creek	Barrett, Kans	May —, 1879	1,000
	do	Kansas River	Big Blue River	Blue Rapids, Kans	May —, 1879	5,000
	do	Big Blue River	Little Blue River	Waterville, Kans	May —, 1879	2,000
	do	Kansas River	Republican River	Concordia, Kans	May —, 1879	5,000
	do	Kansas River	Solomon River	Beloit, Kans	May —, 1879	5,000
	do	Kansas River	Soldier River	Topeka, Kans	May —, 1879	1,000
	do	Kansas River	Silver Lake	Silver Lake, Kans	May —, 1879	500
	do	Kansas River	Vermillion River	Wamego, Kans	May —, 1879	2,500
	do	Kansas River	Big Blue River	Manhattan, Kans	May —, 1879	5,000
	do	Kansas River	Republican River	Junction City, Kans	May —, 1879	3,000
	do	Kansas River	Chapman's Creek	Chapman's Creek, Kans	May —, 1879	2,000
	do	Kansas River	Solomon River	Solomon City, Kans	May —, 1879	2,000
	do	Smoky Hill River	Saline River	Saline, Kans	May —, 1879	3,000
	do	Smoky Hill River	Spring Creek	Brookville, Kans	May —, 1879	1,000
	do	Kansas River	Smoky Hill River	Ellsworth, Kans	May —, 1879	5,900
	do	Smoky Hill River	Big Creek	Hayes City, Kans	May —, 1879	5,000
	do	Smoky Hill River	Big Creek	Ellis, Kans	May —, 1879	5,000
	do	Kansas River	Wakasa River	Ottawa, Kans (?)	May —, 1879	2,000
	do	Missouri River	Osage River (?)	Redding, Kans	May —, 1879	2,000
	do	Arkansas River	Neosho River	Emporia, Kans	May —, 1879	5,000
	do	Neosho River	Cottonwood River	Florence, Kans	May —, 1379	2,000
	do	Arkansas River	Walnut River	Eldorado, Kans	May —, 1879	3,000
	do	Arkansas River	Little Arkansas River	Halstead, Kans	May —, 1879	2,500
	do	Little Arkansas River	Lake Inman	McPherson, Kans	May —, 1879	2,000
	do	Arkansas River	Cow Creek	Hutchinson, Kans	May —, 1879	3,000
	do	Arkansas River	Walnut River	Great Bend, Kans	May —, 1879	3,000
	do	Arkansas River	Pawnee Creek	Larned, Kans	May —, 1879	5,000
Maine	Pembroke hatching-house	Saint Croix River	Keen's Lake Stream	Keen's Lake, Me	Feb. 6, 1879	9,7000
	do	Bay of Fundy	Penmaquan River	Pembroke, Me	Feb. 13, 1879	13,000
Maryland	Druid Hill hatching-house	Bush River	Winter's Run	Wilna, Md	Feb. 1, 1879	4,000
	do	Chesapeake Bay	Patuxent River	Savage Station, Md	Feb. 1, 1879	10,000
	do	Chesapeake Bay	Chesstr River	Millington, Md	Feb. 13, 1879	12,000
	do	Chesapeake Bay	Choptank River	Henderson, Md	Feb. 21, 1879	8,000
	do				Feb. 24, 1879	7,000
	do	Tangier Sound	Black Water	Cambridge, Md	Feb. 26, 1879	3,000
	do	Transguaking River	Chickacomico		Feb 26, 1879	3,000
	do	Tangier Sound	Transguaking River	Airey's Station	Feb. 26, 1879	3,000
	do	Chesapeake Bay	Patapsco and Patuxent Rivers	Hood's Mill and Airey, Md	Feb. 28, 1879	12,000
	do				June 6, 1879	236
Michigan		Lake Michigan	Paw Paw River	Berrien County, Mich	Jan. 8, 1879	25,000
		Dowagiac River	Ropkagon Creek	Cass County, Mich	Jan. 9, 1879	10,000
		Dowagiac River	Peceanic River	Cass County, Mich	Jan. 10, 1879	5,000

	....	Pine Lake	Dowagiac River	Van Buren County, Mich	Jan. 10, 1879	10,000
	....	*Saint Joseph River*	*Walron Creek*	Saint Joseph County, Mich	Jan. 23, 1879	10,000
	....	Saint Joseph River	Fate's Creek	Saint Joseph County, Mich	Jan. 23, 1879	10,000
	....	Lake Michigan	Grand River	Jackson, Mich	Jan. 30, 1879	30,000
	....	Lake Michigan	Manistee River	Wexford County, Mich	Feb. 6, 1879	25,000
	....	Lake Erie	Raisin River	Monroe, Mich	Feb. 13, 1879	30,000
	....	Saginaw River	Cass River	Tuscola County, Mich	Feb. 13, 1879	30,000
	....	White River	Round Lake	Oceana County, Mich	Apr. 18, 1879	500
	....	White River	Crystal Lake	Oceana County, Mich	Apr. 18, 1879	500
	....	....	Private Ponds	Romeo, Mich	July 12, 1879	220
Minnesota	Red Wing, Minn	Mississippi River	Lakes	Goodhue County, Minn	July —, 1879	5,000
	do	Saint Croix River	Silver Lake	Washington County, Minn	July —, 1879	1,000
	do	Mississippi River	Mary's Creek	Mower County, Minn	July —, 1879	1,000
	do	Minnesota River	Cedar Lake	Watonwan County, Minn	July —, 1879	1,000
	do	Minnesota River	Chain Lake	Watonwan County, Minn	July —, 1879	1,000
	do	Minnesota River	Lake Alley	Renville County, Minn	July —, 1879	2,000
	do	Minnesota River	Lake Prescott	Renville County, Minn	July —, 1879	2,000
	do	Blue Earth River	Chain Lake	Martin County, Minn	July —, 1879	5,000
	do	Missouri River	Lake Letook	Lesenr County, Minn	July —, 1879	2,500
	do	Missouri River	Lake Takota	Lesenr County, Minn	July —, 1879	2,500
	....	Minnesota River	Lake Elysian	Waseca County, Minn	July —, 1879	5,000
	do	Minnesota River	Lakes	Douglas County, Minn	July —, 1879	3,000
	do	Mississippi River	Lakes	Wright County, Minn	July —, 1879	3,000
	do	Saint Croix River	Lake Elmo	Washington County, Minn	July —, 1879	2,000
	do	....	Lake Koronis	....	July —, 1879	3,000
	do	Pomme de Terre River	Lake Foss	Stevens County, Minn	July —, 1879	2,000
Missouri	California	Mississippi River	Meramec River	Franklin, Mo	Dec. —, 1878	75,000
	do	Arkansas River	Spring River	Carthage, Mo	Dec. —, 1878	75,000
Nevada	McCloud River station	Bear River	Truckee River	Reno, Nev	Mar. —, 1879	190,000
	do	Carson River	Mexican Dam	Carson City, Nev	Mar. —, 1879	10,000
New Hampshire	Plymouth, N. H	Merrimac River	Pemigewasset River	Campton and Plymouth, N. H	Feb. 1, 1879	317,000
	do	Salmon Falls	Newechewaunock Lake	Wakefield, N. H	Mar. 14, 1879	5,000
	do	Salmon Falls	Tri Echo Lake	Milton, N. H	Mar. —, 1879	5,000
	do	Salmon Falls	Lorewell's Pond	Wakefield, N. H	Mar. —, 1879	5,000
	do	Salmon Falls	Cook's Pond	Brookfield, N. H	Mar. —, 1879	5,000
	do	Lake Winnepiseogee	Smith's Pond	Wolfeborough, N. H	Mar. —, 1879	10,000
	do	Merrimac River	Contoocook	Hillsborough Bridge, N. H	Mar. —, 1879	20,000
New Jersey	Bloomsbury, N. J	Delaware River	Shumaker's Eddy	80 miles north of Trenton	Mar. —, 1879	156,200
	do	Great Egg Harbor	Great Egg Harbor River	Atlantic County, N. J	Mar. —, 1879	50,000
	do	Delaware River	Alloway's Creek	Salem County, N. J	Mar. —, 1879	25,000
	do	Delaware River	Maurice River	Cumberland County, N. J	Mar. —, 1879	25,000
	do	Delaware River	Racoon Creek	Gloucester County, N. J	Mar. —, 1879	25,000
	do	Great Bay	Mullica River	Gloucester County, N. J	Mar. —, 1879	25,000
	do	Raritan River	North Branch	Somerset County, N. J	Mar. —, 1879	30,000
	do	Passaic River	Rockaway River	Somerset County, N. J	Mar. —, 1879	30,000
	do	Hackensack River	Hackensack River	Bergen County, N. J	Mar. —, 1879	30,000
	do	Lake Hopatcong	Lake Hopatcong	Morris County, N. J	Mar. —, 1879	5,000
	do	Shawngum Lake	Shawngum Lake	....	Mar. —, 1879	5,000
	do	Silver Lake	Silver Lake	....	Mar. —, 1879	3,000
	do	Greenwood Lake	Greenwood Lake	Passaic County, N. J	Mar. —, 1879	22,000
	do	Swartswood Lake	Swartswood Lake	Sussex County, N. J	Mar. —, 1879	10,000
	do	Verona Lake	Verona Lake	....	Mar. —, 1879	3,000

TABLE V.—*Disposition of California salmon reared from eggs collected in 1878*—Continued.

Date.	Where finally hatched.	Waters stocked.	Tributaries in which fish were placed.	Locality.	Date of transfer.	Number of fish.
New Jersey	Bloomsbury, N. J.	Cline's Pond	Cline's Pond		Mar. —, 1878	10,000
New York		Hudson River	Tributaries of Hudson River	Greene County, N. Y.	Dec. 5, 1878	20,000
		Genesee River	Spring Creek	Monroe County, N. Y	Dec. 31, 1879	10,000
	Caledonia, N. Y	Lake Ontario	Spring Creek	Livingston County, N. Y.	Jan. 15, 1879	10,000
	do	Hemlock Lake	Spring Brooks	Ontario County, N. Y	Feb. 26, 1879	36,000
	do	Summer Hill Lake	Spring Brooks	Cayuga County, N. Y	Mar. 1, 1879	9,000
	do	Lake Ontario	Spring Creek	Livingston County, N. Y.	Mar. 11, 1879	1,000
North Carolina	Henry's, N. C	Cape Fear River	North Fork Deep River	Friendship, N. C.	Jan. 2, 1879	18,000
	do	Catawba River	John's River and Upper Creek	Morgantown, N. C.	Jan. 10, 1879	30,000
	do	Catawba River	Linville River	Bridgewater, N. C.	Jan. 11, 1879	30,000
	do	Roanoke River	Doe River	Danbury, N. C	Jan. 13, 1879	20,000
	do	Broad River	Broad River	Hickory-nut Gap, N. C.	Jan. 15, 1879	45,000
	do	Roanoke River	Town Fork River	Germanton, N. C	Jan. 18, 1879	15,000
	do	Pee-Dee River	Yadkin River	Patterson's (Caldwell Co.), N. C	Dec. 16, 1878	30,000
	do	Pee-Dee River	Yadkin River	Patterson's (Caldwell Co.), N. C	Dec. 18, 1878	30,000
	do	Broad River	North Pacolet River	Near Hendersonville, N. C.	Dec. 20, 1878	5,000
	do	Broad River	Green River	Near Hendersonville, N. C.	Dec. 20, 1878	20,000
	do	Cape Fear River	Bull Run Creek	Near Jamestown, N. C	Dec. 27, 1878	20,000
	do	Cape Fear River	North Fork Deep River	Near Jamestown, N. C	Dec. 31, 1878	24,500
	Total					4,460,356
Canada	Newcastle hatchery	Lake Ontario	Wilmots Creek	Province of Ontario	Spring, 1879	1,000
	do	Lake Huron	Saugeen's River	Province of Ontario	Spring, 1879	500
	do	Lake Ontario	River Trent	Province of Ontario	Spring, 1879	200

APPENDIX TO SALMON-HATCHING REPORT, 1880.

NEWCASTLE, *March* 4, 1880.

LIVINGSTON STONE, Esq.,

Deputy Commissioner United States Fisheries:

MY DEAR MR. STONE: In addition to the information asked in your note and blank form, sent to be filled up in regard to the California eggs, I beg to send you the following statement, in detail, so that you may draw your own conclusions from it:

In October, 1874, first lot of 20,000 eggs received; May, 1875, turned out as fry.

In October, 1875, second lot of 80,000 eggs received; April, 1876, turned out as fry.

In October, 1876, a small California salmon, about 15 inches long, came up the stream and into the house, full of milt.

In October, 1876, third lot of 8,000 eggs were received; in April, 1877, turned out as fry.

In July, 1877, a beautiful 5-pound California salmon was taken in my nets along with our salmon in Lake Ontario, and during my absence two other smaller ones were taken in like manner.

In October, 1877, three California salmon came up the stream into our reception house, all males; the largest one was 23 inches long, very slim, and very dirty looking.

In October, 1877, fourth lot of 40,000 eggs were received; April, 1878, put out as fry.

In July, 1878, J. J. Robson, esq., had charge of the nets in my absence, and he reported a California salmon of 15 pounds being taken in the nets; also two or three small ones.

In October, 1878, fifth lot of 500,000 eggs received; all turned bad but 2,000.

In April, 1879, put out 1,700 fry.

The above is the history of the California eggs got by me from Professor Baird. The salmon taken in July, 1877, of 5 pounds' weight, was as beautiful, fat, and finely-developed a fish as I ever saw of the salmon family. I skinned and mounted the fish, and have him now in my possession. This fish must have come from the first lot of eggs got by me in the fall of 1874 and turned out as fry in April, 1875; therefore it was only two years and three months old from the hatching out from the egg, or rather from the time of turning out as fry, as the eggs hatched out during the winter were retained in the hatching-troughs till April.

Now, what has become of all the rest of these fry I cannot tell, perhaps you can; if you can't, Seth Green surely can tell all about them. One thing is certain, they have not peopled Lake Ontario in the countless myriads that Seth's shad did the next season after they were turned out as fry.

I must confess that I am quite upset on this question of where these fry go to. I have never seen a "parr" or a "smolt" of these Californians yet in this stream, but I have raised large numbers of them to those stages of their growth in spring-water tanks and put them out, but have never seen any afterwards, except the ones described as above, which were, I should say, in the grilse stage (except the first one) in October, 1876 (I did not see the one reported by Mr. Robson of 15 pounds' weight, in July, 1878, and cannot, therefore, say anything about it, only simply expressing a doubt of its being a "Simon pure" Californian). But, then, here comes in the rub, if any "*five-pounder*" (a thoroughbred one, too) attained that size and weight in twenty-seven months, why havn't some others done the same thing? and if they have, where are they? I believe in perseverance upon the principle that "Faint heart never won fair lady," but then there are lots of people the antipodes to myself who say "Hope deferred maketh the heart sick," and do not believe in "Hope on, hope ever."

I should like very much, indeed, to have a long confab with the Professor and yourself about these truant fish. My own private opinion (but never expressed before) is, that these California fry will not stand as high a temperature of water as our own; this, I think, will be somewhat verified in your own reports of the temperature of the McCloud River, which in July, August, and September averaged about 57°, 55°, 52°. This is colder by some 15 to 20° at these periods than our streams in Ontario. On a trip I made last July up our most famous salmon river, the Restigouche, I found the temperature thus: 60° some 80 miles up from tideway and 52° 130 miles up. I don't know how far your works are up from tide-water on the McCloud, but I should infer they are not that distance; if not, the McCloud water must be very much colder than any of our Atlantic rivers. In fact, looking at your record of temperature and comparing with some of ours, the McCloud is many degrees colder than any of our New Brunswick or Nova Scotia rivers, and far, far colder than any of our Ontario streams. Therefore, by this comparison the California salmon are natives of colder waters than ours, and consequently it is much less suitable to their growth than for our own salmon. Farther observation on my part will go to prove this still more, that whilst I have raised plenty of California parrs and even smolts in spring water at 40° to 50° and 55°, where they thrive very well, I have never yet seen a single one in my creek from the thousands I had put into it as fry. Again, I have taken some of the parrs and smolts from the spring-water tanks and put them into a small pond with a flow of the creek water through it, and shortly afterwards they got covered with small black specks, as if dotted all over with ink.

The spots or specks protruded a little, and the fish in handling felt like a rasp, and soon died, in a lean, lank condition; some were put back again in the "spotted" state to the spring water of 50°, and after awhile recovered. This occurred with our own salmon, parrs and smolts also, but not to such an extent as with the Californians. I am therefore almost constrained to say that the Californians must be natives of colder waters than our own salmon. I notice that the "sun heat" at your works is at times almost beyond endurance, running up to 100° or 125°, far beyond what it is with us. That, however, has nothing to do with my present statement, viz, that your recorded temperature of water where you gather your eggs is infinitely colder than any of our river waters at that period of the year. I therefore fear very much that the Pacific salmon don't thrive in our Ontario waters (though there may be exceptions, like my "five-pounder"), and I should judge that the waters in most of your States is not unlike ours; and I almost go further in giving it as my belief that even the Atlantic and the Wilmot salmon must give way to the increased temperature of our Ontario streams and their consequent impurities, which is growing upon us annually from the clearing off the forests, which reduces the volume of water in the creeks and rivers and gives them greater exposure to the influences of the sun's rays.

May I ask you this question: Do the salmon of their own accord spawn in the river as low down as where your works are situated on the McCloud River? or, if they do, is it not because they are prevented from going farther up stream on account of your weir across it?

You must excuse this literally long scrawl, for it is written in the most hurried and impromptu manner just on the eve of my going away for a few days from home. When I sat down to write you about the blank returns sent me I did not dream of entering into the subject of this California question, but when started I could not well knock off, and so have extended it perhaps beyond decorum. The subject is a very large one, and I should, as before stated, like much to have a few hours' talk with you, who are so well acquainted with this Pacific fish.

Believe me to be yours, respectfully,

SAM'L WILMOT.

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XXII.—REPORT OF OPERATIONS AT THE UNITED STATES TROUT PONDS ON THE M'CLOUD RIVER, CAL., DURING THE SEASON OF 1880.

By Livingston Stone.

Baird, Shasta County, Cal.,
December 31, 1880.

Prof. Spencer F. Baird,
United States Commissioner.

Sir: I beg leave to report as follows: My last report closed with the 31st of December, 1879, up to which time no trout eggs had been taken. Very soon, however, after the new year began, the breeders in the ponds commenced to show signs of preparing to deposit their spawn, and on the 12th of January, 1880, the first eggs were taken to the number of 25,000. The spawning season lasted from January 12 to May 2, the eggs being taken at intervals between these dates. Even after the 2d of May a few straggling spawners were manipulated, the very last eggs of the season being taken on the 26th of that month.

There being a fine supply of water at the trout ponds and every facility for hatching, very little difficulty was encountered in maturing the eggs for shipment.

The method adopted of manipulating the breeders was the same as that in common use among trout-raisers, viz., that of pressing the eggs from the fish by hand without the aid of any apparatus. The eggs are taken directly from the fish into a dry pan, and, after being impregnated and washed, are placed in deep wire trays or baskets, like those used at the salmon fishery for hatching salmon, 15,000 being placed in each tray. The eggs of the California trout are so large that the same baskets were used for hatching the trout eggs that are used for hatching California salmon eggs.

The actual shipping of the eggs was a much more difficult matter than taking and maturing them. To get an idea of the difficulties of this part of the work, it should be remembered that the trout ponds are four miles from the stage road, and that the only path to the road is a rude Indian trail, over a very rough and broken country. The mud in some parts of this trail is in winter knee-deep, and the intervening streams, at that season swollen torrents, have to be waded by the horseman or footman, as the case may be, who carries the eggs.

After reaching the stage-road the eggs must be carried to the railroad station, 22 miles, over a road that is almost impassable on account of the depth of mud. In the course of this ride Pit River must be crossed at a season of the year when it is such a swollen and violent stream that for several days at a time only the Oregon mail is taken over, and that at no little peril to the boatman. After reaching the railroad a journey by rail of 3,500 miles still remains for the eggs before they arrive at their distant destinations.

All these difficulties were successfully overcome last winter by the energy and skill of those who had the work in charge, and in almost every, if not every, instance the transportation of the eggs across the continent was a success.

The total number of eggs distributed from the station was 261,000.

Mr. Green returned to the McCloud River and tributary creeks 68,000 fish left over after all the eggs were distributed. There was a loss of 15 per cent. from want of impregnation and other causes, which makes the total number of eggs taken at the trout ponds in 1880 as follows:

Actual number of eggs distributed	261,000
Number of eggs returned to river as young fish	68,000
Number left over at end of season	2,000
Loss from unimpregnated eggs, &c	57,000
Total number of eggs taken	388,000

The eggs were distributed as follows:

Distribution of trout eggs, 1880.

Jan. 30.	To T. B. Ferguson, Baltimore, Md	40,000
Feb. 3.	To T. B. Ferguson, Baltimore, Md	17,000
Feb. 20.	To T. B. Ferguson, Baltimore, Md	20,000
Feb. 28.	To T. B. Ferguson, Baltimore, Md	22,000
Mar. 13.	To T. B. Ferguson, Baltimore, Md	30,000
Mar. 16.	To T. B. Ferguson, Baltimore, Md	22,000
April 2.	To T. B. Ferguson, Baltimore, Md	24,000
Mar. 15.	To M. Metcalf, Battle Creek, Mich	1,500
Mar. 19.	To R. O. Sweeny, St. Paul, Minn	2,500
Mar. 19.	To B. F. Shaw, Anamosa, Iowa	3,500
Mar. 19.	To W. Welsher, Wis	2,500
Mar. 19.	To S. Webber, New Hampshire	2,500
Mar. 19.	To F. N. Clark, Michigan	2,500
Mar. 19.	To J. G. Portman, Pokagon, Mich	2,500
Mar. 20.	To N. K. Fairbanks, Chicago, Ill.	2,500
April 8.	To C. S. White, Green Spring River, Baltimore and Ohio Railroad	10,000
April 10.	To Seth Weeks, Corry, Penn	4,000
April 10.	To ——— Potter	4,000
April 17.	To J. G. M. Steedman, Saint Louis, Mo	18,000
May 3.	To J. G. M. Steedman, Saint Louis, Mo	9,000
May 12.	To J. G. M. Steedman, Saint Louis, Mo	12,000
May 22.	To R. Klotz, Shasta County, Cal	10,000

As soon as the eggs were all shipped we turned our attention to making improvements about the place. A stable was needed, for it is impracticable here to get along without horses, and the winters are too severe in these mountains to make it safe for horses unprovided with shelter. Many additions of various sorts were also needed in and about the dwelling-house, as everything was done last year almost exclusively with a view to make the trout-egg season a successful one, regardless of personal inconveniences. Accordingly we proceeded to build a commodious stable and a woodshed, and to make additions inside of the dwelling-house in the way of closets, &c. This, with the fishing for parent trout to add to our stock, took till about the 1st of September, when Mr. Redcliff and Mr. Loren Green came to the salmon fishery to help take salmon eggs.

The trout did not bite as well this year in June and July as they did in the same months of last year, possibly because we had taken out about 1,500 from this locality in the river and put them into the ponds.

We had some talk about building a wagon road from the salmon fishery to the trout ponds this summer, but it proved to be too expensive an undertaking, and was given up; but as a substitute I sent for a Bell telephone with wire enough to connect the trout-breeding station with the salmon fishery on the California and Oregon stage road, which now enables us at the trout ponds to hold direct communication with the outside world.

As not much is yet generally known about the natural history of the California trout (*Salmo iridea*), I will venture to present the following rather fragmentary notes, most of which have been furnished me by Myron Green, concerning the eggs, the fish, and the manner of catching them. The eggs of the McCloud River trout (*Salmo iridea*) are about one-fifth of an inch in diameter, twenty-five averaged-sized eggs, one layer deep, just covering an area of a square inch. There is quite a wide variation in the color of eggs, some being of a light straw color and others of a deep salmon red. A two-pound trout gives about 800 eggs.

At 54° Fahrenheit the eggs hatch in twenty-six days, and the eye spots show in twelve days. Seth Green's formula, in regard to the hatching period of the New England brook trout (*Salmo fontinalis*), is that these eggs hatch in fifty days at 50° F., and require six days less for every degree's increase in the warmth of the water. According to this formula the *fontinalis* eggs, in water at 54°, would hatch in twenty-six days, which happens to be precisely the time required by the eggs of the McCloud River trout (*Salmo iridea*) to hatch.

The empty eggs of the *iridea* do not turn white as soon as the empty salmon eggs do, consequently one is more likely, in packing and shipping, to get empty eggs mixed with the impregnated ones than in packing salmon eggs. The empty or unfertilized eggs can, however, usually be made to turn white by running a somewhat violent stream of water through the hatching troughs after the eye spots are plainly apparent in the rest. This will turn the empty eggs white while it will not injure the eggs which have fish in them.

The California trout eggs seem to be peculiar in one respect, namely, that they will stand a great deal of sediment in the water without appearing to suffer from it.

Mr. Green, and Mr. Woodbury who hatched trout eggs for the California fish commission, both say that the eggs can be completely covered with sediment for three days and come out all right. These eggs possess another peculiarity, viz, the embryo, previous to the development of the choroid pigment (eye spots), can be seen quite clearly through the shell, and the form of the fish is distinctly apparent for four or five days before the eye spots show, which usually happens about the eleventh day in water at 54° F.

The California trout (*Salmo iridea*), which is the same fish as Suckley's *Salmo Masoni*, is described by him under the latter name as follows:

SALMO MASONI, Suckley.

Sp. ch.—Body subfusiform; head well developed, forming the fifth of the total length. Maxillary slightly bent, extending to a vertical line drawn inwardly to the posterior line of the orbit. Jaws equal. Anterior margin of dorsal fin a little nearer the extremity of the snout than the insertion of the caudal fin. Back brownish gray; upper surface of head blackish gray; sides silvery gray; fins ash gray; dorsal and caudal spotted; upper regions of head and body studded with irregular black spots or specks; tail emarginate.

I will merely add to this description that the McCloud River trout have a broad red stripe on their sides extending on each side of the lateral line from the mouth to the caudal fin. In the spawning season their silvery-gray color assumes a much darker hue, and the broad stripe turns to a deeper red. During the spawning season the trout get white and flabby and very poor, though they quickly recover when they begin to feed again. The *iridea* in the McCloud River, probably owing to more abundant feed and better water, grow to a larger size than in most other waters. The males in our ponds averaged last January about three pounds in weight and the females two pounds. There were several individual fish that weighed five pounds and six pounds, and even more.

Mr. Green describes them as being good feeders, hardy and well able to hold their own among other voracious fish, while at the same time they are not as destructive to smaller fish of their own kind as many other varieties of trout, notably the *fontinalis*, the common speckled brook trout of the Northern Atlantic States. Large and small fish can consequently be kept together in the same pond with comparative safety. Their favorite food is salmon eggs. After that come the caddis worms, with which the McCloud River abounds. These trout also feed on the dead salmon in the bottom of the river. Mr. Green says he has never found any smaller trout in the stomachs of the McCloud River variety. In other streams, however, when feed on the bottom is less abundant, they may possibly devour their own kind to some extent. The artificial food which we give our trout in the ponds consists, chiefly, in the summer, of boiled salmon. They eat this voraciously, but they like fresh meat better. When salmon are not to be had we give them venison, and occasionally kill a steer for them in the winter. The trout that are in the ponds at the present writing will eat a whole deer at two feeds. We also give them dried salmon and the dead salmon eggs picked out of the salmon-hatching troughs, which we dry for this purpose. Of course it is impossible to purchase any food for them from the markets in this remote region.

As the number of trout in our pond increases it is obvious that more food will be required for them, and the question of furnishing food to the parent trout promises, at no distant day, to be quite a serious one. We probably have now in our ponds upwards of two tons of live trout. They will certainly eat five times their weight, or ten tons in a year. We can easily manage this amount of food, but what shall we do when we have ten tons of fish and they require annually fifty tons of food? Fortunately the salmon which they subsist on during the summer costs nothing, but an allowance of several hundred dollars a year will probably have to be made to supply the trout with food in the winter, when the trout ponds at this station are being carried on on the scale which is now contemplated.

Mr. Green thinks that the males have milt when they are two years old, but that the females do not spawn till they are three years old. He says he never saw a spawning female of less than one and a half pounds weight. In this respect they must be very different from eastern brook trout (*Salmo fontinalis*), as the writer has taken eggs from an eastern trout that weighed only an ounce and a half. Mr. Green is of the opinion that the McCloud River trout do not cross with the salmon unless in rare instances, and if they do at all that the progeny are barren.

FISHING FOR TROUT.

One of the most essential tasks when we began to operate here with trout was of course to catch breeders for the ponds. The fishing has been entirely under the management of Mr. Myron Green, who has shown great sagacity in discovering the ways of the fish and in using his knowledge in capturing them.

Mr. Green's method has been almost entirely to use set lines. These horizontal lines are 150 to 175 feet long when the nature of the water will permit the use of so long a line. The eddies and the comparatively quiet pools of the river are used to fish in. The short vertical lines attached to the long horizontal line are 5 feet apart and are themselves 2 feet long.

We use No. 1 and No. 1½ Sproat's hooks in the spring and summer and No. 2 and No. 3 in the fall. The reason for using a larger hook in the spring and summer is that the salmon, which are so abundant in the river and which occasionally, indeed very often, get hold of the hooks, would break a smaller size. In the fall the salmon are all gone and smaller hooks can be used. We file off the beard of the hook to some extent to make it easier to extract the hook from the fish's mouth without killing it. Sometimes when the hook cannot readily be drawn out the usual way, Mr. Green saves the fish by cutting the line and drawing the hook out the other way. Sometimes in clear pools (and the McCloud is a very clear river usually), the trout will take alarm at the line and will not bite, though they can be seen in considerable numbers about the hooks. When this happens, Mr. Green hides the lines under the sand on the bottom of the river and leaves only the hooks and bait visible. Then the trout will bite. When the trout are suspicious of the bait they disturb it with their tails and examine it before biting at it. Mr. Green is quite sure that these trout are all in the habit of stirring up the bottom of the river with their tails when they are foraging for food. They also have this peculiarity, so different from the eastern trout (*Salmo fontinalis*), viz, that they swim partly on one side when in search of food, with one eye inclined downward so that they see what is on the bottom.

When a new place has been selected for setting a line we usually "salt the ground" pretty well with bait—that is, scatter salmon eggs over it for three or four days before we begin to fish the place. This attracts the trout to the spot and gets them familiar with it. The only bait we ever use is salmon eggs. This is by far the most "killing" bait, to use a sportsman's term, which is rather inapplicable here, as we do all we can to avoid killing the trout. No other bait for trout begins to compare with salmon eggs in effectiveness in this river. It is used altogether here when it can be obtained, not only by us in capturing breeders, but by all the sportsmen who come here to fish. As fish culturists, however, we should feel some compunction about destroying so many salmon eggs did we not recall the many millions of them which we annually hatch for the benefit of this river.

When the dried eggs are used for bait Mr. Green puts two on each hook. This is in the fall when the small hooks are used. At this season and with these hooks we do not lose over one trout in twenty from injuries in catching them. In summer, when large hooks are used, we kill about one in eight in getting the hook out. As soon as the fish are caught they are taken as rapidly as possible to the nearest corral. These corrals, of which we have a good many along the river, are temporary ponds made merely to hold the trout until we are ready to bring them to the regular trout ponds, and are used to save making a journey to the trout ponds every time a fish is caught at a long distance off. When the fishing is over, for the night or day, as the case may be, the trout which have been placed in the temporary corrals are collected together and taken to the trout ponds, where they are deposited.

We use for carrying the live trout the common five-gallon rectangular tin cans which turpentine, alcohol, and other liquids come in. We save all these cans for this purpose and rig them with a bail and a lid, and find them very convenient and safe to carry the trout in, as well as economical.

We have had one set of lines, twenty in number, extending at intervals over nearly four miles of the river, which makes it quite important to have a system of convenient temporary corrals to confine the fish in when they are first caught. We fish somewhat with a rod, but not to any great extent.

The trout fishing lasts from the middle of May till the last of November, June and July being the best months for fishing. Indeed the trout bite very well till the salmon begin to spawn in August, when, till the salmon-spawning season is over, the trout fishing is very poor. In the very hot weather the trout feed mostly at night.

During the spawning season the wild trout in the river sometimes run up the tributary creeks in great numbers when they are swollen by the rains. Taking advantage of this peculiarity of theirs we have taken them in traps placed in the creeks, but the more experience we have of this method of getting breeders and eggs the less we like it, and shall probably not rely much upon it in future.

Owing to the powerful current in the river, which indeed is a succession of cascades and rapids, great inconvenience has been experienced in using the heavy wooden boats which we have at present. I therefore sent for one of Osgood's patent-folding canvass boats this summer for tending the lines with. This boat is extremely light and can be easily carried by the rapids and falls in ascending and descending the river, and saves a vast deal of time and severe labor. With this boat we were enabled to extend our fishing this fall more than ten miles above the trout ponds.

The fishing this fall was conducted with so much success that we were enabled to nearly double the number of breeders in the ponds, and next year (1881) we hope to take half a million eggs.

In concluding, I will say that we now have at the United States trout-breeding station, on the McCloud River, a large and commodious dwelling-house and stable, a hatching-house, with a hatching capacity of several million trout eggs, four large and very substantial ponds, and over two thousand breeding trout, averaging three pounds in weight.

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XXIII.—REPORT ON THE PROPAGATION OF PENOBSCOT SALMON IN 1880-'81.

By CHARLES G. ATKINS.

1. IMPROVED FIXTURES.

The disaster of August, 1879, whereby we lost nearly all our breeding salmon, had taught by a severe lesson that nothing less than a very substantial structure could be relied upon to withstand the force of such floods as occasionally swell the volume of even so small a stream as Dead Brook. Accordingly, the first business of 1880 was to construct two stout barriers to our inclosure, one at the upper and one at the lower end. Heavy piling was driven across the stream to secure against undermining, and this, cut off at the proper depth below the surface to avoid impeding the current, formed the foundation of a superstructure of stout sawed slats, which were inclined to the stream and surmounted by a walk on which workmen could pass constantly to and fro to clear the rack of rubbish. The lower barrier had, in addition, a capacious swinging gate for the passage of loaded boats, and was secured by a heavy ballasted pier in mid-stream and a pavement of heavy boulders on the muddy bottom on the lower side to prevent washing away, and though the substratum is so soft that piles driven into it 20 feet rise with their own buoyancy as if from thin porridge, unless ballasted, there is good reason to believe that a far greater freshet than that of 1879 will now assail our works in vain.

This was about the only important improvement that was made during the year in the inclosures or at the hatching house, though there was, as ever, many a little job to be done to increase the efficiency of the works, such as traps for catching the fish at the spawning season, ceiling up the walls of the hatching house, relaying the floor, adding new troughs and hatching fixtures, improving the water conduits, &c. The towing cars received considerable attention; improvements were made in their fittings and new ones added of models that it is hoped will prove better than the old.

2. Buying salmon.

The same arrangements for our supply of salmon were made as the previous year. The fishermen furnishing them brought their catch every tide to Mr. Whitmore at the lower end of the island of Verona, and thence, after counting and weighing (by Mr. Whitmore's eye), they were sent up the river to the inclosure. The first fish were received June 10 and the last July 2. The total purchase was 522, of which 42 died in transit. There was a serious loss soon after inclosing them, 65 having died and been found up to July 28. Nearly every one of these had sore eyes, and to that cause I attribute their death. The cause of the sore eyes is a problem not yet solved. I am inclined to attribute it to something occurring during their capture or transportation, as the effect followed so speedily on their inclosure. After July hardly any died, only two being found in August. No other trouble occurred, and the bulk of the fish came in good condition to the spawning season.

3. Taking spawn.

Floods interfered with the count of the fish at this season, but it is known that 227 females were manipulated.

The work of spawning began October 25, and closed November 10. The whole number of eggs taken was afterwards computed at 1,930,561.

The impregnation of the eggs was very satisfactory, as is almost always the case with this variety of *Salmo salar*. But 50,854 were taken out known to be unimpregnated, and the total of pickings was but 80,061, by actual count.

The most of the females and a good many of the males were marked for future identification by attaching platinum tags to their dorsals, as formerly practiced at Bucksport. They were then turned loose in Dead Brook below the inclosure. Many of them are known to have staid in the river above Orland village all winter, as they were seen in considerable numbers in the early spring.

4. Shipment of spawn.

As in 1879, the warm water of Craig's Brook hastened the development of the eggs, so that we were compelled to begin shipments early in December; but the water cooled rapidly after that date, so that the final shipment was not made until February 28.

The allotment pro rata with the contributions in money gave the United States about 1,264,000; Maine, 340,000; New Hampshire, 45,500; Massachusetts, 225,000; these being the only contributors. The actual division will be seen by the appended Table II.

The packages of spawn reached their destinations in excellent condition, and the aggregate result was a large number of healthy salmon fry, whose hatching and planting are detailed in Tables III and IV.

In Table I, I give, as usual, a statement of the weights of the salmon purchased.

There being no requirement to reserve any part of the stock of eggs for the benefit of the neighboring waters, the whole of the spawn is yearly shipped away, and at the end of February the establishment was closed for the season.

The personnel of the establishment has remained as the previous year, Mr. H. H. Buck, of Orland, being in charge as foreman.

TABLE I.—*Statement of salmon bought alive at Bucksport in* 1880.

Date.	Whence received.	Number of salmon.	Weight of salmon.			Daily summary.			
			Several weights.	Aggregate.	Average.	Number of salmon.	Weights.		Date.
							Aggregate.	Average.	
			Pounds.						
1880. June 10	A. H. W...	2	12, 11	28	11.50				
10	J. W	8	21, 10, 8½	89½	18.17				
10	H. W	2	12, 10	22	11.00				
10	P. A	7	24, 22, 8, 10, 11, 9, 20	104	14.86				
10	W. A	8	23, 8, 10	41	13.67	17	229½	18.50	June 10.
June 11	A. H. W...	9	10, 18, 19, 21, 19, 8½, 10, 22	118½	14.81				
11	H. J. W...	3	19½, 9, 10	38½	12.83				
11	D. A. A...	5	16, 22, 8, 10, 10	66	13.20				
11	J. W	5	11½, 21, 23½, 10½, 12	78½	15.70				
11	P. A	5	19, 15, 11, 10, 13	68	18.60				
11	W. A	2	21, 11	32	16.00	28	401½	14.34	June 11.
June 12	A. H. W...	7	12, 11, 10, 22, 21, 12, 11	99	14.14				
12	H. J. W...	2	10, 11	21	10.50				
12	D. A. A...	3	10, 10, 11	31	10.33				
12	P. A	3	10, 10, 9.	29	9.67				
12	J. W	3	23, 20, 12	55	18.33				
12	H. W	5	8, 9, 10, 11, 12	50	10.00	23	285	12.39	June 12.
June 14	A. H. W...	7	10, 11, 10, 20, 10, 22, 12	95	13.57				
14	J. W	9	10, 11, 11, 12, 13, 12, 12, 23, 11	115	12.78				
14	D. A. A...	3	12, 9, 10	31	10.33				
14	P. A	16	24, 21, 16, 13, 12, 12, 22, 8, 9, 10, 11, 12, 16, 18, 10, 12.	226	14.12				
14	H. H	3	18, 10, 12	40	13.33				
14	H. W	14	13, 20, 12, 13, 11, 10, 11, 23, 21, 11, 12, 10, 10, 9.	186	13.26				
14	W. A	3	23, 10, 11	44	14.67				
14	H. A	6	20, 12, 9, 10, 13, 20	84	14.00	61	821	13.46	June 14.
June 15	A. H. W...	6	12, 12, 11, 10, 9½, 11	65½	10.92				
15	J. W	2	11, 11	22	11.00				
15	P. A	11	20, 10, 11, 21, 22, 12, 10, 11, 12, 9, 23	161	14.64				
15	H. A	1	13, 18	31	15.50				
15	W. A	1	10	10	10.00				
15	D. A. A...	3	9, 10, 12	31	10.33				
15	H. W	6	12, 19, 10, 10, 9, 10	70	11.67	31	390½	12.60	June 15.
June 16	A. H. W...	4	12, 12, 11, 10	45	11.25				
16	J. W	5	10, 11, 13, 14, 14	62	12.40				
16	D. A. A...	5	20, 10, 10, 9, 12	61	12.20				
16	P. A	4	20, 22, 12, 14	68	17.00				
16	H. A	2	12, 18	30	15.00				
16	W. A	2	8, 11	19	9.50				
16	H. W	8	24, 13, 9, 15, 14, 11, 12, 13	111	13.87				
16	H. H	1	10	10	10.00	31	406	13.10	June 16.
June 17	A. H. W...	21	22, 18, 12, 9, 12, 10, 10, 12, 9, 18, 11, 18, 10, 10, 11, 11, 12, 15, 9, 11, 13.	253	12.05				

TABLE I.—*Statement of salmon bought alive at Bucksport in* 1880—Continued.

Date.	Whence received.	Number of salmon.	Weight of salmon.			Daily summary.			Date.
			Several weights.	Aggregate.	Average.	Number of salmon.	Weights.		
							Aggregate.	Average.	
1880.			*Pounds.*						
June 17	J. W	4	11, 12, 11, 11	45	11.25				
17	D. A. A	10	9, 12, 12, 9, 10, 10, 10, 11, 11, 11	105	10.50				
17	H. W	4	10, 12, 12	34	11.33				
17	P. A	9	10, 11, 13, 20, 9, 10, 13, 11, 10	107	11.89				
17	W. A	3	11, 13, 10	34	11.33				
17	H. J. W	2	18 17	35	17.50				
17	H. A	1	10	10	10.00				
17	H. H	2	13, 11	24	12.00	55	647	11.76	June 17.
June 18	A. H. W	12	24, 22, 12, 11, 8½, 10, 10, 11, 11, 11, 11½, 10.	153	12.75				
18	J. W	7	17, 15, 14, 12, 11, 11, 10	90	12.86				
18	H. W	4	16, 21, 11, 20	68	17.00				
18	P. A	5	9, 10, 10, 19, 21	69	13.80				
18	D. A. A	7	15, 12, 10, 12, 21, 12, 8	90	12.86				
18	W. F. A	1	11	11	11.00	36	481	13.36	June 18.
June 19	A. H. W	24	12, 19, 11, 10, 23, 11, 9, 12, 11, 22, 10, 22, 12, 11, 11, 12, 11, 15, 20, 12, 19, 11, 12, 10.	328	13.67				
19	H. W	5	9, 13, 9, 11, 10	52	10.40				
19	J. W	5	18, 11, 10, 10, 12	61	12.20				
19	D. A. A	4	12, 12, 11, 10	45	11.25				
19	H. H	4	10, 10, 11, 12	43	10.75				
19	H. J. W	6	12, 11, 10, 10, 11, 9	63	10.50				
19	A. H. W	3	12, 11, 10	33	11.00				
19	P. A	5	10, 11, 13, 11, 12	57	11.40				
19	H. H	1	9	9	9.00				
19	J. W	2	12, 10	22	11.00				
19	D. A. A	3	9, 11, 12	32	10.67	62	745	12.02	June 19.
June 21	A. H. W	17	22, 12, 12, 11, 23, 12, 12, 11, 11, 10, 10, 10, 12, 22, 20, 16, 12.	238	14.00				
21	J. W	3	11, 11, 17	39	13.00				
21	D. A. A	17	23, 21, 11, 11, 20, 10, 22, 19, 20, 11, 11, 11, 9, 9, 9, 10, 10.	237	13.94				
21	P. A	12	22, 10, 11, 12, 14, 13, 10, 12, 15, 14, 9, 9.	151	12.58				
21	H. W	4	11, 11, 10, 12	44	11.00				
21	H. A	1	14	14	14.00	54	723	13.39	June 21.
June 22	A. H. W	6	22, 20, 9, 12, 19, 12	94	15.67				
22	H. W	5	20, 19, 13, 8, 19	79	15.80				
22	D. A. A	2	14, 12	26	13.00				
22	P. A	5	11, 12, 21, 13, 15	72	14.40				
22	H. A	2	13, 15	28	14.00	20	299	14.95	June 22.
June 24	A. H. W	2	24, 10	34	17.00				
24	H. W	9	18, 14, 12, 9, 9, 11, 12, 11, 13	109	12.11				
24	J. W	4	8, 9, 11, 12	40	10.00				
24	D. A. A	1	10	10	10.00				
24	H. H	2	12, 10	22	11.00	18	215	11.94	June 24.
June 26	A. H. W	4	12, 11, 10, 11	44	11.00				
26	H. W	7	20, 10, 13, 12, 12, 9, 11	87	12.43				
26	P. A	6	20, 20, 21, 22, 9, 12	104	17.33				
26	H. A	1	9	9	9.00				
26	W. F. A	2	10, 9	19	9.50				
26	D. A. A	1	10	10	10.00	21	273	13.00	June 26.
June 28	A. H. W	2	24, 11	35	17.50				
28	D. A. A	1	19	19	19.00				
28	P. A	2	22, 11	33	16.50				
28	H. A	2	11, 20	31	15.50				
28	W. F. A	1	9	9	9.00	8	127	15.87	June 28.

TABLE I.—*Statement of salmon bought alive at Bucksport in* 1880—Continued.

Date.	Whence received.	Number of salmon.	Weight of salmon.			Daily summary.			
			Several weights.	Aggregate.	Average.	Number of salmon.	Weights. Aggregate.	Weights. Average.	Date.
1880.									
June 29	A. H. W...	5	12, 12, 11, 11, 10	56	11.20				
29	D. A. A...	5	22, 9, 12, 12, 11	66	13.20				
29	H. W	6	12, 21, 15, 11, 12, 19	90	15.00				
29	J. W	4	11, 9, 10, 12	42	10.50	20	254	12.70	June 29.
June 30	D. A. A...	2	12, 11	23	11.50				
30	W. F. A...	3	11, 12, 23	46	15.33				
30	P. A	4	10, 25, 15, 12	62	15.50				
30	H. A.	2	10, 12	22	11.00				
30	H. W	2	9, 12	21	10.50				
30	J. W......	5	11, 12, 13, 20, 22	78	15.60	18	252	14.00	June 30.
July 2	A. H. W...	8	20, 9, 10, 12, 18, 10, 10, 12	101	12.62				
2	J. W......	3	20, 10, 14	44	14.67				
2	D. A. A...	2	11, 11	22	11.00				
2	H. W	1	12	12	12.00				
2	P. A	3	11, 14, 11	36	12.00				
2	W. F. A...	2	12, 11	23	11.50	19	238	12.53	July 2.
			Total	...	......	522	6,787½	13.00+	

TABLE II.—*Record of shipment of salmon spawn from Bucksport, December, January, and February, 1880–'81.*

Date.	Consignee and address.	Final destination.	On whose account.	For what State.	No. of cases.	Weight of case.
1880. Dec. 8	A. H. Powers, Plymouth, N. H	Plymouth, N. H	New Hampshire Commission	New Hampshire	3	240 240 238
9	E. A. Brackett, Winchester, Mass	Winchester, Mass	Massachusetts Commission	Massachusetts	1	163½
16	H. J. Fenton, Windsor, Conn	Poquonock, Conn	Connecticut Commission	Connecticut	2	220½ 180
16	A. H. Powers, Plymouth, N. H	Plymouth, N. H	Massachusetts Commission	Massachusetts	2	179 170
22	A. H. Powers, Plymouth, N. H	Plymouth, N. H	Massachusetts Commission	New Hampshire	1	148
22	H. J. Fenton, Windsor, Conn	Poquonock, Conn	Connecticut Commission	Connecticut	1	146½
22	C. M. Smith, Norway, Me	Norway, Me	Maine Commission	Maine	1	148
	T. L. Page, Phillips, Me	Rangely, Me	Maine Commission	Maine	2	148 146½
29	H. J. Fenton, Windsor, Conn	Poquonock, Conn	Connecticut Commission	Connecticut	1	149
29	O. A. Dennen, Greenville, Me	Mount Kineo, Moosehead Lake, Me	Maine Commission	Maine	1	109
1881. Jan. 12	T. B. Ferguson, Baltimore, Md	Druid Hill Hatchery, Baltimore, Md	Maryland Commission	Maryland	3	115½ 194 188
13	New Jersey Com'ers, Bloomsbury, N. J	Bloomsbury, N. J	New Jersey Commission	New Jersey	2	150 150
12	C. M. Smith, Norway, Me	Norway, Me	Maine Commission	Maine	1	185
13	O. A. Dennen, Greenville, Me	Mount Kineo, Moosehead Lake, Me	Maine Commission	Maine	1	208
18	R. O. Sweeny, Saint Paul, Minn	Saint Paul, Minn	Minnesota Commission	Minnesota	2	194 173
18	N. K. Fairbank, Chicago, Ill	Geneva Lake, Wis	N. K. Fairbank	Wisconsin	1	55
18	S. G. Worth, Morganton, N. C	Morganton, N. C	North Carolina Commission	North Carolina	1	98
18	J. H. Dinkins, Austin, Tex	Austin, Tex	Texas Commission	Texas	1	110
18	A. H. Powers, Plymouth, N. H	Plymouth, N. H	Massachusetts Commission	Massachusetts	1	171
24	Seth Weeks, Corry, Pa	Corry, Penn	Pennsylvania Commission	Pennsylvania	1	91
Feb. 8	E. M. Stilwell, Bangor, Me	Bangor, Me	Maine Commission	Maine	1	108
15	Mrs. J. H. Slack, Bloomsbury, N. J	Bloomsbury, N. J	New Jersey Commission	New Jersey	1	184½
15	T. B. Ferguson, Baltimore, Md	Druid Hill Hatchery, Baltimore, Md	Maryland Commission	Maryland	1	220
22	E. M. Stilwell, Bangor, Me	Bangor, Me	Maine Commission	Maine	2	270
27	E. M. Stilwell, Bangor, Me	Bangor, Me	Maine Commission	Maine	1	210
Total					35	

TABLE II.—*Record of shipment of salmon spawn from Bucksport, December, January, and February, 1880–'81*—Continued.

Date.	Consignee and address.	Number of eggs.			Distance transported.	Date of arrival at final destination.	Date of unpacking.	Hours en route.	Condition.	No. died on journey.
		Belonging to State.	Donated by U. S.	Total.						
1880.					Miles.					
Dec. 8	A. H. Powers, Plymouth, N. H	44,000	156,000	200,000	404	Dec. 10, 1880, 9 a. m.	Dec. 10, 1880, 12 m.	50	Good	284
9	E. A. Brackett, Winchester, Mass	50,000	....	50,000	225	Dec. 10, 1880, 9 p. m.	Dec. 11, 1880, 9 a. m.	38	...do	254
16	H. J. Fenton, Windsor, Conn	....	140,000	140,000	391	Dec. 18, 1880, 10 a. m.	Dec. 18, 1880, 4 p. m.	51	...do	297
16	A. H. Powers, Plymouth, N. H	120,000	....	120,000	404	Dec. 17, 1880, 2 p. m.	Dec. 17, 1880, 4 p. m.	31	...do	280
22	A. H. Powers, Plymouth, N. H	....	50,000	50,000	404	Dec. 24, 1880, 10 a. m.	Dec. 24, 1880, 12 m.	51	...do	24
22	H. J. Fenton, Windsor, Conn	....	50,000	50,000	391	Dec. 24, 1880, 10 a. m.	Dec. 24, 1880, 2 p. m.	51	...do	89
22	C. M. Smith, Norway, Me	....	50,000	50,000	210	Dec. 23, '80, 12.30 p. m.	Dec. 23, '80, 1.30 p. m.	29½	...do	12
	T. L. Page, Phillips, Me	....	100,000	100,000	177	Dec. 24, 1880, 10 a. m.	Dec. 24, 1880, 11 a. m.	51	Good, best I ever saw	67
29	H. J. Fenton, Windsor, Conn	....	60,000	60,000	391	Jan. 1, 1881, 10 a. m.	Jan. 1, 1881, 2 p. m.	51	Good	105
29	O. A. Dennen, Greenville, Me	....	37,500	37,500	121	Jan. 2, 1881, 10 a. m.	Jan. 2, 1881, 11 a. m.	122	Extra good	8
1881.										
Jan. 12	T. B. Ferguson, Baltimore, Md	....	200,000	200,000	694	Jan. 14 and 15, 1881, 5.30 p. m., 9.30 a. m.	Jan. 15, 1881, 5.30 p. m.	58½	Excellent	55
12	New Jersey Com'ers, Bloomsbury, N. J.	....	100,000	100,000	572	Jan. 14, 1881, 7 p. m.	Jan. 14, 1881, 9 p. m.	60	In first-class condition	27
13	C. M. Smith, Norway, Me	50,000	....	50,000	210	Jan. 14, '81, 12.50 p. m.	Jan. 14, '81, 1.30 p. m.	30	Good	4
13	O. A. Dennen, Greenville, Me	....	62,500	62,500	121	Jan. 16, 1881, 5 p. m.	Jan. 17, 1881, 9 a. m.	82	...do	8
18	R. O. Sweeny, Saint Paul, Minn	....	150,000	150,000	1,682	Jan. 22, 1881, 7 p. m.	Jan. 23, 1881	108	...do	68
18	N. K. Fairbank, Chicago, Ill	....	10,000	10,000	1,291	Jan. 22, 1881, 4 p. m.	Jan. 22, 1881, 4 p. m.	102	In good condition	27
18	S. G. Worth, Morganton, N. C	....	20,000	20,000	1,404	Jan. 24, '81, 12.30 p. m.	Jan. 24, 1881, 4 p. m.	148	Very good	25
18	J. H. Dinkins, Austin, Tex	....	3,000	3,000	2,225	....	....	....	Bad *	All.
18	A. H. Powers, Plymouth, N. H	49,500	....	49,500	404	Jan. 19, 1881, 3 p. m.	Jan. 19, 1881, 5 p. m.	32	Good	28
24	Seth Weeks, Corry, Pa	....	25,000	25,000	857	Jan. 28, 1881, 10 a. m.	Jan. 28, 1881, 12 m.	99	...do	10
Feb. 8	E. M. Stilwell, Bangor, Me	80,000	....	80,000	26	Feb. 8, '81, 2.30 p. m.	Feb. 8, 1881, 3 p. m.	7	...do	14
15	Mrs. J. H. Slack, Bloomsbury, N. J	....	30,000	30,000	572	Feb. 18, 1881	....	....	....	9
15	T. B. Ferguson, Baltimore, Md	....	20,000	20,000	694	Feb. 17, '81, 4.40 p. m.	Feb. 18, 1881, 2 p. m.	57⅝	Excellent	5
22	E. M. Stilwell, Bangor, Me	110,000	....	110,000	26	Feb. 22, 1881	....	8	Good	12
27	E. M. Stilwell, Bangor, Me	68,000	6,000	74,000	26	Mar. 1, 1881, 3 p. m.	Mar. 1, 1881, 4 p. m.	8	...do	....
Total		571,500	1,270,000	1,841,500						

* The consignee of this lot was absent at time of their arrival; had made no preparation for their reception, and they were not unpacked until all were spoiled.

TABLE III.—*Hatching of Penobscot salmon from eggs collected in 1880.*

Place of hatching.	In charge of hatching.	Total number of eggs sent from Bucksport.	Died in transit.	Died in incubation.	Number hatched.	Died after hatching.	Number of fish sent out.	Number actually planted.
Connecticut, Poquonock	H. J. Fenton	250,000	491	2,058	247,451	1,820	245,631	245,631
Maine, Bangor	E. H. Gerrish	234,000	26	15,293	218,689	8,689	210,000	210,000
Maine, Machias	Ellis Hanscom	30,000	....	1,000	29,000	100	28,900	28,900
Maine, Mount Kineo	O. A. Dennen	100,000	16	25	99,959	500	99,459	99,459
Maine, Norway	C. M. Smith	100,000	16	4,012	95,972	3,200	92,772	91,997
Maine, Rangely	F. C. Hewey	100,000	67	575	99,358	358	99,000	99,000
Maryland, Baltimore	W. H. Jenkins, jr	220,000	60	2,138	217,802	2,564	198,432	198,432
Massachusetts, Winchester	E. A. Brackett	50,000	254	812	48,934	934	48,000	48,000
Minnesota, Saint Paul	S. S. Watkins	150,000	68	391	149,541	89,541	60,000	60,000
New Hampshire, Plymouth	A. H. Powers	419,500	616	7,533	411,351	16,351	395,000	395,000
New Jersey, Bloomsbury	A. A. Anderson	130,000	36	381	129,583	940	128,643	128,643
North Carolina, Morganton	E. M. Robinson	20,000	25	263	19,712	712	19,000	11,000
Pennsylvania, Corry	Seth Weeks	25,000	10	110	24,880	545	24,335	24,335
Wisconsin, Walworth	W. A. Welsher	10,000	27	75	8,898	8,898	1,000	1,000
		1,838,500	1,712	33,766	1,801,130	135,311	1,650,072	1,641,397

TABLE IV.—*Distribution of Penobscot salmon reared from eggs collected in 1880.*

States.	Where finally hatched.	Waters stocked.	Tributaries in which fish were placed.	Locality.	Date of transfer.	Number of fish.
					1881.	
Connecticut	Poquonock	Connecticut River	Farmington River	Hartland, Hartford County	March 14	40,000
		Do	do	do	March 19	40,000
		Do	do	do	March 21	40,000
		Do	do	do	March 22	40,000
		Do	do	do	April 7	40,000
		Do	do	do	April 21	45,631
Maine	Bangor	Penobscot River	Baskahegan River	Danforth, Washington County	May 16	28,000
		Do	Sandy Brook	do	May 23	20,000
		Do	do	do	May 24	28,000
		Do	Baskahegan River	do	May 25	28,000
		Do	Sandy Brook	do	May 26	28,000
		Saco River	Saco and Ellis Rivers	Bartlett, New Hampshire	May 27	35,000
		Penobscot River	Mattawamkeag River	Bancroft	May 30	15,000
		Kennebec River	Maranacook Lake	Readfield, Kennebec County	May 31	8,000
		Androscoggin River	Lake Auburn	Auburn	June 1	20,000

	Machias	*Machias River*	*Great Brook*	*Whitneyville*		9,000
		Do	*Dan Hill Brook*	do		9,000
		Do	*Longfellow Brook*	do		7,000
		Denny's River		Dennysville		3,900
	Mount Kineo	Kennebec River	Masterman Brook	Tombegan Township	June 22	20,000
		Do	Shaw Brook	Day's Academy Grant	July 2	20,000
		Do	Mansell Brook	Somerset County	July 2	10,000
		Do	West Outlet	do	July 2	19,459
		Do	Moosehead Lake	Piscataquis County	July 2	10,000
	Norway	Presumpscot River	Rogers' Brook	Bridgeton, Cumberland County	May 19	9,975
		Do	Carsley and Eddison Brooks	Harrison, Cumberland County	May 20	5,500
		Do	Crooked River	Norway, Oxford County	May 24	29,800
		Do	do	do	May 25	20,000
		Do	do	do	May 26	19,950
		Do	do	do	June 4	6,772
	Rangely	Androscoggin	Rangely Lakes and tributaries	Franklin and Oxford Counties	June 1-10	99,000
Maryland	Baltimore	Octorara River	Octorara River	De Graw's Mill	April 5	10,000
		Elk River	Elk River	Cecil County	April 5	6,432
		Great N. E. Creek	Stone Run	do	April 5	7,000
		Potomac River	Potomac River	Oakland	April 17	20,000
		Do	Conococheague Creek	Hagerstown	April 19	20,000
		Do	Potomac River	Bloomington	April 20	40,000
		Do	do	Sir John's Run	April 26	20,000
Massachusetts	Winchester	Merrimack River	Nashua headwaters		May —	48,000
Minnesota	Saint Paul	Saint Croix River	White Bear Lake	Ramsey County	March 9	10,000
		Prior Lake	Prior Lake	Scott County	March 11	10,000
		Saint Croix River	Forest Lake	Washington County	March 24	10,000
		Cannon River	Lake Kasota	Waterville, Le Sueur County	March 31	10,000
			Lake Elysian	Janesville, Waseca County	April 5	10,000
		Mississippi River	Lake Minnetonka	Minneapolis	April 7	10,000
New Hampshire	Plymouth	Merrimack River	Contoocook River	Hillsborough, Hillsborough County	May 3	30,000
		Do	Pemmigewasset River	Compton, Grafton County	May 3-31	365,000
New Jersey	Bloomsbury	Delaware River	Delaware River	Shoemaker's Eddy, Warren County, between Columbia and Flatbrookville.	March 28	30,000
		Do	do		March 29	30,000
		Do	do		April 1	30,000
		Do	do		April 2	20,000
		Do	do		April 4	18,643
North Carolina	Morganton	Catawba River	Mill Creek	Old Fort, McDowell County	March 28	5,000
		Do	Linville River	Morganton	March 29	4,000
		Do	do	do	March 30	2,000
Pennsylvania	Corry	Susquehanna River	Towanda Creek	Towanda, Bradford County	April 26	24,335
	Baltimore, Md.	Do	Juniata River	Huntingdon County	April 26	22,000
		Do	Lycoming Creek	Lycoming County	April 28	26,000
		Do	Juniata River	Huntingdon County	April 30	27,000
Wisconsin	Walworth	Illinois River	Geneva Lake	Walworth County		1,000
						1,640,738

XXIV.—REPORT ON THE PROPAGATION OF SCHOODIC SALMON IN 1880-'81.

By CHARLES G. ATKINS.

1.—GENERAL SUMMARY.

The only important changes or improvements in the fixtures at this establishment this season were the construction of two short aqueducts at the old house in the woods and the beginning of a new house at a cove on the west side of the lake close by the dam. The latter was at first intended to be used as supplementary to the other two houses, but it has proved so useful and to possess such facilities that it may yet become our headquarters.

This has been, on the whole, the most prosperous season we have experienced. We caught 2,171 Schoodic salmon of uncommonly large size; 1,473 were females (an unusually large proportion), and 1,427 of these yielded 2,326,740 eggs, an average of 1,630 each, twice the yield common ten years ago. There has been an increase in the vigor and hardiness of the embryos as developed in the hatching houses, due, possibly, in part, to the greater health and vigor of their parents, but probably in greater degree to the better treatment, the greater supply of water, and its better aeration secured by our new facilities. Resulting from this was a greater degree of success in the transportation of the eggs shipped and in their subsequent hatching and rearing, and a marked improvement in the vigor of the fry hatched from the reserved eggs. The new house in which the latter were hatched stands on a hillside, and affords abundant facilities for aerating the water, which we so much needed at the old house. I expect this increased vigor of the young to tell on the future supply of adults in the lake.

The losses sustained during the development of the eggs were only such as ordinarily occur here. As determined by count or careful measurement, they amounted to 218,240, or 9 per cent., reducing the entire stock to 2,108,500. The 25 per cent. reserve still further reduced the number available for shipment to 1,581,500. A *pro rata* division gave the subscribers the following shares, viz: The United States, 527,000; Maine, 124,000; New Hampshire, 124,000; Massachusetts, 310,000; Connecticut, 496,500. All of these were shipped except 10,000 out of the share of Maine, and 30,000 donated to Maine by the United States, which were retained to be hatched for private parties to whom they had been allotted.

The shipment of spawn was made between January 10 and March 28. All were packed in wet bog moss inclosed in dry moss or leaves, in capacious wooden boxes. They were transported on a sled or "pung" to Princeton, 12 miles, and after a stay of a night, thence on the rack of a sleigh 28½ miles further, to Forest Station on the European and North American Railway. Severe weather was often encountered, but only in one instance, or at most in two, does there appear to have been any injury done to the spawn.

The subsequent development and growth of the eggs were very generally satisfactory.

Further details of operations are given in the subjoined notes from my diary, and the tables of "spawning operations," "shipment," and "transportation" of spawn.

2.—Diary.

Grand Lake Stream, 4th November, 1880.—Arrived from Bucksport at 9 p. m. last night, having come through in one day.

Mr. Munson and Mr. Ripley have been at work steadily since my former visit. The aqueducts are all done and in working order. The nets have been maintained at the head of the canal and at the old coffer-dam near by, 270 feet above the driving dam, but no attempt has been made to put in pounds or take any fish. From time to time considerable numbers of them have been seen above the nets, sometimes coming down in heavy schools to the nets. M. told me last night that he had seen no nests made anywhere, but had not looked yesterday. Had looked often before that.

No fish have got into the stream or canal except on one occasion. On the night of October 2, Forbes watched till half-past twelve o'clock, and then went to bed. During the night some one came and plugged up two of the aqueduct logs that Cavanagh had bored, and then took our boat, went to the canal net, cut it down from top-line, inclusive, in one place 4 feet, and in another a boat's length away, 5 feet, and then passed on down the canal letting the boat drift down to the bridge. The net straightened out on the bottom flat, and let fish freely down over it. Munson examined the canal and thinks sixty or seventy ran down at that time. From that date on, Forbes has watched all night long and has, he says, been over by boat to the canal net about once an hour.

The lake has risen, M. thinks, about 4 inches from the lowest stage, now standing at 1 foot 10 inches.

November 4.—I find on examining that several salmon nests have been commenced on the bar above our nets.

We begin to-day early to put in the pounds, very nearly as on last year's plan. We got three of the pounds ready for fish, and they began to come in before the work was done. They came in very freely in the evening.

November 5.—As usual, the most of the fish came in in the early part of the night. This forenoon we got in the remaining pounds and in the afternoon commenced taking spawn.

The fish taken last night are remarkable for size, and are fully up to the average of former years in plumpness and health. This is the evidence of the eye, and so far as the measurement goes, it bears out this conclusion.

November 6.—Not so good a run last night as the night before. The size of the fish is, however, fully up to the first. I went down to the bark-mill and examined the whole length of the canal. Counted thirty-four Schoodic salmon, probably nearly half females. There may have been some that escaped me, but I do not think there are forty in all in the canal. I think they are making nests a little more than two-thirds of the way down. It is possible that some fish get through our net now from time to time, where it goes round the main pier, for Ripley and Munson have found some holes in it.

Just above the dam I saw this afternoon three females spawning, and six to ten males fighting over them; one little yearling or bi-yearling, with bars. Below the dam I looked the gravels and rapids over carefully and found no evidence of salmon having been there this year. Nor anywhere below the dam could I see nest or fish, except one male fish in old channel at head of saw-mill flume.

It does not follow that these fish at the dam and below escaped through our net, for it may be that they have lain below our nets all the season.

I have seen two yearling or bi-yearling salmon—one at the dam, one at the pounds; the latter showed the bars and spots plainly, but was, I think, fully 8 inches long. The new nets of which our pounds are this year largely built will hold a fish of this size.

November 7.—The run of salmon last night was smaller than either of the other two nights, probable not over 100. The rain continued with a southerly wind all night. Between 6 and 7 a. m. we drove the fish into third pound. During the forenoon others came in, more in number, Munson thinks, than during last night. These were driven through with the others into pound 3, and so was another good drive late in the afternoon. In the evening I stood for an hour quite still by the weir, watching for fish to enter, but only four came in during that time. I saw two females spawning just outside the entrance within 10 feet of me; those that came in and others that lingered about did not manifest any fear of me; I think they did not see me. Forbes says that last night the fish all about, both within and without our pounds, were very quiet; to-night he says they are much less so.

Munson put a whole net around the pier.

At the hatching house I find that Mr. Munson has the water from the west aqueduct running into the troughs, and it is strongly colored, but not roily—a good deal of it. Temperature of water of both aqueducts 48°, of spring water 46°.

We looked at a number of the trays of eggs already in the house, and selecting one appearing to contain about average number of eggs Munson and I counted them out with spoons. They counted 2,087. This calls for an increase of estimated number of eggs. The tray was more than covered.

In taking eggs I do not think we have thus far exercised due care in the agitation of the eggs and milt to secure contact. We took, as the record shows, pretty heavy panfuls of eggs before washing off, and we did not agitate constantly enough to suit my idea. I think I shall establish it as a rule never to have the eggs in a pan more than two layers deep. Perhaps one layer would be better. Then as soon as one layer was impregnated they could be turned out into another pan, and when several of these have been collected thus together we could weigh them, thus avoiding frequent weighings.

In former years we have used every male that came to hand. This year I have begun the practice of putting all poor looking and small males directly over into the final pound. It is convenient to pass out all less than 19 inches in length. That would leave us plenty for use this year. But I have not thus far followed this or any other strict rule.

November 8.—A large run of fish yesterday, a small one during the night, and another large one to-day. Both these days have had clear weather, so that in these instances the salmon have run into our inclosures best in daylight and clear weather.

We have from the first, each day (except Sundays), handled over the fish taken the previous twenty-four hours, and immediately taken the spawn of those ripe. We have in no case up to date counted or assorted any of the fish caught until we took them in hand for spawning.

November 9.—They have not been scowing bark down the canal for some time, much to our satisfaction; but to-day they began again, and we must lower the net for them. I saw an eel in the second pound last night, and several nights ago I saw one of large size outside the entrance of the first pound. Have begun the building of a little jetty from the west bank, just above mouth of Ripley's Brook, to keep the water of the brook from mingling with that of Grand Lake in the pool that supplies our aqueduct. I shall merely throw out a narrow mole of earth and face it with stones—two or three days' work.

November 10.—Overhauled the main pound. Find exactly the number of full females that we put there. Don't think any of them have laid any eggs, though there have been a good many attempts at digging in the pounds. The greater part of the females are still unripe; the most of them very hard.

I have now one man all the time ready to take the pans of eggs immediately from the spawn-takers, to stir them up thoroughly, and then immediately weigh them and wash them off.

November 11.—At the old hatching house I find temperature in the troughs 43°; of the west aqueduct, 41°; of the spring, 46°; of the north aqueduct, 44°. In the west aqueduct we get highly-colored water. It is unfiltered, but we propose to fill up the large collecting tank with gravel to form a filter.

November 12.—In old hatching house I find fifth faucet running two-fifths of a quart per second—6 gallons per minute—and for four troughs 30 gallons per minute. This includes the spring and the west aqueduct, the brook not having been admitted and the east aqueduct being temporarily shut off on account of roily water. The east aqueduct is delivering 7½ gallons per minute. Total for whole house, 37½ gallons per minute. There was a half inch of rain last night, and the brooks around the hatching house are running full. The fish taken now are almost wholly females, which indicates that the run is drawing to a close.

We have taken now (7 p. m.) from 417 females, say, 760,000 eggs; 759 females on hand will yield, say, 1,200,000; total, 1,960,000. I think we have a good prospect of catching 400 more fish, of which 324 females will yield, say, 480,000, making total for the season (estimate) 2,440,000.

November 16.—I calculate our trough capacity thus:

At old hatching house:		
Eight troughs, at 80,000 each		640,000
Two troughs, at 100,000 each		200,000
		840,000
At new hatching house:		
(Already in use) two troughs, deep, at 360 M	720,000	
(To be fitted to-day) two troughs, deep, at 320 M	640,000	
(To be brought from old house) one long shallow trough (10 inches, nine stacks)	180,000	
(To be brought from old house) one short shallow trough (6 inches, 6 stacks)	120,000	
		1,660,000
		2,500,000

To fit these out we need 34 deep frames; on hand, 27; the remainder supplied by repairing three frames and making four new ones. We have in the new house and in the storehouse, including those in use, 882 trays, with capacity of 1,646,000 eggs, proper allowance having been made for covers. The hatching trays with oblong meshes have not yet been brought into use, but shall have to use them.

I am reckoning 2,000 eggs per tray. Have had three trays (appearing to contain average) counted, and have got the following results: First tray, 2,087; second tray, 2,040; third tray, 2,025. I think it would be safe to reckon 2,030 per tray; that would increase our estimate 1½ per cent.

We have now by our original reckoning, 1,574,000 eggs; on a basis of 2,030 per tray we should add 23,610—making 1,597,610.

Blodgett counted the eggs of a large female on yesterday's record and found 1,950.

Munson tells me of having discovered a copious spring about half a mile back from the old hatching house; the water from it flows in the other direction, and he thinks the land is "too flat" to bring it to the hatching house.

Now that we are threatened with a very large crop of eggs, I am beginning to consider the facilities existing within our reach for the hatching out of the 25 per cent. reserve. The trough-room in the old hatching house will hardly suffice for the hatching of 300,000; indeed I think 250,000 quite enough; that is what we had last winter. We could put in extra troughs on the floor so as to accommodate, say, another 100,000 or 150,000 by occupying the aisles. But this would be very inconvenient, and it would be much better to put all the extra troughs outside the present building, under a temporary roof. It would also be practicable to put in a house near the east spring.

But after all is it desirable to hatch these fish out here in the woods? The carrying them out to the stream is a laborious job, and very unpleasant in fly and mosquito time. It goes on so slowly, too, that when we have a large number of fish we can hardly get them out in season except by putting on an extra force, and that would necessitate the employment of a less careful man than Munson. Munson says that he brought them all out last year by hand in tin pails pretty nearly full, I suppose holding two gallons of water each. In each pail he took, he guesses, about 500 and made eight trips per day. Thus with two pails a trip it would take 500 trips and over sixty-two days to carry out the 500,000 young fish which we hope to turn out next spring.

I am anxious to save part of this labor and risk, and am thinking of putting in a hatching house, cheap and temporary, near Forbes' Cove, into which I can lead the water near at hand; and also the spring back of Calligan's house if at some future time it appears worth while.

November 17.—To-day we overhauled pound 5, containing the unripe fish on hand from catchings previous to to-day. We took a large quantity of eggs. Having now spawned all but 154 of our females, we are going to proceed immediately to boat the spent fish up the lake. This evening made a beginning by taking up two boat loads (one trip) to a point on the west shore nearly opposite Half Moon Island. They were turned out on a shore of cobblestone. We have discussed carrying them to Mayberry Cove, and all think it would be a fine place to let them out, but apparently it is too far.

Last year the fish were all taken up on the other shore and let loose near Munson's Island. Munson tells me of a deep cove, where part of the fish were turned out and where he afterwards saw traces of their having scratched about. He thinks they do not linger on a rocky shore, but do on a sandy shore. I think that on a shore of proper grade, say fine gravel (or coarse sand, like Mayberry Cove), the fish might find bottom on which they might be satisfied to finish their digging for the season, instead of returning to the stream. The men got back this trip a little after 11 o'clock.

November 18.—This morning quite a number of fish in the outer pound, and among them undoubtedly some of those that were carried up late last night. We know them by their abraded noses, which a great many of the males had.

November 19.—Sent up four boat loads of fish to-day.

November 20.—Sent up four boat loads of fish to-day.

November 22.—Windy and cold. The ice has prevented our doing anything at boating fish since 20th. Have not given up hopes of being able to do something more in that direction, but don't expect to get any more good fish. Have therefore lifted the nets around the first and second pounds, and let all the fish hereafter coming in escape.

November 23.—Lake closed last night for half a mile up.

November 24.—This morning I heard the ice cracking and snapping about 4 a. m., and after. This did not attract my attention at first, but when it did I merely supposed that the saw-mill had been started at an early hour, and had, as usual, drawn down the water near our house. But between five and six o'clock it occurred to me to go down to the stream and look. I found the water very low, and could hear no sound of rushing water from the dam. I ran up to the dam and found that all the gates (seven, and all open) were clogged up with anchor ice so that no water could be perceived running through. We immediately turned to with shovel and pick and soon had the water running again. This was similar to the jam of two years ago. I thought then that the ice all formed above and merely came down with the wind, but I am sure that in this instance the ice must have formed in the gates or close above them, for there was a sheet of ice across above at the old coffer-dam and nearly all the way as far as we could see. Apparently the water did not cease to run in our hatching troughs, and no harm was done.

November 25.—Lake frozen almost as far as we can see. All the fish on hand (say 500) let loose. Nets all submerged (except the cross-net, to prevent fish running down to the dam and the canal net). They were so frozen to stakes and encumbered with ice that I could not hang them on stakes as I had intended, so sunk them and kept them down with the chains and stones to thaw out.

November 26.—I find at old hatching house 20.33 gallons of water per minute. Of this the north aqueduct furnishes 4.28 gallons; west aqueduct, 6.00 gallons; old spring, 10.05 gallons. Temperature of water in the hatching troughs 41°. Tested the Widdifield thermometer in use there, and found the mercury to sink ½ degree below the mark at freezing point. Plunged it in snow and water. The long Wilder thermometer in use now at the house is just right at 32° F. The oil-testing thermometer of Widdifield also shows ½° below the 32° mark. The latter will hereafter be used at the stream-hatching house.

November 27.—Dragged the nets, except cross-net, out of water, and hung up in spawning-shed.

November 30.—Left for Bucksport early in the morning.

January 7, 1881.—Returned from Bucksport yesterday. The new hatching house at Forbes' Cove is boarded, roof shingled, single upper floor laid, upper windows in. S. S. Sprague and George Macartney have been at work at it most of the time since I left, and at that time I had had perhaps $15 worth of work done on excavation. The water appears to be in fair supply, and the little pool under the rock, near the corner of the hatching house, has not frozen over at all.

At the old hatching house the water is getting very low. The measurement to-day gives 8.919 gallons per minute. Of this I find by measurement that the north aqueduct yields 1.875 gallons (or say 1.919), and of the remainder I judge from temperatures that the brook gives one-seventh and the main spring six-sevenths (say one gallon and six gallons per minute. In the rough, one gallon, six gallons, and two gallons). Temperature of main spring to-day, 42°; of north aqueduct, 39°; of brook water, 35°; of water in troughs, 41°. All the eggs are apparently doing well. I looked at several lots from both upper and lower ends of trough, and could distinguish no difference. All the embryos that I saw were strong, with good color and well marked veins. They are all fit to ship, but I think the oldest can wait two or three weeks safely. I shall, however, try to send some away immediately, for we have so many that we must send in two or three batches, first clearing the house, and then bringing out another lot from the stream to develop, and finally a third batch. I hardly dare to bring out next time as many eggs as we have now in the old house (855,000), for I am not satisfied that it is safe with 9 gallons of water—the present limit.

This afternoon Mr. Munson turns some of the earliest eggs, preparatory to picking out unfertilized. He performs the operation thus: He brings the stack to the table, capsizes them into a long, shallow pan of water, pours them from this pan into a common milk-pan, and then pours them from milk-pan to milk-pan five times, holding the pan about 8 inches high each time. He says this is sufficient, according to his observation, and does not injure the good eggs. [I find subsequently that there is quite a percentage in some of the trays of unfertilized eggs remaining clear after this operation, and think it would be better to have the pan held 1 foot high each time, but Mr. Munson thinks these instances were on trays turned by some one else than himself.] After turning, the eggs are replaced on the trays and remain a day or two, when they are picked over. Those turned to-day will be picked to-morrow and packed Monday.

January 10.—To-day began packing. Packed lot 1 (except 2,000 kept for hatching), all of 2 and 3, and 64,500 out of lot 4. Sent away 50,000 to Grand Falls, N. B.

So far as I am able to see, these eggs are in prime order. The fish are not very large—apparently not very near hatching (not so near as I expected to find them, but perhaps as near as I ought to expect; last year the record showed lot 1 was half hatched February 23, and all out March 1). The veins show well, and those at lower end of trough appear as good as any. I have seen no prematurely hatched fish; scarcely any defective ones. All in this house are ready to ship; not much difference in their stages of development, to be sure; only six days difference in their ages.

The picking of eggs has been every three days in the old house and every six days in the stream house.

The eggs in the stream house are very backward. The trunk of the fish can be discerned by close examination, but that is all; not near coloring yet.

January 11.—The packing proceeded to-day until near 2 p. m., when we had three cases ready, all of which went to H. J. Fenton, Windsor, Conn. The first was a 50-thousand case packed with dry moss; the second and third were 80-thousand cases and packed with dry leaves. We have in all cases 3 inches space around the inside boxes.

January 13.—Munson and Macartney worked yesterday all day at "turning" the eggs in the old house and turned 17½ trays. To-day they and Forbes worked all day at picking them (and a few others) over; =400,000 turned by two days' work and picked by three days' work; and only one of these men is an adept.

The results of picking pretty satisfactory. For instance, lot 7, estimated originally at 276,000, picked to-day 12,700 = 4.6 per cent., but some lots much worse.

On 12th in packing I observed just two collapsed eggs in lot 4; no others.

On 11th we shut off water from faucet 1 in old house and shut off most from faucet 2, which feeds now only the remnant of lots 1 and 5 and part of lot 6, not over 20,000 in all.

We measured the volume of water and found 8.103 gallons per minute, which showed a falling of one-eighth, or 12½ per cent., since 7th.

The weather is mild to-day and cloudy, with indications of speedy rain.

At stream hatching-house Blodgett finds 109 gallons per minute. This is the highest head, the head trough being nearly full. When saw-mill is running the amount of water is less. This all runs through without seriously disturbing the eggs.

January 18.—The packing of spawn is waiting until I receive Professor Baird's schedule, which I expect to-morrow. All the eggs in the old house have been picked and are all ready. None have been carried out from the stream yet. The eggs in the stream house very backward. One day last week a man dropped one tray, and out of it Mr. Munson has since picked 1,800, which shows that they are very tender.

January 19.—Having the unimpregnated eggs picked out ahead as far as lot 12 (and all but 1½ stack of that), Munson, Forbes, and Macartney began packing this morning for shipment. During the day they put 195,000 into the packing-boxes, and put 130,000 of these in the cases.

I got Professor Baird's schedule to-day and immediately began to fill it.

January 20.—Yesterday evening I took a deep (3¼-inch) packing-box and filled it with damp moss and put it out in the wood-shed of the old hatching-house on an empty three-quarter-inch case, covered it with an empty packing-box, and left it from 8 p. m. till 8 a. m. to-day. Meanwhile the temperature at dwelling-house was +7° all night, and at shed on the top of this box the thermometer stood at 9° at 8 a. m. On opening, I found that the moss was frozen into a solid mass on top and sides and a little on bottom; by careful measurement, .85 inch on sides, 1.2 inch on ends, 1.6 inch diagonally at corners, one-quarter inch on bottom, and five-eighth inch on top. The moss was from under the bench, the same that we are using constantly in packing eggs; was fully as damp as average; received no extra water; was pressed in hard, much harder than we press with eggs. Had a three-fourths-inch board under it and a one-fourth over it (packing-box bottom). The sides were three-eighths inch thick, ends a little over one-fourth, bottom one-fourth; temperature of moss originally about 35°.

Up to to-day we have used for outside packing only leaves, except in the case sent to Mr. W. H. Barber, Grand Falls, N. B. But to-day we used moss only and packed eight small cases.

To-day I tried the temperature of moss under the table and found it 35°. Also temperature of heap of dry moss up aloft, and found it 37°. The moss was all gathered on a bog on the south side of Princeton road, about 1½ miles out. The dry was dried by spreading out on the open ground near our dwelling-house, after hauling green from the bog. The bog near our hatching-house used to furnish our moss, but we pulled it all over, and the new growth is still too short for use.

I am going to try comparative efficacy of leaves and moss for outside packing. Would like also to try cat-tail-flag down, if I could find enough of it.

In packing the eggs sent to-day we put snow on moss under each layer of spawn—light, dry snow, grated or scattered on. We got on from 1 pint to 1 quart in each deep box (10,000 eggs). Besides this the eggs were rinsed off, before packing, in the coldest water at our command (from brook end of bulkhead, temperature 35°).

January 24.—Packing again to-day. We find now and then a bursted shell, but few.

Last Saturday we packed up, out of lot 7, one deep and one shallow packing-box, making about 15,000 eggs in all, in the same style as usual for shipment, and let them stand in the back part of the room. I suppose there the temperature stood at about 34° or 35°, and that they were as wet as those sent away. This a. m. we opened them and found that they have kept well, except that about 10 per cent. of them have shrunk some and are indented on the side; a few were burst. Not likely to send these away again without some picking. We took out what shrunken ones we could see after turning them out into pans of water. Those taken out, numbering about 1,000, we place upon a tray to keep and hatch. After several hours in the water they seem to have about all swollen out to original size. During the first hour in water but few of them swelled out completely. These weak shells have a greater transparency than the others. I have not yet perceived anything inferior in the appearance of the embryo. So far as I have examined, they appear of good size, good color, and with strong veins.

After the plump eggs (from which the shrunken ones had been taken out) had been in water a few hours they were packed up again and went to McDonald, whose package was made up from lots of 8 and 9.

I do not think this shrinking is due to the water being exhausted by an overstock of eggs. Were this so, the eggs at the upper ends of the the troughs would be good and those at the lower ends bad. However, to test this, I have packed up two small trays from lot 9, of which 5,000 same from the lower stack, in trough 8, and the other 5,000 from upper stack, in trough 9. These are appropriately marked and stand in the back part of the hatching-house.

I also overhauled three boxes put up to test modes of packing against cold. They were packed Saturday afternoon and left in the hatching-house till near 10 p. m., when I put them outdoors on the tops of some old hatching troughs arranged right side up, so that the air had access to them on all sides except merely the edges of the sides of the trough. These were packed as if containing eggs for shipment. Inside were trays full of wet moss, and around them 3 inches of dry protecting material, one of dry sawdust, one of dry leaves, and one of dry moss. The first (with sawdust) was a good deal frozen—I think an average of three-eighths of an inch from all sides into the inside moss. In the other two the frost had penetrated, as near as I could judge, an average of not over three-sixteenths of an inch from all sides—in some places a good deal less, of course—this average including the edges and corners, where the frost had penetrated much deeper. I cannot say surely that there is any difference between the dry moss and leaves. If eggs had been in these boxes they would not have frozen, but part of those in the sawdust would.

These boxes were put outdoors Saturday at 10 p. m., temperature then being +14°. Next morning temperature was +11°. As soon as the sun was high enough the boxes were put under a shed, in the shade, but were brought out again after sundown, temperature +11°; at 7 next morning it was +2°. So I should say that the average temperature for the whole 36 hours was about 10½° F., or, that being 21½° below freezing, I may call it (21½ by 36=) 774 degrees of frost. I think I can say that these packages would protect eggs against 1,000 degrees of frost. I am surprised that there should be no showing in favor of dry moss over leaves, and also that sawdust should have done so well compared with them. One of these boxes I had packed in p. m. in same manner with dry moss, and put out in same place at 4.45 p. m.

January 25.—This p. m., at 2.15, I took in and opened the box put out at 4.45 p. m. yesterday. I find that the inside moss is frozen on top about one-eighth of an inch. Without examining further, the boxes were repacked and put out again. This had been out for 21½ hours. Temperature at 7 this morning was—2°; same at 10 a. m.—say an average of about 0 for 21½ hours. Eggs would not have been reached by the frost had the box contained them. Quite a number of the shrunken eggs picked out of lot 7 have been hatched—weak fish. Lot 1 has not yet begun to hatch.

January 26.—This p. m. Munson carried out from stream to old hatching house eight deep stacks of eggs, making sixteen common stacks, or about 320,000 eggs. They are all out of lot 13. They have just reached the stage of sensitiveness; no color in the eyes yet. We handled them very carefully. They were hauled out on the "toboggin."

January 27.—This morning measured water at the old house. It is all flowing in the fourth and fifth faucets, only those troughs being now occupied by eggs.

I find of this the north aqueduct furnishes 1.67 gallons per minute. Temperature of bulkhead 40°; that is from main spring. Temperature of north aqueduct, 37½°.

Last Monday, 24th, we packed a box with wet moss inside, dry moss outside, and put it out at 4.45 p. m.; examined it next afternoon on the top (see that day's notes) and found frost had penetrated about an eighth of an inch, or a little less. It was then put out again and left. To-day I take it in at 9 a. m., and open and examine it all through. I find frost has penetrated on top about one-half inch, and on bottom about three-eighths of an inch; outsides about three-eighths of an inch; in corners 1½ to 2 inches. Had there been eggs in this box the top layer of upper box and bottom of lower box would probably have been frozen, and the corners of other boxes a little, enough to make three layers in all, or a loss of 7,500 out of 35,000 eggs. The temperature meanwhile has been: Monday, 7 a. m., +2°; Tuesday, 7 a. m. −2; Wednesday, 7 a. m., +12½; Thursday, 7 a. m., −1; and the days have been cold throughout.

January 30.—On the 24th I packed up in two shallow packing-boxes (5,000 each) two selections of eggs from lot 9—5,000 from lower stack of trough No. 8, and 5,000 from upper stack of trough No. 9. They were packed as for shipment, and placed on the shelf on the back (west) side of the old hatching house. To-day we unpacked them and put them into trays again. We found some indented, but by no means so many in either of these lots as in those of lot 7, packed for two days, on 22d and 24th, nor were they so seriously indented as those.

Without doubt the indented eggs were most abundant in those from lower end of trough. We picked out 300 of the indented and put them by themselves as lot 27. The eggs from lower end of trough are numbered 25; those from upper end, 26. Lot 24 consists of the shrunken (indented) ones of lot 7 that were picked out from those picked for experiment on 24th. So far as this goes it rather indicates that the water, after passing through a good many stacks, has lost part of its nourishing powers, and from this cause the shells are weak; but this single experiment is by no means sufficient to settle the question, for there may have been, even in this case, some other difference in the eggs, or some difference in the packing, that would account for it. I think these were packed better than on 22d. Don't know about the pressure. I am inclined to think dryness most favorable to indentation, and that great pressure may favor it some. As to exhaustion of water, this presents the worst case in our house, lot 25 being from lower stack of fullest trough, which also had the smallest supply of water. I have directed that in refilling the house fewer eggs be put in this than the other troughs.

February 1.—Returned to Bucksport, leaving W. H. Munson in charge of the Schoodic station.

The remaining shipments of eggs, amounting to 792,000, were made by Mr. H. H. Buck and Mr. Munson in March, after which Mr. Munson conducted alone the hatching of the 25 per cent. reserve, and the planting of the fry in Grand Lake, which was brought to a very successful issue in June.

TABLE I.—*Record of spawning operations, Grand Lake Stream, 1880.*

Date.	Remarks on the fish used.	Fish at first hauling. Total.	Males.	Females. Unripe.	Ripe.	Spent.	Total.	Females spawned.	Females re-spawned.	Eggs. Estimated number.	Lot.	Impregnation.	Remarks.
1880. Nov. 5	Caught between 4 p. m. of 4th and 9 a. m. of 5th	294	176	84	35	0	118	85	......	55,000	1	*P. ct.*	
6	Respawning of yesterday's fish	......	......	......	......	......	......	......	35	10,000	2	......	
	Caught since 9 a. m., 5th	117	57	53	7	0	60	7	......	12,000	3	......	
8	Respawning of yesterday's fish	......	......	......	......	......	......	......	7	2,000		......	
	Caught from 8 a. m. of 6th to 6½ a. m. of 8th	454	178	185	90	1	276	90			4	......	
	Caught from 6½ a. m. to 4 p. m. to-day	376	114	210	48	4	262	48	......	207,000			
9	Respawning of yesterday's fish	......	......	......	......	......	......	......	134	28,500	5	......	
		1,241	525	532	180	5	716	180	176	314,500	......	......	180 females yield 314,500 eggs, averaging 1,747 each.*
9	Caught from 4½ p. m., 8th, to 6½ a. m., 9th	102	33	59	10	0	69	10	......	16,500	6	......	
10	Respawning yesterday's fish	......	......	......	......	......	......	......	11			......	
	Caught last night	193	34	138	18	3	159	......	18	276,000	7	......	
	Rehandling all previously unripe	......	......	......	......	......	......	172					
	Caught to-day, 6½ a. m. to 5 p. m	88	20	33	33	2	68	33					
	Caught this evening, 5 to 8 o'clock	21	5	12	4	0	16	4	......	52,000	8	......	
11	Respawning	......	......	......	......	......	......	......	229	43,000	9	......	
		1,675	617	774	245	10	1,028	417	416	702,000	......	......	417 females yield 1,683 eggs each.*
11	Caught from 8 p. m., 10th, to 4 p. m., 11th	83	14	43	25	1	69	25	......	36,000	10	......	
12	Respawning	......	......	......	......	......	......	......	25				
	Caught from 3 p. m., 11th, to 9 a. m., 12th	92	13	61	16	2	79	16	......	49,000	11	......	
	Caught to-day, 9 a. m. to 8.25 p. m	66	8	44	13	1	58	13	......				
13	Respawning	......	......	......	......	......	......	......	29				
	Caught from 8.25 p. m., 12th, to 7 a. m., 13th	62	5	44	12	1	57	12	......	456,000	12, 13	.....	
	Overhauling part of those previously unripe	......	......	......	......	......	......	279	......				
	Caught from 7 a. m. to 8.30 p. m., 13th	45	9	21	14	2	37	14	......	20,000	13, 101	......	
15	Respawning	......	......	......	......	......	......	......	305	69,000	14	......	
	Caught from 8.30 p. m., 13th, to 10 a. m., 15th	100	18	41	38	3	82	38	......	51 000	15	......	
	Rehandling of fish previously unripe	......	......	......	......	......	......	151	......	217,000	16	......	
17	Respawning	......	......	......	......	......	......	......	189				
	Caught from 7 a. m., 16th, to 7 a. m., 17th	30	12	12	5	2	18	5	......	420,000	17	......	
	Overhauling all of reserve	......	......	......	......	......	......	285	......				
	Caught from 8.35 a. m. to 4 p. m., 17th	5	2	0	2	1	3	2	......				

19	*Respawning*	......	......	......	......	......	......	......	*292*	*67,000*	*18*	......	
		2,129	698	1,040	370	23	1,431	1,257	1,256	2,087,000	......	......	1,257 females yield each 1,660 eggs.*
19	*Caught from 4 p. m., 17th, to 7 a. m., 19th*	*31*	*0*	*8*	*23*	*0*	*31*	*23*	......	*75,000*	19	......	
	Overhauling unripe	......	......	......	......	......	......	38					
20	Respawning	......	......	......	......	......	......	......	38	79,000	20	......	
	Caught from 7 a. m., 19th, to 7 a. m., 20th	5	0	2	3	0	5	3	......				
	Rehandling fish before unripe	......	......	......	......	......	......	48	......				
22	Respawning	......	......	......	......	......	......	......	48	73,000	21	......	
	Rehandling fish before unripe	......	......	......	......	......	......	46	......				
	Caught from 7 a. m., 20th, to 4 p. m., 22d	6	0	3	3	0	6	3	......				
23	Respawning	......	......	......	......	......	......	......	50	16,000	22	......	
	Rehandling fish before unripe	......	......	......	......	......	......	8	......				
25	Rehandling, &c.—There remain 5 unripe fish, which are turned free	......	......	......	......	......	......	1	......	2,000	23	......	
		2,171	698	1,053	399	23	1,473	1,427	1,392	*2,332,000	......	......	1,427 females yield each 1,634 eggs.*

* These are the estimates made at the time the spawn was taken from the fish. Subsequent measurements and calculations changed some of these figures and reduced the total to 2,326,740 eggs. According to these revised estimates the average yield of eggs is 1,630 for each female.

TABLE II.—*Shipment of Schoodic salmon eggs from Grand Lake Stream, Maine, January and March,* 1881.

Date.	Consignee.	Address.	Final destination.	For whose use.	Number of eggs.			No. of cases.
					Belonging to State.	Donated by United States.	Total.	
1881. Jan. 10	W. H. Barber	Andover, New Brunswick	Grand Falls, N. B	Canadian Government	50,000		50,000	1
11	H. J. Fenton	Windsor, Conn	Poquonock, Conn	Connecticut Commission	207,500		207,500	3
19	......do	......do	......do	......do	80,000		80,000	1
	E. G. Blackford	Fulton Market, New York	Roslyn, L. I	New York Commission		25,000	25,000	1
	E. J. Anderson	Trenton, N. J	Bloomsbury, N. J	New Jersey Commission		25,000	25,000	1
20	R. F. Shaw	Anamosa, Iowa	Anamosa, Iowa	Iowa Commission		25,000	25,000	1
	D. B. Long	Ellsworth, Kans	Ellsworth, Kans	Kansas Commission		25,000	25,000	1
	J. G. Portman	Pokagon, Mich	Pokagon, Mich	Michigan Commission		25,000	25,000	1
	H. B. Miller	Wheeling, W. Va	Romney, W. Va	West Virginia Commission		25,000	25,000	1
	Seth Weeks	Corry, Pa	Corry, Pa	Pennsylvania Commission		15,000	15,000	1
	N. K. Fairbank	Chicago, Ill	Walworth, Wis	N. K. Fairbank		20,000	20,000	1
	L. Leppelman	Fremont, Ohio	Toledo, Ohio	Ohio Commission		5,000	5,000	1
	B. B. Redding	San Francisco, Cal	San Francisco, Cal	California Commission		25,000	25,000	1
24	Col. M. McDonald	Lexington, Va	Lexington, Va	Virginia Commission		25,000	25,000	1
	Wm. Griffith	Louisville, Ky	Louisville, Ky	Kentucky Commission		25,000	25,000	1
	H. H. Cary*	Atlanta, Ga	Morganton, N. C	North Carolina Commission		10,000	10,000	1
	M. Metcalf	Battle Creek, Mich	Battle Creek, Mich	M. Metcalf		10,000	10,000	1
	S. G. Worth	Morganton, N. C	Morganton, N. C	North Carolina Commission		5,000	5,000	1
	C. A. Johnston	Columbia, Miss	Columbia, Miss	C. A. Johnston		2,000	2,000	1
25	T. Hughlett	Druid Hill Hatchery, Baltimore, Md.	Baltimore Md	Maryland Commission		25,000	25,000	1
	James Duffy	Marietta, Pa	Marietta, Pa	Pennsylvania Commission		15,000	15,000	1
	H. W. Mowry	Oak Lawn, R. I	Oak Lawn, R. I	H. W. Mowry		5,000	5,000	1
	P. H. Christie†	Verbank, N. Y	Bloomsbury, N. J	New Jersey Commission		5,000	5,000	1
	E. A. Brackett	Winchester, Mass	Winchester, Mass	Massachusetts Commission	70,000		70,000	1
March 7	W. E. Sisty	Denver, Colo., care of Daniel Witter.	Brookvale, Colo	Colorado Commission		10,000	10,000	1
	R. O. Sweeny	Saint Paul, Minn	Saint Paul, Minn	Minnesota Commission		25,000	25,000	1
8	H. J. Fenton	Windsor, Conn	Poquonock, Conn	Connecticut Commission	62,500		62,500	1
	F. C. Hewey	Phillips, Me., care T. L. Page	Rangely, Me	Maine Commission	50,000		50,000	1
	E. A. Brackett	Winchester, Mass	Winchester, Mass	Massachusetts Commission	130,000		130,000	2
9	George Jelliffe	Westport, Conn	Westport, Conn	Connecticut Commission	110,000		110,000	2
	A. H. Powers	Plymouth, N. H	Plymouth, N. H	New Hampshire Commission	99,000		99,000	2
	J. M. Haven	Rutland, Vt	Rutland, Vt	C. H. Barber		5,000	5,000	1
14	Fred. Mather‡	25 Hill street, Newark, N. J	Paris and Berlin	Paris Acclimatization Society and Deutsche Fischerei Verein.		40,000	40,000	1
15	T. Hughlett	Druid Hill Hatchery, Baltimore, Md.	Baltimore, Md	Maryland Commission		30,000	30,000	1

	S. G. Worth	*Morganton, N. C.*	*Morganton, N. C*	*North Carolina Commission* *		*20,000*	*20,000*	*1*
	Thomas Morrison	*Morrison, Colo*	*Morrison, Colo*	*W. R. Scott*		*5,000*	*5,000*	*1*
16	Silas Woodson	Saint Joseph, Mo	Saint Joseph, Mo	*Missouri Commission*		10,000	10,000	1
21	E. A. Brackett	Winchester, Mass	Winchester, Mass	Massachusetts Commission	110,000		110,000	2
22	George Jelliffe	Westport, Conn	Westport, Conn	Connecticut Commission	36,500		36,500	1
	A. H. Powers	Plymouth, N. H	Plymouth, N. H	New Hampshire Commission	25,000		25,000	1
24	E. M. Stilwell	Bangor, Me	Bangor, Me	Maine Commission	14,000		14,000	1
28	H. G. Parker	Carson City, Nev	Carson City, Nev	Nevada Commission		10,000	10,000	1
	Total				1,044,500	497,000	§1,541,500	48

* Originally intended to be used in Georgia, but reshipped from Atlanta to North Carolina.

† This package, after going to Verbank and not being called for, was ordered to New Jersey.

‡ This lot was repacked in New York by Mr. Fred. Mather, in his method, for transportation to Europe.

§ In addition to the numbers here appearing, there were retained at Grand Lake Stream, to be hatched, the 25 per cent. reserve, amounting to 527,000; also, to be hatched for other parties, from the share of Maine, 10,000; from the share of the United States, 30,000; total retained, 567,000; making, with the above number shipped, a grand total of 2,108,500.

TABLE III.—*Transportation of Schoodic salmon eggs, shipped from Grand Lake Stream in January and March*, 1881.

Date of shipment.	Consignee.	Final destination.	Number of eggs.	How packed.	Time en route.	Distance.	Arrived at final destination.	When unpacked.	Condition on packing.	Number died in transportation.
1881.					*Hours.*	*Miles.*				
Jan. 10	W. H. Barber	Grand Falls, N. B	50,000	Wet moss inside, dry moss outside.	97	210?	Jan. 14, 3 p. m	Jan. 14, 3.30 p.m.	Very good	30
11	H. J. Fenton	Poquonock, Conn	207,000	Outside, 1 case dry moss, 2 cases dry leaves.	78	502	Jan. 14, 10 a. m	Jan. 14, 9 p. m	Good	798
19	...do	...do	80,000	Outside, dry leaves	77	502	Jan. 22, 3 p. m	Jan. 22, 8 p. m	Two per cent. of eggs indented.	384
	E. G. Blackford	Roslyn, N. Y	25,000	......do	140	640?	Jan. 24, 8 p. m	Jan. 25, 10 a. m	Very good	132
	E. J. Anderson	Bloomsbury, N. J	25,000	......do	122	700?	Jan. 24, 12 m	Jan. 24, 4 p. m	In very good condition.	47
20	B. F. Shaw	Anamosa, Iowa	25,000	Outside dry moss; inside, moss and snow.	119	1,607	Jan. 25, 11 a. m	Jan. 25, 1 p. m	Very good	30
	D. B. Long	Ellsworth, Kans	25,000	......do	178	2,095	Jan. 27, 6 p. m	Jan. 28, 8 a. m	Good	Not 1 %
	J. G. Portman	Pokagon, Mich	25,000	......do	98	1,299	Jan. 24, 3 p. m	Jan. 24, 4 p. m	...do	53
	H. B. Miller	Romney, W. Va	25,000	......do	141	1,005	Jan. 26, 9 a. m	Jan. 26, 11 a. m	Very good	337
	Seth Weeks	Corry, Penn	15,000	......do	102	972	Jan. 24, 7 p. m	Jan. 24, 8 p. m	Good	73
	N. K. Fairbank	Walworth, Wis	20,000	......do	146	1,483	Jan. 26, 4 p. m	Jan. 26, 4 p. m	In good condition	18
	L. Leppelman	Toledo, Ohio	5,000	......do	96	1,158	Jan. 24, 12 m	Jan. 24, 2 p. m	Good	5
	B. B. Redding	San Leandro, Cal	25,000	......do	281	3,818	Jan. 31, 6 p. m	Feb. 1, 7 a. m	Not very good condition.	2,075
24	Col. M. McDonald	Lexington, Va	25,000	Outside, dry moss; inside, moss and snow or snow-water.	123	1,363	Jan. 29, 4 p. m	Jan. 29, 5 p. m	Good	100
	William Griffith	Louisville, Ky	25,000	......do	117	1,400	Jan. 29, 8.30 a. m.	Jan. 29, 11 a. m	Good; moss quite wet.	60
	H. H. Cary	Morganton, N. C	10,000	......do	458	2,100?	Feb. 12, 1.30 p. m.	Feb. 12, 4.15 p.m.	Eggs all dead	10,000
	M. Metcalf	Battle Creek, Mich	10,000	......do	115	1,221	Jan 28, 4.30 p. m.	Jan. 29, 9 a. m	Good, except bottom tray, which was frosty	60
	S. G. Worth	Morganton, N. C	5,000	......do	170	1,515	Jan. 31, 12.30 p.m	Jan. 31, 3.55 p.m.	Good	80
	C. A. Johnston	Columbia, Miss	2,000	......do	(?)	2,010?	(?)	....	Package not called for; all perished and express charges returned on C. G. A.	2,000
25	T. Hughlett	Baltimore, Md	25,000	......do	93	805	Jan. 29, 8.45 a. m.	Jan. 29, 11.30 a.m	Good	100
	James Duffy	Marietta, Pa	15,000	......do	118	723	Jan. 29, 10 a. m	Jan. 29, 1 p. m	Very good	32
	H. W. Mowry	Oak Lawn, R. I	5,000	......do	114	450?	Jan. 29, 7 p. m	Jan. 30, 8 a. m	...do	17
	P. H. Christie	Bloomsbury, N. J	5,000	......do	527	700?	Feb. 17, 8.15 a. m.	Feb. 17, 10 a. m	Eggs all dead and decomposed.	5,000
	E. A. Brackett	Winchester, Mass	70,000	......do	65½	389	Jan. 27, 7 p. m	Jan. 28, 8 a. m	Fair	618
Mar. 7	W. E. Sisty	Brookvale, Colo	10,000	Outside, dry moss; inside, moss and snow.	190	2,548	Mar. 15, 12 m	Mar. 15, 1 p. m	Good	200
	R. O. Sweeney	Saint Paul, Minn	25,000	......do	144	1,789	Mar. 12, 1.35 p. m.	Mar. 13, 2 p. m	...do	46

8	H. J. Fenton	Poquonock, Conn	62,500	......do	74	502	Mar. 11, 12 m	Mar. 11, 4 p. m	....do	22
	F. C. Hewey	Rangely, Me	50,000	......do	96	300?	Mar. 12, 12 m	Mar. 12, 2 p. m	....do	40
	E. A. Brackett	Winchester, Mass	130,000	......do	67	389	Mar. 10, 6 p. m	Mar. 11, 9 a. m	....do	1,180
9	George Jelliffe	Westport, Conn	110,000	......do	74	570	Mar. 12, 3 p. m	Mar. 12, 4 p. m	....do	140
	A. H. Powers	Plymouth, N. H	99,000	......do	51	515	Mar. 11, 3 p. m	Mar. 11, 5 p. m	....do	112
	J. M. Haven	Rutland, Vt	5,000	......do	73	525?	Mar. 12, 3 p. m	Mar. 12, 3 p. m	....do	2
14	Fred. Mather	Paris, France	20,000	......do	(?)	3,260			No report received	
	....do	Berlin, Germany	20,000	......do	(?)	3,840			....do	
15	T. Hughlett	Baltimore, Md	30,000	......do	(?)	805			....do	
	S. G. Worth	Morganton, N. C	20,000	......do	147	1,515	Mar. 21, 1 p. m	Mar. 21, 5 p. m	Very good	37
	Thomas Morrison	Morrison, Colo	5,000	Moss with snow inside, dry moss outside.	265	2,563	Mar. 25, 7 p. m	Mar. 26, 3 p. m	Excellent	50
16	Silas Woodson	Saint Joseph, Mo	10,000	Moss and snow inside, dry moss outside.	164	1,847	Mar. 22, 12 m	Mar. 23, 10 a. m	As good as could be	25
21	E. A. Brackett	Winchester, Mass	110,000	......do	91	389	Mar. 24, 6 p. m	Mar. 25, 9 a. m	Not good; part of the eggs were frozen.	2,361
22	George Jelliffe	Westport, Conn	36,500	......do	121	570	Mar. 29, 2 p. m	Mar. 29, 3 p. m	Good	42
	A. H. Powers	Plymouth, N. H	25,000	......do	98	515	Mar. 26, 3 p. m	Mar. 26, 4 p. m	Very good	36
24	E. M. Stilwell	Bangor, Me	14,000	......do	49	137	Mar. 26, 2 p. m	Mar. 26, 3 p. m	Good	(?)
28	H. G. Parker	Carson City, Nev	10,000	Outside, 4½ inches moss and snow; inside, moss and snow.	214	3,540?	Apr. 6, 11.15 a. m	Apr. 6, 12 m	....do	20

XXV.—REPORT ON THE PROPAGATION AND DISTRIBUTION OF SHAD (ALOSA SAPIDISSIMA) IN THE SPRING OF 1880.

Two stations for propagating shad were established and maintained during the season of 1880; one of them in Spesutie Narrows, near Havre de Grace, which had been so successfully operated in previous years by the United States and Maryland Fish Commissions jointly; the other a new one at the Washington navy-yard, through the courtesy of Commodore Richard L. Law, Chief of the Bureau of Yards and Docks, and Commodore John C. Febiger, commandant of the yard. Their hearty co-operation in placing the facilities of the navy-yard at the disposal of the Commission evidenced their interest in the work.

Nearly 30,000,000 of young shad were produced at and distributed from these stations—an increase of about 14,000,000 over the aggregate result of the several stations operated the previous year.

It was not thought practicable to continue the work on Albemarle Sound during this season, but early information of this intermission was given to the State Commissioners of North Carolina, that the station might be occupied by them. Mr. S. G. Worth, the efficient Superintendent of Fisheries of that State, pushed the work with creditable zeal and flattering success, depositing the fish hatched at this station by his corps, in the adjacent waters and in the other rivers of North Carolina.

Havre de Grace Station.—Mr. John S. Saunders, of Baltimore, who had with so much fidelity and zeal administered the work at the Albemarle Sound Station during the operations in North Carolina last season; and, later, had been transferred to the charge of machinery barge No. 2 with its accompanying equipment as a branch of the station at Havre de Grace, was placed this year in charge of the entire work at the mouth of the Susquehanna. The result of the hatching and distribution from this station will appear in the appended tables.

The two barges containing the machinery, and the two furnishing quarters for the operatives, were towed, on the 29th of April, from Baltimore, where they had been kept during the winter, to Spesutie Narrows, the entrance to this harbor having been improved by dredging. The towing of these barges was performed by the revenue steamer "Ewing," which had been kindly detailed for the purpose.

On the 3d of May the first eggs were taken, and the production was gradually increased until about the middle of the month, when the maximum yield was obtained. The operations were carried on with varying success up to the 10th of June, the time at which the Maryland law requires fishing to cease. Up to this date 13,355,000 eggs had been procured.

As the eggs were procured only from those fish taken for market, and as none were taken for the express purpose of obtaining their eggs, the production was dependent upon the fishermen, and when the local laws required a cessation of fishing, there was, of course, no other source of supply, and the operations at this point were necessarily discontinued.

The excessive drought during the month of May, and the prevalence of southerly winds, caused the salt or brackish water to extend unusually high up the Chesapeake Bay, the water becoming so brackish at the station as to make it advisable to move the entire equipment from Spesutie Narrows to a point above Havre de Grace where the water was entirely free from salt. This was done on the 30th of May. The advantage of having such floating apparatus as this station was provided with was demonstrated on the occurrence of this abnormal condition, as the equipment was moved without loss of fish, eggs, or time, to a locality some five miles distant.

The aggregate results of the season were materially lessened, however, as during the period when ripe breeders were most plentiful the gillers declined to let the agents of the Commission handle their catch on account of some dissatisfaction caused by a reduction in the price paid for the fish utilized for hatching purposes. The magnitude of the work having so materially increased, and the number of fish handled being so much greater than in previous years, it was found advisable to lessen the price offered for ripe shad, which, however, was always maintained above the ruling market rates. The fishermen, without due consideration of the subject, refused for a few days to allow their fish to be handled unless they were purchased at the same rate as in previous years. However, after a temporary interruption, the fishermen accepted the conditions, and the results of the season, although somewhat influenced by this interruption, were most gratifying, as the yield of this station, as already stated, aggregated between 12,000,000 and 13,000,000 of young shad, an excess of over 2,000,000 in production beyond the yield of the two stations operated in this locality the previous year.

On the 25th of May the first car-load shipment was made from this station, the car having been furnished by the Philadelphia, Wilmington and Baltimore Railroad Company. Over a million of young shad were transferred from Havre de Grace to the Nanticoke River and deposited in that stream near Seaford, in Delaware. This was effected without loss.

On the 12th of June, while the fish on hand were being transferred from the hatching vessels to the depot for a shipment to Maine, a terrific wind storm, accompanied by heavy rain, broke the barges away from their moorings and cast them ashore, causing a loss of between 800,000 and 900,000 fish and eggs, or rather the involuntary deposit in the Susquehanna River of that number. Sufficient, however, were saved to make a good car-load, with a few additional fish which were sent from the Washington Station. Nearly a million shad were taken on this trip to Maine and divided between the Penobscot and Kennebec Rivers. The Commission is again indebted to the Philadelphia, Wilmington and Baltimore Railroad Company for the car in which this shipment was made and for the arrangements with the other companies for the movement of the car by fast passenger trains to Bangor. Mr. Stillwell, one of the State Commissioners of Maine, met the car at this point and selected the places of deposit.

During the month of May, Mr. J. P. Creveling, of the Pennsylvania Commission, by direction of the Commissioners, procured from this station nearly half a million of young shad, which were deposited in the upper waters of the Susquehanna River.

At the close of the season, half of the equipment was transferred to Baltimore to be remodeled, and from thence taken to Tangier Sound to be used in the experiments in the artificial propagation of the oyster inaugurated by Major Ferguson, Commissioner of Fisheries of Maryland, the barges finally to be transferred to Washington for future service on the Potomac River. The rest of the equipment—that is, one machinery barge, and one barge occupied as quarters—was left at Havre de Grace, to be used again the succeeding year.

The disposition of the fish produced is shown in the tables appended, the yield of this station being incorporated with the distribution of the fish hatched on the Potomac.

Washington navy-yard station.—In order to determine the feasibility of hatching shad by the use of hydrant water, and for the purpose of producing them in large numbers at a convenient center of distribution, a station was improvised at the Washington navy-yard by permission of the Navy Department, and through the courtesy of the commandant of the yard.

At the western end of the "ship-house" a number of cones, arranged according to the Ferguson system, were set up, a few at first, afterwards more and more, until about forty-six were in place. The number was increased as fast as the vessels could be manufactured, and they were kept to their full capacity during most of the season. It was necessary that this apparatus should be operated outside of the ship-house in the open air, as it was deemed imprudent to have lights within the building, and they were a necessity for the proper conduct of the work.

The water was supplied to this apparatus from a hydrant connection near by. The eggs were nightly collected 15 or 20 miles down the river and brought up upon the "Lookout," a small steamer in the service of the Maryland Fish Commission, which had been provided with apparatus for the purpose. On arrival they were at once placed for final development in the cones above referred to. As soon as the fish were ready for distribution they were placed in transporting cans and then transferred to the railroad depots for shipment.

The experiment proved entirely successful, so large a percentage hatching out that the loss of eggs was scarcely appreciable, and the distribution was readily made to all parts of the country.

During the progress of the work, it was found that that section of the Potomac River immediately adjacent to Fort Washington was the most productive of ripe shad, and it was therefore deemed advisable to station a portion of the spawn-takers at this point. Permission having been obtained from the War Department, a building on the reservation was occupied as quarters for this portion of the force. The eggs when collected were placed in vessels suspended in the water, which kept them in good condition until they could be transferred to the hatching apparatus at the navy-yard.

This sub-station was occupied until the 19th of June, when it was abandoned, as shad were no longer taken in sufficient numbers to induce further work at this point.

Advantage was taken of the peculiar facilities of the navy-yard station for conducting several experiments for determining the minimum amount of water necessary for keeping young shad in good health and condition, as very often it is necessary to economize water both in the production of the fish and their transportation. These experiments demonstrated that the eggs could be as successfully hatched with less than one-fourth the amount of water if an abundance of atmospheric air was introduced with the water.

Many other experiments were conducted during this season which have resulted in material modifications in the forms of the apparatus used in the production of, and the vessels for transporting, young shad.

On the 23d of May the first large car shipment was made from Washington. Mr. George C. Wilkins, superintendent of the Pennsylvania system of railroads at Baltimore, having provided a commodious baggage car, and arranged for its movement on the passenger train as far south as the standard gauge roads extended, and also obtained from the connecting lines a similar car at this terminal, about 2,000,000 of young shad were loaded in the car at Washington from the navy-yard station. One-half of these were successfully deposited in the rivers of South Carolina and the other half in those of Georgia.

On June 6 another car-load, consisting of about 700,000, was shipped to Cincinnati in a car kindly loaned by the Baltimore and Ohio Railroad Company. There the fish were turned over to Dr. Griffith, the president of the Kentucky State Commission, who met the car in person and superintended the deposit of the fish in the rivers of Kentucky.

The success at these stations in procuring shad in large numbers led to the inauguration of this system of shipping young shad by the car-load, in place of the single messenger shipments, limited as they were to one or two hundred thousand fish.

Although in previous seasons the production amounted to many millions of fish, this was the aggregation of only one or two hundred thousand daily. Large shipments of one or two millions were impracticable, as before this number could be produced the earlier hatched were so far developed that they would require a much more abundant supply of food than that found in the limited amount of water to which they were necessarily confined.

The production of previous years was necessarily scattered in comparatively small lots throughout the country, no streams except those on which the hatching stations were located receiving a sufficient number to have their presence decidedly marked.

Far greater results can be anticipated from the deposits of one or two millions of fish in a stream during a single season, and this is entirely within the possibilities, so great has been the advancement in the methods employed in collecting the eggs, their development, and the transfer of the young fish produced.

Shipment by car-loads was, therefore, a marked feature in the operations of this season. By this method, it is confidently hoped that the work of distribution, not only of shad, but of carp and other fishes, can be made much more systematically, much more efficiently, and at much less cost.

Having demonstrated the practicability of securing young shad of uniform ages in sufficient numbers to warrant shipments by car-loads, it now becomes necessary to secure properly arranged cars for this purpose. The essentials of a car for this duty are:

First. Arrangements for maintaining even and constant temperatures.

Second. Capacity for conveniently storing special carrying vessels.

Third. Automatic arrangements for change and circulation of water and aeration.

Fourth. Comfortable living, accommodations for the messengers attending the fish, so that they can be constantly at their post of duty.

Designs are being prepared for the construction of such cars, which will be built as the work develops and the means are provided.

The detail of operations at this station with accompamying tables, by Mr. F. N. Clark, who was in charge, will be found in the following pages.

The fish produced at Washington, as well as the yield from the Havre de Grace station, were, as heretofore, transferred to various parts of the country. The places of deposit are given in the accompanying tables, which have been arranged both geographically and chronologically for easy reference.

TABLE 1.—*Record of temperature observations at Spesutie Narrows, made May 3 to June 15, 1880, under the direction of the United*

Date.	Temperatures.									Depth of water at station.	Wind.			
	Air, 7 a. m.	Surface water, 7 a. m.	Bottom, 7 a. m.	Air, 12 m.	Surface water, 12 m.	Bottom, 12 m.	Air, 7 p. m.	Surface water, 7 p. m.	Bottom, 7 p. m.		Direction, 7 a. m.	Intensity, 7 a. m.	Direction, 12 m.	Intensity, 12 m.
	°	°	°	°	°	°	°	°	°	*Feet.*				
Monday, May 3	...	...	...	...	...	...	...	...	...	....	S.W.	Strong	S.W.	Strong
Tuesday, May 4	60	65½	63	72	66	63	65	66	63	15 to 25	S.W.	..do ..	S.W.	Gentle
Wednesday, May 5	62	65	63	73	66	63	72	65	65	....	N.E.	..do ..	E.	..do ..
Thursday, May 6	61	64½	65	81	67	67	72	67	67	....	S.W.	..do ..	N.W.	Strong
Friday, May 7	64½	65	65	79	68	68	64	67	67	....	S.E.	Gentle	S.E.	Gentle
Saturday, May 8	63	65	64	68	68½	67	75	70	69	....	S.E.	..do ..	W.	..do ..
Sunday, May 9	63	67	67	83	71½	69	79	72	72	....	S.	Calm	S.W.	Strong
Monday, May 10	73	69½	69½	83	72½	71½	78	73½	73½	....	S.	Gentle	S.	..do ..
Tuesday, May 11	71	71½	71½	81	73	72½	79	73½	73½	....	S.W.	..do ..	S.S.W.	..do ..
Wednesday, May 12	66	70½	70½	73	69	71	72	73½	73½	....	N.W.	Strong	N.W.	Gale ..
Thursday, May 13	61	68	67	62½	70	69	61	69	69	....	N.W.	High	N.W.	High
Friday, May 14	58	64	64	63	67	65	61	67	66	....	N.	..do ..	N.E.	Strong
Saturday, May 15	52	60	60	60	64	64	63	65	64	....	N.E.	..do ..	N.E.	..do ..
Sunday, May 16	62	61½	61½	72½	64	63½	76	66	65½	....	N.W.	Strong	S.S.W.	..do ..
Monday, May 17	63	64½	64	85	67	66½	77	68	68	....	W.	Gentle	N.W.	..do ..
Tuesday, May 18	70	67	66	82	71	71	79	72	71½	....	S.W.	Light	S.E.	Light
Wednesday, May 19	61	67	66½	82	70	68	75	72	71½	....	N.E.	..do ..	N.E.	..do ..
Thursday, May 20	71½	69	69	85	73	71	80	72½	71½	....	N.E.	..do ..	N.E.	Strong
Friday, May 21	73	71	71	80	73½	73	79	74½	74½	....	S.E.	Strong	S.	..do ..
Saturday, May 22	73	71	69	81	73½	73½	69	74	74	....	S.W.	..do ..	S.W.	..do ..
Sunday, May 23	68	72	72	74	72½	72½	69	73½	73½	....	E.	Light	S.E.	Light
Monday, May 24	71	73	73	85	75	74	80	75	75	....	N.E.	..do ..	S.E.	..do ..
Tuesday, May 25	76	74	74	86	77	76½	82	79	79	....	S.W.	..do ..	S.E.	..do ..
Wednesday, May 26	76	77½	78	96	82	79½	83	82	81½	....	S.W.	..do ..	S.W.	..do ..
Thursday, May 27	83	80	79½	95	80	79½	87	82	81½	....	S.W.	..do ..	S.W.	..do ..
Friday, May 28	79	79	79	87	80½	80½	73	80	79½	....	W.	..do ..	S.E.	Strong
Saturday, May 29	68	76	76	85	78	78	70	77	77	....	N.E.	Strong	E.	Gentle
Sunday, May 30	73	76	76	70	78	78	68	76	76	35 to 40	S.E.	..do ..	S.W.	..do ..
Monday, May 31	73	76	76	83	77	76	80	77	77	....	N.W.	..do ..	N.W.	Strong
Tuesday, June 1	73	73	72½	80	77	75	74	75	74	....	S.E.	Light	S.E.	..do ..
Wednesday, June 2	58	74	74	80	74	74	76	72	72	....	N.W.	Strong	N.E.	..do ..
Thursday, June 3	63	72	71½	86	69	68	78	71	71	....	N.W.	Light	N.W.	..do ..
Friday, June 4	72	71	70	84	71	71	80	71	71	....	N.W.	..do ..	N.E.	Light
Saturday, June 5	69	74½	74	77	75	74	74	72	71½	....	S.E.	..do ..	S.E.	Strong
Sunday, June 6	73	74	73½	78	74	73½	76	72	71½	35 to 40	S.W.	Strong	S.W.	High
Monday, June 7	84	74	74	80	77	75	79	75½	75	....	N.W.	Gentle	N.W.	Light
Tuesday, June 8	75	73½	73	87	79	77	75	78	76	....	N.E.	Light	N.E.	..do ..
Wednesday, June 9	68	76	76	79	3 p.m. 77	76	71	77	76	....	N.E.	..do ..	S.E.	..do ..
Thursday, June 10	67	76	75	72	74	74	69	74	73	....	S.E.	..do ..	S.E.	..do ..
Friday, June 11	64	72	71½	71	72	71½	80	73	72	....	S.E.	..do ..	S.E.	..do ..
Saturday, June 12	82	74	73½	92	79	77	82	78	76	....	N.W.	..do ..	N.W.	..do ..
Sunday, June 13	83	78	76	92	79	78	80	79	78	....	S.W.	..do ..	S.W.	..do ..
Monday, June 14	75	79	77	81	79	77	73	77	75	....	N.W.	Strong	N.W.	..do ..
Tuesday, June 15	64	76	72	65	75	71	65	74	70	....	N.E.	..do ..	E.	Strong

by John S. Saunders, on the United States Fish Commission barges, from States and Maryland Commissions of Fish and Fisheries.

Wind.		Sky.				Tide.			
Direction, 7 p. m.	Intensity, 7 p. m.	7 a. m.	12 m.	7 p. m.	Water.	7 a. m.	12 m.	7 p. m.	Remarks.
S.W.	Gentle	Clear ...	Clear ...	Clear ...	Muddy	Ebb .	Ebb .	Flood	No thermometer to take temperature.
S.W.	..do ..	..do	..do	..do	..do ...	..do .	..do .	..do .	
S.E.	..do ..	Cloudy	Cloudy .	..do	Clear ..	Flood	..do .	..do .	
N.W.	..do ..	Clear ...	Clear ...	..do ...	..do ...	..do .	..do .	..do .	
S.E.	Strong	Overcast	..do	..do	..do ...	..do .	..do .	..do .	
S.W.	Gentle	..do	..do	..do	..do ..	..do .	Slack	Ebb .	
S.W.	..do ..	..do	..do	..do	..do ...	..do .	Flood	..do .	
S.S.W.	Strong	..do	..do ...	..do	..do ...	Slack	..do .	..do .	
W.	Gentle	..do	Overcast	..do	..do ...	Ebb .	..do .	..do .	
W.	Gale ..	Clear ...	Clear ...	..do	..do ...	..do .	..do .	..do .	Very low tide.
N.	High .	..do	..do	..do	Muddy	..do .	..do .	..do .	
N.E.	..do ..	..do	..do	..do	..do ...	..do	..do .	..do .	
W.	Gentle	..do	..do	..do	..do ...	..do	..do	..do .	
S.W.	..do ..	Smoky ..	..do	..do	Clear ..	..ds .	..do .	..do .	
S.W.	..do ..	Clear ...	..do	..do	..do ...	..do .	..do .	..do .	
S.E.	Light .	..do	..do	..do	..do ...	..do .	..do .	..do .	
N.E.	..do ..	Rain	..do	..do	..do ...	..do .	Slack	..do .	
S.E.	Strong	Overcast	.,do	..do	..do ...	Flood	Ebb .	Flood	
S.E.	..do ..	Clear ...	..do	..do	..do ...	..do .	..do .	..do .	
E.	Light .	Overcast	..do	..do	..do ...	..do .	..do .	..do .	Very high tide and water brackish. Rain about 3 p. m.
N.W.	..do ..	..do	Showery	..do	..do ...	..do .	..do .	..do .	
S.W.	..do ..	Clear ...	Clear ...	..do	..do ...	..do .	..do .	..do .	
S.W.	..do ..	..do	..do	..do	..do ...	..do .	..do .	..do .	
S.W.	..do ..	..do	..do	..do	..do ...	Ebb .	Flood	Ebb .	
S.E.	..do ..	..do	..do	..do	..do ...	..do .	..do	..do .	
N.W.	..do ..	..do	Overcast	..do	..do ...	..do .	..do .	..do .	Rain about 5 p. m.
S.E.	..do ..	..do	..do	Cloudy .	..do ...	..do .	..do .	..do .	
S.W.	..do ..	Cloudy .	Rain	Rain	..do ...	..do .	..do .	..do .	Moved barges to Watson's Island, above Havre de Grace, on account of salt water, at 10 a. m.
S.E.	..do ..	Clear ...	Clear ...	Clear ...	..do ...	..do .	..do	..do .	
N.	Strong	..do	Overcast	Squall ..	..do ...	..do .	..do .	..do .	
N.E.	..do ..	Rain	..do	Clear ...	Muddy	..do .	..do .	..do .	
N.W.	..do ..	Clear ...	Clear ...	Stormy .	..do ...	..do .	Slack	..do .	
N.E.	Light .	..do	..do	Clear ...	..do ...	Flood	Ebb .	..do .	
S.E.	High .	Overcast	Overcast	..do	Clear ..	..do .	..do .	Flood	
S.W.	Light .	Clear ...	Clear ...	..do	..do ...	..do .	..do .	..do .	Very little tide; caused by river backing it down.
N.W.	Gentle	..do	..do	..do	..do ...	..do .	..do .	..do .	
E.	..do ..	Clear ...	..do	..do	..do ...	..do .	..do .	..do .	
S.E.	..do ..	Overcast	Overcast	Overcast	..do ...	Slack	..do .	..do .	
N.W.	..do ..	Rain	..do	Rain ...	..do ...	Flood	..do .	..do .	
S.W.	..do ..	..do	Clear....	Clear ...	..do ...	..do .	..do .	Ebb .	
S.W.	..do ..	Clear ...	..do.....	..do	..do ...	..do .	Flood	..do .	Terrible storm at 2.15 p. m., with terrific wind, causing barges to go adrift, losing 8 anchors and be driven high on rocks ashore.
N.W.	..do ..	..do	..do	..do	..do ...	Ebb .	..do .	..do .	Moved alongside Cochran's ice-house wharf, having lost anchors in gale.
N.W.	..do ..	..do	..do	..do	..do ...	..do .	..do .	..do .	
N.E.	Strong	Rain	Rain	Rain	..do ...	..do .	..do .	..do .	Heavy N. E. storm all day.

TABLE 2.—*Record of temperature observations at Navy-Yard station, Wash from May 4 to June 18, 1880; under the direction of the*

Date.	Temperatures.									Wind.			
	Air, 6 a. m.	Surface water, 6 a. m.	Bottom, 6 a. m.	Air, 12 m.	Surface water, 12 m.	Bottom, 12 m.	Air, 6 p. m.	Surface water, 6 p. m.	Bottom, 6 p. m.	Direction, 6 a. m.	Intensity, 6 a. m.	Direction, 12 m.	Intensity, 12 m.
	°	°	°	°	°	°	°	°	°				
Tuesday, May 4	...	...	...	...	...	...	76	68	67	S. E.	Light	S. E.	Light
Wednesday, May 5	67	67	66	82	72	70	78	69	68	E.	..do..	E.	..do..
Thursday, May 6	68	67	66	84	73	66	81	71	70	W.	..do..	W.	..do..
Friday, May 7	65	67	66	80	71	70	78	72	70	S. W.	..do..	E.	..do..
Saturday, May 8	61	68	66	85	73	71	81	72	70	N. E.	..do..	N.	..do..
Sanday, May 9	72	70	67	90	74	72	85	76	75	S.	..do..	S.	Fresh
Monday, May 10	72	71	70	91	76	75	83	75	74	S.	..do..	S.	..do..
Tuesday May 11	71	73	72	82	76	75	61	74	73	S. E.	..do..	N.	Light
Wednesday, May 12	62	71	70	75	74	73	71	73	72	W.	..do..	N. W.	..do..
Thursday, May 13	61	70	70	73	73	73	60	72	72	W.	..do..	N.	Fresh
Friday, May 14	57	70	70	67	70	70	65	69	69	N. W.	Fresh	N. W.	..do..
Saturday, May 15	52	65	65	70	71	71	67	71	71	N. E.	Light	N. W.	..do..
Sunday, May 16	68	67	67	84	72	71	81	72	71	S. W.	..do..	S. W.	Light
Monday, May 17	71	70	70	90	72	71	83	73	72	W.	..do..	W.	..do..
Tuesday, May 18	69	70	70	86	74	73	83	75	74	N. W.	..do..	N. W.	..do..
Wednesday, May 10	66	73	72	88	75	74	81	76	75	N. E.	..do..	N. E.	..do..
Thursday, May 20	78	75	74	87	76	75	87	76	75	S. W.	..do..	S. W.	Fresh
Friday, May 21	71	74	74	88	77	76	86	76	75	S.	..do..	S. W.	Strong
Saturday, May 22	71	74	75	73	75	75	70	75	75	S. E.	..do..	S. E.	Light
Sunday, May 23	70	74	75	68	74	75	67	74	75	N. E.	..do..	N. E.	..do..
Monday, May 24	71	75	75	88	75	75	85	75	75	N. E.	Calm	S.	..do..
Tuesday, May 25	80	76	76	85	76	76	88	77	76	S.	Light	S.	..do..
Wednesday, May 26	75	77	77	87	79	78	89	77	66	S.	..do..	S. W.	..do..
Thursday, May 27	72	79	78	89	82	81	89	79	78	S.	..do..	S. W.	..do..
Friday May 28	75	78	78	85	80	80	78	79	78	S.	..do..	S. W.	Fresh
Saturday, May 29	75	79	78	75	80	80	74	78	78	N. E.	..do..	N. E.	Light
Sunday, May 30	73	78	78	74	77	77	73	77	78	S. E.	..do..	N. E.	Fresh
Monday, May 31	72	77	77	78	77	77	83	78	78	N. W.	Fresh	N. W.	..do..
Tuesday, June 1	75	77	77	94	78	78	85	78	78	S. W.	Light	S. W.	Light
Wednesday, June 2	60	73	73	68	73	73	62	73	73	N. W.	Fresh	N. W.	Fresh
Thursday, June 3	60	75	74	78	77	77	80	77	77	N. W.	Light	N. W.	Light
Friday, June 4	62	75	74	87	76	76	84	77	77	N. W.	..do..	S. W.	..do..
Saturday, June 5	70	74	75	79	76	75	80	77	76	S. W.	..do..	S.	..do..
Sunday, June 6	69	75	74	78	76	75	77	76	75	S.	..do..	S.	Fresh
Monday, June 7	76	74	74	88	79	78	83	76	75	S.	..do..	W.	Light
Tuesday, June 8	73	74	74	83	79	76	86	79	77	N. W.	..do..	N. W.	..do..
Wednesday, June 9	70	75	74	78	75	75	76	75	75	N. E.	..do..	N. E.	..do..
Thursday June 10	68	75	75	72	75	75	74	75	75	S. E.	..do..	S. E.	..do..
Friday, June 11	74	74	74	88	77	77	87	79	78	......	Calm	S.	..do..
Saturday, June 12	76	77	77	94	79	78	79	79	78	S.	Light	N. W.	..do..
Sunday, June 13	80	78	77	95	79	78	90	82	81	N. W.	..do..	N. W.	Fresh
Monday, June 14	77	78	78	85	79	78	83	78	78	N. W.	..do..	N.	Light
Tuesday, June 15	67	78	78	66	77	77	65	76	77	N. E.	..do..	N. E.	Fresh
Wednesday, June 16	65	76	76	74	77	77	75	77	77	N. E.	..do..	N. E.	Light
Thursday, June 17	70	75	76	85	77	77	84	78	78	N. W.	..do..	N. W.	..do..
Friday, June 18	68	75	75	80	77	77	85	79	78	S.	..do..	S.	..do..

ington, made by W. P. Sauerhoff and Wm. Hamlen, on the steamer Lookout, United States and Maryland Commissions of Fish and Fisheries.

Wind.		Sky.				Tide.			Remarks.
Direction, 6 p. m.	Intensity, 6 p. m.	6 a. m.	12 m.	6 p. m.	Water.	6 a. m.	12 m.	6 p. m.	
S. E.	Light ..	Clear ...	Clear ..	Clear ..	Muddy	......	Flood	Ebb .	Left navy-yard 12.45 p. m. Returned at 9.50 p. m. 650,000 eggs.
E.	..do ...	..do	..do ...	..do ...	..do ...	Flood	Slack	..do .	
N. W.	..do ...	..do	..do ...	..do ...	..do ...	..do .	Ebb .	Flood	Thermometer 98° at 2.30 p. m.
S. E.	..do ...	Cloudy .	..do ..	..do ...	..do ...	..do .	..do .	..do .	
N. E.	..do ...	..do	..do ...	Cloudy	..do ...	..do .	..do .	..do .	Left navy-yard 5.40 p. m.
S.	..do ...	Clear ..	..do ...	Clear ..	..do ...	..do .	Flood	Ebb .	Returned to navy-yard 1.20 p. m.
S.	Strong .	..do	..do ...	..do ...	..do ...	..do .	Ebb .	Flood	Left navy-yard 4.15 p. m. Returned 11.10 p. m.
N. W.	..do ...	..do	..do ...	Cloudy	..do ...	..do .	..do .	..do .	Left navy-yard 12.50 p. m. Rain 5.30 p. m. Stopped 7 p. m.
N. W.	Fresh ..	..do	..do ...	Clear ..	..do ..	..do .	..do .	..do .	Returned to navy-yard 8.53 a. m. Left navy-yard 3 p. m.
N. E.	..do ...	..do	..do ...	Cloudy	..do ...	..do .	..do .	..do .	Returned navy-yard 9.25 a. m. Left navy-yard 4. p. m.
N.	Light ..	..do	..do ...	Clear ..	..do ...	..do .	..do .	Slack	Returned to navy-yard 11.35 a. m.
N. W.	..do ...	..do	..do ...	..do ...	..do ...	..do .	..do .	Ebb .	Left navy-yard 1.35 p. m. Returned 10.30 p m.
S. W.	..do ...	..do	..do ...	..do ...	Clear ..	Ebb .	Flood	..do .	Remained at navy-yard. Left navy-yard 1.22 p. m.
W.	..do ...	..do	..do ...	..do ...	..do ...	..do .	..do .	..do .	Returned 12.30 p. m.
S. W.	..do ...	..do	..do ...	..do ...	Muddy	..do .	..do .	..do .	Left navy-yard 5.40 p. m. Returned 11.15 p. m.
N. E.	..do ...	Cloudy .	..do ...	..do ...	..do ...	..do .	..do .	..do .	Remained at navy-yard.
S. W.	Fresh ..	Clear ...	..do ...	..do ...	..do ...	..do .	..do .	..do .	Left navy-yard 3.27 p. m.
S. E.	Strong .	..do	Cloudy	..do ...	..do ...	..do .	..do .	..do .	Returned to navy-yard 9.05 a. m. Left navy-yard 4.10 p. m.
N. W.	Light ..	Cloudy .	..do ...	Cloudy	..do ...	Flood	Ebb .	..do	Returned to navy-yard 7.20 a. m. Left navy-yard 5.30 p. m.
N. E.	..do ...	..do	..do ...	..do ...	..do ...	..do .	..do	Flood	Returned navy-yard 9.10 a m. Left 5.55 p. m.
S. W.	..do ...	..do	Clear ..	Clear ..	..do ...	..do .	..do .	..do .	Returned navy-yard 8.05 a. m. Left navy-yard 6.15 p. m.
S.	..do ...	Clear ...	..do ...	..do ...	..do ...	..do .	..do .	..do .	Returned navy-yard 6.25 a. m. Left navy-yard 6.30 p. m.
S.	..do ..	..do	Cloudy	Cloudy	..do ...	..do .	..do .	..do .	Returned navy-yard 6.45 a. m. Left navy-yard 8.17 p. m.
S. W.	..do ...	..do	..do ...	Clear ..	..do ...	..do .	..do .	..do .	Returned to navy-yard 7 a. m. Left navy-yard 12.50 p. m.
W.	Strong	..do	..do ...	Cloudy	Clear ..	..do .	..do .	..do .	Returned to navy-yard 7.15 a. m. Left 3 p. m. Returned to navy-yard 9.05 p. m. Rain.
N. E.	Light ..	..do	Clear ..	..do ...	Muddy	Ebb .	Flood	Ebb .	Left navy-yard 3.20 p. m. Returned navy-yard 9.40 p. m. Rain.
S. E.	Fresh ..	Cloudy .	Cloudy	..do ...	..do ...	..do .	..do	..do .	Left navy-yard 4 p. m. Returned navy-yard 10.10 p. m.
N. W.	Light ..	Clear ...	Clear ..	Clear ..	Clear ..	..do .	..do .	..do .	Left navy-yard 6.30 p. m. Returned navy-yard 12.25 p. m.
S. W.	..do ...	..do	..do ...	Cloudy	Muddy	..do .	..do .	..do .	Left navy-yard 5 p. m.
N. W.	..do ...	Cloudy .	Cloudy	..do ...	..do ...	..do .	..do .	..do .	Stationed at Fort Washington.
S.	..do ...	Clear ...	Clear ..	Clear ..	..do ...	..do .	..do .	..do .	
S. W.	..do ...	..do	..do ...	..do ...	..do ...	..do .	..do .	..do .	
S.	Fresh ..	Cloudy .	..do ...	Cloudy	Clear ..	..do .	..do .	..do .	
S.	Light ..	Clear ...	..do ...	..do ...	..do ...	Slack	Ebb	Flood	
......	Calm ..	..do	..do ...	Clear ..	..do ...	Flood	..do .	..do .	
N. W.	Light ..	..do	..do ...	Cloudy	..do ...	..do .	..do .	..do .	
N. E.	..do ...	Cloudy .	Cloudy	..do ...	..do ...	..do .	..do .	..do .	
S. E.	..do ...	..do	..do ...	..do ...	..do ...	..do .	..do .	..do .	Rain 6.30. Stopped 11 a. m.
S.	..do ...	..do	Clear ..	..do ...	..do ...	..do .	..do .	..do .	
S. E.	..do ...	Clear ...	Cloudy	..do ...	..do ...	..do .	..do .	..do .	Rain storm 8 p. m. Stopped 4.30 a. m.
W.	..do ...	..do	Clear ..	..do ...	Muddy	..do .	..do .	..do .	
N. E.	..do ...	..do	..do ...	..do ...	..do ...	Ebb .	Flood	Ebb .	Rain 9.30 p. m.
N. E.	..do ...	Cloudy .	Cloudy	..do ...	..do ...	..do .	..do .	..do .	Rain.
......	Calm ..	..do	..do ...	..do ...	..do ...	..do .	..do .	..do .	Rain stopped 7.30 a. m.
N. W.	Light ..	Clear ...	..do ...	Clear ..	..do ...	..do .	..do .	..do .	Strong current with the ebb tide. Water very muddy at 7 p. m.
S.	..do ...	..do	Clear ..	..do ...	..do ...	..do .	..do .	..do .	Water very muddy.

TABLE 3.—*Record of hatching operations at Spesutie Narrows, Md., con from May 3 to June 10, 1880, under the direction of the United*

Date.	Total length of haul-seines visited, in fathoms.	Total length of gill-nets visited, in fathoms.	Fish taken by haul-seines—			Fish taken by gill-nets—	Ripe fish.	
			Shad.	Herring.	Rock.	Shad.	Males.	Females.
			No.	*Lbs.*	*No.*	*No.*		
Monday, May 3	1,860	....	220	20,000	....	....	4	2
Tuesday, May 4	1,860	....	354	15,000	250	....	10	13
Wednesday, May 5	2,060	850	396	30,800	....	88	13	9
Thursday, May 6	3,610	....	464	26,000	....	....	33	20
Friday, May 7	3,610	....	689	36,300	24	....	26	17½
Saturday, May 8	2,600	2,200	258	23,000	....	316	49	30½
Sunday, May 9	....	2,150	....	....	....	271	21	15
Monday, May 10	2,010	225	201	8,835	49	11	16	11½
Tuesday, May 11	1,110	1,825	199	650	20	110	11	10
Wednesday, May 12	....	3,425	....	....	....	230	17	18
Thursday, May 13	....	1,750	....	....	....	159	19	13
Friday, May 14	....	2,100	....	....	....	316	26	17
Saturday, May 15	....	4,900	....	....	....	329	57	40
Sunday, May 16	....	2,350	....	....		232	24	17
Monday, May 17	2,010	3,195	172	748	....	380	53	39
Tuesday, May 18	....	2,650	....	....	....	167	24	21
Wednesday, May 19	....	3,150	....	....	....	252	40	30
Thursday, May 20	....	3,300	....	....	....	249	40	32
Friday, May 21	....	2,100	....	....	....	180	30	24
Saturday, May 22	....	2,925	....	....	....	219	33	27
Sunday, May 23	....	2,575	....	....	....	257	33	26

ducted by John S. Saunders on the United States Fish Commission barges States and Maryland Commissions of Fish and Fisheries.

Eggs obtained.	Loss.		Results.			Remarks.
	Eggs.	Fish.	Fish hatched.	Fish deposited in local waters.	Fish deposited in other waters.	
40,000	30,000	....	10,000	10,000	....	Eggs badly impregnated and a great many taken too young.
275,000	25,000	....	250,000	250,000	....	
190,000	27,000	....	163,000	163,000	....	
475,000	75,000	....	400,000	400,000	....	
420,000	175,000	....	245,000	245,000	....	150,000 eggs lost by some one dropping coal oil in cone. Placed 10,000 young fish out in the Narrows from eggs taken on 3d.
600,000	60,000	....	540,000	540,000	....	
300,000	30,000	....	270,000	270,000	....	
230,000	15,000	....	215,000	215,000	....	Placed 413,000 fish in Spesutie Narrows on evening of 10th, hatched from eggs taken 4th and 5th.
200,000	10,000	....	190,000	....	200,000	Placed 250 000 fish in Spesutie Narrows. Placed 150,000 fish above Havre de Grace, from eggs taken on 6th. Delivered to Mr. Creveling on 17th.
260,000	25,000	....	235,000	225,000	....	Placed 190,000 eggs in Spesutie Narrows. Placed 145,000 fish above Havre de Grace from eggs taken on 7th.
220,000	10,000	....	210,000	210,000	....	Placed 190,000 eggs in Spesutie Narrows. Placed 300,000 above Havre de Grace from eggs taken on 8th. Shad taken very hard and not yielding full number of eggs.
345,000	20,000	....	325,000	325,000	....	Placed 270,000 above Havre de Grace from eggs taken on the 9th.
790,000	40,000	....	750,000	750,000	....	Placed 215,000 above Havre de Grace from eggs taken on 10th. Shad taken small and not yielding full number of eggs. Scarcity of males reported by some of men taking spawn.
840,000	15,000	....	825,000	75,000	250,000	On 21st delivered to Mr. Creveling.
780,000	20,000	300,000	760,000	460,000	....	Delivered to Commissioner of Fisheries of Pennsylvania 200,000 young fish at 6 p. m. from eggs taken 11th and 12th. Lost 300,000 young fish by salt water being backed up by heavy southeast storm on 21st.
420,000	40,000	....	380,000	240,000	140,000	Placed in cylinder overboard on 22d to keep, as per Major Ferguson's order. Placed 225,000 young fish in Spesutie Narrows about 6 p. m. from eggs taken on 12th.
600,000	40,000	....	560,000	....	560,000	Placed 250,000 young fish above Havre de Grace from eggs taken on 13th and 14th, at 10 a. m.
640,000	40,000	....	600,000	....	....	Placed 285,000 young fish above Havre de Grace from eggs taken on 14th, at 10 a. m. Placed 200,000 young fish above Havre de Grace from eggs taken on 15th. Placed 200,000 young fish in Swan Creek from eggs taken on 15th.
480,000	30,000	....	450,000	....	....	Placed 350,000 young fish above Havre de Grace from eggs taken on 15th. Placed 50,000 young fish above Havre de Grace from eggs taken on 16th. Delivered 25,000 young fish to Pennsylvania commissioner on 16th.
540,000	15,000	....	525,000	525,000	....	Placed 460,000 young fish above Havre de Grace from eggs of 17th.
560,000	15,000	....	545,000	545,000	....	

TABLE 3.—*Record of hatching operations at Spesutie Narrows, Md., con from May 3 to June 10, 1880, under the direction of the United*

Date.	Total length of haul-seines visited, in fathoms.	Total length of gill-nets visited, in fathoms.	Fish taken by haul-seines—			Fish taken by gill-nets—	Ripe fish.	
			Shad.	Herring.	Rock.	Shad.	Males.	Females.
			No.	*Lbs.*	*No.*	*No.*		
Monday, May 24	....	700	....	....	....	88	7	5
Tuesday, May 25	....	1,900	....	....	....	131	14	12
Wednesday, May 26	....	825	....	....	....	52	6	4
Thursday, May 27	....	1,000	....	....	....	148	5	5
Friday, May 28	....	....	....	....	....	....	....	....
Saturday, May 29	....	1,400	....	....	....	169	13	11
Sunday, May 30	....	400	....	....	....	50	6	4
Monday, May 31	....	2,100	....	....	....	229	27	25½
Tuesday, June 1	....	675	....	....	....	58	10	9
Wednesday, June 2	....	2,700	....	....	....	179	20	17
Thursday, June 3	....	400	....	....	....	45	8	8
Friday, June 4	....	8,000	....	....	....	210	37	84
Saturday, June 5	....	1,700	....	....	....	62	12	8
Sunday, June 6	....	1,825	....	....	....	241	29	22
Monday, June 7	....	4,600	....	....	....	557	40	32
Tuesday, June 8	....	1,400	....	....	....	52	13	11
Wednesday, June 9	....	1,580	....	....	....	91	17	11
Thursday, June 10	....	2,400	....	....	....	86	24	19
Total	20,730	48,201	2,953	161,333	843	6,109	871	660

ducted by John S. Saunders on the United States Fish Commission barges States and Maryland Commissions of Fish and Fisheries—Continued.

Eggs obtained.	Loss.		Results.			Remarks.
	Eggs.	Fish.	Fish hatched.	Fish deposited in local waters.	Fish deposited in other waters.	
100,000	25,000	75,000	75,000	....	....	Strike among gillers for 50 cents apiece for ripe fish, which accounts for few eggs taken. Placed 240,000 young fish in Narrows from eggs of 18th.
240,000	90,000	....	150,000	1,050,000	150,000	Sent to Havre de Grace for shipment 1,750,000 young fish from eggs of 18th, 19th, 20th, and 21st. Great scarcity of male fish reported.
80,000	60,000	....	20,000	....	....	Eggs taken, very bad, being badly impregnated by scarcity of males. Lost good quantity by new hatching boxes of Mr. Wright.
100,000	70,000	50,000	80,000	....	....	Placed out in Narrows 1,070,000 young fish from eggs of 22d and 23d. Could not send above Havre de Grace for want of cans. Eggs badly impregnated.
220,000	10,000	....	210,000	....	210,000	Sent 150,000 young fish for distribution to Bush River from eggs of 25th.
80,000	5,000	....	75,000	....	75,000	Storm at night; few gillers out. Moved barges to Watson's Island on account of salt water at 10 a. m.
510,000	25,000	....	485,000	485,000	....	
180,000	20,000	....	160,000	160,000	....	Heavy storm preventing many gillers from going out.
340,000	40,000	....	300,000	300,000	....	
60,000	5,000	....	55,000	55,000	....	Heavy squall preventing gillers from laying out.
680,000	30,000	....	650,000	650,000	....	Placed 285,000 young fish in Bush River from eggs taken on 29th and 30th May.
160,000	20,000	....	140,000	140,000	....	Lost out in river 485,000 young fish by overflow of cylinders and break in wire bottom, from eggs of 31st May. Heavy gale from southwest prevented gillers from going out.
440,000	40,000	....	400,000	400,000	....	Placed in river 400,000 young fish from eggs of 1st and 2d.
640,000	40,000	....	600,000	....	600,000	Placed in river 55,000 young fish from eggs of 3d.
220,000	20,000	....	200,000	....	200,000	Placed in river 650,000 young fish from eggs of 4th.
220,000	20,000	....	200,000	100,000	100,000	Placed 140,000 young fish in river from eggs of 5th.
380,000	20,000	....	360,000	360,000	....	Placed 400,000 young fish on flats opposite Watson's Island on 12th, from eggs of 6th.
						Shipped 900,000 young fish at 2 p. m. on 12th, to go to Maine, from eggs of 7th, 8th, and 9th.
						Turned out 100,000 young fish, which were intended to be shipped to Maine, but storm prevented.
						Had terrific storm on 12th at 3.15 p. m., causing barges to drag anchor (and break chains of three), causing us to lose eggs of 10th, which were nearly out, and barges to go ashore.
13,355,000	1,297,000	425,000	12,058,000	9,148,000	2,485,000	

TABLE 4.—*Record of hatching operations at Navy-Yard station, Washington, D. C., conducted by Messrs. F. N. Clark and C. W. Schuermann; and by Messrs. Sauerhoff and Hamlen, on the steamer Lookout, from May 4 to June 27, 1880, under the direction of the United States and Maryland Commissions of Fish and Fisheries.*

Date.	Total length of haul-seines visited, in fathoms.	Total length of gill-nets visited, in fathoms.	Fish taken by haul-seines.				Fish taken by gill-nets.	Ripe fish.		Eggs obtained.	Results.			Remarks.
			Number of shad.	Number of herring.	Pounds of rock.	Other fish.	Number of shad.	Males.	Females.		Fish hatched.	Fish deposited in local waters.	Fish deposited in other waters.	
Tuesday, May 4	300	......	400	700	......	400	....	39	35	650,000	....	....	....	Eggs obtained at Moxley's Point, Captain Skidmore.
Wednesday, May 5	......	......	......	......	......	......	....	......	......	....	....	....	....	Remained at navy-yard. Cones overcrowded.
Thursday, May 6	......	......	......	......	......	......	....	......	......	....	....	....	....	Remained at navy-yard.
Friday, May 7	......	......	......	......	......	......	....	......	......	....	....	....	....	Fish hatching out.
Saturday, May 8	300	......	......	75,000	......	500	....	......	......	....	635,000	635,000	....	
Sunday, May 9	300	......	103	30,000	......	300	....	17	16	320,000	310,000	50,000	....	Obtained 1,220,000 herring eggs at Moxley's Point; lost 120,000 herring eggs at Moxley's Point.
Monday, May 10	......	......	......	......	......	......	....	......	......	....	....	....	....	Seines not hauling on account of tide.
Tuesday, May 11	......	......	227	20,000	15	1,000	320	23	19	380,000	360,000	310,000	....	320 eggs from gill-nets; 60,000 eggs from haul-seines; 300,000 herring deposited in the Potomac.
Wednesday, May 12	......	......	......	17,000	25	450	430	27	25	500,000	470,000	....	....	Obtained 180,000 herring eggs at stake net.
Thursday, May 13	200	......	166	23,000	18	200	179	67	50	1,000,000	850,000	....	....	
Friday, May 14	......	......	......	......	......	......	....	......	......	....	....	....	....	Remained at navy-yard.
Saturday, May 15	......	......	376	3,000	30	75	135	47	38	....	725,000	360,000	....	180,000 herring deposited at Cumberland, Md.
Sunday, May 16	......	......	......	......	......	......	....	......	......	760,000	....	320,000	....	
Monday, May 17	537	......	......	1,500	17	125	425	115	104	2,070,000	2,036,000	400,000	....	
Tuesday, May 18	......	......	979	400	25	150	150	63	57	1,114,000	1,084,000	200,000	....	
Wednesday, May 19	......	......	......	......	......	......	....	......	......	....	....	....	160,000	Remained at navy-yard. Cones overcrowded.
Thursday, May 20	......	......	......	100	37	200	73	87	76	1,520,000	1,300,000	400,000	....	
Friday, May 21	300	......	735	250	75	200	325	130	119	2,320,000	2,000,000	800,000	....	
Saturday, May 22	300	......	650	400	25	150	197	70	55	1,100,000	1,000,000	825,000	....	
Sunday, May 23	300	......	475	250	20	400	250	29	20	520,000	450,000	....	2,000,000	
Monday, May 24	300	......	560	100	15	600	....	25	20	400,000	850,000	800,000	....	

Tuesday, May 25	*300*		*327*	*150*	*8*	*700*	*297*	*19*	*15*	*300,000*	*250,000*	*1,400,000*		
Wednesday, May 26	*300*		*36*	*25*	*50*	*400*	*97*	*2*	*2*	*80,000*		*2,400,000*		*Eggs of the 26th and 27th were so poor that none were hatched.*
Thursday, May 27	*300*		*187*	*125*	*60*	*125*	*129*	*2*	*2*	*40,000*		*450,000*		
Friday, May 28	300		199	200	40	50	179	15	14	280,000	230,000	150,000	200,000	
Saturday, May 29		400					325	21	18	325,000	275,000	250,000		
Sunday, May 30		525					393	22	38	760,000	675,000			
Monday, May 31		575					257	39	53	1,010,000	900,000			
Tuesday, June 1		425					127	19	23	430,000	800,000	30,000	200,000	
Wednesday, June 2		380					251	46	50	840,000	700,000	275,000		
Thursday, June 3		575					249	23	23	410,000	375,000			
Friday, June 4		500					157	23	25	430,000	400,000	675,000		
Saturday, June 5		275					37	5	5	95,000	90,000	900,000		Eggs placed in hatching-boxes at Fort Washington.
Sunday, June 6												800,000	700,000	No boats gilling.
Monday, June 7		450					202	32	37	650,000	615,000	375,000		
Tuesday, June 8		775					254	37	39	670,000	600,000	400,000		
Wednesday, June 9		725					114	18	24	400,000	375,000	100,000		100,000 shad placed in the Potomac at Fort Washington.
Thursday, June 10		500					157	5	6	100,000	85,000			
Friday, June 11													300,000	Steamer remained at navy-yard.
Saturday, June 12												575,000	240,000	Do.
Sunday, June 13												475,000		175,000 shad used for experimental purposes.
Monday, June 14		375					205	29	31	520,000	450,000	85,000		Used for experimental purposes.
Tuesday, June 15		175					72	9	10	140,000	100,000			
Wednesday, June 16		250					276	20	24	315,000	300,000			
Thursday, June 17		275					108	11	10	180,000	160,000			
Friday, June 18												*50,000	400,000	Steamer remained at navy-yard.
Saturday, June 19												*100,000		Do.
Monday, June 21										20,000	15,000			Steamer remained at navy-yard on 20th.
Tuesday, June 22										120,000	85,000	*160,000		
Sunday, June 27												*100,000		
	4,037	7,180	5,420	172,200	440	6,025	6,370	1,136	1,089	20,749,000	18,550,000	14,350,000	4,200,000	

* Used for experimental purposes.

TABLE 5.—*Chronological record of distribution of shad made from May 7, 1880, to June 27, 1880, by United States Fish Commission, under direction of T. B. Ferguson.*

Date of leaving station.		Date fish placed in the stream stocked.		Number of fish.		State.	Place.	Stream.	Tributary of—	Transfer in charge of—
Day of week.	Day of month.	Day of week.	Day of month.	Originally taken.	Actually planted.					
Friday	May 7	Friday	May 7	10,000	10,000	Maryland	Spesutie Narrows	Susquehanna	Chesapeake Bay	John S. Saunders.
Saturday	May 8	Saturday	May 8	335,000	335,000	...do	Washington, D. C	Eastern Br. Potomac	Potomac	William P. Sauerhoff.
Do	May 8	...do	May 8	300,000	300,000	...do	Laurel	Patuxent	Chesapeake Bay	C. W. Schuermann.
Sunday	May 9	Sunday	May 9	50,000	50,000	...do	Washington, D. C	Eastern Br. Potomac	Potomac	William P. Sauerhoff.
Monday	May 10	Monday	May 10	413,000	413,000	...do	Spesutie Narrows	Susquehanna	Chesapeake Bay	John S. Saunders.
Tuesday	May 11	Tuesday	May 11	250,000	230,000	...do	...do	...do	...do	Do.
Do	May 11	...do	May 11	150,000	150,000	...do	Havre de Grace	...do	...do	Do.
Do	May 11	...do	May 11	110,000	110,000	...do	Washington, D. C	Eastern Br. Potomac	Potomac	C. W. Schuermann.
Do	May 11	...do	May 11	200,000	200,000	...do	Savage	Patuxent	Chesapeake Bay	W. H. Jenkins, jr.
Wednesday	May 12	Wednesday	May 12	145,000	145,000	...do	Havre de Grace	Susquehanna	...do	John S. Saunders.
Do	May 12	...do	May 12	100,000	100,000	...do	Spesutie Narrows	...do	...do	Do.
Thursday	May 13	Thursday	May 13	190,000	190,000	...do	...do	...do	...do	Do.
Do	May 13	...do	May 13	350,000	350,000	...do	Havre de Grace	...do	...do	Do.
Friday	May 14	Friday	May 14	270,000	270,000	...do	...do	...do	...do	Do.
Saturday	May 15	Saturday	May 15	215,000	215,000	...do	...do	...do	...do	Do.
Do	May 15	...do	May 15	60,000	60,000	...do	Washington, D. C	Potomac	...do	C. W. Schuermann.
Do	May 15	...do	May 15	800,000	800,000	...do	Cumberland	...do	...do	H. E. Quinn.
Sunday	May 16	Sunday	May 16	20,000	20,000	...do	Washington, D. C	Eastern Br. Potomac	Potomac	C. W. Schuermann.
Do	May 16	...do	May 16	800,000	800,000	...do	Savage	Patuxent	Chesapeake Bay	Newton Simmons.
Monday	May 17	Monday	May 17	100,000	100,000	...do	Washington, D. C	Eastern Br. Potomac	Potomac	C. W. Schuermann.
Do	May 17	...do	May 17	300,000	300,000	...do	Point of Rocks	Potomac	Chesapeake Bay	J. F. Ellis.
Do	May 17	...do	May 17	200,000	200,000	Pennsylvania	Georgetown	Susquehanna	...do	J. P. Creveling.
Tuesday	May 18	Tuesday	May 18	200,000	200,000	Maryland	Washington, D. C	Eastern Br. Potomac	Potomac	C. W. Schuermann.
Do	May 18	...do	May 18	225,000	225,000	...do	Spesutie Narrows	Susquehanna	Chesapeake Bay	John S. Saunders.
Wednesday	May 19	Wednesday	May 19	250,000	250,000	...do	Havre de Grace	...do	...do	Do.
Do	May 19	...do	May 19	160,000	160,000	Virginia	Petersburg	Appomattox	James River	S. M. Rixey.
Thursday	May 20	Thursday	May 20	400,000	400,000	Maryland	Washington, D. C	Eastern Br. Potomac	Potomac	Sauerhoff & Hamlen.
Do	May 20	...do	May 20	285,000	285,000	...do	Havre de Grace	Susquehanna	Chesapeake Bay	John S. Saunders.
Do	May 20	...do	May 20	200,000	200,000	...do	...do	...do	...do	Do.
Do	May 20	...do	May 20	200,000	200,000	...do	Swan Creek	...do	...do	Do.
Friday	May 21	Friday	May 21	350,000	350,000	...do	Havre de Grace	...do	...do	Do.
Do	May 21	...do	May 21	50,000	50,000	...do	...do	...do	...do	Do.
Do	May 21	...do	May 21	25,000	25,000	...do	Spesutie Narrows	...do	...do	Do.
Do	May 21	...do	May 21	200,000	200,000	...do	Washington, D. C	Eastern Br. Potomac	...do	Sauerhoff & Hamlen.
Do	May 21	...do	May 21	600,000	600,000	...do	Savage	Patuxent	Chesapeake Bay	J. F. Ellis.
Do	May 21	...do	May 21	250,000	250,000	Pennsylvania	Harrisburg	Susquehanna	...do	J. P. Creveling.
Saturday	May 22	Saturday	May 22	460,000	460,000	Maryland	Havre de Grace	...do	...do	John S. Saunders.
Do	May 22	...do	May 22	600,000	600,000	...do	Washington, D. C	Eastern Br. Potomac	Potomac	C. W. Schuermann.
Do	May 22	...do	May 22	200,000	200,000	...do	Near Fort Washington.	Potomac	Chesapeake Bay	Sauerhoff & Hamlen.

Sunday	May 23	Sunday	May 23	25,000	25,000	...do	...do	...do	...do	Sauerhoff & Hamlen
Do	May 23	Monday	May 24	2,000,000	375,000	South Carolina	Gaffney's Station	Broad River	Congaree	C. J. Huske.
		...do	May 24		375,000	...do	Seneca Station	Seneca River	Savannah River	Do.
		...do	May 24		60,000	...do	Near Rock Hill	Catawba	Wateree	J. F. Ellis.
		...do	May 24		140,000	...do				J. F. Ellis.*
		...do	May 24		40,000	...do	Railroad Crossing	Wateree	Santee	S. M. Rixey.
		...do	May 24		40,000	...do	...do	Lynch's Creek	Great Pedee	Do.
		...do	May 24		40,000	...do	...do	Big Pedee	Winyaw Bay	Do.
		...do	May 24		40,000	...do	Near Nicholls Station.	Little Pedee	Great Pedee	Do.
		Tuesday	May 25		296,000	Georgia	Railroad Crossing	Oconee	Altamaha	J. F. Ellis.
		...do	May 25		296,000	...do	Near Covington	Yellow	Ocmulgee	Do.
		...do	May 25		296,000	...do	Near Boltonville	Chattahoochee	Apalachicola	Do.
Monday	May 24	Monday	May 24	800,000	800,000	Maryland	Washington, D. C.	Eastern Br. Potomac	Potomac	Clark & Schuermann.
Do	May 24	...do	May 24	240,000	240,000	...do	Spesutie Narrows	Susquehanna	Chesapeake Bay	John S. Saunders.
Tuesday	May 25	Tuesday	May 25	400,000	400,000	...do	Washington, D. C.	Eastern Br. Potomac	Potomac	F. N. Clark.
Do	May 25	...do	May 25	500,000	500,000	...do	Moxley's Point	Potomac	Chesapeake Bay	Sauerhoff & Hamlen.
Do	May 25	...do	May 25	500,000	500,000	...do	Savage	Patuxent	...do	C. W. Schuermann.
Do	May 25	...do	May 25	1,500,000	120,000	Delaware	Wilmington	Christiania Creek	Delaware River	N. Simmons.
		...do	May 25		180,000	...do	Dover	Jones Creek	...do	Do.
		...do	May 25		1,050,000	...do	Seaford	Nanticoke	Chesapeake Bay	Do.
Wednesday	May 26	Wednesday	May 26	500,000	500,000	Maryland	Moxley's Point	Potomac River	...do	Sauerhoff & Hamlen.
Do	May 26	...do	May 26	1,500,000	1,500,000	...do	Laurel	Patuxent	...do	C. J. Huske.
Do	May 26	...do	May 26	400,000	400,000	...do	Washington, D. C.	Eastern Br. Potomac	Potomac	C. W. Schuermann.
Thursday	May 27	Thursday	May 27	450,000	450,000	...do	...do	...do	...do	F. N. Clark.
Do	May 27	...do	May 27	1,070,000	1,070,000	...do	Spesutie Narrows	Susquehanna	Chesapeake Bay	John S. Saunders.
Friday	May 28	Friday	May 28	75,000	75,000	...do	...do	...do	...do	Do.
Do	May 28	...do	May 28	150,000	150,000	...do	Washington, D. C.	Eastern Br. Potomac	Potomac	F. N. Clark.
Do	May 28	...do	May 28	200,000	200,000	South Carolina				C. J. Huske.
Saturday	May 29	Saturday	May 29	150,000	150,000	Maryland	Near Perrymansville.	Bush River	Chesapeake Bay	Newton Simmons.
Do	May 29	...do	May 29	50,000	50,000	...do	Deer Park	Little Youghiogheny	Youghiogheny	S. M. Rixey.
Do	May 29	...do	May 29	200,000	200,000	...do	Washington, D. C	Eastern Br. Potomac	Potomac	F. N. Clark.
Tuesday	June 1	Tuesday	June 1	30,000	30,000	...do	...do	...do	...do	Do.
Do	June 1	Friday	June 4	200,000	40,000	Missouri	Shell City	Osage River	Missouri	G. G. Davenport.
		...do	June 4		20,000	...do	Railroad Crossing	Salt River	Mississippi	J. F. Ellis.
		...do	June 4		20,000	...do	...do	Chariton	Missouri	Do.
		...do	June 4		40,000	...do	Near Jerome	Gasconade	...do	S. M. Rixey.
		...do	June 4		20,000	...do	Railroad Crossing	Grand River	...do	J. F. Ellis.
		Saturday	June 5		20,000	...do	...do	Platte River	...do	Do.
		...do	June 5		20,000	...do	...do	202 River		Do.
		...do	June 5		20,000	...do	...do	Nodaway	Missouri	Do.
Wednesday	June 2	Wednesday	June 2	50,000	50,000	Maryland	Off Watson's Isl'd.	Susquehanna	Chesapeake Bay	John S. Saunders.
Do	June 2	...do	June 2	275,000	275,000	...do	Moxley's Point	Potomac	...do	W. P. Sauerhoff.
Thursday	June 3	Thursday	June 3	285,000	285,000	...do	Near Perrymansville.	Bush River	...do	M. Gleason.
Friday	June 4	Friday	June 4	485,000	485,000	...do	Off Watson's Isl'd.	Susquehanna	...do	John S. Saunders.
Do	June 4	...do	June 4	500,000	500,000	...do	Little Falls	Potomac	...do	Frank N. Clark.
Do	June 4	...do	June 4	175,000	175,000	...do	Washington, D. C.	Eastern Br. Potomac	Potomac	Do.
Saturday	June 5	Saturday	June 5	600,000	600,000	...do	Little Falls	Potomac	Chesapeake Bay	Wm. H. Jenkins, jr.

* Turned over to Colonel Butler.

TABLE 5.—*Chronological record of distribution of shad made from May 7, 1880, to June 27, 1880, &c.*—Continued.

Date of leaving station.		Date fish placed in the stream stocked.		Number of fish.		State.	Place.	Stream.	Tributary of—	Transfer in charge of—
Day of week.	Day of month.	Day of week.	Day of month.	Originally taken.	Actually planted.					
Saturday	June 5	Saturday	June 5	300,000	300,000	Maryland	Washington, D. C.	Eastern Br. Potomac	Potomac	F. N. Clark.
Sunday	June 6	Sunday	June 6	460,000	460,000	...do	Off Watson's Island.	Susquehanna	Chesapeake Bay	John S. Saunders.
Do	June 6	...do	June 6	300,000	300,000	...do	Washington, D. C.	Eastern Br. Potomac	Potomac River	F. N. Clark.
Do	June 6	Monday	June 7	700,000	700,000	Kentucky	Shepherdsville	Salt River	Ohio River	Commis'ner Griffith.
Monday	June 7	...do	June 7	55,000	55,000	Maryland	Off Watson's Island.	Susquehanna	Chesapeake Bay	John S. Saunders.
Do	June 7	...do	June 7	375,000	375,000	...do	Savage	Patuxent	...do	S. M. Rixey.
Tuesday	June 8	Tuesday	June 8	650,000	650,000	...do	Off Watson's Island.	Susquehanna	...do	John S. Saunders.
Do	June 8	...do	June 8	400,000	400,000	...do	Little Falls	Potomac	...do	S. M. Rixey.
Wednesday	June 9	Wednesday	June 9	140,000	140,000	...do	Off Watson's Island.	Susquehanna	...do	John S. Saunders.
Do	June 9	...do	June 9	100,000	100,000	...do	Fort Washington	Potomac	...do	William P. Sauerhoff.
Friday	June 11			300,000	150,000	Georgia	Milledgeville	Oconee River	Altamaha	C. W. Schuermann.
					150,000	...do	Albany	Flint	Apalachicola	Do.
Saturday	June 12	Saturday	June 12	400,000	400,000	Maryland	Off Watson's Island.	Susquehanna	Chesapeake Bay	John S. Saunders.
Do	June 12	...do	June 12	100,000	100,000	...do	Off Watson's Island.	...do	...do	Do.
Do	June 12	...do	June 12	75,000	75,000	...do	Washington, D. C.	Eastern Br. Potomac	Potomac	F. N. Clark.
Do	June 12	...do	June 12	500,000	500,000	...do	Little Falls	Potomac	Chesapeake Bay	William H. Jenkins.
Do	June 12	Friday	June 18	240,000	215,000	California	Tehama	Sacramento	San Francisco Bay.	Ellis & Davenport.
Sunday	June 13	Sunday	June 13	175,000	*175,000	Maryland				F. N. Clark.
Do	June 13	...do	June 13	300,000	300,000	...do	Washington, D. C.	Eastern Br. Potomac	Potomac	Do.
Do	June 13	Tuesday	June 15	675,000	337,500	Maine	Waterville	Kennebec	Atlantic Ocean	H. E. Quinn.
		...do	June 15		337,500	...do	Mattawamkeag	Mattawamkeag	Penobscot	Do.
Monday	June 14	Monday	June 14	85,000	*85,000	Maryland				F. N. Clark.
Friday	June 18	Friday	June 18	50,000	*50,000	...do				Do.
Do	June 18			200,000	200,000	Ohio	Fremont	Sandusky	Lake Erie	C. W. Schuermann.
Do	June 18	Sunday	June 20	200,000	200,000	Indiana	La Fayette	Wabash	Ohio River	H. E. Quinn.
Saturday	June 19	Saturday	June 19	100,000	*100,000	Maryland				F. N. Clark.
Tuesday	June 22	Tuesday	June 22	160,000	*160,000	...do				Do.
Sunday	June 27	Sunday	June 27	100,000	†100,000	...do				Do.
				29,473,000	29,296,000					

* Used for experimental purposes.

† Moved to Smithsonian Institution for experiments.

TABLE 6.—*Record of distribution of shad made from May 7, 1880, to June 27, 1880, by United States Fish Commission, under direction of T. B. Ferguson, arranged according to States.*

Station.	Date of leaving station		Date fish placed in the stream stocked.		Number of fish.		State.	Place.	Stream.	Tributary of—	Transfer in charge of—
	Day of week.	Day of month.	Day of week.	Day of month.	Originally taken.	Actually planted.					
Potomac station	Saturday	June 12	Friday	June 18	240,000	215,000	Cal	Tehama	Sacramento	San Francisco Bay.	Ellis & Davenport.
Havre de Grace station.	Tuesday	May 25	Tuesday	May 25	450,000	120,000	Del	Wilmington	Christiania Creek	Delaware River.	N. Simmons.
			...do	May 25		180,000	Del	Dover	Jones Creek	Delaware Bay	Do.
Potomac station	Sunday	May 23	...do	May 25	888,000	296,000	Ga.	Railroad Crossing.	Oconee River	Altamaha	J. F. Ellis.
			...do	May 25		296,000	..do	Near Covington	Yellow River	Ocmulgee	Do.
			...do	May 25		296,000	..do	Near Boltonville	Chattahoochee	Apalachicola	Do.
Do	Friday	June 11			300,000	150,000	..do	Milledgeville	Oconee River	Altamaha	C. W. Schuermann.
						150,000	..do	Albany	Flint	Apalachicola	Do.
Do	do	June 18	Sunday	June 20	200,000	200,000	Ind	La Fayette	Wabash	Ohio River	H. E. Quinn.
Do	Sunday	June 6	Monday	June 7	700,000	700,000	Ky	Shepherdsville	Salt River	...do	Commissioner Griffith.
Havre de Grace station.	...do	June 13	Tuesday	June 15	675,000	337,500	Me	Waterville	Kennebec	Atlantic Ocean	H. E. Quinn.
			...do	June 15		337,500	..do	Mattawamkeag	Mattawamkeag	Penobscot	Do.
Do				May 7 / June 12	7,863,000	7,863,000	Md	Havre de Grace	Susquehanna	Chesapeake Bay.	John S. Saunders.
Potomac station				May 7 / June 13	9,855,000	9,855,000	..do	Washington, D.C.	Potomac	...do	F. N. Clark.
Do				May 3 / June 7	3,775,000	3,775,000	..do	Laurel	Patuxent	...do	Do.
Havre de Grace station.				May 25	1,050,000	1,050,000	Del	Seaford	Nanticoke	...do	Newton Simmons.
Do				June —	435,000	435,000	Md	Railroad Crossing.	Bush	...do	Do.
Potomac station				May 29	50,000	50,000	..do	Deer Park	Little Youghiogheny.	Youghiogheny	S. M. Rixey.
Do				June 13 / June 27	670,000	*670,000	..do				F. N. Clark's Station.
Do	Tuesday	June 1	Friday	June 4	200,000	40,000	Mo	Shell City	Osage River	Missouri	G. G. Davenport.
Do			...do	June 4		20,000	..do	Railroad Crossing.	Salt River	Mississippi	J. F. Ellis.
Do			...do	June 4		20,000	..do	...do	Chariton	Missouri	Do.
Do			...do	June 4		40,000	..do	Near Jerome	Gasconade	...do	S. M. Rixey.
Do			...do	June 4		20,000	..do	Railroad Crossing.	Grand River	...do	J. F. Ellis.
Do			Saturday	June 5		20,000	..do	...do	Platte River	...do	Do.

TABLE 6.—*Record of distribution of shad made from May 7, 1880, to June 27, 1880, &c.*—Continued.

Station.	Date of leaving station.		Date fish placed in the stream stocked.		Number of fish.		State.	Place.	Stream.	Tributary of—	Transfer in charge of—
	Day of week.	Day of month.	Day of week.	Day of month.	Originally taken.	Actually planted.					
Potomac station			Saturday	June 5		20,000	Mo.	Railroad Crossing.	202 River		J. F. Ellis.
Do			do	June 5		20,000	do	do	Nodaway	Missouri	Do.
	Friday	June 18			200,000	200,000	Ohio	Fremont	Sandusky	Lake Erie	C. W. Schuermann.
Havre de Grace station.	Monday	May 17	Monday	May 17	200,000	200,000	Pa	Georgetown	Susquehanna	Chesapeake Bay	J. P. Creveling.
Do	Friday	May 21	Friday	May 21	250,000	250,000	do	Harrisburg	do	do	Do.
Potomac station	Sunday	May 23	Monday	May 24	1,112,000	375,000	S. C	Gaffney's Station	Broad River	Congaree	C. J. Huske.
			do	May 24		375,000	do	Seneca Station	Seneca River	Savannah	Do.
			do	May 24		60,000	do	Near Rock Hill	Catawba	Wateree	J. F. Ellis.
			do	May 24		†140,000	do				Do.
			do	May 24		40,000	do	Railroad Crossing.	Wateree	Santee	S. M. Rixey.
			do	May 24		40,000	do	do	Lynch's Creek	Great Pedee	Do.
			do	May 24		40,000	do	do	Big Pedee	Winyaw Bay	Do.
			do	May 24		40,000	do	Near Nicholls Station.	Little Pedee	Great Pedee	Do.
Do	Friday	May 28			200,000	200,000	do				C. J. Huske.
Do	Wednesday	May 19	Wednesday	May 19	160,000	160,000	Va.	Petersburg	Appomattox	James	S. M. Rixey.
					29,473,000	29,296,000					

* Used for experimental purposes.

† Turned over to Colonel Butler.

XXVI.—RAISE CARP!*

By Max von dem Borne.

It is well known that carp-raising is a very ancient industry and has been brought to a very high degree of perfection. Any one who wishes to start a carp-raising establishment will not hesitate to undertake a journey for the purpose of studying by personal observation the establishments of experienced carp-raisers. Valuable hints will be found in the following works:

Wenzel Horak. *Die Teichwirthschaft, mit besonderer Rücksicht auf das südliche Böhmen.* Prag, 1869. (Pond Culture, particularly in Southern Bohemia.)

Karl Nicklas. *Lehrbuch der Teichwirthschaft.* Stettin, 1880. (Manual of Pond Culture.)

Adolf Gasch. *Die Teichwirthschaft auf dem Gute Kaniow.* Bielitz, 1880. (Pond Culture on the Kaniow estate.)

As also in my own work, *Die Fischzucht* (Pisciculture).

The president of the German Fishery Association, Herr von Behr, of Schmoldow, has requested me to prepare a short article, which would show in a simple manner that, even independent of pond culture, carp-raising may reach a much higher degree of perfection than it possesses at present. I gladly meet this request, and, as the contents of this brief paper have been very carefully examined by von Behr, I feel convinced that he fully agrees with the views expressed by me.

The main points are, to introduce great masses of young carp in our rivers, which by river improvements have been deprived of the old spawning-places of the cyprinoids; to stock with young carp our numerous German lakes, where, owing to the presence of pike and other fish of prey, carp cannot successfully spawn, as a portion, at least, of such young carp will under all circumstances reach maturity; and to make even small ponds and marl-pits sources of revenue by stocking them with young carp. The manner in which I would like to see the Stettiner Haff stocked with 20 million young carp, may be seen in various newspapers articles on the subject, as well as in Circular No. 6, 1881, of the German Fishery Association.

I therefore gladly meet von Behr's request, and will endeavor to describe how young carp, for the purposes indicated above, can be pro-

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* *Züchtet Karpfen!* | *M. v. d. Borne* | *auf Berneuchen i. N. M.* | *herausgeben vom Deutsche Fischerei-Verein.* | —Translated from the German by Herman Jacobson.

cured in the easiest and cheapest manner, instead of obtaining them from a distance at a comparatively great expense.

The *beau ideal* of carp-raising would be the following plan: Every owner of ground should toward the end of May select a dry piece of ground, well warmed through by the sun—say one-half hectare in extent—and fill it with water from a running stream or brook to the height of three-quarters to one meter, and thus form a so-called "sky-pond." Pike should positively be kept out of such a pond, which is much easier constructed than is generally supposed, especially if one does not mind the small expense of inclosing it with a low dike. Most estates have sufficient running water to keep the water at the same height all the time. The next thing would be to procure from some reliable establishment one spawner and two milters, place them in the pond, and also put in it a quantity of brush-wood of pine, juniper, birch, &c.; and one may with certainty count on seeing this brush-wood, in June, when the sun has warmed the water, and again in August, covered with numberless carp eggs. A female carp is said to contain about one-half million eggs. This figure may be a little exaggerated, but Mr. Gasch, whose pamphlet has been spoken of above, and who, for his carp culture, received the gold medal at the Berlin International Fishery Exposition, calls 60,000 young carp to one-half hectare *a very common result.* He also assures us that 1,000 young fish of this description, in a pond measuring one-half hectare, reach the length of 20 centimeters (in exceptional cases 15 or 25 centimeters) the same summer in which they first saw the light of this world, without giving them any food. As such a carp is worth 20 pfennig (5 cents), the revenue from one-half hectare, from the end of June till October, would be 200 mark ($47.60). This astonishing development of the young carp was owing to the fact that they always had abundant food. When the 60,000 young fish first left their eggs, they found sufficient food on one-half hectare, but as they grew in weight and size they needed a larger extent of pond, which in four mounths increased from one-half hectare to 60 hectares. The small spawning-pond cannot supply sufficient food till autumn, and even if the fish escape starvation, they will always be in poor condition. As our ideal "sky-pond" is of course supposed to enjoy the advantage of a most favorable location, we permit the young fish, when they have reached the length of a few centimeters, and need a larger extent of water, to slip through the grating which closes the pond, in order to scatter over the river or lake, or we let the entire contents of the pond flow into the river or lake. If this is not possible, we assign to the fish a larger space from the very beginning. Fifty thousand young fish can live very well till October in one hectare of water, and be successfully used for stocking other waters, although they will not reach that degree of development which Mr. Gasch attains for his fish. The fish may also be fed with boiled potatoes, broken into small pieces, kitchen refuse, linseed cake, manure, &c.

What becomes of our young fish when the cold season approaches, when in October their power of moving decreases, till the period when they commence their long winter sleep? If the spawning-pond is suited for wintering, where there is no danger of its being covered so thickly with ice as to cause the death of the young fish, it will be best not to take them out *till spring*, when the ice has melted, and when it is certain that the pond can again be filled at the right time.

If the young fish cannot winter in the pond, they may get through the winter by being placed in a so-called "chamber-pond" which is free from fish of prey, and can be laid entirely dry; or, if this should be impossible, the 60,000 young fish may safely be set free in October. We know the dangers to which they are exposed in waters containing many fish of prey, but we also know from experience that, in spite of this, successful results may be looked for. While, during winter, the young fish are in a lethargic condition and the fish of prey are particularly voracious, these latter are in spring in a very lazy condition, owing to their having spawned, whilst the carp are lively and have an excellent appetite. From principle, therefore, it is much better to set out young fish in spring, although the setting out of one summer's young fish is by no means as hopeless an undertaking as is thought by many pisciculturists. I will give an example from my own experience. One of my lakes, the *Hamelung* Lake, measures about 5 hectares, and contains numerous pike and perch. In autumn I stocked this pond with 1,200 one-summer's carp, and three years later I caught, during the ice fisheries, 680 table carp, which on an average weighed 3 pounds each. During the two previous winters the pike, caught during the ice fisheries, invariably threw up small carp, which they had evidently swallowed during the fisheries, because they had not yet been digested. I obtained similar favorable results in several other lakes and in the river *Mietzel*, all of which waters are rich in pike and perch. I have, therefore, come to the conclusion that *one hectare of water, which contains many fish of prey, can, even in autumn, be sufficiently stocked with carp, by placing in it 250 one-summer's carp.* The fear, so often expressed, that such small fish would all be devoured by fish of prey, is in my opinion entirely groundless, because all large fish have, at some time during their life, been small, and been exposed to the danger of being devoured by larger fish.

The larger the carp the smaller may be the number of fish placed in one pond. It will also pay to place large carp in open waters, for a very intelligent pisciculturist in Schleswig-Holstein has for a long time been in the habit of buying a large number of carp measuring 20 centimeters or more in length, and stocking, with these fish, lakes where fishing is easy; and has in this way become a wealthy man. Thus he set out, last year, carp weighing 1½ pounds each, and has been able, this winter, to catch fish weighing 2½ pounds each.

Throughout our entire country people begin to take a greater interest in water culture, and there is a very general and growing consciousness of our *duties* with regard to our large and beautiful lakes and rivers. The hope may therefore not be in vain that landed proprietors of liberal views, and more especially the largest landed proprietor, the State, will here and there, in their fields or forests or along their rivers, construct spawning-ponds of ½ hectare, buy 3 spawning carp for 10 mark ($2.38), and annually let 60,000 young carp loose in the rivers. An example will show what may be accomplished with very small means. When in the autumn of 1881 I visited some of the forests on the shores of the Stettiner Haff, in company with Counsellor von Bünau and the Royal Forester Baron von Dücker, for the purpose of finding suitable places for constructing spawning-ponds for carp, we found that Baron von Dücker had already, by irrigating certain portions of these forests, constructed the necessary ponds by simply closing those ditches through which in former times several of the ponds and one lake had been drained. At an expense of only 71 mark 69 pfennig ($17.19), four ponds had been constructed with a total area of 101 hectares, and by a further expense of 3,500 marks ($833) all the other necessary arrangements could be made. With just as small an expense, spawning-ponds with a total area of 700 to 1,000 hectares could easily be constructed in all the forests on the shores of the Stettiner Haff. The 101 hectares already in existence could probably furnish at least 5,000,000 carp per annum, and therefore produce the quantity demanded by me (20,000,000) in four years.

Magnificent carp, both as to size and flavor, are caught here and there in our rivers, and there is hardly a doubt that they have, when young, escaped from some piscicultural establishment, or that, because not needed there, they have been purposely set at liberty.

As not all those persons who would like to raise young carp are able to construct spawning-ponds, I make the following proposition, which I do not consider chimerical, and which is well worth a trial. I must state expressly, however, that I have not personally made the experiment. At the International Fishery Exposition in Berlin, there was exhibited in the Swedish department a spawning-box which had been used in Sweden since 1761 for bleak and other fish, and might also be used for carp. It is very spacious, made of perforated boards, and the inside is covered with pine brush. At the beginning of the spawning season it is stocked with male and female fish, which deposit their eggs on the brush-wood, and are thereupon let out through an opening in the side of the box. The spawning carp have to be removed, for if they remained in the box they would either injure or devour the eggs. The fish may also, when taken from the box, be placed in a small pond, where they will sufficiently recover to be fit for another spawning. The box is secured by an anchor and floats about in the water; by the motion, the water is constantly renewed, and any injury from strong waves is averted. As soon as the young fish can swim the box is opened, so that they can go out into the open water. It would be an advantage to have portions of the sides of the box made of fine wire grating. Why could not such boxes with brushwood be placed in a lake and stocked with 3 carp (1 spawner and 2 milters)? Would not the brushwood soon be covered with eggs?

Carp may also be transplanted by sending such brushwood covered with eggs to some distance and placing it in floating boxes similar to the one described. It is well known that Mr. R. Eckardt, of Lübbinchen, has frequently shipped carp eggs in this manner to distant places.

There is much talk at the present time of *mirror carp* and *leather carp;* they are generally considered a more delicate article of food than the scale carp, but do not grow as fast as these. Mr. Gasch very justly considers it important to use for purposes of propagation only the finest-shaped carp, which presumably will grow quicker than carp of inferior form.

In the above I have entirely followed Mr. Gasch, as far as the small "sky ponds" are concerned, whilst, with regard to the Swedish spawning-box, I have only urged that experiments be made; but in the following I take the liberty to communicate my own experiences of many years in the Berneuchen piscicultural establishment, as well as those of other pisciculturists.

CONSTRUCTION OF A GOOD SPAWNING-POND.

The first condition is that it can be laid completely dry and be filled again with water at the proper time. No puddles must remain, if any favorable results are to be looked for, and no pains should be spared to remove them. Only in rare cases can a good pond be constructed by digging out of the ground; the best way is to inclose a piece of low ground in the lowest place by a dike. As has already been mentioned, a pond can be constructed at a very trifling expense by closing the drain by means of which swamps, lakes, or ponds have formerly been laid dry.

According to the different sources from which the water for the ponds is drawn, we distinguish—

Brook and river ponds, which are fed by running water;

Spring ponds, which are fed by springs;

Sky ponds, which are fed by rain and snow-water, or by ditches which are dry during the hot season.

The *dike* is made from the material nearest at hand, the fish pit being constructed at the same time. The best material is loam or clay. Wherever the soil is sandy, the dike and pond must have a foundation of clay, if water does not flow into the pond at all times, in order to prevent the pond becoming dry.

Flat spawning-ponds are the best, because in them the water gets warm easier than in deep ponds. The most suitable depth of water is about 1 meter in the deepest places.

In order to let off the water from the pond, a *drain-pipe* is laid through the dike, which can be closed and opened on the water side; it may be either of wood or burnt clay or cement. In sandy soil the drain-pipe must be perfectly tight, because otherwise the sand enters and is carried along with the water, so that the dike sinks and the water of the pond flows out. In sandy soil wooden drain-pipes ought therefore to be incased in cement.

The so-called *tap-house* is located at the end of the drain-pipe on the water side; it consists of a wooden grating or rake, which prevents fish from entering the drain-pipe, and a *valve* for letting off the water. Iron gratings are not suitable, because rust soon destroys them.

The *fish-pit* is a hole near the tap-house, in which the the fish gather when the water of the pond is let off. It should be so constructed that it can be laid entirely dry, must be spacious and have a firm bottom; wherever the bottom is loose, it should, therefore, be made firm by means of sand, gravel, and stones.

Besides the fish-pit there is another pit, into which the water flows after having left the drain-pipe. It is intended to receive the fish when the grating is broken, and for this purpose there is a grating at its mouth. It is not advisable, however, to let too many fish gather in this pit, because they are easily injured in passing through the drain-pipe.

The bottom of the pond is furrowed with small ditches, so that the water can everywhere flow off easily and quickly, and the fish can easily find their way into the fish-pit.

If a brook or stream passes through the pond, a ditch is carried round the edge, so that the water can in this way be let out. In this manner stones, sand, and mud are kept out of the pond, which would otherwise be entirely filled with such matter. High water is also let out in this way, as it might cause a break in the dike.

Small floating *swamp islands* and *reeds* are injurious. The floating is prevented by putting sand on the swampy places when the pond is drained off; and the growth of reeds is checked by laying the pond dry, by using the bottom for agricultural purposes, and by cutting the reeds under the water during summer.

Spawning-ponds for carp should be kept free from fish of prey, because they prevent the increase of the carp. In Bohemia one pike is put in the raising-ponds, to every 10 carp; the increase is thereby so completely prevented that when the pond is laid dry not a single newly-born carp is ever found. When the carp want to spawn, the pike immediately make their appearance and act as if they too wanted to spawn. This probably disturbs the carp to such a degree as to prevent impregnation, for the numerous eggs are always destroyed by a sort of mold. The pike must therefore be carefully kept away from the spawning-ponds; and it will be the safest way to feed such ponds from such rivers, &c., which contain no other fish, but especially no pike. Sky-ponds, which are fed by atmospheric water, are therefore the safest. Water coming from brooks, lakes, and ponds containing pike should therefore be filtered through a *gravel* weir. Such a weir is made by placing a grating in the feeding-ditch and filling the ditch with coarse gravel of the size of walnuts. Pike of the previous year cannot pass the weir, and the young pike are too small to disturb the carp in their spawning process; they grow so rapidly, however, that they devour many small carp till the autumn fisheries commence. Such pond feeders should, therefore, be avoided as much as possible during the period when the young pike can still pass the gravel—from March till the beginning of the opening season of the carp. Following the example of Bohemian pond-culturists, I have, so far, stocked 2-hectare spawning-ponds, with 10 spawners, 6 milters, and 1 male carp weighing one pound, and obtained during one summer on an average 100,000 young carp (the maximum being 150,000). Spawners weighing 4 to 6 pounds are the best, as larger fish are too indolent.

The *fishing* of the ponds takes place during a cool season, in spring or autumn, when there is no danger of any frost. It will be well to introduce fresh water into the fish-pits during the fisheries, so as to freshen up the fish at all times. As soon as the water has been drawn off, and the water-area has been diminished to about one-fifth or one-tenth of its original size, fishing commences, care being taken that the fish never lack fresh water, by occasionally stopping the draining process or by introducing fresh water. The edge of the fish-pit is covered with boards and reeds, and on the edge of the water large tubs are placed filled with fresh water. From the net the carp are removed to these tubs, cleaned from mud and dirt, counted, put in the transporting vessels and carried as quickly as possible to their destination. As in catching the fish the water is stirred up and becomes muddy, and as the fish more or less inhale this impure water, it has to be removed from the gills. Carp which are to be transported any considerable distance are therefore, some days previous, placed in clear running water, where they are not given any food whatever, so that they may be thoroughly purified, and do not make the water impure by their excrements. The temperature of the water should, at most, be 10° Réaumur; the lower, the better. One of my friends in Pomerania has calculated the necessary quantity of water, in the following manner, from the weight of the fish and the time consumed in transportation.

Excess of weight of water over weight of body during a period of transportation lasting:

Carp.	10 hours.	20 hours.	30 hours.	40 hours.
	9	12	15	18

The result obtained in my spawning-ponds is entirely thrown in the shade by that obtained by Mr. Gasch; but, in order not to make any rash calculations, I will make my result the basis, and assume that a spawning-pond of 1 hectare produces annually 50,000 carp of one summer. Supposing that 1 hectare of water, containing fish of prey, needs

250 carp of one summer, a spawning-pond of 1 hectare would be sufficient to completely stock with carp an open water area of 1,000 hectares in 5 years, and to fill up the gaps occasioned by the fisheries.

In *setting out* the young fish, they should be distributed, as much as possible, over the entire water area, and care should be taken to place them in shallow water where they find plenty of food and where they are protected from fish of prey.

If it is intended to raise large carp, which are not exposed to any danger from fish of prey, a larger pond area is needed. I must here refer once more to Mr. Gasch, whose results are unexcelled by those of any other pisciculturist, and, basing my assertions on his experience, I must say that it requires a pond-area of at least 50 hectares to raise 50,000 carp of 20 centimeters length per annum; therefore, 50 times as many as we supposed before.

The *otter* is an exceedingly dangerous enemy to the fish, and must positively be exterminated, if carp are to be raised; herons, cormorants, and ducks also do great damage to the spawning-ponds. It is, therefore, necessary to combat these enemies in the most energetic and persistent manner. In my book *Fischzucht* I have treated of all these matters at length, and any of my readers who desire further advice on this subject are therefore referred to that work.

APPENDIX H.

THE OYSTER

XXVII.—THE OYSTER AND OYSTER-CULTURE.

By KARL MÖBIUS,
Professor of Zoology at Kiel.

INTRODUCTION

Since the first attempt in France, in 1858, to raise oysters by artificial means, very much has been written concerning the oyster and its culture. Authors, themselves astonished, have endeavored, by displaying long rows of figures indicating the great number of oysters that could be produced, to awaken like astonishment among their readers and arouse the inhabitants of the coast to propagate extensively in all their countries this most valuable of all sea invertebrates. These accounts of the immense production resulting from the artificial culture of the oyster went from paper to paper and book to book, and carried with them such an appearance of credibility that even practical oyster-breeders and acute biologists believed that, with little labor, great sums might be realized by raising oysters for the table. This is comprehensible, for the reason that the official reports of England, France, and America concerning oyster-culture, from which the large figures were taken, present either no information as to their true significance, or that only of a scattered nature, intelligible to those alone who are already acquainted with the subject. In order to gain this acquaintance and comprehend the true significance of such figures it is necessary to become informed as to the nature and the condition of life of the oyster; and in regard to both of these subjects biologists, as well as breeders and consumers of oysters, will find in the present work all that is necessary to enable them to form an opinion upon the questions which will arise in regard to the breeding and rearing of oysters. I believe I have clearly demonstrated that true oyster-culture must be conducted according to the same principles that are employed in the extensive cultivation of any other living commodity. If I have done so, then I have accomplished what should not have been necessary; for what is more natural than that both oysters and oyster-culture should be subject to the same universal, controlling, biological laws. And yet an explanation was

* Die Auster und die Austernwirthschaft; von Karl Möbius, Professor der Zoologie in Kiel. Mit einer Karte und neun Holzschnitten. Berlin, Verlag von Wiegandt, Hempel & Parey. 1877. Small octavo; pp. 126. Translated by H. J. Rice, B. Sc., by permission of the author, by whom electrotypes of the original cuts have been furnished.

necessary, for not only the ignorant in natural science, but men also who teach and write upon biological subjects have, even in our day, expected the most impossible results from the artificial breeding of oysters. The investigator has seldom to seek for new facts and ideas alone; generally, in the first place, he must be able to recognize and expunge from the system any errors which may exist in the knowledge previously acquired, and in their places establish those facts and ideas which he has found to be true. And while I am well aware that the little book hereby presented to the world contains but a very modest share of what we wish to know with certainty concerning oyster biology and oyster culture; still I have allowed it to appear because, incomplete as it is, it will give welcome information to many biologists and oyster-breeders, and will serve as a safe basis for the operations of those governments which have within the limits of their territories natural oyster-banks which they desire to have managed in the best interests of the general public. Those, of course, who delude themselves with the belief that, by means of artificial cultivation, oysters can be bred in great quantities wherever there may be sea-water, will scarcely agree with my book, and it is indeed quite certain that it will not convince them of their error. But the most dazzling error does not become transformed into truth, however long and firmly one may believe in it.

KARL MÖBIUS.

KIEL, *July* 8, 1877.

CONTENTS.

1.—THE SEA-FLATS.

Among those oysters which are produced in the waters of the west coast of Europe the Holstein oyster has, for more than a hundred years, maintained a well-merited celebrity. The beds which furnish them lie along the west coast of Schleswig-Holstein, in a territory only 74 kilometers long by 22 broad. The most and the best oysters are found on the east side of the island of Sylt and in the neighborhood of the islands of Amrum and Föhr.

Along the northern boundary of the German oyster-territory, near the island of Röm, and along the southern boundary, near the islands of Pellworm and Nordstrand, opposite the city of Husum, there are only a few insignificant beds. And since the flavor of the oyster is entirely dependent upon the quality and quantity of food in the water in which it grows, it becomes necessary, first of all, to examine into the character of the soil and water of the Schleswig-Holstein Archipelago. In comparison with the open North Sea this portion of our coast is a very shallow division of the ocean. Along the entire southern portion of the open North Sea, between Germany, Holland, England and Scotland, the general depth is from 35 to 45 meters. In no place in the Schleswig-Holstein Archipelago is the water as deep as this, the greatest depth being 15 to 20 meters, and this only in the channels which connect it with the open sea. The floor of this archipelago is raised above the deep

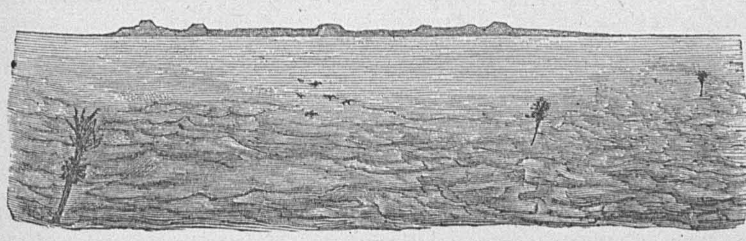
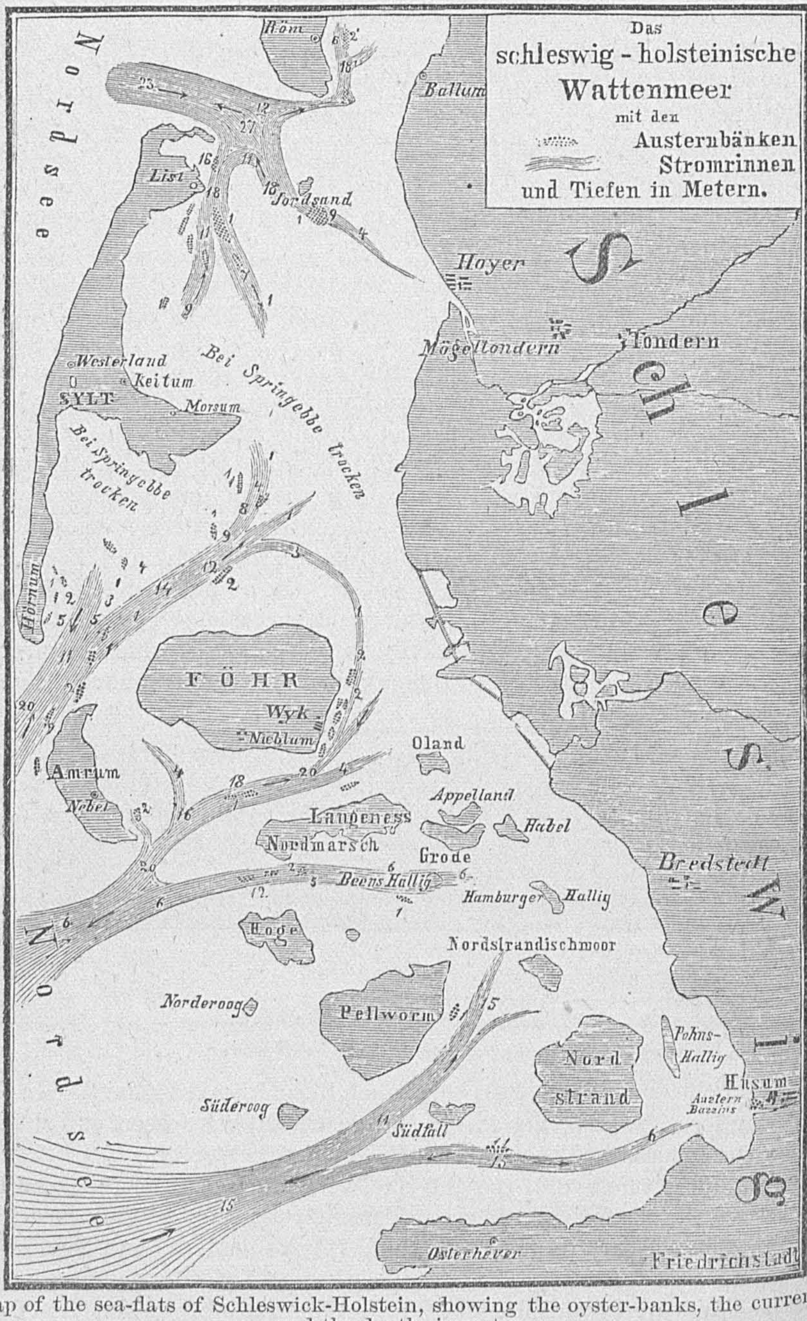


FIG. 1.

The *sea-flats*, with three buoys indicating navigable water. In the background the Hallig Langeness is seen above the surface of the water.

bottom of the open North Sea, very much like a high table-land. In this table-land valleys, varying in depth and width, have been cut out between the islands and the mainland. At high water, the entire floor is covered, but at the end of the ebb-tide, very much of this table-land lies dry above the surface of the sea. These stretches of sea-bottom which thus become dry are termed "Watten," (plains or flats,) and from these "Watten" this archipelago has received the name of "Wattenmeer," (sea-flats.) The water, which during the ebb-tide runs off from the flats, flows in both shallow and deep channels, called by the sailors "Leien" and "Tiefen," partly in a northerly, partly in a southerly direction, into the open sea, until the incoming flood-tide, which flows in from both sides twice daily, stops the ebbing water and turns it back. The water now



Map of the sea-flats of Schleswick-Holstein, showing the oyster-banks, the currents, and the depths in meters.

rises once more. The Leien and Tiefen can no longer hold it, and it pours over their banks and over the flats, finally flooding them to such a depth that small vessels can pass over places where only a few hours before men and wagons might travel with perfect safety. In an investigation of the oyster-beds our little steamer got into too shallow water between the island of Föhr and the mainland, and ran fast aground about nine o'clock in the morning. The water was falling, and in a few hours it was entirely out. We descended and went on foot to Hallig Oland,* which lay like a green plate, upon the level, grayish sea-bottom, about one kilometer to the eastward of our vessel. While upon this Hallig we visited a hill which had been formed by artificial means. Upon the hill was a fresh-water pond surrounded by a small group of dwellings, among which was a church encompassed by graves. We then returned to our vessel before the water had again flooded the flats. At about seven o'clock in the evening the water had risen so high that our vessel began to rock; it soon floated, and we steamed to Föhr, to anchor for the night in the harbor of Wyk.

Along the entire German coast, from Röm in the north, upon the Danish border, to Borkum in the west, near the islands of Holland, the sea is of a similar character. Thus, before the mouth of the Elbe, from Cuxhafen to the island of Neuwerk, the sea-bottom is laid bare with every ebbing of the tide, for a breadth of 7 to 8 kilometers. At such times one can reach the island on foot, on horseback, or with a wagon. In passing over this flat one finds himself at such times on a level with the sails of vessels which are passing by upon the sea, and along the border of the retreating waters and the emerging sea-bottom one sees scattered flocks of sea-birds hunting the uncovered worms, mussels, and crabs before they withdraw into the earth. When the flats, at the time of the lowest ebb, are lying, dry and silent, above the water, one can already hear in the distant depths the roar of the incoming flood. First it comes in slowly, then faster and faster, and finally more slowly again, until at the full flood the water stands over the northern por-

* *Halligen* is a name given to small, low islands in the Schleswig-Holstein Archipelago, composed of marsh land, and not protected by dikes from high tides. They are green plains, enlivened by pasturing cattle and sheep, and lie only a foot above ordinary high-water level. They are overflowed by the water during storms. The word *Hallig* is perhaps derived from *Haf-lik*. That portion of the coast which is dry during the ebb and covered during the flood tide is called *Haf; lik* means like, similar. No other land is so similar to the *Haf* land as the land of the Halligen.

The islands of the Schleswig-Holstein sea-flats consist either of low marsh land protected by dikes, or of higher sand tracts and downs.

Nordstrand and Pellworm are marsh islands; Föhr is marsh and sand together, and Sylt and Amrum have high sand tracts and downs.

The marsh soil is a gray, uniform, fine mass without any stones; when wet it becomes tough and sticky. It originated from muddy material brought down by rivers and streams and deposited in quiet places along the sea-coast. The high sand tracts are composed of old raised sea-bottoms. They are uneven, consist principally of coarse sand, and are much less fertile than the rich marsh soil, which, without manuring, yields abundant harvests.

tion of the flats nearly 2 meters higher, and over the southern portion, out from the mouth of the Elbe, nearly 3 meters higher than at the ebb. The tide generally attains three-fourths of its entire height about three hours after turning. In this short time immense masses of water move towards the coast, and in many places currents are formed as swift as the current of the Rhine between Coblenz and Bonn, the rate of which is from 1.5 to 2 meters per second. Yet the ebb-currents are nearly everywhere stronger than the flood-currents, since they not only carry off the sea-water which has been brought in, but also the fresh water from the land, which was checked in its flow during the flood. Hence the ebb-currents bring about much greater changes in the soil of the sea-flats than the flood-currents, and they displace and transport the constituents of the flats in the most powerful manner, wherever great fresh-water streams enter the sea, as at the mouths of the Eider, Elbe, Weser, and Ems. Here the floating buoys and the implanted buoy-stakes (Baken), which indicate navigable water for vessels, are changed nearly every year because of the changes in the channels.

The principal ingredient of the bottom of this changeful sea is quartz sand. In many places there are accumulations of mud, which is very slimy and sticky, and contains much organic matter. This mud is found along the shores of the mainland and on the east side of the island of Sylt, principally at those points where, after the changing of the currents, the water does not flow fast enough to carry away all of the muddy material which was deposited upon the bottom as the tide ran out. Along the slopes which lie between those portions of the flats, which the tide leaves dry, and the deep channels are long dry stretches of soil where the ground is covered with coarse sand, small and large stones, and shells. At such places colonies of oysters, so-called oyster-beds, are found, along with many other sea-animals.

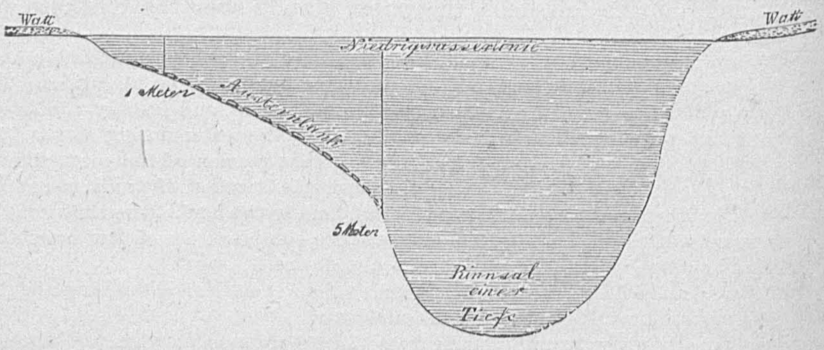


FIG. 2.

Diagram of a cross-section of a deep channel in the sea-flats, upon the left bank of which lies an oyster-bed. Upon both sides are flats which are left dry by the ebb-tide. (The breadth of the channel is drawn upon a much smaller scale than the depth.)

2.—OYSTER-BANKS AND OYSTERING.

By far the greater number of our oyster-beds are never exposed to view on account of the muddiness of the water of the sea-flats, from the continual stirring up of the sediment upon the bottom. Only when, during the lowest ebb of the spring-tides, easterly winds drive off a great deal of water from the land, does the sea along the border of many beds become so shallow that the oysters can be seen, and even taken up with the hand. This state of affairs occurs upon the oyster-beds which are numerous along the east coast of the island of Föhr, and in one autumn as many as 20,000 oysters could be gathered from these beds by hand and transplanted into deeper waters.

Generally one is obliged to use measuring-sticks or dredge-nets in order to tell when he is over a desired oyster-bed. The measuring-sticks are poles, five to six meters long, with the lower half divided off, by different colors, into feet. They are used from vessels, in shallow portions of the flats, in order to ascertain during the journey whether the depth increases or diminishes, so that the vessel may not run aground. The measuring-rod is pushed down to the bottom, and one can thus easily tell whether the bottom is composed of soft mud or pure sand, or whether it is covered with shells.

The dredge used by the oyster-men (Fig. 3) consists of an iron frame upon either side of which there is a shank. These shanks, or side-pieces, are brought together and united, at a short distance from the frame, so as to form a ring in which the dredge-rope is fastened. Fastened to the frame upon the opposite side from the shanks is a net whose upper half consists of coarse yarn or cord, and the lower half, that which drags along the sea-bottom, is, for greater durability, made of iron rings united together, each of which has a diameter of from six to seven centimeters. The entire net weighs from 50 to 60 pounds.

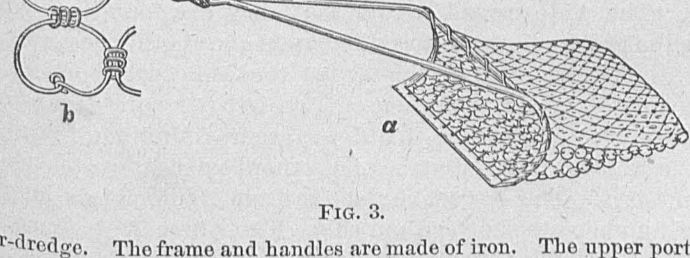


FIG. 3.

Oyster-dredge. The frame and handles are made of iron. The upper portion of the bag is made of coarse net-yarn, the under portion of iron rings from six to seven centimeters in diameter. The form of the rings and the method of uniting them is represented with greater exactness at *b*.

The older oyster-dredgers know the position of all the oyster-beds with great precision, and they guide their vessels to the desired places by reckonings from high-lying points of the coast and islands, from light-houses, churches, windmills, and houses. Their vessels are yacht-like, with a capacity of from three to six tons. Each one generally carries two sailors in addition to the owner.

Upon the Schleswig-Holstein banks there are fourteen vessels engaged in the oyster business. When the wind is favorable and brisk, four dredges can be used at the same time; but with a light wind, two, or one only can be dragged. They are fastened by means of strong ropes to the windward side of the vessel. One hand is kept upon the dredge-rope, in order to tell by the feel whether it is passing over smooth ground or over oyster-beds, for the rope is given an irregular, jerking motion upon rough bottom. Generally the net is allowed to drag from five to ten minutes; then it is drawn up by two or three men, and the entire contents of the bag emptied upon the deck. This mass consists of old oyster-shells, mussels of various kinds, living oysters, snails, crabs, worms, star-fish, sea-urchins, polyps, sponges, and sea-weeds, which are generally mixed up with sand and mud. From this heterogeneous heap all the matured oysters are now picked out. As they pass singly through the hands of the fishermen, the coarsest of the foreign material is cut and scraped from the shells with a knife, and then the oysters are thrown into baskets. In these they are shaken about, in order to get off any material which has escaped the knife. Ropes are then fastened around the baskets, which are put overboard, and raised and lowered in the sea until all dirt is completely washed from the oysters. They are now for the first time in the condition in which they appear in commerce. Despite these manifold cleansings, many oysters when they are exposed for sale are covered with dead and living animals, and the peculiar odor which oysters have when carried into the interior arises from the death and decay of the organic material upon the outside of the shells, and does not pertain to the living oyster itself. In no place upon the sea-flats do oysters grow upon rocky bottom. They grow best where there is a substratum of old oyster and other shells. The most of them lie singly, and they are seldom found growing together in clumps or masses. The wide-spread notion that they are found growing firmly attached to the sea-bottom, and piled upon one another, layer upon layer, is accordingly false. Upon the best of the Schleswig-Holstein beds the dredge must drag over a surface of from 1 to 3 square meters, and often over a still greater distance, in order to secure a single full-grown oyster. Over the Schleswig-Holstein sea-flats there exist 50 oyster-beds of very different sizes. The largest is not far from 2 kilometers long, but the greater number are shorter than this. Their breadth is much less than their length, which is in the same direction as the channels along the slopes of which they lie. The greater number of the beds have a depth of water of at least 2 meters above them when the ebb-tide has left the neighboring flats dry.

There are no beds upon our sea-flats which have a greater depth of water over them than from 6 to 9 meters. Although all the beds lie within an area 74 kilometers long by 22 broad, yet the nature of the oysters, and especially the form and solidity of the shell and the flavor of the animal, differ very greatly. Upon two beds inside of the south point of the island of Sylt are found oysters which in fullness and delicacy of flavor are not inferior to the best English "natives."

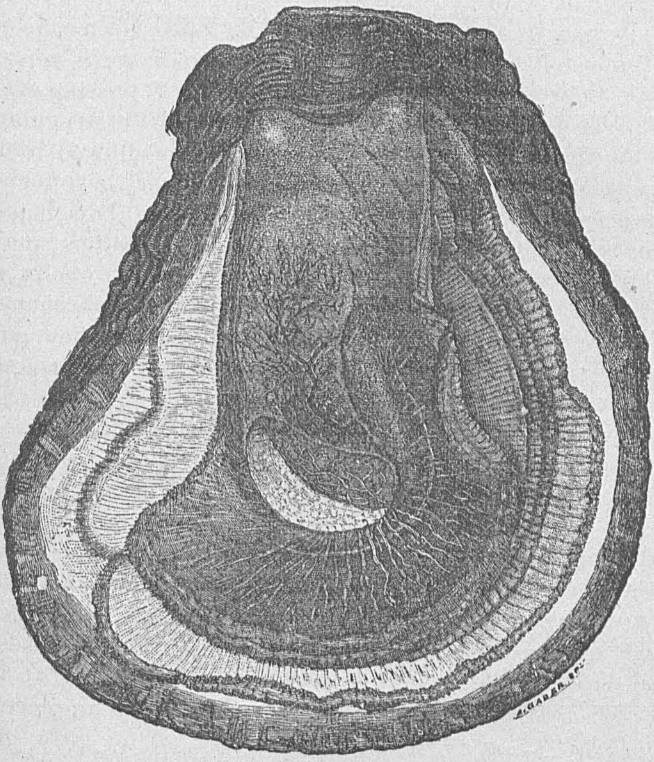


FIG. 4.

A full-grown Schleswig-Holstein oyster, about ten years of age. It is a female with eggs, and was drawn from life, on the 14th of June, 1871, by Mr. J. Wittmaack. The right, or upper, valve of the shell has been removed. The oyster lies in the hollow of the left valve, in its natural position. On the upper side the thickened layers of the shell can be seen. Each year new shell-layers are formed. The inner surface of the shell is white to near the edge, where it becomes of a brownish color. Above, close to the back of the animal, which is somewhat curved, is a crescent-shaped brown mass, the shell band or ligament. In separating the valves this band is broken across in the middle. The right side of the animal is exposed to view; the left rests upon the inner hollow surface of the left valve. The upper layer, with its edge turned back, is the mantle-lobe or fold of the right side. The white lines seen in it are muscular fibers. The left mantle-lobe lies close upon the shell, and is more expanded than the right. The gills are to be seen just below the inverted edge of the right mantle-lobe. In the oyster they are four in number. The outer gill of the right side is the most exposed; a narrow border of two others can be seen. All four have furrows running from the inside to the edges. Upon these furrows are situated cilia, by the motion of which water is driven over the gills for the purposes of respiration. Along the upper portion of the gills hang two pairs of furrowed folds, or lobes (the labial palps), between which is the mouth opening. The swollen upper portion of the body contains the generative organs, the liver, stomach, intestine, and heart. The bean-shaped organ near the center of the body is the adductor muscle, the so-called *stool*. This muscle which closes the valves consists of an upper grayish and a lower whitish portion.

3.—THE REPRODUCTION OF THE OYSTER.

If the surfaces of all the Schleswig-Holstein oyster-beds should be united together they would not cover a space equal to the one-hundredth part of that portion of the sea-flats which remain under water. Why is this? Is it because from a lack of oyster-broods all the places between the banks are yet to be peopled? I cannot accept this view for the following reasons: The entire number of full-grown oysters existing upon the Schleswig-Holstein beds I estimate to be not far from five millions. According to my observations, 44 per cent. at least of these oysters will bring forth broods of young oysters in the course of a summer.

*The data from which I arrived at the conclusion that at least 44 per cent. of full-grown oysters spawn during each spawning season were derived from the following observations:

I opened on—	Oysters.	These contained— White germs.	Bluish germs.	In all.	Per cent.
June 16, 1873	112	5	4	9	8
July 6, 1873	63	7	6	13	20.6
August 12–17, 1869	480	......	......	72	15.8
Total	......	......	......	......	44.4

I do not know the length of time of development, from the beginning of segmentation of the egg until all the embryos have passed out from the mother animal, but it is probably less than four weeks; for while, in the last weeks of May in the years 1871 and 1874, from June 4 to 6 of the year 1873, and June 6 to 9 of the year 1876, in hundreds of oysters which I opened, I found no embryos in the beard, yet of 112 oysters dredged on the 16th of June, 1873, five contained germs of a white color, and four contained germs already bluish, and possessed of shells and vela.

If by the end of the first week in June no eggs have been laid, but by the beginning of the third week germs are found of a bluish color, then the transformation of the white germ into the blue cannot consume more than a week, and these germs will hardly remain in the beard for an additional period of more than two weeks. Those oysters, then, which are found with eggs during each of the following months must be different individuals from those which spawned during the earlier periods; hence, it is right to add together the percentage of egg-bearing oysters found separately in June, July, and August in order to arrive at the percentage of egg-bearers for the entire summer. And since many oysters are found upon the Schleswig-Holstein beds with germs of a bluish color in the mantle even in the beginning of September, then the percentage of 44.4 per cent. surely cannot be too high. Oysters are hermaphrodite. In a large number of oysters which I examined I found ova in the generative organs, but no

Longitudinal cross-section of a seven or eight years old oyster.

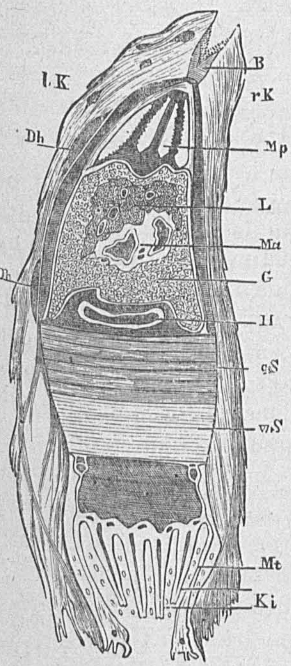


FIG. 5.

The curved left valve (lK) of the shell is, as usual, somewhat thicker than the right (rK). They are bound together by the ligament B, which keeps them separated a certain distance from each other so long as the adductor muscle (gS and wS) does not by its contraction stretch the ligament and close the valves. The shell-muscle consists of fine gray (gS) and coarse white muscular fibers (wS). In the neighborhood of the ligament, in the left valve, are four small perforations made by a sponge (*Clione celata*) which lives housed in the oyster-shells of the sea-flats. Other larger holes are often found in the shells of old oysters. They are filled with water, which has a rank, gaseous smell; hence they are called "gas-holes." The thickest part of the shell is near where the shell-muscle is attached. The shell consists principally of carbonate of lime, arranged in firm, glistening layers. Close above the shell-muscle lies the heart (H). The mass over the heart, which in life is of a bright color, consists principally of the organs of generation (G). These surround the stomach (Ma) and the liver (L), which during life is brown in color. In the space above the intestines is seen the sections of the four mouth-plates (Mp). Under the shell-muscle and close to the shell are the two mantle-lobes (Mt), whose edges are thickened and beset with fringes. They contain muscle and nerve fibers. During life the mantle-lobes can be thrust out over the edge of the shell. From the edges of the mantle-lobes all the shell material is secreted. Between the two mantle-lobes there is a wide space, in which hang the four gills (Ki). Each gill-

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spermatozoa; in many others I found spermatozoa, but no ova; and in seven oysters which bore embryos of a blue color upon the beard I found spermatozoa in the generative organs.

Three oysters with embryos of a white color attached to the beard had no spermatozoa in the generative organs. Most mature oysters produce either ova or spermatozoa, and not both at the same time. Of 309 oysters which were dredged on the 25th of May from four different beds along the east side of the island of Sylt, and which were examined from the 26th of May to the 1st of June, the sex of 18 per cent. could not be determined; of the remaining 82 per cent., one-half were males and one-half females In none of them were the generative products completely matured. From these results I conclude that the ova and spermatozoa do not arise in the generative organs of the oyster contemporaneously, but that one follows the other. The spermatozoa can arise very soon after the expulsion of the ova, and probably one-half of the oysters of a territory during any spawning period produce eggs only, the other half spermatozoa only.

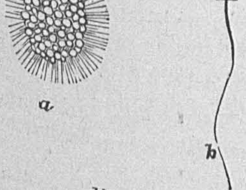

FIG. 6.

a. A mass of spermatozoa, still clustered together just as they arise in the generative organs, enlarged 275 times.

b. A single spermatozoan, enlarged 1,000 times. By the motion of the tail the body is driven forward.

The ripe spermatozoa pass from the generative organs into the water, with which they pass into the brood-chamber of the female oyster, where they impregnate the freshly-laid eggs by penetrating the yolk and uniting with it.

lobe consists of two plates, which grow together above and below. The mantle-folds and the gills taken together form the so-called "beard" of the oyster. In the spaces between the layers of the beard the development of the eggs takes place. In the figure a few germs are represented in this brood-cavity.

Now, a mature egg-bearing oyster (Fig. 4) lays about one million of eggs, so that during the breeding season there are upon our oyster-beds at least 2,200,000,000,000 young oysters, which surely would suffice to transform the entire extent of the sea-flats into an unbroken oyster-bed; for if such a number of young oysters should be distributed over a surface 74 kilometers long by 22 broad, 1,351 oysters would be allotted to every square meter. But this sum of 2,200,000,000,000 young oysters is undoubtedly less than that in reality hatched out, for not only do those full-grown oysters which are over six years of age spawn, but they begin to propagate during their second or third year, although it is true that the young ones have fewer eggs than those which are fully developed. At a very moderate estimation, the total number of three to six years old oysters which lie upon our beds will produce three hundred billions of eggs. This number added to that produced by the five millions of full-grown oysters would give for every square meter of surface not merely 1,351 young oysters, but at least 1,535. In order to determine how many eggs oysters produce, they must be examined during their spawning season. This begins upon the Schleswig-Holstein beds in the middle of June, and lasts until the end of August or beginning of September. The spawning oyster does not allow its ripe eggs to fall into the water, as do many other mollusks, but retains them in the so-called beard, the mantle, and gill-plates (Fig. 5) until they become little swimming animals (Fig. 7). The eggs are white, and cover the mantle and gill-plates as a semi-fluid, cream-like mass. As soon as they leave the generative organs the development of the germ begins. The entire yolk-mass of the egg divides into cells, and these cells form a hollow, sphere-like body, in which an intestinal canal arises by the invagination of one side (Fig. 7). Very soon the beginnings of the shell appear along the right and left sides of the back of the embryo, and not long afterwards a ciliated pad, the velum, is formed along the under side. This velum can be thrust out from between the valves of the shell at the will of the young animal, and used, by the motion of its cilia, as an organ for driving food to the mouth, or, in swimming, as a rudder. During these transformations the original cream-white color of the germ changes into pale gray, and finally into a deep bluish-gray color. At this time they have a long oval outline, and are from 0.15 to 0.18 of a millimeter in breadth. Over 300,000 can find room upon a square centimeter of surface. If an oyster in which the embryos are in this condition is opened, there will be found upon its beard a slimy coating thickly loaded with grayish-blue granules. These granules are the embryo oysters, and if a drop of the granular slime be placed in a dish with pure sea-water the young animals will soon separate from the mass, and spread swimming through the entire water. When the embryos are at this stage their number may be estimated in the following manner: The whole mass of embryos is carefully scraped from the beard of the mother oyster by means of a small hair-brush. The whole mass is then weighed, and afterwards a small portion of the mass. This small portion is then diluted with water or spirits of wine, and the embryos portioned out into a number of small glass dishes,

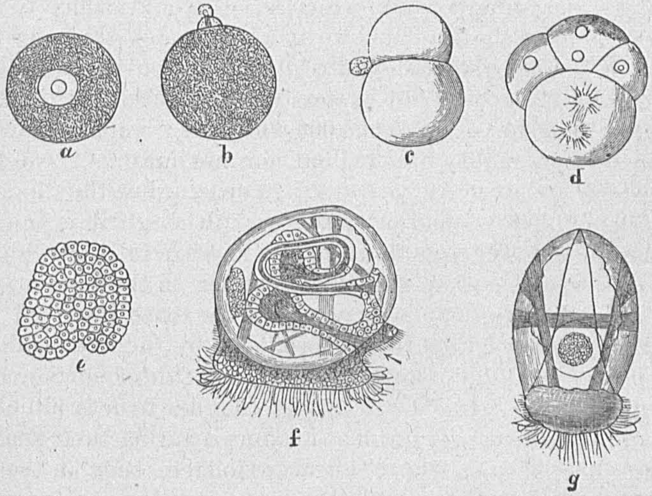

FIG. 7.

A few stages of development of the embryo oyster; *a* to *e* enlarged 125 times, *f* and *g*, 150 times.

a. The freshly-produced egg. In the yolk-mass is seen the germinative vesicle, with its nucleus.

b. Commencement of development. A part of the vesicle has passed out.

c. Division of the egg into two unequal portions.

d. A later stage.

e. The germ now consists of a layer of cells, which have arisen by repeated divisions of previous cells. They form a hollow vesicle, with a depression upon one side, which is the beginning of the digestive system.

f. The embryo is now represented at about the stage at which it leaves the brood-cavity. It has a transparent two-valved shell, and inside of the body the course of the digestive tract can be made out. An arrow shows the position of the mouth, and those within the body indicate the course which the food takes. Behind the œsophagus is the stomach, with two enlargements. The end of the intestine is shown over the mouth. To the left of the first enlargement of the stomach is the shell-muscle. On the under side is the velum, which is the locomotive organ of the young oyster. The young oyster can, by means of muscles, draw the velum entirely within the shell.

g. An embryo, seen from behind. Upon the sides are seen the valves of the shell, and across the body, from one valve to another, passes the shell-muscle. Below this muscle is the velum, with the muscles, one on each side, which serve to withdraw it into the shell.

so that they can be placed under the microscope and counted. Thus, knowing the weight of the small portion and the number of embryos in it by count, we can estimate the total number of embryos from the weight of the entire mass, which is also known. In this manner I estimated the number of embryos in each of five full-grown Schleswig-Holstein oysters, caught in August, 1869, and found that the average number was 1,012,955.

4.—WHY ARE OYSTERS NOT FOUND OVER ALL PORTIONS OF THE SEA-FLATS?

It is now clear that the fruitfulness of the oyster is extraordinarily great, and that the extension of oyster-beds over the entire surface of the sea-flats does not fail of being accomplished from a lack of young oysters, but from other causes. It then becomes our duty to investigate into the characteristics of our sea-flats; in order to determine whether some portions are more suitable for the growth of oysters than others; and whether the saltness, temperature and movement of the water, the amount of food which it contains, and the nature of the ground composing the oyster-banks, differ in any respect from these same features as observed in other places over the bottom.

The saltness of the upper layers of the water of the open North Sea is from 3.47 to 3.50 per cent.* The water of the sea-flats is slightly less salt, being only from 3 to 3.3 per cent.† Here upon our sea-flats, and in other European coast-seas, where the water is less salt, the oysters acquire a much finer flavor than upon the ground of the open North Sea,‡ where they live in water 35 meters or more in depth, with a percentage of salt of about 3.5.

That coast-water is, then, the most desirable for oyster-culture which

*Dr. H. A. Meyer has published a paper concerning the *saltness, temperature,* and *currents* of the North Sea in the "Bericht der Commission zur Untersuchung der deutschen Meere über die Expedition zur chemisch.-phys. und biologischen Untersuchung der Nordsee, 1872. Berlin, 1875." (Report of the commission for the investigation of the German Ocean upon the expedition for the chemico-physiological and biological investigation of the North Sea.) (Specific weight and saltness, page 18.)

† I have myself repeatedly determined the temperature and saltness of the water during investigations of the oyster-beds of the sea-flats; and since 1872 the commission for the investigation of the German Ocean have caused regular stated observations to be made, which, since 1874, have appeared under the title "Ergebnisse der Beobachtungs-Stationen an den deutschen Küsten über die physik. Eigenschaften der Ostsee und Nordsee. Berlin, 1874, 1875, 1876." (Results of investigations into the physical characteristics of the North and East Seas made at observation stations along the German coasts.)

‡ Many oysters are taken north of Germany and Holland, east of England, and in the channel between England and France. The German fishermen of Blankenese and Finkenwärder, near Hamburg, who fish with great dredge-nets for flounders, turbots, and soles out from the mouth of the Elbe, often dredge oysters along with their fish. The oyster-grounds of the open North Sea lie mostly from 33 to 34 meters beneath the surface of the water. They begin with a small stretch to the southeast of the island of Heligoland, extend from this island in a west-northwest direction, and form a territory 15 to 22 kilometers broad, which spreads out far to the west. Fishermen from Holland and Germany dredge for oysters here, especially during the months of August,

contains about 3 per cent. of salt; and since not only over our oyster-beds, but over our entire sea-flats, the water possesses this degree of saltness, neither a lack nor an excess of salt can hinder the extension of the beds over the whole area. Even less can the temperature of the water hinder their extension, for the variation is the same over the oyster-beds as at other points, and it fluctuates, during the course of the year, from 20° C. above zero to 2° C. below. Nor can a lack of motion of the water or of nutriment be the cause why the oyster-beds have not during the past hundreds of years extended themselves beyond certain definite limits, for floating everywhere, in the ebbing and flooding water, are microscopic plants and animals, and much dead organic matter, which would nourish large numbers of oysters, just as they do multitudes of soft clams (*Mya arenaria*), edible mussels (*Mytilus edulis*), and cockles (*Cardium edule*). There remains, then, as the single natural hinderance to a further extension of the oyster-beds, the unfavorable condition of the ground over the greater portion of the sea-flats. Oysters cannot thrive where the ground is composed of moving sand, or where mud is being deposited, and one of these conditions or the other is found over the greater part of the sea-flats. The number and size of those places where, notwithstanding the daily ebb and flood currents, the ground remains unchanged and free from mud are very limited. Only along the slopes of certain channels to the north of the mouth of the Eider do we find united all the conditions favorable for such places, and only within these limited districts can young oysters grow to complete maturity.

When the young oysters attached to the beard of the mother have reached a diameter of 0.15 to 0.18 of a millimeter, when their digestive organs have reached such a stage that the young animal can receive nourishment through them, and when the velum, by means of its cilia, is in a condition to enable them to move about, they leave the brood-cavity, swarm at the surface, and after swimming about for a short time finally sink once more to the bottom. If the swarm of young oysters settles upon a spot covered with clean stones or mussel shells to which they can become attached, they have a prospect of growing to maturity; but if, on the contrary, they settle upon a changing sand-bank or upon a muddy bottom, they will surely be lost; for at the close of their swarming period their velum, which is their swimming organ, is absorbed, and

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September, and October, and often catch, at a single drag of the dredge, as many as 1,000 oysters. Sometimes great bunches of oysters growing attached to one another are gathered into the net.

The deep-sea oysters grow much larger than those found along the coasts. Specimens are taken with shells 13 centimeters broad. Their flesh is tough, yet large numbers are consumed in England, France, and Germany; in England and France chiefly in pastries and sauces, but in Germany many are eaten fresh, especially in Hanover and Bremen. For general winter use they are kept under water in certain places adapted to them, especially near the island of Wangeroog. (S. Metzger's Beiträge zu dem Jahresbericht d. Commiss. zur Unt. d. deutschen Meere, 1873, page 171, u. 1875, page 252.)

no muscular foot, as an organ of locomotion, is formed in its place, as with most other bivalves. The oyster must thus remain upon that spot where it settles at the close of its swimming career. If currents and waves cover it with sand, if, during tidal changes, the quiet water allows mud to sink down upon it, if plants luxuriate over it, then, being unable to work its way out into free water, and wander to a better place, it must remain as it is, and, from lack of air and nourishment, soon perish.

5.—ARTIFICIAL OYSTER-BREEDING IN FRANCE.

The yield of many once rich oyster-beds along the west coast of France had fallen off to such an extent from 1850 to 1860 that Prof. P. Coste* of Paris, the originator of the celebrated fish-breeding establishment near Hüningen, in Alsace, presented, in 1859, to the Emperor Napoleon III, a plan for the artificial breeding of oysters, by which means he would prevent the destruction of a large number of young oysters at the beginning of their lives as independent animals. The first attempt to render the impoverished oyster-beds once more fruitful was made in the Bay of Saint-Brieuc, upon the north coast of Brittany. Here, where 1,400 men were formerly engaged yearly in fishing for oysters, and where the yield was of the annual value of from 300,000 to 400,000 francs, the oyster-fishery, during the ten years from 1850 to 1860, had become almost entirely valueless.

In the months of April and May, 1858, under the direction of Professor Coste, vast numbers of the old shells of oysters and other mollusks were scattered over the ground, and great numbers of fascines were sunk and anchored with stones so as to float in the water just free above the bottom. After 1,000 hectares of sea-bottom had thus been excellently prepared for the reception of the young oyster-broods, three millions of mature oysters were planted upon it.

In the autumn all the shells and the twigs of the fascines were found so thickly covered with young oysters that even the wildest expectations were more than realized.

This abundance of young oysters was something indeed entirely natural. Professor Coste, in his report to the Emperor, January 12, 1859, says, when speaking of this experiment in the Bay of Saint-Brieuc, that every mature oyster produces from two to three million embryos, but he does not inform us as to his authority for this statement. If we allow that those oysters which were planted for breeding purposes in the Bay of Saint-Brieuc produced each only the same number of embryos as are produced by a Schleswig-Holstein oyster, the entire progeny would amount to the enormous sum of 1,320,000,000,000, young oysters. Such a number would allow 132,000 to fall upon every square meter of sea-bottom, and for the reception of this number

* *Professor Coste* died in 1873. His chief work, upon the artificial breeding of oysters, mussels, and fish, appeared under the title: "Voyage d'Exploration sur le Littoral de la France et de l'Italie, 2. éd., Paris, 1861."

there was enough suitable material already spread out about the mother oysters.

This experiment at Saint-Brieuc was considered to completely demonstrate the possibility of artificial oyster-breeding. It was believed by many that the whole coast of France might be bordered with oyster-beds, and they began already to reckon, according to the market-price of oysters at that time, which was 20 francs per thousand, how many millions of francs would be the result of this sea-harvest. Capitalists hastened to form companies for the purpose of engaging in the business, and obtain from the government the right to lay down oyster-beds upon certain definite portions of sea-bottom along the coast. But in not a single case were the rich earnings which had been reckoned upon beforehand as resulting from the sale of marketable oysters ever realized; and not only this, but the money which had been paid for the preparation of the ground and the purchase and transportation of breeding oysters from natural beds gave no returns, and for the most part proved an entire loss. The young oysters were nearly all covered up by sand or mud, or eaten by other sea-animals. This explains why, in the year 1869, I found in the Bay of Saint-Brieuc nothing remaining of the beds which had been thus artificially formed in 1858. The bottom of the bay had become unsuitable for the growth of oysters because of the wide-spread distribution of sand and the changes which it was constantly undergoing.

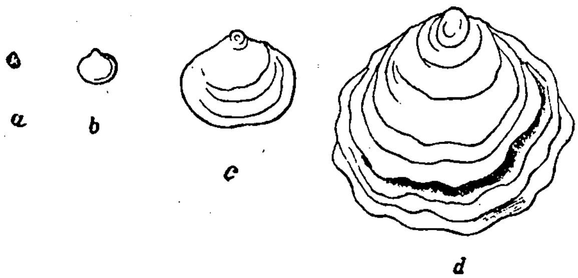

FIG. 8.

Outline figures of young oysters, natural size.—*a*. About one month old. *b*. About two months old. *c*. About four months old. *d*. From twelve to fifteen months old.

At the present time the extensive propagation of oysters by this method of breeding is carried on with success only in certain places along the French coast where the natural conditions are especially favorable. The Bay of Arcachon, south of Bordeaux, is one of the favored places. There, as I myself have observed, the soil and the saltness of the water are very similar to that of our sea-flats. We find there wide-spread shallow sand and mud banks which are covered with vast numbers of bivalve-shells. These banks are left dry by the ebb-tide, and between them are deep channels through which the water at ebb and flood tide flow out and in. In places which remain always under water natural oyster-beds are found, and at other places longer stretches along the soft, bare slopes of the water-courses are made use of as breeding-beds. Here mother oysters from natural beds are planted, and among them, towards the end of May, are placed old shells and tiles with a covering easily detached, as objects of attachment for the young broods.

In October the young oysters, which have become firmly attached, are freed by means of chisels from the larger of these objects of attachment, and are then placed in flat boxes, 2 meters long, 1 meter broad, and 15 to 30 centimeters high. In detaching the young oysters about one-third are destroyed.

The boxes into which the young oysters are placed are made of thick plank, with wire-sieve bottoms, through which the water can pass in and out. At the corners of each box are fastened stakes which serve to raise the box above the sea-bottom, so that there will be a depth of water of about 10 centimeters between the ground and the wire netting. The object of this protection is to guard the young oysters against small crabs (*Carcinus mænas*), "drills" (*Murex erinaceus*), and other enemies, which formerly destroyed great numbers of young, as the breeders of Arcachon found out by bitter experience. At this period the shells of the young oysters are too thin to protect their soft bodies from their enemies. While in these breeding-boxes the young oysters must be kept continually under water, so as not to be destroyed, either by being left dry, by the heat of summer, or the cold of winter. In order to accomplish this square trenches, from 30 to 40 meters long and 4 to 5 meters broad, are dug in those portions of the oyster-territory which are left dry by the ebb-tide. The side walls of these excavations are made firm by means of posts and planks, and the spaces between the planking and the banks are packed with clay. The bottom is covered with sand and gravel to serve as a bed for the oysters. At one of the four sides a canal, with a gate, is formed, through which, at the pleasure of the breeder, water can be allowed to flow in during the flood or to pass out during the ebb-tide. In these artificial ponds, called *claires*, the boxes containing the young oysters are placed, nourishment being brought to them by the water which forces its way in through the sieve-bottoms. As often as the condition of the water renders it possible, the breeder opens the tops of the boxes, in order to permit the free entrance of air and light and to remove any accumulations of dirt which may have lodged upon or around the oysters. Two months later he takes the oysters from the boxes and strews them about upon the bottom of the breeding-pond. In these ponds they must not be placed too close together if their best growth is desired. Even into these ponds their numerous enemies will make their way, and in order to protect the oysters from these hordes of spoliators a small-meshed net is drawn over them. It is very desirable to change the oysters, once or twice during the course of the year, into neighboring ponds which have been purified by lying entirely dry for several months. During the warmest and also during the coldest months, especially during ebb-tide, a depth of water of at least 20 centimeters must be retained over the oysters. This troublesome and tedious handling is demanded for at least two years before the oysters can be brought to market. At least this is the case in the Bay of Arcachon. In the year 1874–'75 there were produced in this bay 112,000,000 artificially grown oysters, and in 1875–'76 about 196,000,000. This important yield of the last year, as compared with the poor returns of former years, may be accounted for principally through two causes:

First. The natural oyster-beds in the Bay of Arcachon had had complete rest for the entire two years immediately preceding these rich harvests. During the years 1870–'71 they had produced only 4,897,000 oysters, but after this period of rest, in November, 1874, 8,500 persons assembled, and in the space of three hours, during which time the gathering was in progress, 40,360,000 oysters were taken from the sea. A great number of these were transplanted, as breeding oysters, to the prepared beds, which covered altogether an actual area of sea-bottom of 2,669 hectares (about 5,338 acres).

Second. The former imperfect method of caring for the oysters had been improved to the extent that the young oysters were protected from their enemies, and care was exercised that during hot and cold weather they should always be kept under water.

With the earlier methods very many of the young oysters were destroyed by their enemies, and often, during a few unfavorable summer or winter days, when a low tide left the beds dry, all the young oysters died. The extraordinary yield of oysters in the Bay of Arcachon and at other points along the coast of Brittany, as a result of the improved method of artificial oyster-breeding, has very materially lessened the price of oysters in France, despite the greater consumption occasioned by this abundance. In 1873 oysters sold for 43 francs per thousand, while in 1876 the price was 25 francs per thousand. On this account only those oyster-breeders who attend personally to the work and are assisted in it by their families make anything over and above all expenses. Those who undertake the breeding of oysters, relying upon outside help to do the great amount of work necessary, can gain returns scarcely worthy of the name; at least this is the case in the Bay of Arcachon, as I know from trustworthy sources.

The cost of transforming a hectare of sea-bottom along this coast into an oyster-bed, together with the necessary apparatus for oyster-culture, and a guard-vessel as required by the government, is not less than seven to eight thousand francs.*

* Besides the works of Coste, which have already been mentioned, the following also treat of oyster-breeding in the Bay of Arcachon:

K. Möbius. Ueber Austern- und Miesmuschelzucht und die Hebung derselben an den norddeutschen Küsten. (A report to the hon. minister of agriculture.) Berlin, 1870. pp. 8.

A. Tolle. Die Austernzucht und Seefischerei in Frankreich und England. (A report to the hon. minister of agriculture.) Berlin, 1871. pp. 8.

De Bon. Notice sur la situation de l'ostréiculture en 1875. Paris, 1875. (Extract from the Maritime and Colonial Review.)

6.—ATTEMPTS TO INTRODUCE THE FRENCH SYSTEM OF ARTIFICIAL OYSTER-BREEDING INTO GREAT BRITAIN.

In Great Britain a large number of men are employed in oyster-dredging and in the oyster-trade, and, according to the published official estimate for the year 1870, the yearly value of oysters sold in the kingdom is not far from £4,000,000 sterling. If we take the average price of oysters as one penny (two cents) apiece, which is rather too much than too little, this amount would account for 960,000,000 of oysters.

In the year 1864 there were brought to the London market alone more than 495,000,000 of oysters, which were worth over £2,000,000 sterling. The culture of oysters being thus of so much importance to Great Britain, it was very natural that attempts at artificial oyster-breeding in France should be watched with intense interest, and imitated at various points along the British coast. It was carried on most extensively upon the coast of the small island of Hayling, east from Portsmouth, by the South of England Oyster Company, organized in 1865 with a capital of £50,000. Inside of a dike upon the west side of the island five oyster-beds were prepared, having an extent of sea-bottom of about 32 hectares (about 80 acres). May 11 and 12, 1869, when I visited these beds, several of them had not been overflowed. The natural bottom, which was a sticky mud, had been covered with gravel and mussel-shells, and upon the largest bed hurdles, each 2.4 meters long by 75 centimeters broad, and composed of birch twigs, had been placed so as to rest horizontally at about one-half a meter above the ground. Besides these hurdles, laths, with oyster-shells and bundles of small rods nailed to them, were stuck about over the ground, so that there should be plenty of objects of attachment for the young oysters. The inward and outward flow of the water was regulated by means of a sluice and gate. The mother oysters are generally placed in the beds just before the breeding season.

In 1869 they expected to place upon the beds 50,000 breeding oysters. The water is generally changed every day, except during the winter months, when there would be danger of freezing the oysters, and also except during the swarming period, when the young would be liable to escape into the sea with the changing water. In 1867, 600,000 mature deep-sea oysters were placed on an oyster-bed which covered a surface of 7.3 hectares, and over which 10,000 hurdles were placed as objects of attachment. Upon an average over 12,000 young oysters were found attached to each hurdle, making for all the hurdles a total of more than 120,000,000. In these and other experiments at artificial oyster-breeding in England all the experiences of French oyster-breeders were made use of as far as possible, but, notwithstanding this, at no single breeding station were the expectations of a great yield of marketable oysters ever realized. In London, on the 4th of May, 1876, Mr. Blake, the inspector of fisheries, made, before the commission for the investigation of the oyster-fisheries, the astounding statement that every oyster grown by means of artificial culture near Reculvers, at the mouth of the Thames, cost £50 sterling, that every one grown in Herne Bay cost £100, and in a third place about £500, and that he was prepared to furnish several other examples of a like character. Mr. Blake, who is very well acquainted, from personal observation, with French and English oyster-culture, considers artificial oyster-breeding according to the French method impossible along the British coast, on account of the unfavorable character of the climate.

The most important source whence I have drawn my information in regard to the culture of oysters in England is the report of the select committee on oyster-fisheries, together with the proceedings of the committee, minutes of evidence, appendix, and index, ordered by the House of Commons to be printed July, 1876. This report contains 3,941 questions and answers concerning oyster-culture.

What I have been able to learn, through my own observations, of the English oyster industry I have described in a work referred to in chapter 4. To this, Mr. A. Tolle, who accompanied me as hydraulic engineer of the commission of the Prussian minister of agriculture, has, in a report to the honorable minister, issued a supplement, which is also referred to in the same chapter.

7.—CAN THE FRENCH SYSTEM OF ARTIFICIAL OYSTER-BREEDING BE CARRIED ON IN THE WATERS OF THE GERMAN COAST?

What German who loves oysters has not wished that the whole German coast might be bordered by fruitful oyster-beds? For this reason we wish to investigate as to whether the necessary conditions for artificial oyster-breeding are to be found in the coast-waters of Germany. As regards the saltness of the water, the currents, the food, and even the composition of the soil, our sea-flats will compare as favorably for the artificial gathering of the young broods and for the raising of the same as the Bay of Arcachon, but not as regards temperature and the depth of water.

In the Bay of Arcachon the difference between ordinary high and low tide is 4.5 meters, and during a storm a meter more. But along our North Sea coast during a storm the water rises with the tide even more than twice as high as during ordinary flood-tide. The power of the water during a storm, as compared with the power of the water during an ordinary flood-tide, is much greater along our coast than in the Bay of Arcachon. Hence, we would be obliged to give to our oyster-beds a much greater firmness than the French breeders have to give to theirs. We would also be obliged to place them so far out in the sea that they would be entirely covered with water, even at the lowest ordinary tide, and also give them sufficient stability to withstand, during a storm, a rise of water of from 2 to 2.5 meters, as well as the great and powerful force of this water-mass. Beds thus laid down would cost much more than the ditched and planked ones of Arcachon. But even if they were so placed as to bid defiance to the most severe flood-storm, they would indeed hardly suffice to protect the breeding oysters from being covered with mud and sand; and thus one flood-storm, or storm in connection with a flood-tide, might destroy the accumulated oysters of many generations. A visit made to the island of Norderney showed us how destructive nature can be to the oyster-beds of our sea-flats. Upon the inner side of this island, early in the year 1869, a surface of 825 square meters was dug out, and made firm by double-planked walls to about the height of half tide. The space between the walls and banks was filled in with sand and mud, and the inclosure itself was divided into two compartments, one of which was longer than the other.

In the smaller division the water was detained to enable it to deposit its coarser materials before it was allowed to pass into the larger one. In the beginning of June, 20,000 mature oysters were placed in these artificial beds, with the expectation of reaping a rich harvest of young oysters; but the harvest never came. Star-fish and crabs attacked the oysters, in the beginning of August flood-storms broke down the walls, and the storms of autumn completed the work of destruction, so that very soon nothing was left of the entire enterprise. If the situation of the free sea-flats is not suitable for the formation of oyster-beds, perhaps there is still a possibility of artificial oyster-breeding being carried on inside of the dikes which protect the fertile marsh-land along the German coast from the encroachments of the waters of the North Sea. For this purpose basins would have to be dug out inside of the dike and placed in connection with the sea by means of canals. Where these canals cut through the dike it would be necessary to build a gate, in order to prevent the sea-water from passing in during high-tide. Then, oyster-beds could not be laid down in the neighborhood of this gate, because it would serve not only as an inlet for salt water, but as an outlet for the fresh water from the marsh-land, and so fresh water instead of sea-water would cover the oyster-beds. But even if it is admitted that oyster-beds might be laid down inside of a dike without danger to the diked lands, and with sluices and gates to permit the inflow of sea-water, there are yet several questions to be answered. How will oysters thrive in such beds? Will they receive enough nourishment to become fat? How will they exist during continued cold weather? And will they produce young in such a place? It is certain that they will not receive as much food as in the open sea, since they cannot have nearly as much water as will pass over them upon the natural beds; and the quantity of nourishment varies in proportion to the amount of water which passes over the beds. In these beds the oysters would also be in danger of being buried in the deep mud, and in order to prevent this they must either be changed very often into clean beds, or else a cleaning-pond must be formed beside the breeding-pond. But while the water is rendered clear by being allowed to stand quiet, yet by this means a large amount of organic matter which serves as food for the oysters is taken from it. Especially dangerous, however, to oyster beds within the dikes would be the cold during winter weather, for along our North Sea coasts the water is lowest during an east wind, and at the same time such a wind is accompanied by the lowest degree of temperature. Hence, at such times, when a great depth and a constant change of water over the beds would be the best protection from freezing, we cannot have high water, nor can the water then standing over the oysters be constantly changed; thus during every cold winter, a large number of oysters would be sure to perish in their beds. Even now, upon the shallow oyster-beds of our sea-flats, oysters are frozen exactly in proportion to the depth of the water over them during these cold spells; the shallower the water the greater the destruction upon the beds during a severe winter. During the severe winter of 1863–'64, when, on account of ice, no oysters could be taken from December 21 to February 17, and during the winter of 1864–'65, when the fishing was interrupted from January 24 to March 26, dead oysters were found upon a large number of the banks. The greatest destruction of oysters within the memory of the oldest fishermen took place during the severe winter of 1829–'30, when Schleswig-Holstein was visited by an unusually low temperature, which continued from the middle of November until the beginning of the next February. Most of the beds suffered greatly, and it was many years before they again recovered their former fruitfulness. In cold weather slime collects upon the gills and mantle-lobes of the oyster, the power of the muscles and cilia being weakened by the cold. Accordingly, the oyster is no longer in a condition by means of its rapidly-moving cilia, and the quick closing of the valves of its shell, to drive out the particles of slime brought in with the water. But the power of the cilia and the elasticity of the muscles are again restored as the water becomes warmer, providing the cold has not lasted too long. The gills become clean once more, and respiration and nourishment, which have been disturbed by the sliming, proceed again as before. If the cold spell is prolonged, then, in addition to the sliming of the gills and mantle, there are yet other pernicious results. The shell-muscle becomes so soft that it can no longer close the valves. The cilia move slower and slower, and finally, when the shell-muscle has allowed the valves of the shell to gape wide open, cease moving altogether. The mantle and gills become pale in color, infusoria nest in them and hasten their destruction, and soon their ciliated layer separates and disappears. The softest portions of the body, the generative organs, the liver, and the stomach quickly vanish, probably consumed by snails, crabs, worms, and starfish as soon as they can make their way unhindered into the open shell. The last part of the mollusk which is to be found in the shell is the shell-muscle. It remains free between the two valves, or attached to only one of them, until finally but a trace of its fibers is to be seen at the points of attachment, the so-called muscular-impressions. During the latter part of March, 1870, I was able to follow out for myself, at the Schleswig-Holstein beds, the entire course of the changes produced in the oyster by freezing. Long-continued east winds had kept the water extraordinarily low, and for more than a month thick ice had covered the flats, so that from the 4th of February to the 7th of March no oysters could be taken. On the 14th of February the water in the neighborhood of an oyster-bed at the north end of the island of Sylt was found to be of a temperature of 2° C. below zero. At this point the depth of water was 3.5 meters. Of those oysters which were taken in my presence from the shallower beds 7 to 8 per cent. were frozen. Upon beds which lay in deeper water, nearer the open North Sea, the cold had killed only from 2 to 3 per cent. Evidently, then, these latter beds had suffered less damage because at every flood-tide they received water of a somewhat higher temperature from the open sea. I have frozen the mantle and gill lobes of oysters in North Sea water and allowed them to remain inclosed in ice for an hour at a time, with the temperature of the water varying in degree from 4° C. to 9° C. below zero. When the ice had melted, the cilia began to move feebly, and four hours later, when the temperature of the water had risen to 5° C. above zero, their movements were once more fully established. Other gill and mantle lobes which had been three hours in water of a temperature of 1° C. to 2° C. below zero moved quite lively on the following day. This recalls to me a very weighty difference between fresh and salt water, which is often overlooked. It is generally known that fresh water is densest and heaviest at a temperature of 4° C. above zero. When any portion has arrived at this temperature during freezing weather, it sinks to the bottom of the body of fresh water, where it remains until the entire mass above it is of the same density. That portion which first becomes lower in temperature than 4° C. then expands, rises to the surface, and stiffens into ice as it reaches the temperature of 0°.

The fact is less known that with sea-water the lower the temperature the greater the density and weight of the water. Therefore, it also sinks to the bottom until it has reached the temperature at which it forms ice, which, when it holds 3 per cent. of salt in solution, is 2.28° C. below zero. It is evident, then, that water may be found at the bottom over the sea-flats of a temperature of 2° C. below zero, while, during the most severe cold, water at the bottom of the lakes and deeper rivers of North Germany is found to be constantly several degrees warmer than this. When, finally, the sea-water, from the surface to the bottom, has reached its freezing point, it does not become solid ice for the whole thickness, but thin layers of ice, at greater or less distances apart, are formed in it. These layers, which are crystallized from the salt water, are free from salt, are hence lighter than the surrounding water, and accordingly ascend to the surface; consequently, those animals which live upon the ground of the deeper portions of the sea-flats remain surrounded by water whose temperature is 2° C. lower than the freezing point of fresh water. In shallow places which the ebb-tide leaves dry, the frost kills all animals which have not the ability to dig their way to such a depth in the sand and mud that they will be beyond the influence of frost, and where the water remains liquid.

Here only a few kinds of mussels, worms, and crabs possess this ability; hence all of those sand and mud banks of the sea-flats which are left dry by the ebb-tide are comparative "barrens," occupied only by very few animals and plants.

Our investigation, then, has led to the grievous conclusion that profitable artificial oyster-breeding, according to the French system, is not possible along our North Sea coasts. Whoever should attempt to carry out this system, despite the unfavorable conditions of our waters and climate, would be certain to find that his breeding oysters were more costly than many English oyster-breeders have found theirs to be; for upon the English coasts the difference between ordinary high tide and the tide increased by a storm is much less than upon our sea-flats, the lowest water does not occur simultaneously with the coldest winds, as along the southeast shore of the North Sea, and the climate there is milder than upon our coasts.

8.—CAN NATURAL OYSTER-BEDS BE ENLARGED, AND CAN NEW BEDS BE LAID DOWN, ESPECIALLY ALONG THE GERMAN COAST?

It will thus be seen that the German oyster industry remains dependent now, as ever, upon the natural oyster-banks of our coast-seas, where oysters have lived for thousands of years, and where they exist to-day fruitful and well-flavored. And in regard to these beds we have now to consider the important questions:

First. Is it possible to increase their size?

Second. Can we still farther increase the surface of our oyster-territory by laying down new beds?

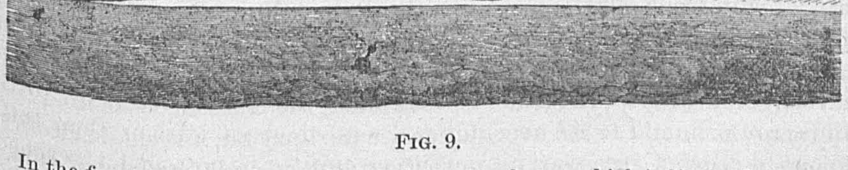

FIG. 9.

In the foreground are the *sea-flats*, with two can-buoys which indicate the course of the channel for vessels. In the background are seen the dunes or sand-hills of Hörnum, the southern point of the island of Sylt.

The water in the neighborhood of the banks, and over all the stretches between them, has the same character as over the banks themselves. All that is necessary, then, in order to increase the size of these beds is to render the sea-bottom between them habitable for oysters. Old beds increase naturally in size whenever the shifting and slimy sea-bottom which borders them becomes changed into stable and clear ground. This can take place if changes occur in the force and direction of the ebb and flood currents. In such cases the extension can be hastened artificially by placing upon the newly forming ground shells of oysters and other mollusks, in order to furnish just outside the borders of the old bed the most judicious objects of attachment for the young broods as they swarm out from the mother oysters. For the establishment of new beds, within the limits of the German sea-flats, in places where no oysters are found at present, it will be necessary to find stretches of sea-bottom which are free from mud, where the soil is not being constantly shifted about by currents, and where the ebb-tide will leave at least one to two meters in depth of water over the beds. But nearly all such places are at present occupied by oyster-beds. In the year 1876 the buoy-tenders, who are best acquainted with the bottom over the entire Schleswig-Holstein sea-flats, and who have to mark out the channels for vessels, by means of cask and stake buoys (Figs. 1 and 9), sought to find some places upon the flats suitable for oyster-beds, where no oysters yet existed. They found within their whole territory only eight such places where it might be possible for oysters to thrive; and it would be very hazardous to immediately distribute over all these places a great number of breeding oysters, since it is yet doubtful whether new beds would be able to flourish there or not. It would be much wiser to experiment with one only of these places at first. Upon this let oyster and other mollusk shells be scattered in May and again shortly before the breeding period; then, upon the ground thus prepared place several thousand mature oysters. If, by next fall, a deposit of young oysters is found to have taken place, it will not be certain even then that the experiment will prove successful, but only after three or four years, when a large number of half-grown oysters are found lying beside the old mother oysters, and when these young are found in turn to have produced other broods which locate upon the new bed. Over the entire German sea-flats lying south and southwest of Schleswig there can hardly be found a single place which is suitable for the formation of a profitable oyster-bed; for in front of the mouths of the Eider, Elbe, Weser, Jahde, and Ems the sea-bottom is so covered with mud, or so subject to change, that oysters could not live and multiply there. In the fall of 1868, when I investigated with a dredge-net the sea along the German coast from the Eider to Borkum, I found over this entire territory but one single locality upon the coast of Hanover, between the mainland and the island of Juist, west of Norderney, which in any manner would be suitable for such an experiment. Here, in the spring of 1869, a large number of breeding oysters from the Schleswig-Holstein beds were distributed. But no permanent bed has been established there, for in June, 1875, during an investigation of the bottom near Juist and Borkum, only seven oysters were taken, notwithstanding the dredge was used for three whole days. The sea-bottom in the neighborhood of Juist is, therefore, not suited to the growth of oysters. It is too muddy, and already in possession of the edible mussel (*Mytilus edulis*). During the last century, and the first half of the present one, the Hanoverian Government was accustomed to lease the oyster-fisheries along its coast. These fisheries were principally in the neighborhood of Juist and Borkum, and from 1841 to 1846, inclusive, 193,684 oysters were taken there, making an average yield of 38,727. In 1851, in a survey of the beds, very few oysters were found, and in 1855 the beds were so impoverished that no one would rent them.

The exhaustion of the beds resulted from excessive fishing and from the increase of mud upon the ground occupied by the oysters. Whoever, therefore, would establish new oyster-beds along the German portion of the coast of the North Sea, between the Eider and the mouth of the Ems, must begin his difficult work by changing the ebb and flood currents in the southern portion of the North Sea, in order to prepare a surface upon which oysters can thrive; for to attempt to adapt oysters to a bottom of shifting sand or mud is not natural, nor is it conducive to an industry which is to last for a hundred years. For thousands of years innumerable young oysters have been scattered from the oyster-beds over changing mud and sand banks, and yet not one has so altered its organization as to become adapted to such a bottom and transmit its new nature to its progeny; they have all been destroyed.

Since the sixteenth century, along the west coast of France, on both sides of the mouth of the Seudre, near Marennes and La Tremblade, the oyster-breeders have been in the habit of transplanting oysters, one year old, from natural oyster-beds to prepared ponds in order to fatten them and improve their flavor. These ponds, called *claires*, are shallow excavations of various shapes and sizes. The greater number are square or rectangular, and cover from two to three thousand square meters of surface. They lie near together, but irregularly, and are divided off into sections by deep trenches or canals, by means of which the sea-water flows in and out during spring-tides. The bottom of the ponds is somewhat higher near the center than around the edges. The walls surrounding the ponds are formed of the earth dug from within, and are about one meter in height. The neighboring ponds are placed in communication with one another by means of ditches or wooden pipes in the walls. Flood-gates are placed in the larger trenches, by means of which the water can be retained in the ponds from one spring-tide to another. In the fall, when fishing upon the sea-beds is permitted, young oysters are taken and transplanted to these ponds. From August until the breeding season next year, these transplanted oysters acquire a cloudy, dark-green color in the tissues of the mantle, gills, liver, and stomach. The delicate flavor, for which the green oysters of Marennes are especially famous in Paris, is only acquired after three or four years. During this time they must often be cleansed from the mud which has accumulated upon them, and transferred to fresh ponds, if they would be kept healthy. In these feeding-ponds the oysters spawn well, and at times, when there are any objects of attachment free from mud, such as stones, shells, and pieces of wood, the young oysters become attached, but they do not mature into marketable oysters. Oyster breeders, after three hundred years of practice in rearing young bank-oysters in the mud of feeding ponds, have not as yet been able to transform the oyster into a mussel which can live and propagate in the mud. The breeders of Marennes and La Tremblade have been able to change the color and flavor of mollusks, but they have not been able to give the oyster a foot for the purpose of locomotion. Along the German coast, in the East Sea, the sea-bottom, over many extensive tracts, is firm, and also free from mud. These places possess, then, in this respect, one of the most important conditions for the successful formation of oyster-beds. Yet several attempts to plant oysters in the Baltic have proved entire failures. In 1753, 1830, and 1843, oysters were planted along the coast of Pomerania. The last of these attempts was made by a company, of which the Kings of Prussia and Hanover and the Prince of Putbus were members. Fifty thousand oysters, taken in the northern portion of the Cattegat, near Frederikshavn, were placed, on the 6th and 13th of April, 1843, in the waters southeast of the island of Rügen, near Greifswalder Oie. Two years later, investigations showed that they were all dead, since not a single living one could be found. The much talked-of attempt at oyster-breeding by Coste gave a new impulse to the question of planting oysters in the Baltic. In the Bay of Kiel, on the south coast of the island of Laaland, in the neighborhood of Korsör, and in the Isefjord, on the coast of the island of Seeland, mature oysters were planted, upon apparently suitable ground, but the desired result was not attained in either place. The water of the Baltic is not salt enough for the propagation of the oyster. East of the island of Rügen the water at the bottom contains only 1 per cent. of salt, and near the surface still less, since the rivers bring in much fresh water. West of Rügen, south from the Great Belt, to near the coast of Mecklenburg, the water at the bottom contains indeed as much as 3 per cent. of salt, but here also the surface-water everywhere contains a less degree. The young oysters, as soon as they had left the mother oysters, would then ascend to the surface, and thus come into water which throughout the entire southern portion of the Cattegat contains less than 2 per cent. of salt, while they need water with at least 3 per cent. of salt. This I infer from the fact, that such a degree of saltness is to be found at all places along the European coast where natural oyster-beds exist. There are two other conditions of the Baltic besides the low percentage of salt, which certainly hinder the growth of the oyster—the long-continued low temperature of winter, and the lack of regular tidal-currents; for in the North Sea, where there are strong and regular tidal-currents, the oyster, which is a stationary animal, will receive daily a greater quantity of oxygen and food in the water brought to it than it will in an interior sea, where the water is in less regular motion. These chemical and physical differences between the North and East Seas render it not only impossible for the oyster to live in the latter, but also for many other North Sea animals, of which I will mention only the lobster, the larger punger (*Platycarcinus pagurus*), and the edible sea-urchin (*Echinus esculentus*).

If nothing further were necessary in order to establish a permanent settlement of oysters in the Baltic than to plant there several thousand fresh and healthy mature oysters, why then cannot lobsters, crabs, sea-urchins, and all the other animals which are found associated with the oysters upon the banks, and indeed the entire fauna of the North Sea oyster-banks, flourish in the Baltic? If this could have been accomplished, I should long ago have had a large number of the animals of the North Sea naturalized in the Bay of Kiel, in order to facilitate my own investigations, and for the purpose of instruction to students. Nature has already made frequent efforts to introduce not only oysters, but other North Sea animals, into the Baltic. Nearly every year fish and other animals from the North Sea appear in the Baltic, but they are not permanent, and soon disappear again from our fauna.

The great storm-flood of the 13th and 14th of November, 1872, brought *Noctiluca scintillans* from the North Sea into the harbor of Kiel in such numbers that for weeks they made the waters of the harbor brilliant with their phosphorescent flashes, but very soon they had entirely disappeared. Under the present geognostic and physical conditions the oyster can advance no farther towards the Baltic than into the south-western part of the Cattegat. Here a line drawn from Samsöe over the island of Anholt to Gothenburg represents the limits of those conditions suited to their welfare. Along this extreme border of their existence one could not expect such productiveness and size among the oysters as a costly artificial system of breeding would demand in order to be profitable.

Every change in the saltness of the water below the general mean, or in the temperature of the sea-water, would incur heavy loss to any artificially conducted system of oyster-breeding which might be carried on here. That oysters of their own accord spread out from their great breeding home in the North Sea into all places where they find the external conditions favorable, is proven by their substantial immigration into Lim Fiord, in the north of Jutland. This fiord, up to the year 1825, consisted of a number of connected brackish-water lakes, with an eastern out-flow into the Cattegat. During the last century futile efforts were made to establish oyster-beds in these seas; but on the 3d of February, 1825, a fearful storm-flood broke through the dam which separated the western portion of the Lim Fiord from the North Sea, and after this the water of the fiord became more salt every year, the brackish-water animals and plants which had lived there vanished, and in their place came North Sea animals, and among them, in 1851, the oyster was first noticed. From year to year they spread over more surface. In 1860 only 150,000 were dredged; presently 98 places were known where oysters had become established, and in 1871–'72 the oystermen were able to take for foreign consumption seven millions of mature oysters from the beds of Lim Fiord. Their distribution was very rapid. In 1851 the first were found; had there been many there before this time, they would certainly have been noticed by the fishermen. The water must first contain a percentage of salt of 3 per cent before they can enter a new territory. If we admit the first appearance of oysters here in 1840, then in an interval of thirty years they had spread over an extent of surface 15 miles (German) in length, which shows a yearly advance, in territory covered of about one-half mile in length, or rather more, about 3,700 meters. The beds of the Lim Fiord are from 1 to 8 kilometers from one another. Their length is from 1 to 7 kilometers and their breadth somewhat less. These facts show that the young swarming oysters are capable of moving over a stretch of bottom 8 kilometers in length. In the same manner as it has thus immigrated into the Lim Fiord the oyster would have established itself in the Baltic had the water been similar in its characteristics to that of the North Sea, and this would be the condition of affairs if the connection between the North Sea and the Baltic were broader and deeper than it is at present. At one time it was broader and deeper, and, for this reason, oysters once lived four miles east of the point where the city of Kiel now stands. This is proven by the fossil oyster-beds found near Waterneversdorf, in the eastern part of Holstein, which, together with the entire bottom of the western portion of the Baltic, have been raised more than 30 meters. By this elevation the Cattegat, the Belt, and the Sound were made shallower and smaller pathways for the water coming in from the North Sea than they were in olden times, when the oyster-beds of Waterneversdorf still produced oysters. Yet, by this elevation of the sea-bottom, which took place thousands of years ago, the percentage of salt in the water has been lessened but very little. Thousands of years later, when the oyster-beds of Waterneversdorf had been dry land for a long time, oysters were found in such abundance along the coast of the Danish Islands that they served as food for the people of the Stone Period who lived in this vicinity, since great masses of oyster-shells are found in the heaps of kitchen refuse of that time.

And since the oyster-shells of Waterneversdorf and of the kitchen-heaps of the Stone Age fully agree with those of to-day, since they are also bored like ours by the boring sponge (*Clione celata*), and since the whelk (*Buccinum undatum*) and other animals at present found upon the sea-flats lived with them, conditions favorable to their growth must have existed at that time in the meridian of the present Cimbrian Peninsula, the same as now to the west of Schleswig-Holstein. The oyster has thus not changed during the course of at least ten thousand years. It has not accommodated itself to the changes which have taken place in the territory occupied by it, but has yielded to those changes, although they were brought about very slowly. Hence it is impossible for any human power to change their nature in a short time and accustom them to the water of the Baltic as it is to-day.

The following Danish works treat of the oyster-beds of the Lim Fiord, the extension of the oyster into the southern portion of the Cattegat, and of the unsuccessful attempts to plant oysters in the Baltic:

Jonas Collin. Om Östersfiskeriet i Limfjorden. (With a chart of the oyster-beds.) Copenhagen, 1872.

G. Winther. Om vore Haves Naturforhold med Hensyn til konstig Östersavl og om de i den Henseende anstillede Forsög. Copenhagen, 1876.

F. Krogh. Den konstige Östersavl og dens Indförelse i Danmark. Hadersleben, 1870.

In the royal archives at Stettin and Stralsund are to be found the acts under which the attempts to locate oysters along the coast of Pomerania in 1830 and 1843 were made.

9.—SIZES AND PRODUCTIVENESS OF THE OYSTER.

The delightful hopes of bordering the entire German sea-coast with fruitful oyster-beds, and of seeing German oysters as food upon every table, must, therefore, be given up. The nature of our waters, as well as the nature of the oyster itself, forces us to do so. Yet it is especially difficult for those to understand this who share the widespread opinion that all eggs which are spawned by oysters are destined to become transformed into young mollusks. Most animals, however, whose ova and young are exposed to attacks and liable to be destroyed, produce a large number of eggs, while those animals, on the contrary, which guard their broods until they can take care of themselves, as is the case with mammals, birds, and some invertebrates, generally produce but few eggs; but in those cases where care for the brood is entirely lacking, or lasts for a very short time only, eggs are produced in such great numbers that the numerous enemies which regularly attack them are not able to destroy them all. A certain number escape destruction and arrive at maturity. The tape-worm of man (*Tænia solium*) produces from its eight hundred segments not far from forty million germs, and the parasite *Ascaris lumbricoides* forms in its ovary about sixty million eggs. Under the normal condition of affairs for the development of these worms, only a very few of the great number of eggs laid ever go so far in growth that they in turn produce eggs. This is satisfactory to everybody, since none desire that all of the forty million eggs of the tape-worm or the sixty million eggs of the "itch-insect" should ever become mature parasites. It would be a horrible state of affairs if such a thing should happen. On the contrary, every one very much desires that all the young broods which the oyster sends forth into the water should become mature table-oysters, since, when fully grown, they become one of the most delicious of delicacies. But in observations and investigations which have for their object the discovery of the methods and means by which nature brings these things about, such desires as these must not be allowed to have an influence upon our opinion; for whoever would have nature especially attractive, beautiful or useful, whenever he is in immediate contact with her becomes easily led away from the pathway of strict scientific investigation and lost in the dark and boundless territory of speculation.

Nature accomplishes at every place just what she is obliged to accomplish there with her united forces, according to the conditions upon which the development of the world has proceeded. Throughout her entire limits there are no such distinctions as useful or injurious. The terms agreeable or disagreeable, beautiful or frightful, useful or harmful, as applied to the workings of nature, exist only in the thoughts and comprehension of intelligent and sensitive beings. Yet very frequently we hear it said, when speaking of the fossil oyster-bed which now lies near Blankenese, below Hamburg, 80 meters above the level of the Elbe, that it did not make any difference that oysters should once have lived there and produced young, of which only a small proportion should ever come to maturity, since no human beings were there at that time who could have fed upon them.

Oysters belong to that class of animals which secures the continuance of the species, not by guarding the young for a long time, but by producing a vast number of embryos every season. They are able to produce so large a brood that enough of the number will be certain to arrive at maturity to maintain the status of the bed, and supply the places of those old oysters which die or are destroyed; and this result takes place notwithstanding many of the young are destroyed by sand, mud, or unfavorable temperature, and many others are eaten before their shells are thick and large enough to protect them from the numerous enemies which live upon the same banks with them. The number of descendants from any one oyster which thus arrive at maturity is so small even upon the best beds, where for more than a hundred years the finest and most productive Holstein oysters have been caught, that I am persuaded no one would give credit to my words if I was not able to substantiate them by means of figures. In 1587, Frederick II, King of Denmark and Duke of Holstein-Gottorp, appropriated the oyster-beds of Schleswig-Holstein as royal prerogatives.* They

* The public order by which the Ducal-King Frederick II took possession of the oyster-beds of the sea-flats along the coast of Schleswig-Holstein and Jutland, is printed by H. Kröyer in his work "De danske Östersbanker," Kjöbenhavn, 1837, page 110. Translated into English, through the German, it reads as follows: "We, Frederick, &c., make known to all by these presents, that since it has been brought to our knowledge that in the waters of the West Sea, in the fief of Ribe, a kind of fish called an oyster can be found and caught, therefore we have commanded our liege Albert Friis, superintendent and guardian at our castle at Ribe, that he permit this kind of fish to be caught in our name and sent to us; and in order that a future lack of them may not occur, we forbid one and all, whoever he may be, from taking oysters or allowing

were then leased, generally for a long term of years. From time to time the government caused the banks to be officially examined, in order to find out their condition and prevent their depletion by overfishing. The examination was conducted by commissioners appointed by the government, and the dredging carried on in their presence was performed by fishermen specially sworn for the purpose. The smaller beds were dredged in three, the larger in six, different places, and all the oysters taken were divided, according to size and age, into three classes, known as—

1. Zahlbar Gut, or marketable.
2. Junggut, or medium (half grown).
3. Junger Anwachs, or young growth.

The *marketable* oysters are those which are large and full grown. Their shell is at least 7 to 9 centimeters in length and breadth, and when closed the greatest thickness must be more than 18 millimeters. The left valve, or the one which is most curved, is from 6 to 9 millimeters thick at the point of attachment of the shell-muscle, and also under the ligament.

The greater number of full-grown oysters are from seven to ten years of age, yet many older ones are found, which can be distinguished from the younger ones by the greater thickness of their shell. Oysters more than twenty years old are seldom seen. The oldest which I have personally examined I estimated to be from twenty-five to thirty years old. The left valve, at the muscular impression and below the ligament, was 20 to 25 millimeters in thickness.

The shells of the half-grown oysters, when closed, show a thickness of from 16 to 18 millimeters. The valves, where thickest, are, at the most, only 5 millimeters thick, and their breadth is less than 9 centimeters. They are cleaner than the old oysters, upon whose shells are generally to be found many animals and dlants. The *young growth* are those small and thin oysters which are not older than from one to two years (Fig. 8 *d*).

In the record of each inspection we find indicated the number of marketable and the number of medium oysters caught in each haul of the dredge, but the number of the young growth is not given, mention only being made as to whether there were many or few.

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them to be taken in that place. We except, however, those who take them in our name by the authority of our liege at Ribe. Whoever shall dare to act contrary to this command, and he can be justly convicted of so doing, shall be punished according to his deserts. Each one is then to govern himself accordingly, and guard against transgressing. Given at Skanderborg, the 4th day of February, 1587."

* The work of Kröyer contains also a tabular review of the numbers of mature and medium oysters of the official investigations which took place from 1709 to 1830. This table, and also tables for which I have to thank the royal government at Schleswig, have furnished me the numbers from which I have estimated the proportions between half and full grown oysters. I have not considered the investigations previous to the year 1730, partly because in the beginning of the eighteenth century a number of beds were unknown, and partly because the numbers of the first five inspections (1709 to 1728) give no positive results. On six official investigations made between the years 1869 to 1876 I have participated myself. The results of these I will give later.

During the period from 1730 to 1852 ten records were made of all the oyster-beds of the Schleswig-Holstein sea-flats. If from these records the numbers of all the marketable and all the medium-sized oysters are taken and added together, we will have a series of very different totals, showing no particular general law. But if for each of these reports the proportion of marketable to medium oysters is taken, then we will arrive at the surprising result that this proportion fluctuates but very slightly during all the records.

The following table gives a summary of the marketable and medium oysters recorded as caught during each of the ten investigations. From these numbers I have reckoned for each record the proportion of medium oysters to every thousand of those which were full grown.

Year of record.	Number of marketable oysters.	Number of medium oysters.	Proportion of marketable to medium.	
1730	5,394	2,602	1,000	486
1734	16,770	5,205	1,000	310
1740	7,185	3,007	1,000	418
1756	6,793	3,333	1,000	490
1795	2,078	1,006	1,000	484
1799	2,705	831	1,000	307
1819	2,828	1,087	1,000	388
1830	1,950	797	1,000	417
1839	3,272	1,552	1,000	440
1852	3,534	1,673	1,000	473
Total			10,000	4,218
Mean proportion			1,000	421.8

The following table gives the quantities of oysters which were taken during these investigations from two of the largest and most productive beds of the Schleswig-Holstein coast, the Huntje and the Steenack Banks:

Year of record.	Huntje.		Steenack.	
	Marketable.	Medium.	Marketable.	Medium.
1730	355	164	158	69
1734	1,353	874	405	90
1740	323	158	26	110
1756	736	99	149	85
1771	931	66	607	197
1795	87	461	261	106
1790	183	119	236	56
1819	363	178	53	79
1830	40	3	11	4
1852	128	64	116	58
Total	4,409	2,181	2,082	804
Proportion	1,000	484	1,000	395

The proportion of marketable to medium-sized oysters is thus seen to be almost the same upon single beds as in a mean of all the beds taken together.

In this similarity of proportions between the marketable and medium oysters in different years and upon different beds a natural law is very strikingly manifested. The medium-sized oysters of any bed consist of the descendants of the marketable ones. They are those members of the young broods which have escaped the numerous enemies living upon and around the beds, and which, despite the numerous attacks made upon their lives, have grown into very respectable-sized animals.

The medium oysters thus represent the total number of embryos from the bed which, in the struggle for existence, have continued to exist. A thousand mature oysters will produce during a breeding period, as I have already shown in chapter 2, at least 440,000,000 of young; but upon the beds alongside of these 1,000 mature oysters are to be found, on an average, not more than 421 half-grown ones; so that, as a rule, for every Holstein oyster which is placed upon the table more than 1,045,000 young are destroyed or die; and indeed even more than this, for not only do those oysters which are over six years of age produce eggs, but those which are two and three years old also reproduce their kind to a certain extent. The younger oysters, however, produce much less spawn than those which are mature, so I estimate that those half-grown oysters lying beside the mature ones on the same banks, and which are their offspring, will produce 60,000,000 young oysters.

We thus have, upon a surface of oyster-bed occupied by 1,000 full-grown and 421 half-grown oysters, at least 500,000,000 of young produced during the course of the summer, and of this immense number only 421 arrive at maturity. *The immolation of a vast number of young germs is the means by which nature secures to a few germs the certainty of arriving at maturity.* In order to render the ideas of germ-fecundity and productiveness more easily understood, I will make a comparison between the oyster and man.

According to Wappäus,* for every 1,000 men there are 34.7 births. According to Böckh,† out of every 1,000 men born 554 arrive at maturity, that is, live to be twenty years or more of age; thus, on an average 34.7 children are produced from 554 mature men, or 62.6 children from 1,000 mature men. Since 1,000 full-grown oysters produce 440,000,000 of germs, then the germ-fecundity of the oyster is to the germ-fecundity of man as 440,000,000 to 62.6, or as 7,028,754 to 1. On the other hand, the number which arrive at maturity, is 579,002 times as great with mankind as with the oyster; for of 1,000 human embryos brought into the world 554 arrive at maturity, or of 440,000,000 newly born 243,760,000 would live to grow up, while of 440,000,000 young oysters only 421 ever become capable of propagating their species. The proportion is then 421 to 243,760,000, or as 1 to 579,002. I am fully per-

* Wappäus, Handbuch der Geographie und Statistik. Band I, 1855, Abth. I, p. 197.

† R. Böckh, Sterblichkeitstafel für den Preussischen Staat im Umfange von 1865. Jena, 1875.

suaded that these figures represent the number of oysters which arrive at maturity more favorably than is really the case, since from every thousand of full-grown oysters it is certain that, on an average, more than 440,000,000 young are produced. The correctness of my argument that the number of oysters which arrive at maturity is very small indeed as compared with the exceedingly large number of germs produced is corroborated by the experience of those who have engaged in oyster-culture in France and England. In the year 1870 a small oyster-bed was discovered at the mouth of the Thames, north-east from Whitstable.* It was about 18 meters long by 6 meters broad. Forty-eight hours later 75 boats were there, close alongside of one another, fishing up the oysters. Upon every old oyster which was taken were found only from nine to ten young ones of different ages. This bed had never been previously disturbed, and the oysters were accordingly found in their natural condition. Whoever is not informed in regard to the small number which arrive at maturity, but knows only of their immense fecundity, will, in thinking of the growth and production of oysters, consider the oyster-beds as inexhaustible. It has, indeed, really been thought that if millions and millions of oysters were taken from a bed no harm would be done to its prosperity, since it was the opinion that the dredges would leave everywhere as many breeding oysters as would be necessary to supply the place of those taken away, by means of the immense number of young which would be produced. In accordance with this view, the oyster-fisheries were made entirely free in England in 1866. But the consequence of the continuous fishing which followed was everywhere a quick impoverishment of the beds, concerning which result the official reports upon the oyster-fisheries in France and England contain a vast number of authentic proofs. According to the statement of Mr. Webber, mayor of Falmouth, 700 men, working 300 boats, were profitably employed in oyster-fishing in the neighborhood of Falmouth so long as the old laws of close-time were observed. But since the year 1866, when those old laws were set aside, the beds have become so impoverished that now, in 1876, only about 40 men, with less than 40 boats, can find employment, and even with this greatly diminished number of boats no single boat takes daily more than from 60 to 100 oysters, while formerly in the same time a boat could take from ten to twelve thousand. About the year 1830 an oyster-bed was discovered upon the English coast near Dudgeon Light, containing an immense number of oysters, among which were very many old ones.

* The statistics concerning English and French oyster-fishing were taken partially from my own notes, made during a visit to the English and French coasts, and partially from two official English reports: I. Report on the Oyster and Mussel Fisheries of France, made to the Board of Trade by Cholmondeley Pennel, Inspector of Oyster-fisheries. London, 1868. II. Report from the select Commission on Oyster-fisheries. 1876.

These reports are attached to summaries of the profits arising from oyster-fishing in France, which were delivered to the authorities at the French department of marine and fisheries.

During the next three or four years this bed was fished so perseveringly and disastrously that since then it has not produced enough oysters to be worth recording. Between the years 1840 and 1850 there were in the harbor of Emsworth so many oysters that one man in a single tide (five hours) could take from 15 to 20 casks, each containing 1,600 oysters. Later, 70 to 100 sailing vessels from Colchester came into the harbor and fished up so many young and old oysters during the two or three weeks they were there that, in the year 1858, scarcely ten vessels could load there, and in 1868 the beds were so impoverished by this fishing that a dredger in five hours could not gather more than 20 oysters. These figures are taken from the statement of Mr. Messum, oyster-dealer, and secretary of an oyster company at Emsworth, made before the commission for the investigation of the British oyster-fisheries, on the 1st of May, 1876. From the beds of the districts of Rochefort, Marennes, and the island of Oléron, on the west coast of France, there were taken, in the years 1853–'54, ten millions of oysters, and in 1854–'55 fifteen millions. By means of long-continued and exhaustive fishing they were rendered so poor that in 1863–'64 only 400,000 oysters were furnished for market.

The very celebrated rich oyster-beds of the Bay of Cancale, on the coast of Normandy, have produced, according to official reports, the following numbers of oysters:

Year.	Number of oysters.	Year.	Number of oysters.
1800	1,200,000	1835	43,000,000
1801	1,500,000	1836	40,000,000
1802	1,300,000	1837	36,000,000
1803	900,000	1838	44,000,000
1804	1,400,000	1839	42,000,000
1805	800,000	1840	52,000,000
1806	500,000	1841	56,000,000
1807	1,090,000	1842	63,000,000
1808	1,800,000	1843	70,000,000
1809	1,200,000	1844	68,000,000
1810	700,000	1845	67,000,000
1811	1,130,000	1846	65,000,000
1812	1,100,000	1847	71,000,000
1813	600,000	1848	60,000,000
1814	400,000	1849	52,000,000
1815	800,000	1850	50,000,000
1816	2,400,000	1851	47,000,000
1817	5,600,000	1852	20,000,000
1818	5,300,000	1853	40,000,000
1819	6,800,000	1854	20,000,000
1820	6,700,000	1855	20,000,000
1821	6,000,000	1856	18,000,000
1822	11,800,000	1857	10,000,000
1823	18,000,000	1858	24,000,000
1824	20,000,000	1859	16,000,000
1825	20,000,000	1860	8,000,000
1826	25,000,000	1861	9,000,000
1827	28,000,000	1862	3,000,000
1828	33,000,000	1863	2,000,000
1829	31,000,000	1864	2,200,000
1830	36,000,000	1865	1,100,000
1831	42,000,000	1866	1,960,000
1832	38,000,000	1867	2,000,000
1833	41,000,000	1868	1,070,000
1834	46,000,000		

The records of inspections of the Schleswig-Holstein oyster-beds have furnished the means by which such an impoverishment of these rich beds can be explained. From 1800 to 1815 there were taken yearly from the beds of Cancale less than two million oysters. The oysters, both marketable and spawning, had thus an opportunity to accumulate in greater quantity to form the increased production which occurred in 1822. If the French oysters live as long as those of the Schleswig-Holstein beds, some of this stock, which had accumulated during the period of comparative rest at the time of the Napoleonic wars, would have been lying upon the banks as late as about 1830. From this time on for nearly a score of years it is probable that the ever-increasing yield was the produce of only those oysters existing upon the beds from 1820 to 1830. From 1840 to 1847 the number of oysters taken was extraordinarily great—evidently too great for the productiveness of the beds, since from this time they produced fewer oysters each year.

The total number of oysters taken between the years 1840 and 1847 was about 512,000,000, being on an average about 64,000,000 per year. If this average represents the natural stock of marketable, full-grown oysters upon the beds of Cancale, then the number taken yearly should not have been over twenty-six to twenty-seven millions, if it was desired that this degree of productiveness should be maintained. This I assert upon the supposition that the productiveness of the oysters in the Bay of Cancale is no greater than upon the Schleswig-Holstein banks. If this productiveness was higher than upon our sea-flats, then we ought to have at Cancale, not 421 half-grown oysters for every 1,000 full-grown ones, but, for example, 500. Under these circumstances the presence of 64,000,000 matured oysters would permit the fishing of 32,000,000 yearly, but no more if the fruitfulness of the beds would be kept at that number, since such a stock would be absolutely necessary in order that a sufficient number of young should be produced to secure the maturing of 32,000,000 yearly.

After the impoverishment of the beds of Cancale the inspection officers enforced once more the laws protecting the oyster, since they did not believe that all the mature breeding oysters had been taken off the beds. Upon some of these beds there has already been a very significant increase of oysters through this action; for in 1872–'73, 7,300,000 oysters were taken, in 1873–'74, 9,056,000, and in 1874–'75, 9,342,000. To preserve oyster-beds a stock of full-grown oysters, for the purposes of propagation, must be left lying upon the banks. The number thus left must depend upon the fruitfulness of the oysters of each section, or, still better, of each single bed. According to the experience of oystermen, the most fruitful as well as the largest of the Schleswig-Holstein oyster-beds is the Huntje Bank. The proportion of medium oysters upon this bed is 484 per thousand, which is thus greater than the mean productiveness of the whole Schleswig-Holstein oyster-beds. The productiveness of smaller beds is belowthe average of 421 per thousand. As examples, we give the proportions of the following beds: Steenack, 385 per thousand; Hörnum, 319 per thousand; West Amrum, 165 per thousand.

These beds are only from 1,000 to 1,050 meters long by about 300 meters broad, while the Huntje Bank is more than 1,800 meters long by about 900 broad. The speedy extension of oysters in the Lim Fiord has taught us that young swarm-oysters can wander from 4 to 8 kilometers away from their home-bed before they become attached to any object. So if the oyster-bank is of small extent, the young oysters are in danger of swimming out beyond the limits of the bed and settling upon unsuitable ground, and thus of being destroyed in much larger numbers than upon a larger bed. Of such broods of swarm-oysters the large banks will retain many more than the small beds; and if upon both all other conditions are the same, a much larger number of young will grow to maturity upon those beds which have a large extent of surface than upon the smaller beds.

10.—AN OYSTER-BANK IS A BIOCÖNOSE, OR A SOCIAL COMMUNITY.

The history of the impoverishment of the French oyster-beds is very instructive. When the beds of Cancale had been nearly deprived of all their oysters, by reason of excessive fishing, with no protection, the cockle (*Cardium edule*) came in and occupied them in place of the oyster; and vast hordes of edible mussels (*Mytilus edulis*) under similar circumstances appeared upon the exhausted beds near Rochefort, Marennes, and the island of Oléron. The territory of an oyster-bed is not inhabited by oysters alone but also by other animals. Over the Schleswig-Holstein sea-flats, and also along the mouths of English rivers, I have observed that the oyster-beds are richer in all kinds of animal life than any other portion of the sea-bottom. As soon as the oystermen have emptied out a full dredge upon the deck of their vessel, one can see nimble pocket-crabs (*Carcinus mænas*) and slow horn-crabs (*Hyas aranea*) begin to work their way out of the heap of shells and living oysters, and try to get to the water once more. Old abandoned snail-shells begin to move about, caused by the hermit-crabs (*Pagarus bernhardus*), which have taken up their residence in them, trying to creep out of the heap with their dwelling. Spiral-shelled snails (*Buccinum undatum*) stretch their bodies as far out of the shell as they can, and twist from side to side, trying, with all their power, to roll themselves once more into the water. Red star-fish (*Asteracanthion rubens*), with five broad arms, lie flat upon the deck, not moving from the place, although their hundreds of bottle-shaped feet are in constant motion. Sea-urchins (*Echinus miliaris*), of the size of a small apple, bristling with greenish spines, lie motionless in the heap. Here and there a ring-worm (*Nereis pelagica*), of a changeable bluish color, slips out of the mass of partially dead, partially living, animals. Black edible mussels (*Mytilus edulis*) and white cockles (*Cardium edule*) lie there with shells as firmly closed as are those of the oysters. Even the shells of the living oysters are inhabited. Barnacles (*Balanus* *crenatus*), with tent-shaped, calcareous shells and tendril-shaped feet, often cover the entire surface of one of the valves. Frequently the shells are bedecked with yellowish tassels a span or more in length, each of which is a community of thousands of small gelatinous bryozoa (*Alcyonidium gelatinosum*), or they are overgrown by a yellowish sponge (*Halichondria panicea*), whose soft tissue contains fine silicious spicules. Upon many beds the oysters are covered with thick clumps of sand which are composed of the tubes of small worms (*Sabellaria anglica*). These tubes, called "sand-rolls," resemble organ-pipes, and are formed from grains of sand cemented into shape by means of slime from the skin of the worm. The shell forms a firm support upon which the worms can thus live close together in a social community. Upon certain beds near the south point of the island of Sylt, where the finest-flavored oysters of our sea-flats are to be found, there lives upon the oyster-shells a species of tube-worm (*Pomatoceros triqueter*) whose white, calcareous, three-sided tube is very often twisted about like a great italic *S*. The shells of many oysters upon these beds also carry what are called "sea-hands" (*Alcyonium digitatum*), which are white or yellow communities of polyps of the size and shape of a clumsy glove. Often the oyster-shells are also covered over with a brownish, clod-like mass, which consists of branched polyps (*Eudendrium rameum* and *Sertularia pumila*), or they may be covered with tassels of yellow stems which are nearly a finger long and have at their distal ends reddish polyp-heads (*Tubularia indivisa*). Among these polyps, and extending out beyond them, are longer stems, which bear light yellow or brown polyp-cups (*Sertularia argentea*). Within the substance of the shell itself animals are also found. Very often the shells are penetrated from the outside to the innermost layer, upon which the mantle of the living oyster lies, by a boring sponge (*Clione celata*), and in the spaces between the layers of the shell in old oysters is found a greenish-brown worm (*Dodecaceræa concharum*), armed with bristles, and bearing twelve large tentacles upon its neck. I once took off and counted, one by one, all the animals living upon two oysters. Upon one I found 104 and upon the other 221 animals of three different species. The dredge also at times brings up fish, although it is not very well adapted for catching them. Soles (*Platessa vulgaris*), which seek by jumping to get out of the vessel and once more into the water, stone-picks (*Aspidophorus cataphractus*), and sting-rays (*Raja clavata*), which strike about with their tails, are abundant upon the oyster-banks. Besides those already mentioned, there are many other larger animals which are taken less frequently in the dredge. There are also a host of smaller animals covered up by the larger ones, and which can be seen only with a magnifying glass. Very few plants grow upon the banks. Upon only a single one of the oyster-beds of the sea-flats has eel-grass (*Zostera marina*) taken root. Upon other beds reddish-brown algæ (*Floridiæ*) are found, and, floating in the water which flows over the beds, occur microscopic algæ (*Desmidiæ* and *Diatomaceæ*), which serve as nourishment to the oysters. If the dredge is thrown out and dragged over the sea-flats between the oyster-beds, fewer and also different animals will be found upon this muddy bottom than upon the sand. Every oyster-bed is thus, to a certain degree, a community of living beings, a collection of species, and a massing of individuals, which find here everything necessary for their growth and continuance, such as suitable soil, sufficient food, the requisite percentage of salt, and a temperature favorable to their development. Each species which lives here is represented by the greatest number of individuals which can grow to maturity subject to the conditions which surround them, for among all species the number of individuals which arrive at maturity at each breeding period is much smaller than the number of germs produced at that time. The total number of mature individuals of all the species living together in any region is the sum of the survivors of all the germs which have been produced at all past breeding or brood periods; and this sum of matured germs represents a certain quantum of life which enters into a certain number of individuals, and which, as does all life, gains permanence by means of transmission. Science possesses, as yet, no word by which such a community of living beings may be designated; no word for a community where the sum of species and individuals, being mutually limited and selected under the average external conditions of life, have, by means of transmission, continued in possession of a certain definite territory. I propose the word *Biocœnosis** for such a community. Any change in any of the relative factors of a biocönose produces changes in other factors of the same. If, at any time, one of the external conditions of life should deviate for a long time from its ordinary mean, the entire biocönose, or community, would be transformed. It would also be transformed, if the number of individuals of a particular species increased or diminished through the instrumentality of man, or if one species entirely disappeared from, or a new species entered into, the community. When the rich beds of Cancale, Rochefort, Marennes, and Oléron were deprived of great masses of oysters, the young broods of the cockles and edible mussels which lived there had more space upon which to settle, and there was more food at their disposal than before, hence a greater number were enabled to arrive at maturity than in former times. The biocönose of those French oyster-banks was thus entirely changed by means of over fishing, and oysters cannot again cover the ground of these beds with such vast numbers as formerly until the cockles and edible mussels are again reduced in number to their former restricted limits, because the ground is already occupied and the food all appropriated. The biocönose allows itself to be transformed in favor of the oyster, by taking away the mussels mentioned above, and at the same time protecting the oysters so that the young may become securely established in the place thus made free for them. Space and food are necessary as the first requisites of every so-

* From *βίος*, life, and *κοινόειν*, to have something in common.

cial community, even in the great seas. Oyster-beds are formed only upon firm ground which is free from mud, and if upon such ground the young swarming oysters become attached in great numbers close together, as happened upon the artificial receptacles in the Bay of Saint-Brieux, their growth is very much impeded, since the shell of one soon comes in contact with that of another, and they are thus unable to grow with perfect freedom. Not only are they impeded in growth in this manner, but each oyster can obtain less nourishment when placed close together than when lying far apart.

In an oyster-breeding trench upon the island of Hayling, in the south of England, I saw, in May, 1869, oysters three years old which had grown thus far towards maturity attached to hurdles. Nearly all had twisted shells, which were not larger in diameter than from 2 to 3 centimeters, while a Holstein oyster three years old is from 5 to 6.5 centimeters broad. Evidently, the reason for their small size is to be found in the fact that in the trench they receive less nourishment daily than they would in the open sea. In the Bay of Arcachon the breeders are obliged to loosen the oysters from their artificial points of attachment and place them in boxes and trenches where they can grow to maturity, and in these the oysters must not be placed too close together or they will not grow to the best advantage. Even upon the best beds the oysters will remain poor if they are allowed to lie too thick upon the bottom; but if a portion of these poorly nourished oysters are taken away, those which remain—as has been found out by experience upon the Huntje Bank, the largest and most fruitful of all the Schleswig-Holstein beds—will soon become fatter, that is, their generative organs will become larger because more eggs or spermatozoa are produced than with poorer oysters. Thus, if a bed is above its mean in productiveness, every single one of the excessive throng of full and half grown oysters will not receive sufficient nourishment to enable them to generate a full number of germs, so that the number of germs produced and the number of young which arrive at maturity being thus regulated the entire bank will very soon be brought back to its former or normal condition. Since this law is in operation upon even the most productive of the Schleswig-Holstein beds, where the number of young which arrive at maturity is 484 for every thousand of mature oysters, while the average for all the beds is only 421 to each thousand, then a productiveness of 484 to the thousand is the highest which can be reached and maintained among the oysters existing under the biocönotic conditions of our sea-flats. Near Auray, in Brittany, the oyster-breeders collect many more young than they can grow to maturity, since they possess comparatively little oyster-territory, and this territory is not supplied with sufficient suitable food to nourish large numbers of oysters; so that whenever the breeders fail to find a purchaser for their extra stock of young they lose all the profits of their labor. Thus, it is with oysters as with all other animals; their increase in size and numbers depends upon the quantity of food which they get and consume. The peasants of Jutland are great breeders of horned cattle, but they have not sufficient food to grow and fatten all their calves. Accordingly, many are sold to the peasants of the marsh-lands on the west coast of Schleswig-Holstein, and upon these extensive pasture-lands great numbers of cattle can be raised. Upon the estate of Hagen, near Kiel, there is a carp-pond of more than 80 hectares in size which is drawn off every three years, and while in this condition sown with oats and clover. It is afterwards refilled with water and 30,000 yearling carp placed in it. In three years from this time, as a rule, the production is 40,000 pounds of food-fish. In order to obtain a still greater profit, another lot of young carp was once placed in the pond, and this time more than 30,000. In three years the produce is indeed a larger number of fish than before, but they weigh, taken all together, only 40,000 pounds. The quantity of food which the pond supplies in three years is thus sufficient only for the growth of 40,000 pounds of carp.

I do not consider it practicable to fatten oysters by artificial means, although in North America and Europe an effort should be made to fatten planted oysters upon corn-meal. The food of oysters consists of very small organic particles which float in the water, and if one should attempt artificial feeding by carrying to the oysters of a bed water containing pulpy pulverized flesh, bone-meal, fish-guano, or corn-meal, it would be necessary to prevent the water from flowing off from the bed until all the organic matter had been eaten. But by so doing a large quantity of foul gas would certainly be generated upon the bed and remain there, so that the oysters, instead of fattening, would become sick and die. Among the external life conditions of a biocönose, temperature plays an important part.

In our seas, with their equitable temperature, a mild winter, followed by a spring and summer with the temperature much higher than usual during spawning time, is especially favorable to the production of a vast number of embryos. All living members of a social community hold the balance with their organization to the physical conditions of their biocönose, for they live and propagate notwithstanding the influence of all external attractions, and notwithstanding all assaults upon the continuance of their individuality. Although every species is differently organized, in each the different forces act together for the growth and maintenance of the individual, and although each species has from this fact its own organic equivalent, yet they all possess the same (balancing) power for the totality of the external conditions of life of their biocönose. Hence all species must respond to a deviation in the conditions of life from the ordinary mean by a corresponding action of their forces, so that their efficacy may increase or diminish uniformly. If favorable temperature makes one species more fruitful, it will, at the same time, increase the fertility of all the others. If more young oysters exist upon an oyster-bed because the old ones receive more warmth and food than during ordinary years, then the snails, crabs, sea-urchins, and star-fish, and all other species living together upon the bank, will also produce more young, as repeated observations have shown to be the case. But since there is neither room nor food enough in such a place for the maturing of all of the excessively large number of germs, the sum of individuals in the community soon returns to its former mean. The surplus which nature has produced by the augmentation of one of the biocönotic forces is thus destroyed by a combination of all the forces, and the biocönotic equilibrium is by this means soon restored again. Where it is possible for one to furnish suitable ground and food for an excessive number of young germs, a greater proportion of them can arrive at maturity than in an entirely natural biocönose. The oyster-breeders of Arcachon and Auray increase very much the mean number of oysters which arrive at maturity upon their beds by placing tiles in the water, upon which the young can attach themselves. These young are then provided with a suitably prepared ground over which water containing food is allowed to flow. If in a community of living beings the number of individuals of one species is lessened artificially, then the number of mature individuals of other species will increase. Thus, upon the west coast of France cockles and edible mussels took the place of the oysters which had been caught from the beds; and upon the fertile prairies of North America herds of tame horses and cattle are now pastured where immense throngs of wild buffaloes (*Bos americanus*) once ranged in full liberty.

If the germ-fecundity of a species is lessened by the artificial distinction of many mature breeding individuals, while all the other forces of the community are working with their accustomed vigor, so surely must there be a decrease in the number of individuals of this species which arrive at maturity. A large number of the most productive oyster-beds upon the west coast of Europe have been devastated by overfishing, and many fresh waters have, through the incessant catching of half-grown fish, been almost entirely depopulated. It is very natural that those years during which a large number of herring, salmon, or sturgeon are caught upon a certain stretch of territory should be followed by years when fewer fish appear, because in the years when large catches are made very many breeding individuals are destroyed.

If in a case of subtraction the minuend is lessened while the subtrahend remains the same, the remainder will be lessened also. By the continued artificial destruction of breeding individuals, the fecundity of any one species of a community may sink so low that it is no longer able to produce sufficient germs to insure in all cases the maturing of a sufficient proportion which shall escape the ordinary natural assaults to which they are subject in the community; the species therefore dies out. In this manner the dodo (*Didus ineptus*) became extinct upon the island of Mauritius in the seventeenth century, after the Portuguese, in 1507, had disturbed the biocönose of the island by the introduction of swine and other animals, and after the Dutch, still later, had ruthlessly killed many of these birds. Also, at present, there are no turtles at Mauritius, while up to the year 1740, according to written testimony, hundreds were caught there for the provisioning of ships. Certainly many young dodos and turtles must have been devoured by the pigs. The beaver (*Castór fiber*) will perhaps very soon have vanished from our biocönotic transformed portion of the earth. The Greenland whale (*Balæna mysticetus*) is now seldom seen in the neighborhood of Spitzbergen and Greenland, on account of the persecution to which it has been subjected since the seventeenth century. Every biocönotic territory has, during each period of generation, the highest measure of life which can be produced and maintained there. All the organic material which is there ready to be assimilated will be entirely used up by the beings which are procreated in each such territory. Hence at no place which is capable of maintaining life is there still left any organizable material for spontaneous generation. If, in a biocönose the number of individuals which arrive at maturity would be maintained at the highest point, even though the number of breeding individuals is being artificially lessened, the natural causes which act towards the destruction of the embryos must be diminished at the same time. In the Bay of Arcachon the breeders raise to maturity an unusually large number of young oysters by guarding them artificially from their enemies.

In an example in subtraction the remainder may be kept unchanged, or even increased, if the subtrahend is decreased at the same time as the minuend; and the mass of individuals of any species may be increased permanently if the biocönotic territory is extended. Thus, when the Lim Fiord became filled with water from the North Sea, the number of mature oysters over the territory of the North Sea coast of Denmark increased to more than seven millions (chapter 8, p. 30). The oyster-beds in the Bay of Arcachon and the *claires*, or fattening-ponds, at the mouth of the river Seudre (p. 27), are artificial extensions of oyster-territory.

The individual number of cultivated plants and animals has been immensely increased because man has artificially extended their biocönotic territory; and this artificial increase in the number of plants and animals by means of cultivation is the foundation for the increased fecundity of the human species and the greater number of individuals which arrive at maturity—that is, for the extension of the biocönotic territory of *Homo sapiens*. The average yield of our woods, fields, and gardens is the result of natural force and human labor, for in addition to the chemical and physical forces of earth and air, the organic forces of wild and cultivated plants and animals, the bodily and mental forces of man play an important rôle in the culture of field and forest, and a very significant share of the large yields of harvests is due not only to the numerous workmen of the woods and fields, but also to the makers of implements of labor, to the mechanics and opticians who produce instruments for the investigation of natural phenomena, and to the careful studies of the many investigators of nature and of those interested in land and forest culture. And these manifold interdependent human powers must unceasingly oppose the average uniform workings of natural forces if a permanent mean profit would be derived from the artificial communities of cultivated lands, or if Nature would be prevented from introducing again into each such territory her own communities. This was entirely disregarded in the case of the banks along the west coast of Europe. Millions and millions of oysters were taken from these beds, and great astonishment arose when it was noticed that their productiveness had diminished. Notwithstanding that the number of breeding animals was extraordinarily diminished at each annual gathering, yet every succeeding year an equally large number of mature descendants would be harvested. Oystermen wish the oyster to be exempted from the workings of those communal laws, according to which field and forest culture must be conducted in order to achieve a certain measure of success; and there are oyster-breeders in England who desire, for the entire satisfaction of their great yearly demands upon both the oyster-banks and the oyster-beds, that every year, during the breeding period, the temperature of the water should remain at from 18° to 20° C., that no wind should blow, and that no storm should suddenly disturb the good weather, in order that none of the young swarming oysters may be destroyed.

In France they expected that all of the million germs produced by a full-grown oyster would grow into marketable oysters, if only suitable objects were provided to which they could attach themselves. It was thus believed that some miracle would be wrought by means of which oysters would reach maturity, for there existed in the water which passed over the beds where the millions of young oysters were laying not a particle more food than was brought there years before, and that was only enough to feed the much smaller number of oysters existing there at that time. In Germany they desire that oysters should live and thrive upon changing sand-banks and mud-bottoms, and accustom themselves to the brackish water of the Baltic, and that at the same time they should remain animals of the same tenderness and delicacy of flavor as the oysters of the good Schleswig-Holstein beds. Such desires could only be realized by means of miracles or by the exemption of certain single cases from the necessary workings of Nature's laws. There must be an entire change in the form of our coasts and in that of the islands lying along them, in the direction of the mouths of the rivers and in the flood and ebb currents, before oysters can be made to thrive over our entire sea-flats. It would thus be necessary to supersede the natural oyster biocönose by an artificial one, which would have to be cultivated as farmers and gardeners cultivate their fields and gardens; and in order that oysters should be able to live in the waters of the Baltic to-day, their physiological activities would have to be so changed that they could thrive in water in which the percentage of salt is much more vacillating than in the water of the North Sea; that is to say, it must become another animal, and yet, at the same time, retain the flavor of the oyster. People have experienced a thousand times that the best-flavored and most agreeable animals and plants are brought to perfection only under entirely definite external conditions of life, yet they wish an exception to this law of nature in favor of the oyster. They wish for miracles in order that oysters may be supplied to the many who are now oyster-eaters, as cheaply and plentifully as they formerly were to the few who at that time appreciated their value.

11.—CONCERNING THE INCREASE IN THE PRICE OF OYSTERS AND THE NUMBER OF CONSUMERS, AND THE DECREASE IN THE NUMBER OF OYSTERS.

In England there are breeders of oysters and others who are well versed in oyster economy who maintain that the oyster-banks have become impoverished because of a long series of seasons which have been unfavorable as breeding years, and not because of overfishing upon the beds. According to their observations, there have been no large broods of young oysters since 1857, 1858, and 1859. This may be the case in regard to a number of localities, but it has no significance in the management of a permanent, profitable oyster-culture, since such culture is not conducted according to an unusually favorable summer, but according to the average of climatic conditions. And that these conditions have not changed in the west of Europe in our century, and thus during the time of the impoverishment and exhaustion of many beds along the west coast of Europe, is proven by the temperature observations which have been made at the Observatory at Paris since the year 1806. According to these, the mean yearly temperature of Paris during this century has remained, up to present time, at 10.8° C., from which it follows that the climate is the same now as before any impoverishment took place. In 1859 there were many young oysters spawned upon the beds along the west coast of France. In 1860 there were many young broods upon the beds near the island of Ré and near Rocher d'Aire, and but few broods at Arcachon; 1861 was a good brood year for all three places; 1862 bad for the island of Ré and good for both the others; and in 1865 there were very many young in the Bay of Arcachon and but few near Rocher d'Aire and the island of Ré. These facts show that local conditions can either favor or prevent the production of broods of young oysters in one and the same year.

On the 6th of April, 1876, Mr. F. Pennell made a communication to the commission for the investigation of the British oyster-fisheries, and at the same time remarked that, according to his experience, the number of young oysters in each brood period was dependent upon the number of breeding oysters, but that, nevertheless, at times, extraordinarily large numbers of young were produced.* Whoever has followed thus far the detailed statements which I have made must be obliged to confess that Nature is not to blame for the impoverishment of the oyster-beds along the western coast of Europe during the last century, for neither have the external conditions of life for the oyster become less favorable nor has the fecundity of single animals become less.

Nothing else but excessive fishing, without protection, has depopulated the beds. Most of the oystermen and those thoroughly acquainted with oyster industry, who reported their experience and opinion, in London, in 1876, to the commission for the investigation of the British oyster-fisheries, were entirely of this opinion. But the question will be asked, Why were the beds of the west of Europe not overfished in olden times? Because, before the time of steamboats, locomotives, and railroads, there was a much smaller number of consumers than at present. Then genuine connoisseurs were rarely to be found except along the coast where the oyster lived.

In the autumn, when oyster-fishing began, those only were very costly which were first caught, but as more were brought in the price rapidly fell. On the 21st of September, 1740, the first hundred fresh Schleswig-Holstein oysters sold in Hamburg for 1.42 marks (about 35 cents) of present money. Later the same day 900 were sold at 1.20 marks (30 cents) per hundred; then 3,400 at 15 cents; and finally 10,800 at 7½ cents per hundred. On the 15th of October of the same year, and at the same place, the first hundred fresh, newly arrived oysters sold for 2.40 marks; the second hundred for 2.10 marks; then 1,025 were sold for 1.80 marks per hundred; then 1,000 at 1.50 marks; then 2,000 at 1.20 marks; and finally 12,500 at 60 pfennige (15 cents) per hundred. These numbers are taken from the report upon the Schleswig-Holstein oyster-banks,† and show that it was necessary to lower the price of oysters very soon after the arrival of a large importation into Hamburg harbor, if they were to be disposed of in an eatable condition and not entirely lost, because there was no adequate means of transporting them into the interior. Such a fall in price guarded the oyster-beds from too destructive fishing. Soon, by means of steamers and railroads, oysters fresh from the beds could be spread far and wide into the country; then oyster-eaters began to increase in number; and so, despite the rapid advance in price, the demand for oysters increased from year to year. This demand was very much in proportion to the spreading of the network of railroads in England, France, and Germany. It did not come into the heads of the oystermen that a more exhaustive fishing would tend to depopulate the beds. Year after year they had found an ever-ready supply of oysters upon the same beds; why should they not, then, take away whatsoever came into their dredge?

* Report on Oyster-fisheries, 1876, p. 116, Nos. 2386 and 2387.

† *H. Kröyer.* De danske Oystersbanker. In this work several examples are given, at pages 92 and 93, taken from the reports of oyster-culture in Schleswig-Holstein, of the decrease in price of oysters upon one and the same day at Hamburg.

In former times, fishing was carried on only in those places where the oysters lay thickly together, for where only a few oysters could be caught it did not pay to fish, because of the low price; hence all of those banks which were covered only with scattered oysters were left to rest until a sufficient number of mature oysters had accumulated upon them to repay the labor of fishing. But when, however, the number of oyster-eaters increased, and likewise the price of oysters, it became profitable to fish upon less fertile stretches, and the dredges were used so persistently that finally very little more could be found upon the banks. Before the time of railroads the decline in price of oysters regulated the fishing in favor of a good condition of the beds; but since the time of railroads the ever-increasing price has acted as an incentive to the oystermen to depopulate their banks. The official reports upon French and English oyster-breeding contain abundant proofs of this, as evidenced by the facts there set forth. The oyster-fishers of Cancale were made happy by receiving, each succeeding year, for those oysters which they sent fresh to Paris, more money than they had received the year before, and the possibility of depopulating their rich banks was not thought of.

Learned authorities had said that every mature breeding oyster produced from two to three millions of young. They believed, then, that if they left upon the beds only a hundred breeding oysters they would be doing all that was necessary in order, in a short time, to find upon the overfished beds two hundred to three hundred million descendants of the same. Up to 1854, the oyster-beds of Rochefort, Marennes, and the island of Oléron were fished with some regard to their preservation, since their oysters found a market only in those places which were situated along the neighboring coast. But in 1854 Rochefort was placed in connection with the interior by means of the network of railroads, and the market for these oysters, and the profits from them, increased so much that they were taken until these beds were almost entirely depopulated. From 15,000,000 in 1854–'55, the catch fell off to 400,000 in 1863–'64. (See chapter 9, p. 37.)

The last report upon the English oyster-fisheries in the year 1876, contains many instructive instances of the great advance in price as the result of the decrease in number of oysters. At Whitstable, where the finest kinds of native oysters are produced, the price for a bushel, 1,400 to 1,600 oysters, was, during the period from 1852 to 1862, never higher than £2 2*s*. sterling. In 1863–'64 it had risen to £4 10*s*., in 1869 to £8, and in 1876 to £12 sterling. Thus, in 1876, a single oyster cost there about 16 pfennige (3 to 4 cents) in our currency.

At Colchester, another celebrated market for oysters on the east coast of England, a bushel of oysters cost, during the years 1856–'63, 66*s*.; 1864–'65, 80*s*.; 1865–'66, 95*s*.; 1866–'67, 100*s*.; 1867–'68, 130*s*., English money.*

* Report upon oyster-fisheries, 1876, p. 63.

At Falmouth, a tub of oysters (1,600) cost, in 1830, 1s.; 1860, 2 to 2½s.; 1863, 4 to 14s.; 1867, 9 to 37s.; and in 1869, 45s. A cask of Schleswick-Holstein oysters (700 to 800) was sold, in 1875–'76, to oyster-dealers, for 105 marks (about $26.25).

Fifteen years previous the price was only a third of that sum. By the incorporation, in 1864, of Schleswig-Holstein in the German tariff-union, the territory into whose markets the Schleswig-Holstein oysters could be brought free of duty was very significantly increased, and at this time English oysters were becoming very rare in German markets. The political changes in Germany, and at the same time the great increase in the consumption of oysters, evidently increased the incentive to a more complete fishing of our oyster-beds than in former times, and this accounts for the extraordinary decrease in the number which arrive at maturity to-day, for at the inspection of these beds in 1869 there were found only 282 half-grown oysters for every 1,000 full-grown, and in five inspections during the years 1872 to 1876 there were found, on an average, only 107 half grown. This is in striking contrast to former inspections, where the average was 421 half-grown oysters for every 1,000 full-grown, as has been shown in chapter 9, p. 35.

12.—THE CHEMICAL CONSTITUENTS AND THE FLAVOR OF OYSTERS.

The heaviest portion of an oyster is its shell, and this, on an average, constitutes about 8¼ per cent. of the total weight of an ordinary Holstein table-oyster. Internally, the oyster is a soft animal; externally, it is a stone animal. The dried shells of very old oysters weigh from 250 to 320 grams. In such heavy, thick-shelled oysters the soft portion is generally very poor, and the body-space is smaller than at the time when it first attained its complete maturity. From this it follows that the edges of the last-formed shell-layers do not pass over those which were formed earlier, but lie under them. The principal constituent of the shell is carbonate of lime, which forms about 96 to 97 per cent. of the whole weight. The shell also contains 1.2 to 1.3 per cent. of sulphate of lime, 0.09 per cent. of phosphoric acid, 0.03 per cent. of oxide of iron, and traces of magnesia and aluminum. If these inorganic constituents of the shell are dissolved in acid, there will remain undissolved brownish bits and flakes of an organic substance which has been named *conchyolin*. This contains the elements oxygen, hydrogen, nitrogen, and carbon. The left or arched valve of a Holstein oyster contains from 1.01 to 1.025 per cent. of conchyolin, the right somewhat more, from 1.10 to 1.15 per cent. This increase in the percentage of conchyolin makes the right valve less brittle than the left.

At times pearls are found in oysters. They generally lie in the mantle, but also in the shell-muscle. Pearls are isolated deposits of shell-material. Their chemical constituents are accordingly the same as those of the shell. In some pearls taken from Schleswig-Holstein oysters there has been found a proportionally greater amount of carbonate of lime than is found in the shells themselves. Brilliant pearls, suitable for ornaments, are seldom found in oysters, those generally taken being white and without brilliancy. However, an oyster-eater in Hamburg once discovered, by means of his tongue, a pearl which he sold to a jeweler for 66 marks (about $16.50). Nearly all mussels have more beautiful shells than that of the oyster, but in delicacy and fineness of flavor the oyster surpasses every other mollusk. Only those materials can be tasted which, dissolved in fluids, come in contact with the organs of taste. Hence the flavor of the oyster depends upon substances which are either in solution in the juices of the body of the oyster or which become dissolved in the mouth of the eater. Fresh, living oysters, as is the case with all sea-animals, contain very much water. In order to estimate the proportion of water the greatest care must be taken in removing the oyster from the shell, especially when the shell-muscle uniting the two valves is cut. The exterior of the body must first be dried with blotting-paper, the body then weighed and finally placed under the air-pump and all the water drawn out. Two Schleswig-Holstein oysters which were taken from the shell and dried, weighed together 14.70 grams, and after all the water had been drawn from them they weighed only 3.05 grams. They thus contained 79.25 per cent. of water and only 20.75 per cent. of solid material. Two other large oysters, which had been previously deprived of their gills and mantles, weighed together 20.55 grams; after being thoroughly dried they weighed 4.809. Thus, their edible portion contained 76.64 per cent. of water and 23.36 per cent. of solid material.

A large number of investigations upon Schleswig-Holstein oysters demonstrated that the entire animal contained from 21.5 to 23 per cent. of solid material, while the body, without the gills and mantle, contained from 23 to 24.5 per cent. of solid material.* Making due allowance for size, there is a somewhat greater difference in the proportion of solid material between oysters and fish than between oysters and birds and mammals, for—

	Per cent. of solid material.
Trout-flesh contains	19.5
Carp-flesh contains	20.2
Pork contains	21.7
Veal contains	21.8
Beef contains	22.5
Fowl-flesh contains	†22.7

* I am indebted to Prof. O. Jacobsen, of Rostock, for all the information that I have given in chapter 12 in regard to the chemical constituents of the Schleswig-Holstein oysters. In June, 1871, when he lived in Kiel, he analyzed, at my request, a number of oysters which I had received fresh from the Schleswig-Holstein beds.

† The figures quoted in the comparison of the amounts of solid materials in different kinds of flesh are based upon the analyses of Schlossberger and Von Bibra. They were taken from the Elements of Physiological Chemistry of Gorup-Besanez, third edition, 1874, p. 682.

One hundred parts of dried oyster-meat contain 7.69 to 7.81 parts of nitrogen, and 100 parts of fresh oyster-meat contain 1.85 to 1.87 parts of nitrogen. By burning the dried oyster-meat we can obtain the amount of inorganic material which it contains. By this method it has been found that the meat of completely dried Schleswig-Holstein oysters, when deprived of the beard, contains 7.45 per cent. of inorganic substances, while in those which have not been dried the amount is only 1.79 per cent. According to these determinations, 100 parts of the bodies of fresh edible Schleswig-Holstein oysters, contain—

77.00 parts of water.
21.21 parts of organic material.
1.79 parts of inorganic material.

The principal inorganic substances are salt (*sodic chloride*) and phosphoric acid. The proportion of salt in fresh oysters is 0.58 per cent., and of phosphoric acid 0.38 per cent. In fresh beef the proportion of salt is 0.49 per cent., and of phosphoric acid 0.22 per cent. From these results it is evident that the oyster contains as much food substance as the better sorts of meat used for food, or even somewhat more. In addition to this, it is still farther distinguished from the greater number of animal foods by being more easily digested. But if we compare the price of oysters with the price of equal quantities of the best kinds of ordinary meats, we find that, with us, the oyster furnishes a much more costly means of nourishment than the others. If the edible portions of a dozen Holstein oysters weigh 125 grams, or one-fourth of a pound, and if that number cost 2 marks (50 cents), then the oyster, as a means of nourishment, is 6¼ times more expensive than beef-steak, at 1 mark 20 pfennige (30 cents) per pound. The value of an oyster does not depend principally upon the amount of nourishment which it contains, but chiefly upon its delicacy and uniformly fine flavor. Oysters form the finest article of food which our seas produce—food which can be eaten fresh from the water, and which requires no artistic cooking to develop its excellencies. They resemble the noble pearls, which attain their greatest perfection in the place of their growth. What particular constituent of the oyster it is which gives it its flavor is as little known as the origin of the flavor of various other kinds of food. The liver and the generative organs contain glycogen and grape-sugar. Pure glycogen has no taste, and it is composed, as is grape-sugar, of carbon, hydrogen, and oxygen. Probably the fatty matters aid greatly in giving flavor to the oyster. I have repeatedly found that in May and the first half of June, when the generative organs are very much developed, the females have a much finer, nut-like, and full flavor than the males.

I have repeatedly placed fresh oysters, whose sex I had previously ascertained by means of the microscope, before different people in order to get their opinions of the flavor. They also, without knowing anything about the difference in sex, found the female superior in flavor to the male. Those females which are well developed are generally somewhat thicker and more cream-like in color than the males, whose bodies are more transparent and watery. In the middle of winter these differences are not so apparent as shortly before the breeding season. Immediately after the emission of the generative products, oysters are poorest and they are more watery then than at any other time. After the breeding period their size increases from month to month, and, in case their nourishment is not interrupted by long-continued severe cold, their flavor becomes fuller and richer in proportion to the rapid development of the generative organs. From this it follows that winter, but more especially spring, are the periods of the year for the enjoyment of oysters. I have repeatedly heard people, who rated themselves as genuine oyster-eaters, say that "oysters ought never to be bitten, but should be swallowed whole." If this were so, then one might better use, in the place of the high-priced oyster, a succedaneum made of tasteless thin paste, and having merely the form of the oyster.

As with all other kinds of food, the flavor of the oyster is more effective and can be better appreciated the more intimately its constituent elements come in contact with the surface of the organs of taste. Therefore, if one would obtain the full flavor of the oyster, it must be bitten to pieces and chewed, in order that all the constituents may be free to produce their greatest effects. The Schleswig-Holstein oyster-banks produce oysters of very different flavors. Those having the finest flavor exist upon beds which lie not very far from the deeper channels, through which the water passes in and out during the flood and ebb tides. (See the chart of these beds on page 4.) Thus, very superior oysters are found upon the beds at the northern and southern ends of the island of Sylt, and upon a single bank north of the island of Röm; but the very finest oysters are found upon the beds near Hörnum. The oysters of these beds are especially distinguishable by the large growth of their organs of generation. Their flavor is very delicate, and never bitter and watery, as is the case with the oysters of many other beds. This superiority in form and flavor must be the direct result of the action upon the oysters of these banks of the external conditions of life under which they exist. The oysters upon the beds near Hörnum lie deeper and nearer the open sea than those farther in upon the flats. The water, also, which flows over them during the course of the day and year is less subject to fluctuations in temperature than that which flows over the beds lying nearer the mainland, and there is here a somewhat greater percentage of salt than in the water over the beds of the shallower portions of the sea-flats. To these external physico-chemical properties of the Hörnum banks are also united faunal peculiarities. Here are to be found the three-sided worms (*Pomatoceros triqueter*), and colonies of polyps which, from their form, are called "sea-hands" (*Alcyonium digitatum*). Both of these forms are found abundantly upon the bottom of the open North Sea. They are not to be found upon any other beds of the sea-flats, and it is very evident that they cannot live upon the inner beds, since these do not furnish the necessary conditions for their growth. Thus, just in those places where the extreme limiting line of the territory inhabited by the "sea-hands" and three-sided worms passes across our oyster-beds, the most favorable conditions exist for the growth of the finest-flavored oysters. A three-sided worm upon the shell of a Schleswig-Holstein oyster is, therefore, a sign of its arrival from one of our best beds. A pastor living upon the island of Sylt was fond of good oysters, and was also well acquainted with this external indication of them; so he was accustomed to say to the out-going oyster-fishers: "Bring me some fresh oysters when you return, but only such as the good Lord *has marked*." In Paris the green oysters of Marennes and Tremblade are especially prized on account of their delicious flavor. This cannot come from the green constituents of their body, for if old oysters are taken there during the winter months and placed in a fattening-pond, they will, indeed, become green, but by no means so well-flavored as those oysters which were placed there when young and have lived there several years. (See chapter 8, p. 27.)

The flavor of oysters is best at the banks themselves, if they are opened very carefully and all the sea-water which is inclosed in the shell when shut is allowed to escape. This can be done most judiciously if the oyster is placed upon the flat right valve, after the loosening of the shell-muscle. This valve is a superior natural plate for the oyster, since it has no cavities like those of the left valve, filled with disagreeably smelling water, which flows out when the shell is opened and contaminates the flavor of the oyster. (See Fig. 5, p. 11.) The oyster can live for days perfectly dry without dying, but it gradually loses its softness, and soon begins to smell, from the dying of the animals which inhabit the outside of its shell. It is very seldom that these can be entirely removed by the usual means of purification (p. 8), so that the flavor of the oyster inland is almost always affected by these contaminating odors.

In order that oysters may be furnished to those who want them, in the freshest and best-flavored condition possible, only such a number should be caught at any one time, and for any one market, as can be disposed of in a very few days. But since wind and weather are often so unfavorable, just in the height of the oyster-season, that vessels cannot go out to the beds and fish, the oystermen are obliged to dredge a large supply of oysters during good weather and plant them in some place where they will live and at the same time be available whenever they are wanted. For this purpose large reservoirs have been built near Husum. These consist of four four-sided ponds, with perpendicular walls, lined with plank. The length of the ponds is 14 meters, the breadth 12 meters, and the depth about 2 meters. The bottom is paved with tiles. The ponds can be divided into compartments by means of perpendicularly placed wooden partitions. In these compartments the oysters are planted as soon as they are brought from the banks. They are then covered with water which has stood for a while in a neighboring pond, the clearing-basin, in order to let the mud settle. During cold weather 500 tons, or 350,000 to 400,000 oysters, can be kept in these storage-ponds, but during warm weather only 200 tons. If it be necessary, oysters can be stored in the clearing-pond and in the trenches which lead to the ponds. In order to preserve the oysters in the storage-ponds in a healthy condition they must not be placed too close together, especially in warm weather. They must also be changed very often from the compartment which they have occupied to a clean one, and be subjected to a rapid flow of water in order to wash off all the dead material from their shells. Most of the English oysters which are eaten in Germany come from Ostend. They are kept there in basins similar to those at Husum, which have been built behind the walls of the old fortress. In 1869 I found there nine of these basins, which could be filled to a depth of about 2 meters with sea-water, supplied through sluices which connect the basins with the sea. In these ponds oysters are only stored and fattened. Those not sold by the close of the oyster-season are generally sent back to the English beds, because they are kept with difficulty during the summer, but principally because, after lying in the ponds for a long time, they become very poor from the lack of food. In the years 1875-'76 it is reported that a weekly supply of 500 bushels (750,000 oysters) were received at Ostend from England.

The most celebrated oyster-port in England is Whitstable, situated on the southern side of the mouth of the Thames. Here the best natives are found. Their shells are indeed not very large, but their bodies are thick and very full, on account of the great depth of the cavity of the left valve.

The oysters which are sent over to Germany, by way of Ostend, are smaller varieties than the celebrated Whitstable oysters. These last are seldom sent to the continent, nearly all being demanded for the London market, where they command a higher price than any other kind. Oysters for exportation are packed in casks. In these they are placed with the left valve always undermost, and are packed so close together that, when the cask is closed, no room is left for them to open the valves of their shells. Upon many oyster-beds along the west coast of France those oysters which have very nearly arrived at a marketable size are at frequent intervals left uncovered, and longer and longer each successive time. As long as they are deprived of water they will keep their shells closed, and thus they are trained to retain, while in the dry casks, and until the knife prepares them for the table, the water which they inclosed in their shells when taken up. If ice is used to keep oysters fresh, care must be exercised that the water from the melting ice does not come in contact with the mollusks, or their flavor will be injured. Care should also be taken, especially with shelled oysters, that the ice used to cool them off does not entirely cover them.* Preserved oysters, packed in tin cans, are brought into the markets from North America. In these the natural flavor, for which the fresh oyster is so highly prized, is as much destroyed as is that of the tropical fruits which come to us cooked in sugar. If they were not preserved oysters they would hardly find purchasers. They serve merely as suggestions of fresh oysters.

13.—THE OBJECT AND RESULTS OF OYSTER-CULTURE.

The object of a good oyster industry is to gain from the territory cultivated the greatest possible profit, and at the same time to render the industry permanent. From a bed of inanimate material one can take away as much of the mass as he can use with profit. Such a proceeding does no harm to the prosperity of the bed, since what is left has nothing to do with the production of a new supply. With living objects, on the contrary, it is different. They are not quiet, immovable masses, but combinations of materials and active forces, which are engaged among themselves in a continual renewal; and if one is to derive the greatest possible benefit from them, their mass must not be indiscriminately reduced, as with minerals in a mine, but care must be taken that their powers of renewal are not weakened by a lessening of their available forces and materials. A breeder of cattle who would maintain a certain definite degree of productiveness in his herd must keep a definite number of breeding animals. If it is desired to have a definite permanent production of wood from a given extent of forest, only such an amount must be cut yearly as will be offset by the yearly growth. If a permanently larger quantity is desired, the forest surface must be increased. A profitable permanent system of oyster-culture is also dependent upon these same laws. Hence its foundation is the preservation of a stock of mature breeding oysters. No artificial system has yet succeeded in bringing to maturity, in inclosed parks, generation after generation of oysters, and the most clever breeders are obliged to rely upon the natural banks in order to obtain breeding oysters or young for their fattening-ponds. Hence the foundation of all oyster production, whether artificial or natural, is *the preservation of a stock of full-grown breeding oysters upon the natural oyster-banks.*

In France, ever since the government undertook to retain upon the natural banks along its coast a sufficiently large number of breeding oysters to keep up the stock, artificial oyster-breeding has maintained a secure basis. By this means the French Government has been enabled, through its fishery commissioners, to determine the beds which are in a suitable condition to be fished and the time at which they can

* The Romans were in the habit of cooling their oysters with ice from the mountains: "Addiditque luxuria frigus (ostreis) obrutis nivo, summa montium et maris ima miscens." C. Plinii Sec., naturalis historia, lib. xxxii, 6, 21.

be profitably worked. In the rich oyster-regions of Cancale and Saint-Vaast-de-la-Hogue, on the coast of Normandy, and in the Bay of Arcachon, there are great banks which, during spring-tide (at the time of full and new moon), run dry, or are covered with so little water that people can wade over them and pick up the oysters with their hands. Near Cancale crowds, resembling caravans, of from 500 to 1,000 persons, mostly women and children, fish for oysters upon these exposed banks. One of the best of these beds in the Bay of Arcachon, called Le Cés, has an extent of 11 hectares (about 26.73 acres). When oyster-fishing is permitted on this bank, it is generally performed by women, who are placed in rows of about ten each, and, headed by two men, proceed over the bed. The oysters are gathered into sacks which are carried by women following behind the others, and who empty the sacks, as they become filled, into larger baskets. The gathering cannot continue longer than from two to two and one-half hours in any one spring-tide, because the bank is not exposed for a longer time. Yet, in this time, 40 to 50 persons can gather about 60,000 oysters. Immediately after any place is fished in this manner it is marked by four cask-buoys, so that it may not be fished again the same year, and in order that it may be readily found later, when they scatter oyster and mussel shells over the ground for the attachment of the young oysters. About the year 1870, the beds in the Bay of Arcachon had become almost entirely exhausted, but by this strict method of protection, the fecundity of the 19 beds which are located there has once more become so great that the water of the bay, from June till into August, is filled with swarms of young oysters. Hence it is no wonder that at times, and in favorable places, single tiles can be found to which from 1,000 to 1,200 young oysters have become attached. According to an official report* upon French oyster-culture which appeared in January, 1877, there were, in 1876, in the fattening-ponds upon both sides of the mouth of the Seudre, 80,000,000 oysters; near Oléron, 7,000,000; near Sables-d'Olonne, 10,000,000; near Lorient the same number; and near Courseulles-sur-Mer, 20,000,000 to 30,000,000. This extraordinary fruitfulness of the oyster-beds along the west coast of France is the result of the careful preservation of a rich stock of mature breeding oysters upon the natural banks, especially in the Bay of Arcachon, on the coast of Brittany near Auray, and on the coast of Normandy near Saint-Vaast-de-la-Hogue, Cancale, and Granville. Thousands of persons are industriously employed, during the season, in taking, upon shells, tiles, &c., the im-

*Rapport adressé au ministre de la marine et des colonies sur l'ostréicultur, par M. G. Bouchon-Brandely, Published in the official journal of the French Republic, January 22, 1877. Under an act of Parliament of May 17, 1877, an English translation of this appeared, with the title: Copy of translation of a report made to the minister of marine in France, by M. G. Bouchon-Brandely, relative to oyster-culture on the shores of the channel and of the ocean.

From this report I have taken all the remarks which I have made in chapter 13, in regard to the latest condition of the French system of oyster-breeding.

mense swarms of young oysters, which are produced upon these beds, in guarding them from their enemies, and then in transplanting them to the numerous fattening-ponds along the coast, where, at last, by careful rearing, they are brought to marketable size. The number of persons employed daily in oyster-culture near Saint-Vaast-de-la-Hogue is 300, and near Cancale 4,000. In the district of Auray, for the year 1876, the total number of days' employment for all the men, women, and children who were engaged in this industry was 89,678. In Arcachon an oyster-breeding company laid out 110,000 tiles as objects of attachment for the young oysters. In 1876, 300,000 tiles were used for the same purpose near Vannes, and as many at Oléron. At Auray, in 1874, as many as 2,580,000 tiles were employed as objects of attachment for the young broods. At Lorient 60,000 troughs of cement, each trough 50 centimeters long by 30 to 40 broad, are used in rearing and fattening young oysters. In these the water remains constantly, during the lowest tides, 10 to 12 centimeters deep. Near Saint-Vaast-de-la-Hogue there are 185 oyster-beds, which cover an area of 88 hectares (about 213.84 acres); near Cancale the amount of surface which has been artificially changed into oyster-beds is 172 hectares (about 411.96 acres).

At Auray the amount of oyster-ground is over 300 hectares. Here there are 277 storage-beds and 20 fattening-ponds. In 1876, in the neighborhood of Marennes and Tremblade, on the Seudre, there were 13,526 artificially prepared beds, covering an area of 4,000 hectares (9,720 acres), and at the same time the Bay of Arcachon contained 3,317 such places. The production of oysters from these beds is so great that machines have been invented to sort them. With the help of a machine two women can sort in a day 30,000 to 40,000 oysters. Railroads connect the feeding-ponds with the cleansing-basins, packing-houses, and landing-places of the boats which bring the young oysters from the banks and brood-beds for fattening. From these accounts it will be seen how large a surface of sea-bottom, how much money, and how much human labor are requisite in order that the embryos which under natural conditions originate in the sea shall be transformed into the immense number of full-grown oysters which the French oyster-breeders now place upon the market. The original plan of Coste to line the entire coast of France with a network of oyster-beds has indeed not been carried out; but in consequence of his exertions and experiments many oyster-parks have been established in favorable places along the coast from Normandy to south of the mouth of the river Gironde. The French, favored with innumerable bays and with a mild sea temperature along their coast, have, by diligence, perseverance, and the invention of new methods, brought oyster-culture to such a high degree of perfection, and given it such wide range, that now, in that favored land, it is to be reckoned as one of those cultured industries in which man converts to his service vast numbers of plants and animals. The large number of oysters produced as a result of the French system of oyster-culture has been held up very often to the inhabitants of the German coasts, in order to incite them to establish in their seas similar places for the artificial harvesting of oysters. The writers who did so knew neither the nature of the oyster nor the character of our seas. They might just as well have said to the inhabitants of the lower portion of the Elbe: "Lay out vineyards, for in 1874 the department of the Lower Loire produced 1,914,427 hectoliters of wine, and the department of Gironde 5,123,643 hectoliters." In Egypt there is nothing lacking, except water, in order to produce dates and wine in abundance upon the desert which stretches from Cairo to Suez. So it is with us; all we lack in order to carry on successfully artificial oyster-breeding upon the mud-flats of the North Sea are mild winters, with no ice, and security against the force of storm-floods. There is food enough there to feed billions of oysters. The old English method of oyster-culture was much simpler than the new French method. The work consisted chiefly in transplanting young oysters from the natural banks along the coast to suitable beds in the mouths of rivers, where they became fat and well flavored. They also removed the mud and plants from these new beds, destroyed as many of the enemies of the oyster as possible, and improved the ground by scattering over it the shells of oysters and other mollusks. This industry is carried on in a much better manner at Whitstable, where there is an oyster company which, it is claimed, has been in existence for six or seven hundred years. It numbers over 400 members, who work 120 vessels. Only the sons of those who are, or have been, members are admitted into the guild. In 1793 an act of Parliament adjudged to this company, as their property, an extent of oyster-ground about two miles long and the same in breadth, situated in the mouth of the Thames, and which they had claimed up to that time only by right of possession. This territory consisted partially of natural oyster-banks, partially of beds upon which oysters from the open sea had been placed to spawn, and partially of beds upon which oysters from along the coast had been placed to fatten. In order to still further improve these beds, empty oyster-shells, sent back principally from London, were often scattered over them. The Whitstablers consider that a thick layer of oyster-shells forms the very best bed for oysters, and they pride themselves that they possess the "best oyster-grounds in the world," as I myself have heard them say. The fecundity of the oysters upon their fattening-beds is very small. The cultivation of the oyster is carried on at Colchester, Burnham, and other places along the coast of England very much as it is at Whitstable. From these places many oysters are taken to Ostend. The efforts which have been made to bring living oysters from North America to England and plant them there have not succeeded well enough to warrant imitation. But if they could succeed in transplanting large quantities of young oysters from the breeding-stations of Normandy and Brittany to the excellent feeding-grounds of England, English oyster-breeding would probably soon take a very significant upward tendency.

The oyster industry is conducted in North America very much as it is in England. In protected muddy bays and mouths of rivers near the coast, great quantities of young oysters, which have been taken from the natural beds, are planted for the purpose of fattening, the method thus resembling that in vogue at Whitstable and at other places along the west coast of Europe. In North America places are also chosen where the oysters will be protected from frost and heat. In localities rich in food they arrive at marketable size in from two to three years. The North American oyster is a different species from that of Europe. Its scientific name is *Ostrea virginiana.* It is longer from the hinge-ligament to the shell-muscle than is the European oyster, *Ostrea edulis*, and the left valve is generally more curved than with our oyster. Very few efforts have ever been made in North America to catch and grow oysters artificially according to the French system. The natural banks produce such an abundance of young oysters that all the beds artificially planted can be abundantly and cheaply supplied from them. During late years the North American beds have furnished an annual average of about thirty million bushels of oysters for market; this is about nine to twelve billions of oysters, since there are from three to four thousand oysters in a bushel. In 1859 the number of oysters sold amounted to from six to eight billions.

The principal markets for North American oysters are New York and Baltimore. In 1867 there were over 10,000 men employed in the oyster-trade in Baltimore. The yearly capital employed in this business in New York was, about 1870, over $8,000,000.* The North American oysters are so fine and so cheap that they are eaten daily by all classes; hence they are now, and have been for a long time, a real means of subsistence for the people. This enviable fact is, however, no argument against the injuriousness of a continuous and unprincipled fishing of the beds. The size of the territory over which oysters are found, and the number of inhabitants, must not be left out of account, however, if a right judgment would be formed in regard to those great sums which appear in the oyster statistics of North America. The territory of the North American oyster-beds is of very great extent, comprehending the greater portion of the east coast of the United States. Oysters occur from Cape Hatteras, in North Carolina, to the mouth of the river Saint Lawrence, and Chesapeake and Delaware Bays are especially rich oyster localities. In the United States there are now 52,000,000 of people; in Germany, France, and England, altogether, over 109,000,000. Hence, in North America, with a less number of inhabitants, there is a much greater supply of oysters per person than there is in Europe. But as the number of consumers

* In the following works will be found more detailed statements in regard to oyster-culture in North America:

P. de Broca. Études sur l'industrie huitrière des Etats-Unis. Paris, 1865.

Spencer F. Baird. Report on the condition of the sea-fisheries of the south coast of New England in 1871-'72. Washington, 1873. Oyster-beds, p. 472, by A. E. Verrill.

increases in America, the price will also certainly advance, and then the desire will arise to fish the banks more severely than hitherto; and if they do not heed in time the unfortunate experiences of the oyster-culturists of Europe, they will surely find their oyster-beds impoverished from having defied those biocönotic laws which have been given in chapter 10.

As man has uprooted the greatest forests, so can he also annihilate the richest oyster-beds. In England it is now understood to be absolutely necessary that the natural oyster-banks should be regularly and systematically protected if they are to remain uniformly and permanently productive. A commission for the investigation of the English oyster-fisheries, which met in London early in the year 1876, recommended to Parliament that fishing for oysters be forbidden by law from the 1st of May until the 1st of September each year, and that definite limits of time be designated, during which certain definite oyster-territories must be allowed entire rest. During the close-time all handling of oysters for the purposes of food should be prohibited under penalty of fines; yet it should be permitted, even during close-time, for the purposes of transplanting, with the design of preservation and improvement, oysters taken in a lawful manner upon public beds. Upon the banks in the open sea the close-time was to last only from the 15th of June until the end of August, since these banks can very seldom be fished during the stormy seasons of the year. The size of the sea-oysters brought to market was to be at least 2½ to 3 inches in diameter.*

A close-time has been enforced upon the Schleswig-Holstein beds for a long period. This time extends from the 9th of May to the 1st of September, and, furthermore, no oysterman is permitted to take away any oysters which are less than 2½ inches in diameter. All oysters which are not of this size must be thrown back into the water. Both of these laws have been carried out; yet, nevertheless, in the course of the last twenty years the fertility of the beds, in comparison with earlier rental periods, has very significantly fallen off. These laws in regard to close-time and a minimum size for marketable oysters, which were designed to preserve to the banks an undiminished power of renewal, did not, therefore, attain their object at the very time of the high price of oysters, and when oysters should have been plentiful. It is, therefore, not enough to regulate the time of catching and the size of oysters, if, at the same time, care is not used to prevent too large a number of oysters from being taken from the beds during any one fishing season. *But what number is too great?* A foundation for an estimate of the number of oysters which may be taken away from the beds without injury to their productiveness can be obtained, for the Schleswig-Holstein beds, by means of the inquiry in regard to their productiveness. This productiveness is, upon an average, 421 per thousand; so for every 1,000 full-grown

* Report on oyster-fisheries, 1876, p. iii.

oysters which are now upon the beds not more than 421 ought to be taken away annually. Upon a number of banks where the productiveness is less than this the number taken should be less. Upon the Huntje Bed, where the production is more than 421 per thousand, as many as 484 for every thousand can be taken yearly without endangering or lessening the productiveness, since that number of medium oysters grow into marketable oysters every year. But although the productiveness is thus expressed by a proportional number, yet the absolute number of full-grown oysters which may be taken from a bed during any one season cannot be arrived at without further consideration. One must know how thick the full-grown oysters lie upon the beds; whether, in fact, there is a sufficient number to secure an average fecundity to the bank. Upon banks such as those in the Bay of Arcachon and near Cancale, which are left dry during spring-tides, it is not difficult to observe the number of oysters necessary per square meter, in order to maintain the fecundity of the bank at its highest point, for at such times they are so exposed that they can all be counted. But those beds along the German and English coasts and in the open North Sea, which, on the contrary, remain continually under water, are much less favorably situated for the purposes of these inquiries. I have often been told that "such beds could be best investigated by means of divers." The general impression is that the divers can see, through the glass in the front part of their helmets, everything which lies upon the sea-bottom. But this is erroneous, for in those shallow coast-seas which have ebb and flood tides the water is so clouded by the floating particles of mud that very little light can penetrate to the bottom. But even in clear water a diver would not be in a condition to ascertain by sight the number of oysters, for whenever he steps he renders the water cloudy, by stirring up the lighter particles lying upon the bottom; and so he would have to depend principally upon his hands, and ascertain, by feeling, those oysters which could just as well be taken up by means of the dredge, for the dredge brings from the bottom not only some of the soil, but also a portion of its inhabitants. And if the contents of the dredge be placed in large vessels or aquaria, with sea-water, the animals will very soon assume their customary positions and motions, so that we can see, in quiet and clear water, just how they live at the bottom of the sea. An aquarium with the living inhabitants of an oyster-bank is thus a segment of the bank itself.

When, in imagination, I have united many such segments together, I can picture to myself the sea-bottom, with its inhabitants, as a diver would never be able to see it. I can see the ground covered with oyster-shells, and here and there among them a living oyster with open shell, out of which protrude the fringed borders of its mantle. Upon the upper valve polyps are growing with expanded heads, looking like delicate, many-rayed stars. Hermit-crabs, bearing their snail-shell houses, are crawling hither and thither over the rough surface, and groping about with their claws for something to eat. Worms stick their heads out of holes and crevices; sea-urchins stretch out their sucking feet beyond the points of their spines and pull themselves slowly up on to a stone; a star-fish, with greatly arched back, has fastened itself about a mussel in order to suck it out of its shell; and a small fish has stationed itself under an open oyster and snaps up the embryos as they come from the shell.* Of this life of the oyster-bank the diver would see little or nothing, even if he happened to be a zoologist, for as soon as he had descended to the bottom the oysters would shut themselves up, the crabs and worms creep out of sight, and the fish swim away. I thus sketch this picture of a small portion of the really abundant life of an oyster-bank in order to show that one may become really very well acquainted with an oyster-bed by means of a dredge. It can also be used to estimate the thickness of oysters upon a bed, if the distance passed over by the dredge while it is taking oysters be measured. In the inspections of the Schleswick-Holstein banks, during the last few years, this has been accomplished in the following manner: At those points, where the dredge is dropped upon the bed, an empty cask, attached by means of a rope to a heavy weight, is cast overboard. The weight sinks to the bottom and holds the cask securely anchored, floating upon the surface of the water. Connected with the rope of the cask is a measuring-line, which is wound upon a roller, and which runs off as long as the vessel is going forward and the dredge drags over the bottom. The mouth of our larger dredges is one meter in width. Thus, if we let the dredge drag over the bottom until 100 meters of line have run off, and find that we then have 50 oysters in the bag, we can conclude that one oyster came from every two square meters of bed-surface; and if an oyster-bank, the length and breadth of which are known, is dredged over in this manner in different directions, a foundation is obtained from which to estimate the number of oysters upon the bed with certainly as much accuracy and with far greater speed and ease than a diver; and when the proportional productiveness of a bed thus examined is ascertained, we can estimate the number of oysters which can be taken from the bed without injury to its productiveness.

Practical persons will object to these methods as being too detailed, and yet not leading us to a sufficiently high estimate of the number of oysters; but they will be obliged to admit that there is no better means of finding out, with any degree of certainty, the number of oysters upon these banks. A skillful oysterman, one who has been acquainted with the beds for a number of years, will notice, without the use of a measuring-line, whether the oysters lie upon the banks in sufficient

* An oyster-breeder, Captain Johnston, saw, at some oyster-station for artificial culture, small fish of the genera *Gobius* and *Mullus* swallowing young oyster-swarmlings. He caught the fish, opened their stomachs, and found therein partially digested embryos. (Report on the oyster-fisheries, p. 87, Nr. 1711.)

numbers for the prosperity of the banks, or whether the beds have become impoverished. He will reach this conclusion from the number of oysters which he can catch with a certain speed of his vessel, and during a certain definite time which his dredge drags over the bottom.

Those authorities who have control of the inspections of the oyster-fisheries might, therefore, be able to avail themselves of the services of skillful dredgers to find out the condition of the banks before they decide, each season, the particular places which can be fished and the number of oysters which can be taken from each. The inspectors at Arcachon, after observations extending over many years, have arrived at a definite conclusion in regard to the number of breeding oysters which it is absolutely necessary to retain upon the banks, in order to maintain them at that stage of fruitfulness necessary for a permanent and profitable oyster-culture.

The report of January, 1877, upon oyster-culture in France says: "Although the natural oyster-beds in the Bay of Arcachon are regarded as breeding-beds, yet, nevertheless, the government allows them to be fished for some hours ever year, in order to remove the surplus of oysters." This is a fundamental proposition which a judicious oyster-breeder must carefully consider if the greatest amount of profit would be gained. In accordance with this proposition, oysters should never be allowed to remain upon a bank after they have passed the period of their greatest growth and fecundity, or until they die of old age; but we should anticipate nature, which demands the death of the old and weak as an indispensable condition for the production and bringing to maturity of the greatest number of young upon any bed. I do not consider it, then, as for the best interests of the beds to prevent dredging upon one or all of them for any long periods of time. The French Government has not, therefore, in my estimation, acted in the best interests of the beds, in entirely forbidding dredging upon a strip of territory which lies along the edge of the oyster-banks of Cancale and Granville. The object of this protection is to retain there an undisturbed stock of breeding oysters, from which to rejuvenate the impoverished beds of both these places. Upon such unfished beds the natural biocönotic balance, from which a certain definite average germ-fecundity results, will very soon become established. But this will become less if, with the same proportion of nourishment, more superannuated than mature oysters are to be found upon the beds. The productiveness of any territory will thus be much less, if it is left entirely undisturbed than if it is judiciously fished, and, moreover, the profits which result from the food-oyster taken from such territory are lost. Upon the Schleswig-Holstein banks the oysters are best when from about seven to eight years old. In warmer regions they become fully matured in a shorter time.

The amount of increase in the length of oyster shells during a given time is very different upon different portions of the Schleswick-Holstein sea-flats, but their average growth in thickness is much more uniform;

hence it would be more correct to estimate the minimum size for marketable oysters according to the average thickness of the shell than according to its breadth. Estimated thus, a thickness of shell of 18 millimeters would be a judicious minimum size for the Schleswig-Holstein oysters. In conclusion, I hereby give, as a foundation for all oyster-culture, the most important rules for the preservation and improvement of natural oyster-banks.

An oyster-bank will give permanently the greatest profit if it possesses such a stock of full-grown oysters as will be sufficient to maintain the productiveness of the bank in accordance with its biocönotic conditions.

Whenever the natural conditions will admit of it, the yielding capacity of an oyster-bed may be increased by improving and enlarging the ground for the reception of the young oysters.

The natural banks should be improved by removing the mud and sea-weeds with dredges and properly constructed harrows, and by scattering the shells of oysters and other mussels over the bottom. When circumstances will permit, all animals which are taken in the dredge, and which kill the oysters or consume their food, should be destroyed.

It would be much more judicious, and much better for those who eat oysters, if the close-time could be extended until the 15th of September or the 1st of October, so as to allow the oysters sufficient time, after the expulsion of the contents of the generative organs, to become fat before being brought to the table.

If it is desired that the oyster banks should remain of general advantage to the public, and a permanent source of profit to the inhabitants of the coast, the number of oysters taken from the beds yearly must not depend upon the demands of the consumers, or be governed by a high price, but must be regulated solely and entirely by the amount of increase upon the beds.

The preservation of oyster-beds is as much a question of statesmanship as the preservation of forests.

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XXVIII.—A PRACTICAL GUIDE TO OYSTER CULTURE, AND THE METHODS OF REARING AND MULTIPLYING EDIBLE MARINE ANIMALS.

By Félix Fraiche,*
Professor of the Natural Sciences and Mathematics.

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INTRODUCTION.—PRESENT CONDITION OF THE OYSTER INDUSTRY UPON THE COAST OF FRANCE.

The oyster industry, which was formerly carried to a high degree of perfection by the Romans, as shown by the results obtained at Lake Lucrin by Sergius Orata, who, according to the testimony of his contemporaries, would not have found any difficulty in causing oysters to thrive upon the roofs of buildings, and by the industry yet in full activity at Lake Fusaro, has always been left in France entirely to the forces of nature. As a result of this our numerous oyster banks, furnishing sufficient supplies for all demands when the imperfect means of communication hindered the shipment of this mollusk from point to point, have not been able to resist the abusive fishing to which they have been subjected since our railroads have afforded facilities whereby the oyster can be carried to all parts of the country, and thus to millions of new con-

* Guide Pratique de L'Ostréiculteur et Procédés d'Élevage et de Multiplication des Races Marines Comestibles, par M. Félix Fraiche, Professeur de Sciences Mathématiques et Naturelles. Paris; Eugène Lacroix, Éditeur, 15 Quai Malaquais. 12mo, 174 pp., 25 woodcuts.—Translated by H. J. Rice, B. Sc.

sumers. In 1858 M. Coste addressed to the Emperor a report upon the condition of the oyster fisheries of the coast, and exposed in these terms the deplorable impoverishment of "the oyster industry, which has fallen into such decline that unless prompt measures are taken, the source of all production will very soon be entirely exhausted. At Rochelle, Marennes, Rochefort, and the islands of Ré and Oléron, of twenty-three banks, which formerly constituted one of the sources of wealth of this part of the coast, eighteen are completely depopulated; while those which yet furnish oysters are seriously affected by the increasing invasion of mussels. Moreover, the oyster breeders of these regions are no longer able to find there, not to mention those necessary for consumption, a sufficient harvest to supply their 'parks' and 'claires' with oysters, which are there fattened and brought to perfection, and are obliged to bring them, at great expense, from the coast of Brittany. The bay of St. Brieux, which is so admirably and naturally adapted to the production of the oyster, and where there formerly existed, upon a hard and permanent bottom, thirteen beds in full activity, has to-day not more than three beds, from which twenty boats might in a few days carry away the last oyster. At the time when the gulf was in its prosperous condition, more than two hundred vessels, manned by fourteen hundred men, were engaged in fishing each year from the 1st of October to the 1st of April, and took from these waters a harvest valued at three to four hundred thousand francs ($60,000 to $80,000). In the harbor of Brest, and at the mouths of the rivers in Brittany, the decrease has been less rapid, because these fertile sea-territories have not as yet been subjected to so active a fishing; but as the decimation of other parts of our coast forces us to resort to these beds for what can no longer be found elsewhere, they will soon share in the general ruin. At Cancale and Granville, two classical quarters for the growth of the oyster, it is only by dint of care and good administration that they succeed, not in increasing the crop, but in moderating its decline." Such, then, was the deplorable condition of the oyster industry upon the coast of France in 1858, when M. Coste wrote his report,—a condition much more threatening for the future, in that it coincided exactly with the completion of our net-work of railroads, which permitted the products of the ocean to be carried in a few hours throughout the entire territory of France, even to the departments most remote from the sea, thus tending unquestionably to increase the consumption by placing a large number of our people in a position to profit by the delicacies which were formerly forbidden them, on account of their distance from the centers of production. A continued rise in the price of oysters, coincident with a decrease in their delicacy and fatness, were the immediate results of this state of things. But still another very grave and menacing result was the continued diminution of our maritime population, the sole source whence, in our days, are recruited the sailors for our fleets; for, where fifty boats, each with from five to eight men, formerly found profitable labor in gathering oysters, it is now barely possible for ten boats to provide support for fifteen to twenty families, who have, moreover, no other means of support than gathering this mollusk. Hence we find a very general abandonment of maritime careers, the impoverishment and degradation of our coast population, and, finally, the imminent weakening of our marine. At this time M. Coste discovered a remedy for the evil he had announced, and through the munificence of the Emperor obtained the means of experimenting, upon a grand scale, with the object of restocking the oyster banks of the coast, and of applying to this great and useful end the principles which had been revealed to him in his long and arduous scientific labors.

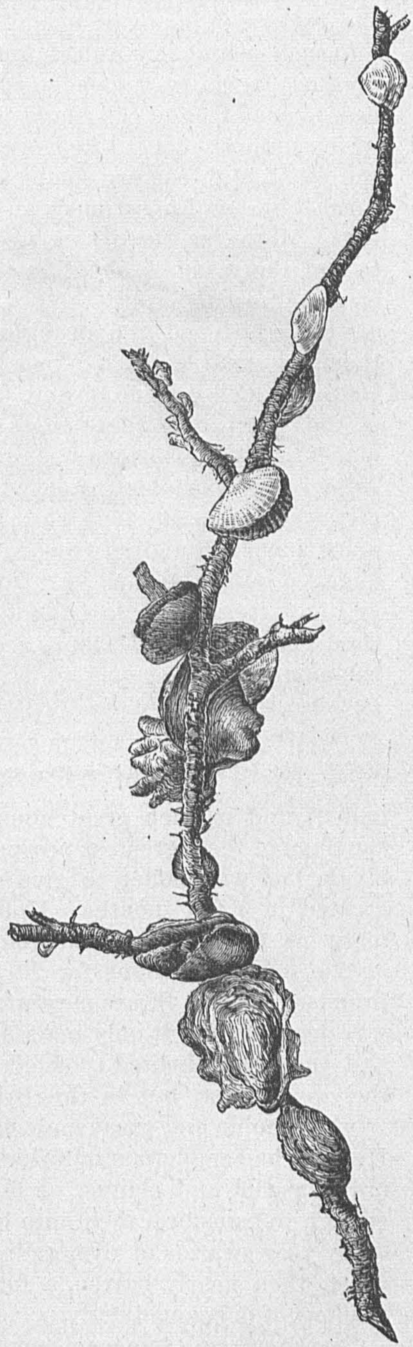

FIG. 1.—A twig bearing young oysters (natural size).

The harbor of St. Brieux was chosen as the site of the first experiment; and during the months of March and April, 1858, the general planting took place with oysters brought from the sea at Cancale and Tréguier. Two imperial guard-boats, the Ariel and the Antilope, were employed to assist in this work. The oysters were placed in six long beds, situated in various portions of the bay, and these beds were then carefully buoyed out so that they could be easily found and examined when necessary or desirable. Besides the oysters, the bottom was paved with oyster shells and the shells of Cardium and various other mollusks, with the object of offering support and shelter to the young oysters; then bundles of twigs, from two to three meters (6 to 10 feet) in length, were anchored with stone and maintained at a short distance from the bottom; thus completing a series of collecting apparatus sufficient to secure and hold all the young which might appear. Six months later, the experiment had already promised complete success; for the shells and fascines planted for the reception of the young were found, upon examination, to be literally covered with young oysters (Figs. 1

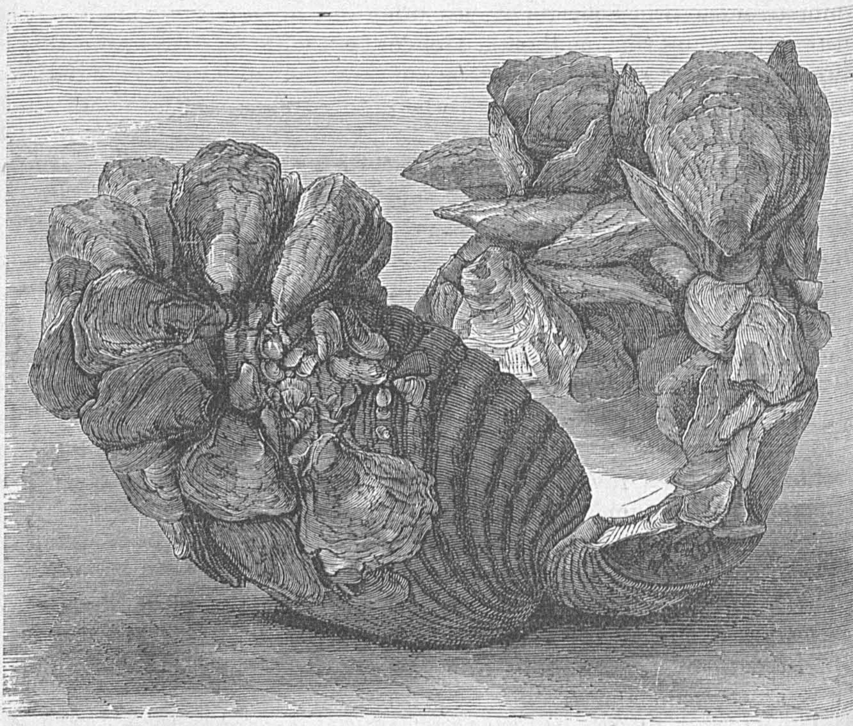

FIG. 2.—Shell of cardium covered with young oysters (natural size).

and 2), and in such great abundance that Cancale and Granville, in the days of their greatest prosperity, never saw such a spectacle. One single fact will suffice to give some idea of the immense wealth thus created in a few months. Upon one single bundle of the twigs as many as twenty thousand young were counted; and as oysters sell at the fishing stations for 20 francs ($4) per thousand, this bundle promised for the future a return of 400 francs ($80). The experiment was decisive, and it only remained to have these teachings propagated and the people incited to similar efforts, not only at other points along the ocean coast, but in the British Channel and the Mediterranean. It was a noble and great undertaking, in which M. Coste had *not* failed. He soon had numerous imitators. In the Bay of Arcachon the possessors of parks and claires, or fattening and feeding places, were wise enough to transform them into breeding places, veritable hives, whence every year swarms of oysters issued forth into the sea, assuring to this coast, then nearly barren, a future revenue of from twelve to fifteen millions of delicious bivalves.

By the efforts of government two model establishments were founded upon this bay, and one hundred and twelve persons, associated with the marine, came to carry on the new industry, which occupied an extent of 400 hectares (about 960 acres) of emergent lands, made over by the administration. In 1863, during six tides and upon only one-half of the restocked lands, the oystermen took sixteen millions of oysters—that is to say, more than the public fisheries of Cancale and Granville have ever produced. Not long ago I had occasion to visit an artificial park, which had been instituted only three years before, at a total cost of $2,400, and which sold at the time of my visit for $8,000.

On the island of Ré three thousand people migrated from the interior to occupy the emergent sea-territory, ceded to them in individual lots by the government. The condition of these lands necessitated arduous and long-continued labors on the part of the men, since these portions of the island were simply vast wastes, where to-day more than two hundred parks can be seen in full activity, occupying the entire coast from the point of Rivedoux to that of Loix, a distance of twelve miles, and covering an area of nearly 205 hectares (about 492 acres). In these parks, or prepared oyster-beds, there are to-day, on an average, six hundred oysters to the square meter, or a total of two billion oysters, representing a value, when of marketable size, of about 40,000,000 francs ($8,000,000). Before this new industry had transformed the arid and desolate character of these portions of the coast, the 18,000 inhabitants of the island of Ré had no other source of revenue except from the growth of barley and the culture of the vine, whence there were few returns, the production being slight and of poor quality, and by fishing, which produced about 50 francs ($10) per month for each boat employed.

This state of affairs, instead of growing better, grew worse until the year 1858, when Hyacinthe Bœuf, of Rivedoux, upon the island, undertook for the first time the artificial breeding or cultivation of oysters upon eighteen hundred meters of emergent lands granted him by the state. Bœuf was a mason, and commenced his labor by inclosing his property with a wall of rocks. He then covered the soil with straw and branches to consolidate the mud and render the place suitable for the reception of the oysters which he proposed bringing from Brittany, since the coast of the island was entirely destitute of them. What, then, was his astonishment when he saw the stones of his wall become covered spontaneously with a young growth of oysters, which appeared in the water surrounding the island and probably came from the parks along the coast of Nieulle; they were so numerous that they averaged about two thousand young oysters per square meter. He at once demolished his wall, stone by stone, and placing the oysters upon the bed of the park, he succeeded, by favoring their development by intelligent care, in creating on the island an industry destined to bring wealth and prosperity. His example was soon followed by others, and numerous parks were laid out, so that in 1860 oysters were sold to the value of 3,150 francs ($630), and in 1863, 53,000 francs ($10,600), without counting the thousands of oysters deposited in the fattening-ponds, the value of which could not have been less than from 25,000 to 30,000 francs ($5,000 to $6,000). I cannot omit to mention in this connection, without injustice, the name of Dr. Kemmerer, of St. Martin, whose labor and example have been of great value in the progress of oyster culture on the island of Ré. The work of transformation thus begun in the Bay of Arcachon and upon the coast of the island of Ré gradually extended to the entire ocean coast and even into the Mediterranean, multiplying to an almost unlimited extent the edible treasures, of which the ocean contains inexhaustible germs, creating upon these desolate and barren territories wealth and abundance, and attracting there a hardy and numerous maritime population, from which to draw recruits for our marine. Such, then, are the grand results already due to the learning and devotion of M. Coste, and to the powerful and efficient aid which he has received from the Emperor, who has not hesitated to place at the disposal of this great worker the lands and material resources required for the undertaking.

The domain of the sea is public property, and it becomes the duty and the right of the state alone to extend prompt aid to the increasing impoverishment and sterility of one of the branches of public industry and wealth, and it is evident from what has already been done, that the state has not failed in this duty. But although this is the chief cause of the renewed activity in the oyster industry, is it to be considered or does it follow that this industry can prosper only over great tracts of waste territory, like the bays of St. Brieux and Arcachon, with the help of powerful auxiliaries, such as the government vessels with their many intelligent men and officers? Does it follow, in a word, that there is nothing to be done, so far as personal endeavor is concerned, by the dwellers in coast territories? We think just the contrary; we believe there is much to be done, and that the cultivation of marine species is an inexhaustible mine, in the fruitful working of which each one can find his place according to his strength and means, and with that belief in view we have written this book, designing it especially for the proprietors of marine lands and salt marshes, and for the possessors of parks and claires, the products of which can be easily increased a hundred-fold. While the labors of restocking, executed under the authority of the state, the reconstruction of old breeding or fattening ponds and the creation of new banks where none previously existed, are undeniably great results; as is also the re-establishment of the national maritime wealth by the reconstruction of the fishing grounds; yet it is important in another respect that it forms a grand example which each individual possessor of emergent or tide lands, of salt lakes, or simply of lands bordering the coast, can follow with profit, in creating artificial oyster stations, or fattening ponds, where oysters, mussels, crustaceans, or even marine fish can be confined, and where, as a result, there will gather an uninterrupted, fruitful, and abundant harvest, even upon ground primitively condemned to eternal sterility on account of mud or stones. It is with the object of instructing proprietors of fishing privileges, or dwellers upon the sea-shore, concerning a source of immense wealth, the labor of which concerns them alone, and in order to facilitate the methods of attaining the best results, that I have endeavored to present in this book a summary of those principles, now sanctioned by experience, which ought to guide them in this new culture. The question of oyster culture will then be treated here from a restricted point of view, as a private industry, such as a small farmer, who is desirous of increasing his revenue from his marsh or fattening pond, can readily undertake. In accordance with the plan which I followed in a former work, upon the culture of fresh-water fishes, I have preceded the account of the special processes of oyster culture with some remarks upon the functions, habits, and structure of various species of mollusks and crustaceans, the cultivation of which can be undertaken with profit, and with a study of the causes of the depletion of our coast waters. For it is only when acting with a full knowledge of the cause, that is to say, in reasoning in regard to his labors, and choosing his processes according to the nature of that which he grows, and the circumstances and conditions of growth, that one can hope to prosper in a work of this kind. Many of the earlier attempts in this direction miscarried simply from not having followed rational methods. But their authors had one excuse, the nearly universal ignorance in regard to the habits and needs of the species upon which they experimented, and they had to guide them only the numerous and accredited errors which tainted this branch of natural history.

To M. Coste belongs the honor of having destroyed these illusions, and his learned researches enable us to work with better results. Thanks to him, the route is now defined, the guide has been found, and success is insured to all except those who are willfully ignorant or careless. This latter cannot be said of the experiments recently made by M. Thibaut upon the rocks of Bouchots near Oléron; by the government upon the bank of Richelieu at Rochelle; by M. Boissière at Arcachon; and, finally, among others, by M. Cressoles in the marsh of Kermoor, where, in practicing the principles of a sound agriculture in regard to oyster culture, he has been able to transform an uncultivated and pestilential morass into vast reservoirs for fish and oysters, thus changing into a source of great wealth what was before a barren and disease-breeding tract. Their example is both a proof and encouragement; my most earnest desire is that this book may stimulate numerous others to imitate their labors.

THE NATURAL HISTORY OF MOLLUSKS AND CRUSTACEANS.

MOLLUSKS.

The third division of the animal kingdom, that of Mollusks, contains animals having a generally symmetrical body, that is a body with similar parts upon either side of a median line, and which never presents an internal skeleton, as in vertebrates, or external one, as in the crustaceans, and never becomes divided into segments, as with the annelids. The body is soft, and is generally inclosed in a calcareous test or shell, which may be univalve or bivalve.

The nervous system of mollusks, especially the ganglionic, does not present a median longitudinal disposition as in the vertebrates and articulates, but consists simply of symmetrically disposed little nodules or ganglions of nerve matter, united together by nerve cords, and located throughout the body in the neighborhood of the principal organs. Mollusks breathe in the same manner as fish, by means of gills, which are either superposed laminæ or branched filaments, and which act by separating from the water and absorbing those gaseous elements held in solution. Some few species present an internal respiratory cavity, to which is given by analogy the name of lung. These exceptional species are always terrestrial. Those mollusks having the most perfect organization are ranked in the class of Cephalopods (χεφαλή, head, πούς, foot; head-footed animals), so named because of the tactile or prehensile appendages, which are located upon the head end of the body in a complete circle about the mouth, and called arms, feet, or tentacles. The only useful species is the cuttle-fish (*Sepia officinalis*), which produces the color called sepia or India ink, and the bone sold in commerce under the name of sea-biscuit or cuttle-fish bone. The poulpe or squid also belongs to this class, and is likewise called cuttle-fish; it serves as food for some of the poorer classes along the coast of Italy.

The second class of mollusks is that of the Gasteropods (γαστήρ, belly, πόύς, foot; belly-footed), which owe their name to a fleshy, contractile base serving as an organ of locomotion. Their shell, when it exists, is always univalve. As examples may be mentioned the slug, the snail, and those animals which furnish the helmet and porcelain shells.

The last class and the least specialized group of mollusks, which, however, contains species of great importance in a commercial point of view, is that of the acephalous mollusks (ἀ, without, χεφαλή, head; headless). This class contains all of those mollusks having a bivalve shell, such as the oyster and the mussel, which we propose to study. All are without a distinct head, hence the name. The body has the form of a flattened, oval disk, and is pierced at one extremity with a mouth orifice surrounded by tactile appendages, the palps, which seem intended to take the place of the organs of sight and touch. From each side of the body hang two folds of integument, formed of a double membrane, which clothe the inner surfaces of the shell, protecting the body of the animal from immediate contact with the hard external covering, and guarding it from any rubbing that might take place if in contact with such a surface. These protecting folds form the mantle, which also secretes the shell.

Some species, the mussels among others, possess a sort of fleshy foot, which can be protruded at will from between the valves of the shell and the folds of the mantle, and can also aid in locomotion. But the greater portion of the acephalous mollusks live firmly attached to solid objects under the water, either by a union of the calcareous matter of their shells with the object upon which they are stationed, or by means of a small bunch of hair-like threads, which arise from near the ligament uniting the valves, and which are called collectively the byssus. Other species live buried in the mud, or move about in the water, sometimes swimming great distances. They are met with in the fresh water of our rivers and lakes, and in all salt water.

THE OYSTER.

Naturalists have united under the common name of oyster a large number of mollusks having very different aspects; they are the genera *Gryphæa*, *Plicatula*, *Vulsella*, *Malleus*, *Lima*, *Meleagrina* or pearl-oyster, &c. These mollusks are widely distributed, and have been very abundant in both fresh and salt water, in all ages of the world, so much so that they have left some very extensive fossil remains, as in the cretaceous beds of Versailles, of Meudon, and in all of those deposits to which, from their marine origin, the name of Neptunian beds has been given. Without entering, however, into useless details in regard to the various species of this family—since as articles of food they are of little or no interest—we will confine our attention to the edible oyster (*Ostrea edulis*), which is easily recognized by its compressed, roundish body and bivalve shell, the two valves of which are quite unlike, one being nearly flat, the other convex, and both without teeth at the hinge joint. The two valves are formed of a series of imbricating, circular layers of carbonate of lime secreted from the mantle, and are held together and closed by a single large and powerful adductor muscle, attached near the center of each valve. The layers of shell material have very much the appearance of shingles upon the roof of a house. The best-known forms of this animal are the common oyster, used upon our tables; the horse-foot oyster (*Ostrea hippopus*), very large and broad, but little esteemed, found at many places along the shores of the Mediterranean, and also at Bologne-sur-Mer; the oyster of Beauvais (*Ostrea bellovacina*), taken at Bracheux, near Beauvais, &c. But the oyster is so well known to every one that, without attempting a minute description of its structure we will pass at once to the study of the phenomena of reproduction, which have for us a very important significance. The oyster is hermaphrodite*; that is to say, each individual contains in itself the organs of both sexes—the ovary, or egg-producing organ, and the testicle, or organ for the formation of the male element or spermatozoa. This question, which for a long time was the subject of debate, is now entirely settled (MM. Quatrefages and Blanchard sustained the contrary opinion, and several memoirs read before the Academy of Sciences treat of the artificial fecundation of the eggs and the artificial formation of oyster beds). It is recognized that in every individual are to be found at the same time both eggs and spermatozoa, and that, moreover, the eggs present all the phases of fecundation before they have left the ovaries of the animal and have reached a place where an external impregnation could be possible. One should not think, therefore, of artificially impregnating the eggs of the oyster, for this would require the removal of the eggs from the ovary of the mother while in course of development, which would be incompatible with an independent existence.†

The spawning season of oysters lasts about three months, from June to September. The eggs are produced in the ovary,‡ which is situated deep in the body of the animal, and whence, after they have arrived at a certain stage of maturity and have been impregnated, they descend along spacious canals into a fold of the mantle, where they remain inclosed in a mass of mucus, until they have completed their development. The eggs form at this time two whitish, creamy masses, which increase the size of the oyster very much, and cause it to be much sought

* This is without doubt not true so far as regards the American oyster (*Ostrea Virginiana*). I have examined, under the microscope, hundreds of oysters during the last two years, and throughout nearly the entire spawning season as late as the middle of October, and never in a single instance have I found any evidence of hermaphroditism, the sexes always being well marked and perfectly distinct. Neither have I seen any evidence of the development of the egg until after it had passed from the ovary and come in contact externally with the floating spermatozoa; from my own observations, and from those of accurate observers with whom I am acquainted, I am of the opinion—which coincides with that of Quatrefages and others as to the European form—that the American oyster is as truly unisexual or diœcian as any mammal.—(Tr.)

† Notwithstanding this statement in regard to the oyster in general, Prof. W. K. Brooks, of the Johns Hopkins University, Baltimore, Md., has succeeded, during the past summer of 1879, at Crisfield, Md., in successfully impregnating great numbers of eggs of the American oyster. The impregnation was effected by taking the ripe eggs from the ovary of the female and mixing them artificially with the spermatozoa taken from the male animal. Many others of the party, of the Chesapeake Zoological Laboratory, including myself, also succeeded with the artificial impregnation, and there is no question but that such a process can be successfully performed, although to what extent it is practicable is a question yet to be settled.—(Tr.)

‡ The statement of the author in regard to hermaphroditism and its results, and the changes undergone by the eggs within the ovary, must, in all probability, be considered as entirely erroneous.—(Tr.)

after by certain amateurs; but this should not be done, for when in this condition the animal should be especially protected. Although we may now consider the eggs as laid, yet they will not be ready for some time to leave the protecting mantle of the mother; they must undergo a sort of incubation, during which the mass loses some of its fluidity, and assumes a dark, violet color, a certain indication of maturity. From this time the embryos can lead an independent existence, and if they are now taken from the mantle they can be preserved alive for several days in sea-water; and, moreover, by frequently renewing this water and arranging solid bodies for their attachment, such as bits of wood or fragments of shells, one can reproduce artificially what takes place at every spawning season in the depths of the ocean. When the embryonic mass has assumed a bluish black or muddy color, the young leave the mantle of the mother and become dispersed in the surrounding waters. Each individual is furnished, at this time, with a special swimming organ, which disappears as soon as the animal has found a suitable place of attachment where it can continue its growth. This fleshy pad, or velum, is covered with cilia, and by the aid of these and of powerful muscles, which seem to retract or extend the velum, the embryo can move in any direction.

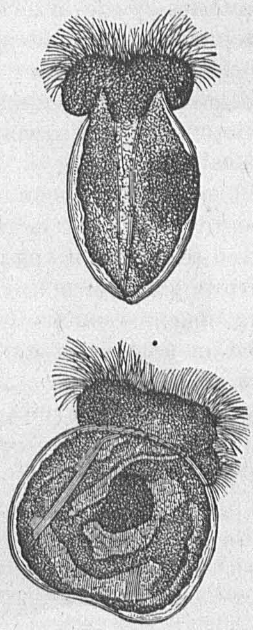

FIG. 3.—Embryo of the oyster (much enlarged).

The accompanying figures represent much enlarged a young oyster which has just left the mantle-cavity of the mother oyster; the first shows it in front view; the second, as seen in profile; at the upper part can be seen the ciliated velum. The number of embryos spawned in a single year from a single mature oyster cannot be estimated at less than from one to two millions, and the imagination is simply astounded at the idea of the immense numbers which would result from each annual spawning of a single bed of oysters, if this living cloud, which at a given moment almost darkens the waters, found for each one of the minute beings composing it a support and a protection which would enable it to escape the innumerable causes of destruction to which the laws of nature and human negligence expose them, and develop into mature and edible oysters. In order that an embryo oyster may live to acquire a shell which shall serve to protect it, it is necessary that it should find near at hand a solid body, stone, bit of wood, or shell, for its attachment, so that it may be protected from too strong currents, which would carry it off; from deposits of mud, which would smother it; and from the voracity of the inhabitants of the sea, among which there are countless varieties of crustaceans, worms, and polyps, which prey upon these animated organic corpuscles, so easy to capture and so attractive as food. And, finally, it is especially necessary that no blundering or greedy hand shall come with rake or dredge to seek for a few oysters of edible size and by so doing tear to pieces and overturn the objects upon which the young are attached, and thus kill or bury in the mud all the young generations to which the few old ones have given birth. If the young oyster can escape its many enemies and causes of destruction it will in about six months acquire a diameter of 8 to 10 millimeters, a very rapid increase when one takes into account its size at the time of swarming, about one-fifth of a millimeter. At one year of age the oyster is from 4 to 5 centimeters in diameter, and in about three years it attains marketable size—from 8 to 10 centimeters—when it can be gathered and sold for consumption.

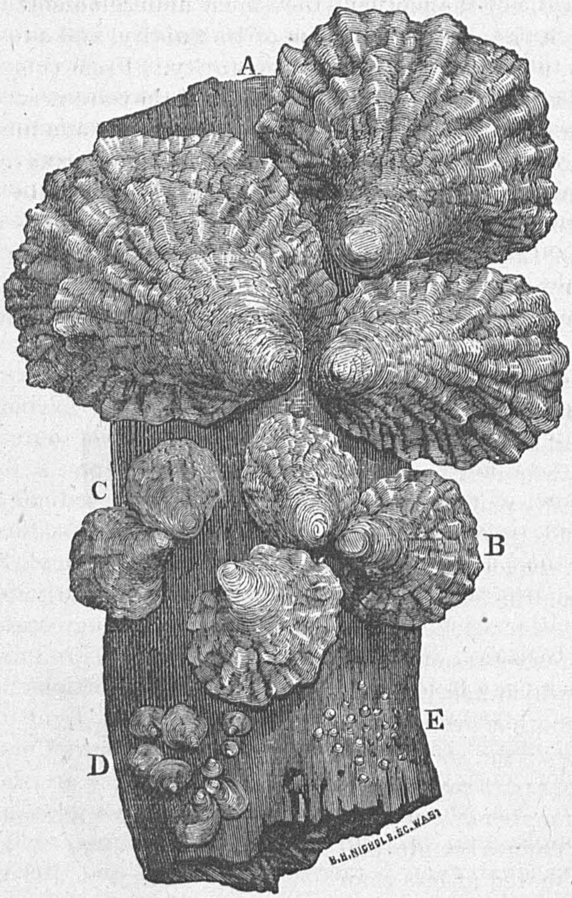

FIG. 4. Oysters of different ages (natural size).—A, oysters from 12 to 14 months old. B, oysters from 5 to 6 months old. C, oysters from 3 to 4 months old. D, oysters from 1 to 2 months old. E, oysters from 15 to 20 days old.

Figure 4 represents a number of oysters of various ages attached to the same object.

But like nearly all animals destined for man's use, the oyster is susceptible of great improvement by special cultivation, which gives it a flavor and appearance very different from those of oysters freshly taken from the great common reservoir—the ocean.

Upon our entire coast, especially where oysters are taken, it is well known that a prolonged sojourn in a fattening pond, or park, is necessary in order that they may acquire those qualities which place them in favor with consumers.

Under the generic name of *parks* are designated reservoirs containing sea-water, which communicate with the ocean by means of sluices and flood-gates, that can be opened at each flood-tide or at pleasure; here it is that the oysters are deposited, after being taken from the beds, in order to protect them, and make them convenient for the demands of trade. In this stagnant water, charged with organic material and protected from all agitation, the oysters increase in size very rapidly, become fat, and lose the bitter flavor and slightly tough consistency common to the natural oyster. It is greatly to be regretted that the steady diminution of this mollusk will not allow the oystermen to retain the oysters in their parks but a very short time; the full benefit of the park is then not attained, while at the same time the continually increasing price makes the oysters articles of luxury reserved for the tables of the rich. Often, one can see placed on sale in our markets oysters which have been sent in immediately after being taken, and without having been placed in a park at all.

This mode of cultivating oysters by means of parks forms an important industry for the inhabitants along the coasts between the harbor of Brouage and the mouth of the Seudre, and constitutes the chief source of wealth of the territory of Marennes. There, in ponds or parks, to which they give the name of *claires*, and which differ from ordinary parks in that they do not receive any water from the sea except during spring-tides, while the parks receive it at every flood; there, I repeat, the oystermen, known under the name of *amareilleurs*, cultivate their oysters, procured either from the banks of the neighboring coast, or from the coasts of Brittany, Normandy, or Vendée, and produce those delicious bivalves known in the southern and central portions of France as green oysters. Oysters which leave the ocean very light in color, after being placed in the claires at Marennes for a short time, acquire a deep green color, most pronounced in the gills; these are the veritable oysters of Marennes, which are preferred to any other growth. The reason of this is simple, and the color has little, or nothing, to do with it. The oyster, deposited when young in the claires—and this is an indispensable condition—undergoes a careful nursing, a sort of stabling, and acquires, at the same time that it receives its characteristic color, a fineness and delicacy of flavor and a fatness which it could not acquire upon the muddy and disturbed natural banks; from this cause arises its real superiority, a superiority which it would acquire equally well in any other park where it could be treated with similar care and where it would even retain its natural color. This is so true that adult oysters placed in the claires at Marennes rapidly acquire the green color, but always remain just what they were when they were taken from the sea, although they present all the external characteristics of the most highly prized oysters. As to the peculiar color of the oysters which have been kept in the claires, it has been attributed to certain marine algæ growing in that neighborhood, to the presence of a small animal (*Vibrio ostrearius*), and also to a disease of the oyster, a sort of jaundice or affection of the liver; but to-day it appears certain that this coloration is due solely to the peculiar nature of the soil forming the bottom of the claires, and that every park having as a base a soil composed of a blue or a rich ferruginous clay will give to oysters placed in it this esteemed color; but this character will no longer be of any importance when colorless oysters raised in parks with the same care as those in the claires at Marennes shall present the same qualities. Upon those coasts where favorable circumstances permit their multiplication, oysters form beds or banks often several hectares (a hectare is 2.41 acres) in extent. These banks are formed by the aggregation of oysters of different ages and sizes, whose shells become firmly attached or soldered to the stones or rocks covering the bottom or to the shells of neighboring oysters. If it were not for the destructiveness of oyster-fishing, these banks would go on increasing in size and depth, without limitation, and also, as a natural result, in value, by the annual accumulation of new germs; an accumulation singularly favored by great numbers of vacant places over the bottom of the ocean.* The oysters which are most esteemed in Europe come from England, while the best of the French oysters are found upon the coasts of Brittany and Normandy. Those most commonly eaten at Paris come from the north, from Cancale, Dieppe, Étretat, Dunkerque, &c. The southern and central portions of France are supplied from Bordeaux and Rochelle, and from the few rare banks of the west coast which are not yet exhausted.

The principal parks are those of Marennes, Saint-Waast, Courceul, Étretat, Fécamp, Dieppe, Tréport, and Dunkerque. The fishing is done by means of a dredge, which is dragged over the bottom of the sea. This dredge scrapes over the soil and gathers up into a bag of leather or twine, which is attached behind it, everything that lies in its course. When the dredge net is felt to be full the dredge is drawn on board of the boat and its contents emptied and sorted, those oysters only being retained which are of the size established by law, the rest being cast back into the water. We will now end this study by some observations upon a foreign species of oyster which it may be possible to acclimate in our southern waters, and which, although without value as an article of food, is of very great commercial importance; I refer to the pearl-oyster.

The shell of this species is semicircular, greenish externally, and of a beautiful nacreous color upon the inside. The animal is white, soft, and similar in form to the common oyster. The pearls found in the shell of this mollusk appear to be calcareous secretions from the mantle lobes

* A judicious fishing or working of an oyster-bed tends to increase both its size and value, while a natural unfinished oyster-bank, instead of being of unlimited growth, is always limited in size by the condition of the soil upon which it is formed as affected by the currents of the surrounding waters.—(Tr.)

and of the same nature as the secretions which form the nacreous lining of the valves, but which in consequence of peculiar conditions, either a sickness of the animal or the presence of some strange body, assume a spherical or pyriform shape. It is certain that the presence of a foreign body, by irritating the mantle, produces an abnormal secretion of the nacreous material which soon entirely covers that body with a material identical in character with that forming the pearls.

For a long time the Chinese have made use of this peculiarity of the pearl-oyster and of certain other mollusks. Among the class of pearl-producing or nacre-producing animals must be placed our fresh-water mussel. In order to have any ornament covered with nacre it should be placed within the shell of a pearl-oyster and left there for several months, after which time it will appear as though entirely composed of pearly material. The most valuable pearls come from Ceylon and the Persian Gulf. The pearl-oysters are found in banks, like the common oyster, at a depth of from 5 to 20 meters. The pearl-oyster bears a general resemblance to the edible oyster, except that it is much larger, attaining sometimes a diameter of 30 centimeters (between 9 and 10 inches). They are taken in Asia at four principal places: around the island of Bahren in the Persian Gulf, on the coast of Arabia near Carisa, in the Gulf of Manaar in Ceylon, and upon the coast of Japan. The fishing commences in February and ends in April; it is performed by native divers furnished simply with a knife to detach the shells and a basket to gather them in. The fishing of the banks is subject to a sort of police supervision on the part of those who lease the right to fish for pearls. Only a certain number are taken, and the banks are carefully inspected at every fishing; the divers are always careful to spare the young ones, and take only those which look as if they ought to contain pearls, since all do not contain them. The valves of the pearl-oyster are also objects of commerce, as they furnish nacre. But they are not the only ones which furnish this product; upon our coasts a great number of mollusks are found, among others the *Haliotus*, which furnish a very valuable nacre, more beautiful even than that of the pearl-oyster. In seeking conditions of soil, depth, and temperature as nearly as possible like those surrounding the pearl-oyster in Asia, it would seem possible to acclimate this mollusk in the waters of our coast and of the African shores of the Mediterranean; waters which even now contain much unexplored wealth, particularly vast beds of coral, and which would seem to cover naturally fertile places for the abode of the pearl-oyster.

MUSSELS.

Under the generic name of mussel (*Mytilus*) are united bivalve mollusks having a symmetrical shell and equal valves, and with the mantle, is divided into two similar lobes, entirely separated along the ventral edges, both of which are smooth, much thickened and attached to the edges of the valves. These mollusks have two very powerful adductor muscles and are furnished with a foot or thick and fleshy prolongation of the central portion of the body, which can be protruded from the shell at the will of the animal. From the foot posteriorly arises the *byssus*, a small bunch of hair-like stiff threads, secreted by a gland, and by means of which the animal is permanently attached to some solid body, such as a rock, shell, bit of wood, &c. The gills, differing from those of the oyster, are made up of two laminæ fixed to one end of the ventral mass along either side and free at the other, which is prolonged from either side of the posterior adductor muscle.

The mussels are hermaphrodite like the oyster, and reproduce in the same manner (?), giving birth, after an incubation in the folds of the mantle, to a gelatinous mass, composed of a great number of young mussels, each furnished with its byssus and ready to float away in the water, to become fixed to the first solid body which it encounters, or to perish in the mud, or serve as food for its innumerable enemies. Mussels cannot move about, or at the most move very slightly, yet, nevertheless, if a mussel becomes detached from its support by the rupture of its byssus it can move some by thrusting its foot out from between the valves of the shell and pushing against the ground as against a fixed point. Mussels live nearly everywhere; there is not a point upon the coast of France where they cannot be met with, clustered in groups upon the rocks, in crevices, upon piles, and upon bits of submerged wood. They are to be found especially at the mouths of rivers and in muddy bays, the contact of fresh water not being objectionable to them, and, according to Beudant, they can even be acclimated out of sea-water. Of the many species of mussels, we shall speak here only of the edible one (*Mytilus edulis*), which has an oblong shell, of a very deep violet color externally, and white within except along the border and at the two muscular impressions, where the violet color also appears.

In Normandy the light-colored mussel is much esteemed; it is smaller than the above and the valves are of a brown-fawn color. It is found principally at Villerville (Calvados).

In France the mussel is taken throughout the entire year, except during the hottest months and the spawning season. The women and children, armed with a strong knife, gather them from the rocks which are uncovered at low tide, or dig them from the mud of the sea-shore. These mussels, however, are small, tough, and bitter, while those which grow in quiet and protected places, where the bottom is muddy but not sufficiently so to bury them, attain a large size and a delicate flavor. The mussel banks are practically inexhaustible, but as this mollusk is not of great value until it has attained a certain size, and lost the bitterness and toughness belonging to the sea-mussel, the means of bringing it to perfection have long been sought for. Upon certain parts of our coast they are placed in parks like oysters, and in the Bay of Aiguillon they are made the object of a very important enterprise, which we will describe in the chapter in which we treat of the rearing of this mollusk. At other places they are taken from the sea and placed in salt marshes, since it has been noticed that a sojourn in water less salt than that of the sea improves their flavor. Finally, there are no places along our coast where this mollusk cannot be cultivated with advantage and profit, and our many railroad facilities will cause it to be still more widely known and esteemed throughout France.

CRUSTACEANS.

The important class of crustaceans constitutes one of the divisions of the sub-kingdom *Articulata*. The animals of this class are characterized by a symmetrical body divided into a number of more or less similar segments, and provided with a nervous system, consisting of a row of ganglia, or small, nervous masses, connected by nerve cords and arranged in a longitudinal chain following the median line of the body, with a ganglion located in each segment. The appendages constitute a variable number of pairs, each pair being carried by a segment. Respiration is aquatic, or by means of gills; the skin is sometimes soft, and sometimes hard or coriaceous, forming an external skeleton moved by internal muscles. This last characteristic is peculiar to crustaceans, as is also the pyramid-like gills, furnished with hairs or little tufts, and placed on each side of the thorax at the base of the feet, or under the abdominal portion of the body. The segments of the body are generally twenty-one in number, but the first are nearly always united into a firm, inflexible portion, containing the head and thorax and named, accordingly, the cephalothorax. The remaining segments remain distinct and together form the abdominal portion of the animal. This division is very easily recognized in the crab and lobster, in which animals that portion which is popularly known as the tail represents the abdomen. The limbs of crustaceans number from five to seven pairs; those which are borne by the abdominal segment being generally only rudimentary and designated false feet. These false feet subserve respiration, in some forms, and in others carry the eggs during incubation, as in the species to be mentioned farther on. The crustaceans are subdivided into several families, among which we shall call attention to those containing useful species, all of which belong to the same order, that of decapods (δεκά, ten; πούς, feet). The name clearly indicates the distinctive character, that of having five pairs of feet. Of these five pairs, the anterior is often terminated, as in the cray-fish, crab, and lobster, by large and powerful pincers or claws, which are of use in prehension and in defense. A large abdomen, lengthened into a caudal appendage and terminating in a broad swimmeret, characterizes the macrurous decapods (μακρός, large; οὐρα, tail). When, on the contrary, it is short, flat, and recurved under the cephalothorax, it classes the animal among the brachyurous decapods (βραχύς, short; οὐρα, tail), as the crab, &c. With these general definitions we can now pass to the consideration of those species which are useful to man as food, and which, thanks to the patient studies of M. Coste, can now be reared in great numbers.

CRAY-FISH, LOBSTER, ROCK LOBSTER, AND CRAB.

There is a single edible species of crustacean called the cray-fish, which is found in our fresh-water streams. This animal, which it is scarcely necessary to describe since it cannot be confounded with, or mistaken for, any other aquatic animal in the waters which it inhabits, is provided on the anterior pair of limbs with two strong but unequal-sized pincers; the abdomen is generally very much developed, the six segments composing it being very convex above, furnished with powerful muscles, and supplied below with false feet, movable at the base, which serve as swimmerets. The false feet of the male differ somewhat from those of the female, and present moreover two pieces which are formed beneath the first segment, are movable at the base upon a cartilaginous articulation, and generally lie directed forward upon the sternum. There are two rolled laminæ forming a sort of tube which repesents the male copulating organ, and connects with a triple testicle and seminal vessels. The female has two ovaries placed one upon either side of the body and opening beneath at the base of the first joint of the third pair of walking appendages. At the period of spawning these ovaries become elongated and much distended with eggs. Copulation is effected as with many species of flies, belly to belly. When the male attacks the female he turns her over upon her back and the two then closely clasp each other by means of their claws and walking legs. It does not appear that the male organs enter into the oviducts of the female, but the semen is simply shed upon the plastron and around the orifices of the oviducts, where it solidifies, allowing, without doubt, the spermatozoa to escape and penetrate into the ovaries.* When a female is found full of eggs and with certain whitish flakes adhering to the under side of the carapace, it is pretty certain that the eggs have been impregnated. Spawning takes place about two months after fecundation, and the eggs when laid become attached to the false feet upon the abdomen. They are secured to the feet by means of a membraneous pedicle formed by a prolongation or hardening of the envelope or glutinous mass in which the eggs are laid, and are held in this position until the young are hatched, and even after this period the young cray-fish, soft and delicate, find protection under the abdomen of the female, whom they do not entirely abandon until their

* According to the careful observations of Mr. P. R. Uhler, president of the Maryland Academy of Science, the fecundation of the eggs of the cray-fish is external, or after they have left the oviducts; that is, the seminal fluid of the male is emitted, while in the position described above, upon the plastron and swimmerets or false appendages of the female; the eggs are then discharged from the body, pass back to the swimmerets, where they are retained during the incubatory period, and where they at once come in contact with the fecundatory spermatozoa and are impregnated.—(Tr.) [See "The Cray-fish," by T. H. Huxley.]

calcareous test or covering is sufficiently hard to completely protect them. The cray-fish change or shed their skin or test once a year, and this shedding takes place from May to September. During the shedding period the animal retires into some hole or sheltered place so as to protect itself from the thousand dangers to which its soft and defenseless body would subject it. It remains concealed for two or three days, in which time its new covering acquires nearly the solidity of the old envelope. Among the cray-fish and other crustaceans of the same family the feet and antennæ possess the remarkable property of being renewed in case they are accidentally lost either in part or wholly. A few days after a leg is lost a reddish membrane forms over the place, covering and obliterating the wound; soon a conical bunch appears, which elongates and finally bursts through the membrane and shows a small, soft foot, which increases in size, regains its calcareous test, and in a short time duplicates completely the lost member. The river cray-fish, which is also much sought after for food, is found in fresh-water streams throughout Europe, but it is quite particular in its choice of habitation. It loves clear, flowing water, where the bottom is composed of small stones and pebbles without mud, and where it can find protection and plenty of holes and crevices into which to retire, and which it leaves only to seek food, consisting of mollusks, little fish, and the larvæ of insects; it also feeds upon, and even prefers a more wholesome diet, decaying animal substances, or dead bodies floating upon the water, and in default of any of the above-mentioned articles it will make a bountiful meal of vegetables or young shoots. It lives for about twenty years, and as it increases in size at each moult, it may become relatively of considerable magnitude. It can be very easily acclimated in foreign waters, providing the water is sufficiently pure and the surrounding conditions suitable to its existence; it also conforms readily to a state of confinement, and will readily develop and reproduce in small basins, analagous to those in general use for artificial fish culture.

The lobster (*Homarus vulgaris*) may be known by its smooth carapace and greenish-brown, sometimes bluish, color, which, when cooked, changes to a pale red, thus diminishing a little, when upon our tables, the repulsive aspect characteristic of all crustaceans. The head of this animal is terminated anteriorly by a sort of three-pronged rostrum, and is armed with long reddish antennæ and two pedunculated eyes. The anterior pair of feet are armed with powerful pincers, which are often out of proportion to the size of the rest of the body. The lobster is widely distributed in the ocean, the British Channel, and the Mediterranean, and inhabits rocky bottoms, often at great depth.

The rock-lobster (*Palinurus vulgaris*), which is nearly as much sought for as an article of food as the lobster, is distinguished by the large fan-shaped termination of its abdomen, by the five pairs of similar legs without pincers, by possessing long and strong antennæ and a moderately long carapace covered, especially in front, with small points or protuberances. The female is distinguished from the male, at the spawning season, by a character, which was recognized even in the time of Aristotle: the last pair of walking legs, that is, the pair nearest the abdomen, presents near their distal extremities a spur, which is absent in the male, and the use of which will be revealed later. This animal is very common in the Mediterranean, but rare along the ocean coast except in the harbor of Brest. Like the lobster it is carnivorous and very voracious, consuming mollusks, worms, and fish, which are abundant upon the bottom in the waters where it lives. It rarely swims, or leaves the bottom, except to escape some threatened danger.

The crab (*Cancer*) is distinguished by having a large, broad carapace, and its posterior pairs of legs all modified for walking; the anterior pair is furnished with powerful pincers. The carapace is broader than long, and is denticulated, much like a saw, along the anterior border. The eyes are close together in front and furnished with short peduncles. The crab is partly terrestrial, partly marine; it inhabits holes among the rocks and in the sand, which are covered by the sea during every tide. It is carnivorous, its principal food being dead mollusks or any pieces of animal matter that may be within its reach. The most important edible species is the *Cancer pagurus*, which has the carapace smooth above and with the edges marked with prominent serrations. The rostrum is three-pointed and the large anterior feet are black and furnished with large, smooth tubercles upon the inside. This crab is very abundant in the ocean but rare in the Mediterranean. It grows quite large, and its flesh is, with reason, much esteemed, and must not be confounded with that of the common crab, about the only form found in our interior markets, and which the fishermen of our coast consider of very little value.

After this summary of three marine species which are useful as food to man, it is especially important that we should carefully study their mode of reproduction as well as the method of exercising this function, and the precise length of its duration, since by this means we shall be able to obtain a foundation for our efforts in artificial breeding. The period of reproduction with the lobster commences in October, with the rock-lobster in September, and it lasts about six months; but the union of the sexes takes place most commonly in November for the rock-lobster, and in December for the common lobster. It does not end, however, until towards the close of January. As with the cray-fish, the sexual act is accomplished belly to belly, and so closely and firmly do they clasp each other, that, if taken from the water at this period, it is with difficulty that they can be separated. With the rock-lobster the penis or copulating organ of the male does not penetrate into the body of the female, the seminal fluid being shed upon the plastron in the neighborhood of the external orifices of the oviducts, where it hardens, forming plates of a gelatinous consistency, from which the spermatozoa escape and work their way into the oviducts and thus to the ovaries, which are filled with eggs, the latter in this manner becoming impregnated. With the lobster and crab the seminal fluid appears to be introduced directly into the oviducts. As already indicated, the autumnal months are, as a rule, the time for the union of the sexes; but, especially with the lobster, this time is extended somewhat into the winter. The spawning takes place about one month after fecundation. When the eggs are ready to issue the female folds the abdominal portion of the body against the plastron, thus forming a close cavity into which the oviducts open, the orifices being located at the base of the third pair of walking appendages. This cavity receives the eggs as they pass from the body, and in the course of one day the common lobster will deposit in this chamber about 20,000 eggs and the rock-lobster about 100,000. During the period of spawning the sides of the abdomen secrete a kind of viscous substance, which incloses the eggs, and hardening around them, attaches them in irregular groups to the abdominal appendages. In this manner the cavity formed by the incurved abdomen soon becomes a nearly solid mass of ova. Incubation now commences, and while in this condition the female is said to be ripe. This new stage of reproduction lasts about six months, or until about March to June. During this time the female attends closely to the welfare of its eggs.

By reversing their abdomen as much as the calcareous nature of the segments will allow, the eggs are exposed to the light, or by gentle movement of the false appendages they are subjected to a hygienic bathing; now, by refolding the abdomen, the eggs are carefully protected from the many dangers which threaten them; and so well is all this managed, that among the thousands of eggs of a ripe lobster one can rarely find any that are sterile or bad. When the young crustaceans are about to escape from the eggs the mother animal assists in releasing them by the aid of the spur upon the last joint of the last pair of walking legs. With this she detaches the groups of eggs, and at the same time, by an oscillatory movement of the false or abdominal appendages, she scatters the myriads of newly-born animals on every side. The young animal at this time has no resemblance whatever to its parent, and up to the date of the recent investigation of M. Coste, to whom we are indebted for the preceding account, these young crustaceans had been placed in a special genus under the name of *Phyllosomes*. These embryos, with a soft, nearly gelatinous body, are furnished, upon each limb and at each joint, with a sort of tuft of vibratile cilia, by the incessant motions of which they float in the water and are carried about in different directions. Upon leaving the maternal protection the young animals mount to the surface, and there often form quite extensive swarms, which, from the constant movement of the animals and the constant changes in position of the swarms, sensibly alter the transparency of the water. They continue to live in this manner for quite a time—thirty or forty days—during which they undergo three moults; finally they lose the cilia from their feet, fall to the bottom, and gradually work their way, by means of their walking appendages, back to the shore where they were born. From this time onward their form is like that of the adult, or nearly so, but they are very small and grow very slowly. They increase in size only at intervals, that is, at each period of moulting, for the animal, enveloped upon all sides by a solid and inelastic covering, preserves almost exactly the same size up to the moment when its envelope is removed, and while awaiting a new covering the body can enlarge to but a limited extent. The number of moults is quite considerable, and is not the same during the same period of time for all individuals, for it is known that when placed under apparently similar conditions individuals of the same brood will vary much in size. Every moult is a very critical period for the animal, and a cause of great mortality, not only because at this time there is a considerable interval when the animal is without defense against its numerous enemies, which at other times might have been kept away by its hard and formidable pincers, or resisted by its firm carapace, but especially because this period forms a sort of crisis, occasioned by its increase in size with every moult.

Mr. Coste has shown that the common and rock lobsters change their carapace or moult—

The first year from 8 to 10 times; size then, $0^{m}.04$.

The second year from 5 to 7 times; size then, $0^{m}.09$.

The third year from 3 to 4 times; size then, $0^{m}.14$.

The fourth year from 2 to 3 times; size then, $0^{m}.18$.

In five years the two forms above mentioned attain a size of 20 centimeters (about 6 inches), this being the size established by law as the smallest that can be caught for the market, and at this time they begin to reproduce their kind. After the fifth year, moulting takes place only once a year, for, if it were more frequent it would, in the case of the female, seriously interfere with the reproductive functions.

CAUSES OF THE CONTINUED DEPLETION OF THE OYSTER BEDS AND THE IMPOVERISHMENT OF THE FISHERIES.

What are the causes that have so greatly impoverished the oyster beds of our coast, as announced by M. Coste in the report from which we have already cited certain extracts? This is the question which we propose to discuss in this chapter—a question of prime importance, for if it explains the past it also indicates the entire future of the oyster industry. The productive forces of nature are so powerful, and the laws of general harmony, which preside over the increase and the existence of animated beings, are so evenly balanced, that sometimes an apparently futile modification in the conditions of development of these beings is necessary, in order to give an unlimited range to their reproduction, just as an inequality of these conditions may suffice to lead to the decline or disappearance of an entire species.

Like all of those organized beings, animal or vegetable, which are obliged from their nature to live securely fastened or attached at the place of their birth, forming there aggregations of similar individuals, aggregations which are always increasing, and which, when reaching beyond certain limits, become fatal, first to other species inhabiting the same places, and finally to themselves, oysters have numerous enemies, which restrict their increase and retain them within the just limits of fruitfulness, not permitting the general encroachment or usurpation of outside localities and the destruction of other marine species.

Innumerable hordes of fishes, mollusks, crustaceans, and polyps gain their nourishment almost exclusively from the spawn of the oyster and from the oyster itself; for, even in an adult state, the oyster is the prey of crabs, aquatic birds, and certain worms which pierce the valves of the shell and destroy the animal sheltered within them. But the fecundity of the oyster is so great, and the number of living germs which float in the water during the spawning season is so large, that all of these enemies together are not able to diminish the number and extent of the oyster banks, nor even arrest for an instant their continued growth and enlargement. It is not then against these enemies that we shall have especially to seek a means of defense, since such defense would be valueless, as it would not operate against the real cause of the evil, and powerless, as it is impossible to subvert natural laws.

Along all portions of our coast where oysters exist this mollusk has very sensibly diminished in numbers. This fact is unfortunately acknowledged by all; diversity of opinion exists only with regard to the causes which have led to this decadence, the principal ones, dependent upon locality, being accumulations of mud or sand upon the bottom, invasions of mussels, or the invasion of the *maërle*. To these pretended causes we will add a fourth, the only true one, according to our opinion, which can account for the continued decadence of the oyster industry, and in fact the only one which demands prompt remedy. It is, unintelligent and avaricious fishing of the oyster banks by oystermen, a fishing which has heretofore been directed by routine and the selfish carelessness of the fishermen, and not by a profound knowledge of the nature and wants of this mollusk.

In fact the encroachment of mud and sand, and the invasion of mussels, and *maërle*, are not, as are generally believed, the causes of the destruction of the oyster banks, but are consequences of their destruction, or at least coexisting occurrences. People are, in general, very easily led to establish between two facts, by reason of their simple coincidence, a relation of cause to effect, while really they are both only consequences of some common and unknown cause; thus in the country, and even in the most enlightened centers, the frosts of early April are attributed to the influence of the moon, because its appearance coincides with a clear sky, which is really the true cause of the phenomenon. In like manner with the oyster banks; just in proportion as they diminished in size, as became manifested by vacant places appearing where oysters formerly grew, people said of the work of destruction, here it is mud or sand; there mussels; and at other places the *maërle*, without reflecting that the dredge which, in tearing up the soil and plowing over the beds, brutally and ruthlessly destroying countless oysters, young and old, was the prime cause of these vacancies and of the filling in by mud and sand which shortly followed. This can be easily understood. When a bed of oysters is intact, that is, before the dredge has commenced its work of destruction, the oysters, congregated upon the rocks and pebbles, firmly united to one another and superimposed without order, form at the bottom of the sea a complicated network of prominences and hollows, of tortuous channels and rocky crests. When, during high tide, these beds are covered with several meters of water, which always holds quantities of mud in suspension, the tendency is always for this mud to be deposited upon the beds, and it is actually deposited during tidal changes. But when at low tide the water passes down the beds, the eminences and crevices of the bottom formed by the irregular disposition of the oysters constitute so many obstacles to its onward flow, that it is divided into a thousand little streamlets, which, however calm the sea may be, form a sufficiently rapid current to carry away any mud which may have been deposited, and in this manner subject the oysters to a sort of hygienic cleansing. So true is this, that the fishermen to whom the government conceded the tidal or emergent lands of the island of Ré, which formed an immense sand-flat or sand-morass, working from these data, undertook and succeeded in obtaining, in a relatively very short time, the entire removal of the deep mud which rendered their lands sterile. They paved the muddy bottom of their territory with irregular fragments of rock taken from the island, and by ingeniously varying the hollows and eminences, so as to break up the water into thousands of currents and streamlets, they had the satisfaction of seeing the mud sensibly diminished in depth with every tide, and the young growth of oysters coming in from the open sea soon took possession of this territory, which had been so long deserted by these animals. By the accumulation of the oysters upon the rocks which follows this reclamation, the beds are preserved from mud and sand, and consequently from the invasion of mussels; but as soon as the dredge is used indiscriminately upon this surface, and a vacant place or hollow produced, where the water can remain stagnant at each flood tide, a deposit of mud soon forms, which augments every day, gaining perceptibly in length and breadth, invading the oysters, leveling the bottom, and tending by its presence even to destroy the beds and at the same time to favor the birth and development of mussels. It is the same with the *maërle*, which is the common name for a submarine plant, an alga, having a kidney-shaped form, and closely resembling both in shape and appearance a fresh brain, of a whitish color, tinted with rose externally, and inclosing a glutinous, greenish tissue, or growing into ramified branches. This plant has the singular property of absorbing or secreting lime, which, by hardening at the surface, forms an external coating or semi-solid test. It is gathered in considerable quantities along the coasts of Brittany and Normandy as a fertilizer for very silicious soils, which in this manner receive their lime. And this is the plant which is wrongfully accused of destroying the oyster banks and usurping the territory. I say wrongfully, for, as in the case of the mud, the *maërle* never attacks the oyster banks until after the dredge has commenced the work of destruction. In fact a surface completely restocked with oysters, which are absorbing animals, furnished with calcareous shells, cannot supply all the calcareous elements demanded by the oysters for the formation of their shells, and at the same time supply the *maërle*, which also requires a large quantity of the same materials to enable it to multiply. Wherever the *maërle* exists it is certain that the oyster cannot flourish, for it could not find subsistence there; and, reciprocally, wherever the oyster occupies the entire territory and absorbs all the shell-producing elements, the *maërle* can neither flourish nor live. But when human industry, yielding without reflection to selfish and grasping desires, carries away incessantly and by thousands the oysters and their progeny, leaving the surface absolutely bare in patches, it is not surprising that the germs of the *maërle*, which lives near by in the same waters, should come and plant themselves upon the ground, whence the enemy has disappeared, and there developing, become predominant, and finally entirely supersede the former occupant. From all this it is evidently necessary to seek the true and only cause of the depletion of our oyster deposits in the mode of fishing practiced at the present time.

Some details will here be necessary in order to explain our ideas. In all sections of the country oysters are taken by means of the dredge. This is a heavy iron frame, which is loaded with stones to render it more effective, and cause it to "bite" the ground deeper. A rope is attached to the dredge, which is dropped overboard from a vessel of some kind, and the vessel set in motion causes the dredge to drag over the bottom upon one of its sides, which, having a sharp edge, cuts or tears up everything in its course and gathers them into a net or bag attached to the lower side or bottom of the dredge. When the dredge appears to be full it is drawn on board of the vessel and its contents emptied upon the deck. The heap is then culled, and those oysters which are not of the size established by law are thrown back into the sea, and the rest placed to one side either for market or, as in Cancale, for the parks or fattening ponds.

In the month of August the commissioners of fisheries inspect the beds so as to ascertain their condition before permitting any fishing upon them, which, before M. Coste had made known the time when they could be worked with the least damage, commenced in September and lasted until May.

In certain localities where the fishing of oysters is a national industry, as at Cancale and Granville, in order to obviate the evil as much as possible and prevent the entire depletion of the banks, the oyster territory has been divided into zones or sections, and each section is fished in turn, while the others are left for perhaps a year or two to repair their losses and fill up the vacancies caused by the dredge. Thanks to this system, which, unfortunately, has not been general, these two quarters have been able to preserve their beds from complete ruin, but have not been able to increase their fruitfulness or restore them to their ancient splendor. In fact the use of the dredge—bad at any time, for it not only tears up oysters of all sizes, but also buries the spawn and the young beneath the mud which it stirs up, and destroys thousands of oysters which should be left to mature, for every thousand procured for the market—becomes more injurious every day, since, in order to increase the returns of fishing upon a devastated soil, and supply the demands of an ever increasing consumption, the oystermen are obliged to employ stronger and larger dredges and drag them more frequently over the same territory, so that the bottom becomes torn up, denuded of shells and rocks which are indispensable to the young growth, and offers a surface ready to receive a deposit of mud suitable for the development of mussels.

Further, in designating September as the time of opening of the fishing season, the administration acted with a desire to protect the oysters during the spawning period, but it did not perceive that the measure was useless, because incomplete. Of the immense number of germs produced at this time from a bed of oysters, only a very small proportion escape the innumerable enemies always near at hand, or, failing to be carried away by the ocean currents, become attached to the valves of the mother oysters or to the prominences of their native bed and serve to restock it. In September, when the fishing commences, these oysters, now only about a month old, are scarcely visible, requiring very close scrutiny to detect them, and when an old oyster is taken from the water at this season all the young upon its shell are inevitably destroyed. If, on the contrary, the fishing was begun in February, these oysters could be easily seen and removed from the objects of attachment, either to be returned to the sea or placed in parks or claires. This method would be of triple advantage to these latter places, since the fishing would not last longer than three months, and the parks would receive the harvest, which could be held there and retailed in accordance with the demands of commerce. Upon such considerations as these, which are in a high degree protective, the new fishing regulations have been founded, and these prudent measures, added to the practice of restocking, will be sure to re-establish and increase the oyster industry of our coasts. The state, as proprietor and guardian of the domain of the sea, has thus done its share; the fisheries are regulated by wise and efficacious laws, and the restoration of the devastated banks is in a fair way of being accomplished, so that in the near future not only will the evil be repaired, but a return to the former state of affairs will become impossible. But is this all that can be done? We have already said that among the myriads of germs sent forth from a bed of oysters at every spawning period, a small proportion only, that which becomes attached to objects on its native bed, is apt to furnish any recruits for the bed, or any subjects for the fishermen, while by far the greater share are devoured by their many foes, carried away by the tides, or buried up in the shifting sand and mud. Now, if it were possible to gather up at the time of spawning all of these swarms and place them where the conditions are favorable to their development, what incalculable wealth would result, and the truth of the matter is that this gathering up and guarding of the young is entirely feasible. It has been tested by so many experiments that it rests beyond a doubt, and one can even now with ease and certainty labor in this direction, since we know the conditions favorable to the growth of the young, such as are met with in the depths of the ocean, and which it would be necessary to provide artificially in order to favor their development. This is the work reserved for private enterprise, and it has been with the desire of furnishing a guide in this labor that this book has been written, and that the practical development of the oyster industry has been made the subject of the following chapters.

Among crustaceans the common and the rock lobsters occupy an important rank as food animals and as objects of trade; the fisheries of our coast supply not only all of France, but also a great part of Europe. The high price of these animals during the last few years, which has banished this kind of food from the tables of the poor, at least in the interior, and at the same time their relative scarcity in our markets, are consequences of the increased fishing to which they have been subjected, and of their gradual disappearance from our waters, where they were formerly so abundant. As in the case of the oyster fisheries, it is necessary to seek for the cause of this disappearance in the avariciousness of the fishermen and in the uselessness of the old protective regulations. In fact, if one has carefully followed the details which we have already given on a previous page, in regard to the manner of reproduction of crustaceans, it will be seen that the period of time intervening between the fecundation of the female and the hatching of the eggs, is about nine months, the fecundation beginning in September and the incubation ending in May. During these nine months these animals ought then to be entirely protected, for the death of a female at any moment whatsoever of this time is equivalent to the destruction of many thousands of individuals, even where great allowance is made for the many chances of destruction which surround the young before they are fully developed. It is thus during only three months, June, July, and August, that regulations really protective to these animals would allow of their capture, especially as concerns the common and the rock lobsters. But far from conforming to these natural requirements, the old regulations authorized the taking of these crustaceans at all times throughout the year, with only two restrictions: first, to return to the sea all ripe females, that is, females with eggs attached to the abdomen; and, second, to return all individuals less than 20 centimeters in length. The first of these requirements of the law was excellent in principle, but it was impossible to secure its rigorous execution.

The fishermen would not consent to throw back into the sea often as much as half of their catch, and so eluded the law by tearing off the bunches of eggs from the females, thus destroying at a blow myriads of young ones. It is evident that such action as this has had not a little to do with the increasing scarcity of these animals and their nearly complete extinction in certain sections. On the other hand, if the fishing season were limited to three months it would ruin the fishermen in thus restraining the use of a commodity now generally in demand at all seasons of the year. So under the new regulations now actually in force, and which are due to the exertions of M. Coste, the taking of these crustaceans is forbidden only during the last three spawning months, March, April, and May, during which time most of the young are hatched from the egg. To this eminently protective measure is added the obligation to return to the water every animal less than 22 centimeters in length from the eye to the beginning of the abdominal portion; for all animals smaller than this not only sell for a minimum price, and, being too young for reproduction, their destruction before having fulfilled this function at least once would be a loss without any compensation. What has thus far been done is all that can be done judiciously in the present state of affairs, when both the common and the rock lobsters, as soon as they are taken from the water, are delivered immediately to the consumers, or at least are preserved in small live ponds or boxes only as long as is necessary to find a purchaser. But it is known to-day that both of these animals do well in confinement, and when kept in spacious basins where the conditions suited to their normal existence are artificially realized, they will live, increase in size, fatten and reproduce their kind just the same as in a state of nature. And it is even to be supposed that, like oysters in parks, this mode of breeding should improve them in flavor and delicacy.

Here, then, is a new industry open to the inhabitants of our coast; an industry which, in multiplying products, is suppressing non-values, since every individual which is under the marketable size can be preserved until such a size is attained. By being able to satisfy instantly all the demands of commerce, even at times when bad weather or other circumstances prevent fishing, the consumption in the interior and the exportation to foreign countries will be considerably augmented, and a wise and effective protection will become possible, since the fishing grounds will be invaded only to supply vacancies in the breeding-basins, made in answer to the demands of the market. The industry, moreover, far from being independent and distinct from the breeding of oysters, or of forming the basis of a special labor, is simply supplementary, and additional in that it increases the supply and the revenue without increasing the expense at the beginning. The breeding of mussels will also be considered in detail; for if their disappearance is not to be feared, there is such a vast difference between the sea-mussel and the mussel of the parks that the latter alone should be used for food, and this method of breeding enables a useful article of food to be grown upon bottoms whose nature is entirely incompatible with the production of oysters. In the following pages I shall only mention methods which have been sanctioned by long experience, dating back certainly for several centuries. I shall not entertain any theories or enter the domain of hypothesis, but remain faithful to the practical idea in which this book was conceived.

METHODS OF BREEDING AND REARING OYSTERS, MUSSELS, LOBSTERS, &c.

CHAPTER I.

INDUSTRY AND PRESENT METHODS.

In the preceding pages we have said that the only methods described in this book would be such as had been sanctioned by centuries of experience, and we now propose to prove that our assertion was not falsely made by describing in a few words the artificial breeding of oysters, taking as guides, if not as models, two examples: one, that of Lake Fusaro, which dates far back in the Christian era, and the other, that of Marennes, which began in the earlier times of our history. About the beginning of the seventh century a Roman knight, Sergius Orata, undertook the artificial breeding of oysters in the waters of Lake Lucrin, the Avern of poets. Historical documents prove incontestably the existence of this establishment of oyster culture, and Pliny informs us that the enterprise was very successful, and its author in a short time became very rich. The methods followed, and probably invented, by Orata have been perpetuated to our day upon the banks of Lake Fusaro, a small salt-water lake, about a league in circumference, situated in the neighborhood of Cape Misène, near the ruins of Cumes, which has been poetized by Virgil under the name of Achèron. Upon the blackish mud, which covers the volcanic soil of this basin to a depth of from one to two meters, the fishermen have constructed here and there artificial rockeries formed of rough stones gathered together and thrown into heaps sufficiently elevated to be protected from deposits of mud or slime. Upon these rocks oysters taken from the sea were deposited, to form an artificial planting ground for all time, except, as is well understood, in the case of accidental mortality, such as has been occasioned by volcanic eruptions, which have sometimes necessitated their renewal. Each rockery (Fig. 5) is surrounded by a circle of stakes, which are fastened

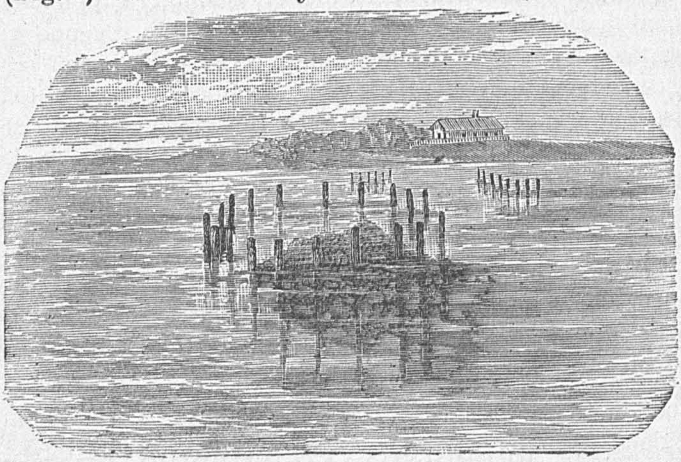

FIG. 5.—Artificial oyster rockery of Lake Fusaro.

in the bottom of the lake by one end, while the other extends up out of the water so that they can be seen and removed when necessary. Often these stakes are united by a cord passing from one to another (Fig. 6), and to which is suspended, between each two stakes, a small bundle of twigs, floating in the water a short distance from the bottom. These, together with boats, tools, and a storehouse, constitute the entire apparatus used for oyster culture at Fusaro, and such is the apparatus which common experience has found to be invariably efficacious. At the spawning season the oysters deposited upon the artificially formed rockeries, and living there as if in the open sea, allow the myriads of germs to which each gives birth to escape, as an animated cloud of dust-like particles, which, finding close at hand suitable materials for their attachment, become located there almost as a mass, beside the mother oysters. An insignificant portion only of these young oysters are lost, either by being carried away by the current of the water, or by being buried in the mud of the bottom. The colony is thus continually increasing in size by the

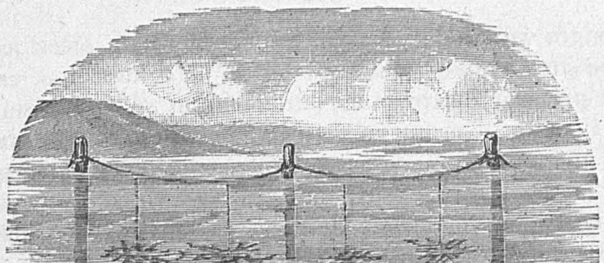

FIG. 6.—Bundles of twigs suspended between upright posts of oyster rockery.

annual deposit of new germs, which develop under favorable conditions of shelter, light, and temperature. When the fishing season arrives the owners or leasers of these artificial banks take up the stakes and bundles of fagots, select without any trouble from among the oysters which cover them those of a suitable size for the market, and then replace the stakes, &c.; the remaining oysters continue their growth, and the vacant places become filled another season with a new lot. The industry at Lake Fusaro, which has prospered for centuries, employs, as can be readily seen, only methods of great simplicity—probably the same as were used by Sergius Orata—and it teaches for our benefit, that by careful and skillful management, aided by suitable means of collecting the spawn of the oyster, all of which is neither difficult nor expensive, one can indefinitely multiply this bivalve, while the processes employed by us at present lead only to the ruin of our naturally excellent beds. At Marennes, upon both sides of the mouth of the Seudre, a similar industry is perpetuated, and is being developed more and more under the patronage of the state, but unfortunately it is merely directed to the work of bringing to perfection these animals taken from the sea and transplanted in the new regions without any effort to reproduce and multiply them. In spacious live-ponds, called claires, constructed upon a definite plan, to be described in one of the following chapters, are placed the oysters taken from the sea, preference being given to those about 12 to 18 months old; that is, much below marketable size. These claires are so arranged as to allow of a careful inspection on the part of the breeders, to facilitate the distribution of the sea-water at will, the clearing of the bottom, and the gathering of the products. In these claires the oysters are arranged by hand upon the bottom, which has been made hard and free from mud; they are so deposited that they do not crowd one another or lie in piles, and are left there to increase in size, grow fat, and acquire that greenish color which is so much desired by amateurs. During the period of their growth the water is renewed only during the spring-tides. The additional labor consists simply in regulating the depth of water over them according to age and temperament, in changing them from one claire to another if any danger arises of their becoming covered with mud and thus smothered, and in culling them according to size. In about two years they attain marketable size, and compensate largely by their extra value for the necessary outlay in their rearing. This method is far from perfect, since in the first place the great mistake is made of drawing from the claires only one-half of what they might be made to produce. As breeding places they ought also to be places of reproduction and multiplication, and they might be such, as has been often shown accidentally. But, such as it is, it offers us a good model as a method of management, and also an argument in favor of the new industry, the reality and success of which is, I trust, no longer doubted by the reader; thus we can enter without fear upon the details of the practical workings of oyster culture, which we shall proceed to develop in the following chapters.

CHAPTER II.

MEANS AND METHODS OF GATHERING AND TRANSPORTING OYSTER-SPAWN.

If the reader has attentively followed and understood what has been recorded on the preceding pages concerning the causes of the ruin of our oyster-beds, the evil resulting from the present mode of gathering oysters, and, finally, the methods of reproduction, especially that employed at Lake Fusaro, he has probably been able to recognize that the first, and by all odds the most important, thing to be done in the new industry, is to gather up, with the least possible loss, the young growth sent forth by the mother oysters during each spawning season, then to cause them to attach themselves to some object which will give them sufficient support for their future growth, and also allow of their removal, either to preserve them from mud or other causes of mortality, or to transport them to a distance in order to restock barren territories, or acclimate foreign species.

Accordingly we propose to proceed at once to the description of various styles of apparatus used in such collecting, and indicate, for each one, the conditions under which it is especially to be recommended.

Movable collecting apparatus.—In those sections where oysters already exist, and where the fishermen have not completely stripped the beds, the fixed collecting apparatus is alone necessary for the multiplication of this mollusk; but when it is demanded of the beds that they not only furnish supplies to the ordinary fishermen, but also the young necessary for restocking barren lands, and medium-sized oysters for the artificial parks and basins, then movable collecting apparatus should be used. This is the most economical method, and the most certain, when it is desired to plant oyster-beds upon virgin soil. Many efforts have already been made to stock new waters and restock old by throwing into the sea oysters which have been taken at a distance and transported at great expense to the place of the experiment; but nearly all the attempts have proved futile, either from the impossibility of keeping oysters alive on board of vessels during a long voyage, or from their soft condition at the time of their arrival and their sudden change into a strange water, or possibly from not encountering in their new locality conditions suitable to their existence. Moreover, this process is very expensive, and very slow, for the oysters destined to be the source of the future supply are necessarily always very limited in number, and must be above all carefully preserved and no fishing allowed until the young from the first spawning, which may have been much retarded by reason of the change of locality of the old ones, have attained a marketable size. Thus a period of five or six years at least must elapse before sufficient returns can be expected to compensate for the advances made; during this period, from the impossibility of knowing precisely what is taking place beneath the surface of the water, everything must be left almost entirely to chance. On the contrary, when the movable collecting apparatus is used the territory can be planted not with thousands alone, but with millions of young, of various ages, whose management is easy, since they are all bound together, thanks to their common support, which permits them to be placed at will in the most favorable conditions of bottom, depth, temperature, and light. Inspection is also easy, and can be undertaken at any moment. At the end of three or four years, when the oysters should have attained marketable size, they can be culled, on account of their large number, and the largest sold, leaving still a sufficient number to assure the continuous and definite repeopling of the bed.

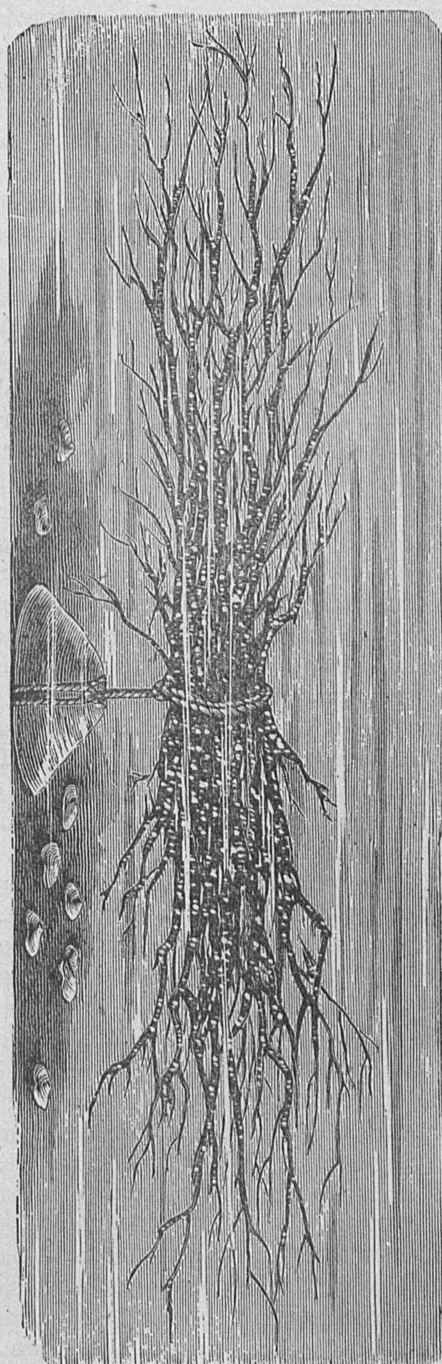

FIG. 7.—Fascine collector.

Fascine collector (*Fig.* 7).—The most simple movable collecting apparatus, and the least expensive, at least in the beginning, consists of bundles of small branches of chestnut, oak, or elm, fragments of grapevine, or, in fact, of any wood containing no poisonous or aromatic principle which by dissolving in the water can injure the spawn or prevent its adherence. The fascines or bundles of fagots, from one and one-half to two meters in length, are bound around the middle with strong galvanized and tarred iron wire, experience having shown that hemp cords cannot endure, without decay, a prolonged sojourn under the water. The fascines are also furnished with stones, which, being attached by other wires to the first-mentioned central wires, serve to anchor the fascines and maintain them at a depth of from 20 to 30 centimeters above the bottom.

About three weeks before the spawning season the fascines are placed over the beds from which the spawn is to be gathered, and are so disposed, according to the configuration of the bed, that obstacles as collectors shall be met with in every direction where the tidal currents may be transporting the embryos. Experience has shown that fascines thus disposed receive the young in such abundance that each often holds several thousand. They are left in place from five to six months; by this time the young oysters have attained a size of from 2 to 3 centimeters in diameter, and can very easily be removed from the branches to which they are attached, and placed in such grounds as it is desired to restock, whether these be far or near, for nothing is easier than to carry these young animals, either upon the fagots or off, providing fresh sea-water is supplied them. The disadvantage of this apparatus is that the same fagots cannot be used more than once, or for a single gathering. The action of the sea-water soon destroys them, and they do not generally last long enough to permit the oysters which cover them to acquire a marketable size. This process may be advantageously employed to increase the supply of oysters in a park, but always upon the condition that it is to replace those taken away and for the multiplication of the quantity in the park, for the entire renewal of the fascines each year would be too expensive. This is not the method, however, to which we would give the preference in the case of a long journey by land or sea, in transporting the young growth from the place of production to the breeding ponds.

Platform collector.—This collecting apparatus is susceptible of all manner of modifications as to form and size to adapt it to the character of the ground upon which the bed is located. Not only is it easily made, arranged, and handled, since one person can perform all the labor necessary, but it also does no injury whatever to the oysters which it covers. It is generally placed in position one or two weeks before the spawning period, and during its stay over the bed it preserves the oysters from all deposits of mud; when it is charged with a young growth it can be taken down in a short time and transported to any required distance, leaving the bank which it had covered not only in its primitive condition, so far as the original stock is concerned, but moreover enriched by a large number of germs which, had it not been for the presence of the collector over the bed, would have been carried away, at least in great part, by the tidal currents, and thus lost. The platform collector consists (Fig. 8) of several rows of posts arranged in pairs, A, each pair being fastened together, with an intervening space of 12 to 15 centimeters (4 to 5 inches), and planted in the ground over the entire area of the bed.

at a distance apart of about 2 meters, with each pair occupying one of the angles of a square, so that the surface covered is divided up into

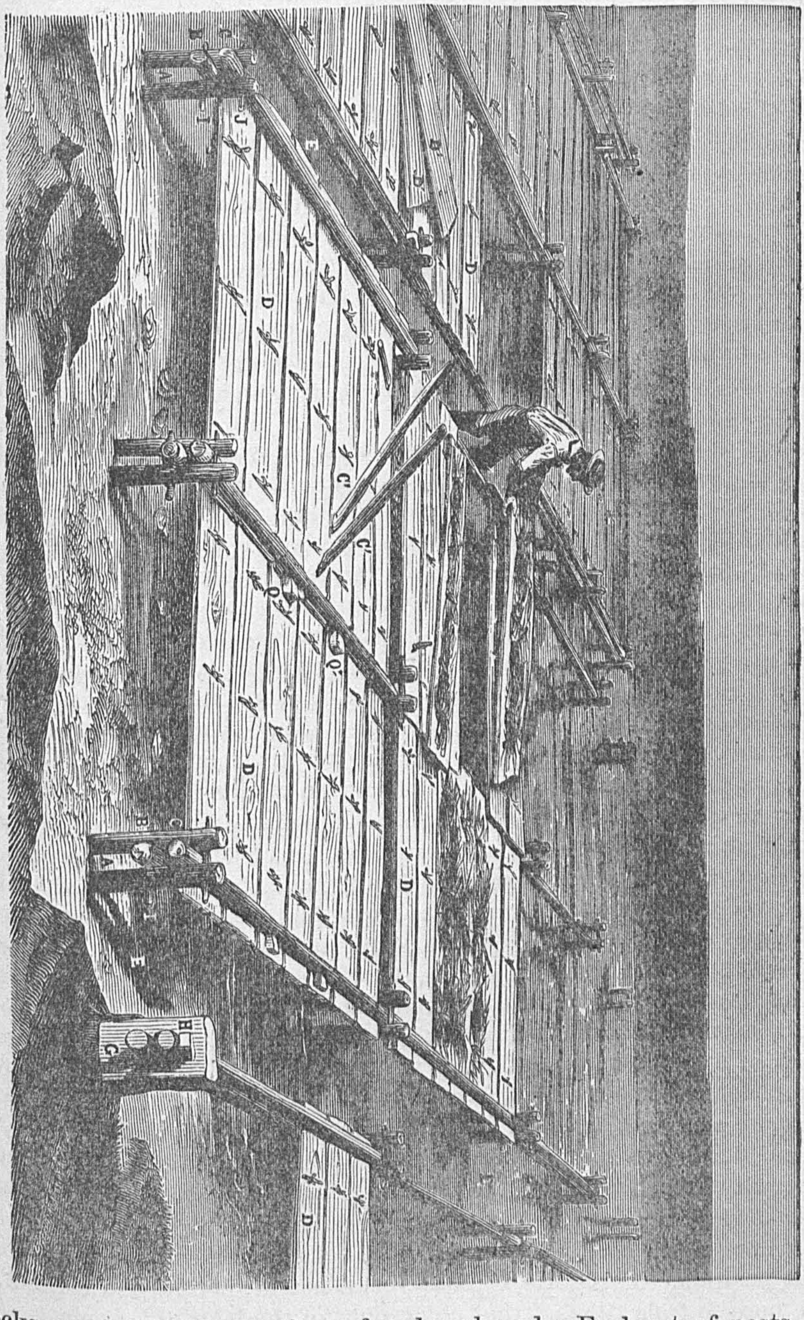

Fig. 8.—Platform collector.

blocks, much like the surface of a chess-board. Each set of posts is pierced through by two sets of holes, the first at one-half meter and the second at .75 to .80 of a meter from the bottom; bars of wood or iron are passed through these holes, thus making each pair a sort of ladder with two rounds. Upon the lower rounds, from post to post, are laid bed-pieces, or stringers, B, which should be quite strong, and which together constitute a frame-work of contiguous squares, upon which a platform of rough planks, D, is built and maintained in position by a second series of stringers, C, held down by the upper round, J, of the posts; the pressure upon the planks is regulated when necessary by means of beveled wooden blocks, Q, Q′.

It will be readily seen that, by the aid of these stringers and rounds, nothing can be easier than the mounting and dismounting of the planks, either to change or turn them, or transport them elsewhere. Whenever desired the stringers and posts can be so arranged as to leave free spaces, E, as passages, to facilitate the working of the platform. The planks should be of pine or fir, and from 2.10 to 2.15 meters (6 to 7 feet) in length, by .20 to .25 of a meter in breadth (8 to 10 inches), and .04 of a meter (about 1½ inches) in thickness.

In order to facilitate the adherence of the spawn, planks with a rough surface are used, and the rougher the surface, as by gouging it out so as to increase its irregularities, the more easily can the young oyster adhere to it. The sides of the planks can also be covered with a layer of pitch and tar, in which, while it is yet soft, valves of oysters, mussels, or any other shells, which occur abundantly along the shore, or bits of coral, or small stones of about the size of a nut, can be placed, so as to form a sort of artificial rock formation, favoring very much, by the roughened surface and the multiplication of points of attachment, the deposition and development of the young animals. This is much preferable to the other method, since it preserves the planks from the action of the water and the destructive borings of certain worms and mollusks. In order to afford a still greater number of points of attachment for the young germs, the lower face of the planks is covered with fascines of chestnut, oak, or other wood, which are held close to the planks by means of cords, passing through holes in the planks and fastened upon the upper side (see Fig. 8). Upon sandy or muddy bottoms the posts which support the stringers can be set without difficulty; but when the bottom is rocky or too hard they cannot be employed. They should then be replaced by blocks of stone, G (Fig. 8), about .70 of a meter in height by .25 of a meter in breadth and thickness, pierced through by a hole of sufficient size to receive the ends of the stringers, which are fastened there by means of a small block, H, driven in upon the upper side. These blocks can then be simply placed upon the bottom or fastened there with iron clamps; or the wooden stakes can be employed by fixing their lower ends into blocks of stone which when in place should be large enough to give steadiness to the collector and maintain it in its right position. This form of collector, it is true, is costly to establish, and more so from the fact that on account of the long time it must stay in the water it is necessary to select firm, solid wood, of good quality, but in its adjustment there is no need of any particular nicety of workmanship or finish, and there is moreover this advantage that it lasts a long time and can be used for several harvests. However, in those waters where boring worms and mollusks occur, a single season will render the platforms unfit for further service. In this case galvanized iron supports can be used in place of the wooden frame-work and the planks may be replaced by sheets of metal having the two faces covered, as already described, with a mixture of pitch and tar, in which valves of shells, bits of coral, or small stones have been imbedded. The metallic sheet, which forms the body of these pitch planks, will give sufficient solidity to the structure, and the supports can be in the form of a frame-work, capable of holding at least three sheets, which can be fastened in position by means of bolts; the entire structure may be arranged like a table upon four or eight legs, which can be driven into the ground, or fastened into blocks of stone, which will give the desired stability to the whole. These tables can be placed in rows according to the configuration of the bed, leaving passages between each two rows to facilitate working them. After the spat or germs have been collected upon the planks of the platform they can be easily transported either by sea or land. If by sea the planks are taken from the stringers and suspended lengthwise and vertically in a frame-work provided with floats, or arranged in the direction of the current, like a series of shelves, about one-fourth of a meter apart, and thus kept constantly in the water; in this shape they can then be towed without trouble to any distance. When they are transported by land the planks are either carried in tanks full of sea-water, or placed between layers of wet sea-grass, and when so managed the young oyster can sustain, without serious damage, a journey of one or two days. When their destination is reached the young oysters are detached from the planks without trouble, as this operation demands only a slight amount of skill and attention, and deposited in the places to be stocked; or the planks may be placed upon supports similar to those whence they were taken, and the young oysters allowed to continue their development protected from the mud, and in such a position that by turning the planks the conditions of light and aëration can be varied to suit the wants or requirements of the growing brood.

Box collector.—This apparatus unites the double advantage of presenting in a relatively small compass the greatest possible extent of surface for the attachment of germs, and, at the same time, the most favorable conditions for the transportation and ultimate development of the young, in the movable and independent parts which compose it. It consists, essentially (Fig. 9), of a rectangular box, two meters in length by one meter in breadth and height, and is without any bottom. It is formed of planks, O, placed from 2 to 3 centimeters apart, or pierced with holes, for the entrance and circulation of water in the interior. These planks are permanently maintained in place upon the front and back sides by two cleats, R R, extending below the edge of the box and are nailed to transverse pieces, which pass across the bottom from side to side. The ends are pierced by three sets of holes to accommodate the transverse bars, S, upon which in the interior are placed movable frames, dividing the box into superimposed compartments. The cover is formed of thinner planks, D, placed side by side, and maintained in position by the bar T, which slides into the two sockets, A, at the ends of the two stakes supporting the ends of the box. It is hardly necessary to add that the apparatus should be constructed of solid planks of a durable wood, such as oak, and that the fastenings of the parts should be, so far as possible, of the same kind of wood, employing neither iron nor nails; but if their use is absolutely necessary, then the preference should be given to iron or galvanized nails. The frames for the inside are of wood, about 4 centimeters in thickness, and furnished with two handles to facilitate removing. The bottom is covered with brass wire netting (Fig. 10), the meshes of which are about 2 centimeters upon a side, and in order to increase the strength of the frame and sustain the netting, diagonal wires can be run across from corner to corner, or a central bar of wood from side to side.

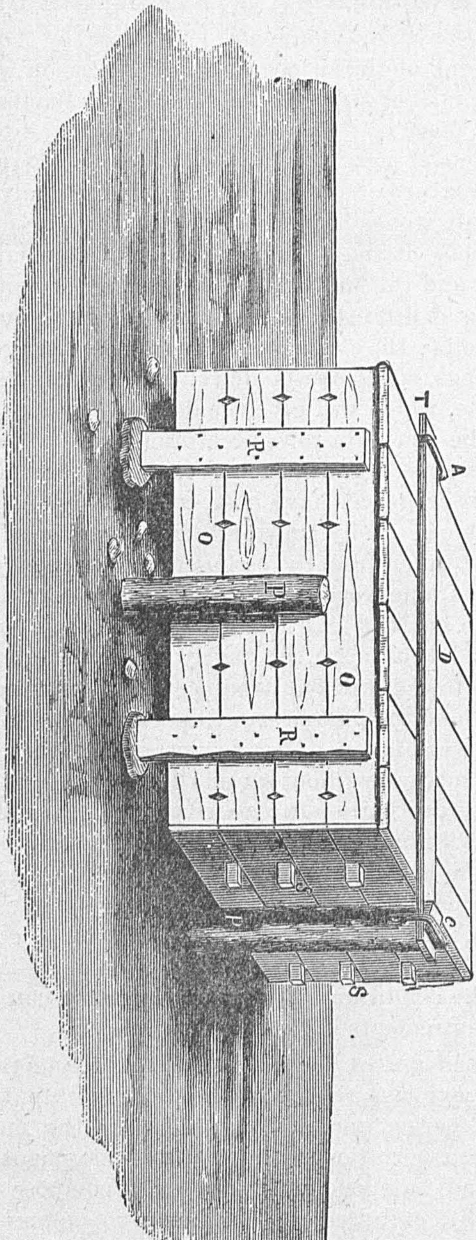

Fig. 9.—Box collector. Exterior view.

These frames are made of such a size that when placed side by side, two of them will form a continuous flooring or division across the box, as shown in Fig. 11, where the front portion of the box has been removed so as to show the arrangement of the interior. It is necessary, however, to give sufficient play to the frames, so that they can be moved at any instant without trouble and without shaking. We herewith give the conditions in which this apparatus is used, and the method of operation.

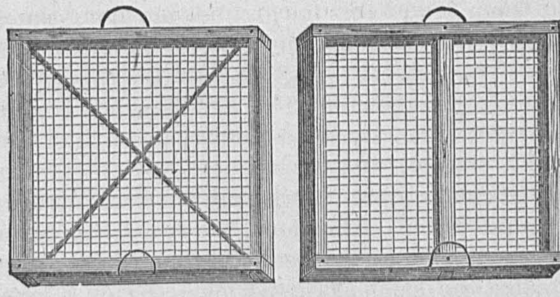

FIG. 10.—Inner frames of box collector.

The box collector is especially valuable when the oyster culturist has no natural bed near at hand whence to gather germs, and yet wishes to procure a large number of young to rapidly stock a park or live-pond. For he can always, just before the spawning season, have several hundred oysters brought from the bed nearest his basin, since oysters when they have attained a certain size will sustain transportation for several days without damage, providing the precaution is taken to furnish them with water now and then. Once in possession of these oysters, in a good location, where the water is calm without being stagnant, the bottom pebbly and properly protected from mud, and the light and depth suitable—or even in an artificial basin of from 1 to $1\frac{1}{2}$ meters in depth, which communicates with the sea at each tide—the box is placed upon the bottom in such a manner that the lower transverse pieces rest upon stones and the entire lower side is off

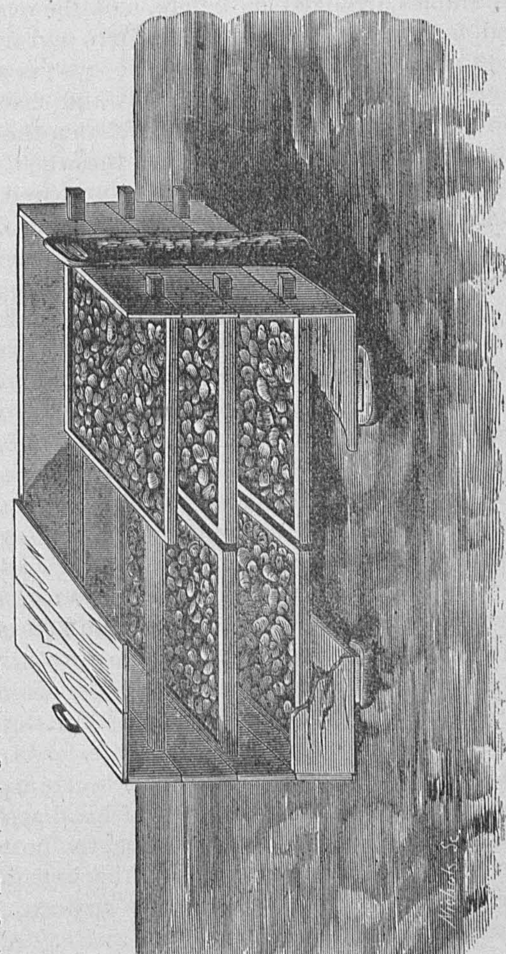

FIG. 11.—Box collector. Interior view

the ground, enabling a free circulation of water. Four stakes, P P, Fig. 9, are then driven into the ground, one along the middle of each face of the box, so as to prevent any swaying or change of position, by the action of the waves and currents, and maintain the apparatus in the same position. The cover is then removed, and sixty mother oysters are deposited upon that portion of the soil circumscribed by the box, care being taken, if the soil is soft or muddy, to cover it previously with empty shells, so that the oyster, when placed there, may not become covered up but always remain in pure water. This done, the two lower stringers, S S, are placed in position, and upon them two frames (Fig. 10), are arranged, which are treated the same as the bottom; that is, a layer of shells is first placed upon them, and then a certain number of mother oysters above and over the shells. The second set of stringers is then placed in position, the frames arranged as before, and the oysters distributed over them, and, finally, the third set of stringers and frames are arranged and covered with shells (Fig. 11), but no oysters are placed upon them. The cover is then placed upon the box and fastened down by means of the top bar and the wedges, C, which fasten the ends of the bar in the sockets of the end posts, and render the whole apparatus solid and immovable. The apparatus being thus prepared, it is easy to conjecture the result. The oysters, under such excellent conditions of existence and in such pure and quiet water, soon spawn; the young growth, finding itself imprisoned, or nearly so, in the various compartments of the box, and coming upon suitable places of attachment near at hand, remain in the box and dispose themselves nearly everywhere, but from preference upon the shells covering the frames, and proceed in their development under the best possible conditions and protected from all danger. In from five to six months the young oysters have attained such a size that they can be removed without danger. The apparatus is then taken apart piece by piece, commencing with the cover, and as each tray is removed its contents are deposited upon the bottom of a park, live-pond, claire, or such place as one wishes to restock or supply. If it is desired to carry them to a distance the trays can be placed in a floating box pierced with holes, and if arranged in layers, like shelves, and with sea-weed packed between them, so as to prevent the disturbance and shaking incident to movement in the water, they can be towed for long distances without danger of injuring the shells of the young oysters or detaching them from their supports. And if the trays are packed in boxes with wet sea-weed between them they can be transported by land very nicely. For one who has limited means at his disposal, and when labor and expense is an important consideration, the box collector ought by all means to be given the preference; by the ingenious method of multiplying surfaces, which is its distinctive feature, innumerable germs can be hatched out in a very restricted space. A small case of a few square meters in area, a small artificial basin which can be filled at each tide, and a narrow passage-way between two rocks, is amply sufficient for the production of the thousands of germs necessary for the stocking of a live-pond, or even a larger inclosure; for the possibility of placing two or more of these boxes close together without injury to the oysters or the germs which they contain, permits a response to all the demands of the breeder, however restricted or extended they may be. Moreover, the apparatus itself, besides being easy to manage, arrange, and transport, will last for several years if suitable wood is used in its construction, and if the outside at least is protected in some such manner as are the bottoms of vessels, by a sort of sheathing. As to the inside, as well as the cross-pieces and the wooden parts of the trays, they can be covered with the mixture of tar and pitch already mentioned, and incrusted with shells and stones, which will not only preserve them from rapid decay, but also render them suitable places of attachment for the young oysters.

Fixed collecting apparatus.—When the bottom is already covered with oysters, either from the existence there of a natural bank or by artificial means, movable collectors are useless, and for the multiplication of these oysters, the proper method is by means of fixed apparatus, which, while much less expensive and complicated than the preceding, performs the same office. The various kinds of fixed apparatus are as follows:

First. *Pavement collectors.*—This method, employed at the island of Ré, at Rochelle, &c., consists in covering the bottom with blocks of stone irregularly broken and formed into a sort of uneven pavement, and by so arranging the pieces that as many crevices and prominences may exist as possible. The best way of arranging these pieces is to group them in threes, two being placed flat, at a short distance apart, and the third above and resting at its extremities on the other two, in such a manner as to form a sort of bridge with the arch, or third stone, sufficiently elevated above the bottom to be out of reach of mud.

The young growth, moving freely in the water, becomes attached to these rocks, in the hollows and under the arch stone of each set of three, where they are protected, and where pure water and a mild light are offered them, conditions which are very necessary during the early stages of their existence. During the first year they should be left entirely in peace, and at the spawning period all that is necessary is to simply turn over the upper stones without touching in any manner the lower ones. The oysters which have become attached to the lower sides of these stones are thus exposed to a full light, a condition favorable to their future development, and the upper faces of the stones, now turned downward, are ready for the attachment of the next growth. During the third year the oysters upon the upper surfaces of the stones can be taken off, having acquired a sufficient size to permit of their being placed with others upon the beds or in the fattening ponds, and the stones can again be turned so as to expose the oysters upon the under side to the full light, and leave a fresh under surface for a third growth. This process is not expensive, at least in those sections where, as in the island of Ré, the rocks of the coast furnish ample supplies for all the pavements necessary in the working of the beds. Moreover, it demands neither much skill nor long and wearisome labor; but there is one bad feature: the oysters which develop upon the stones become attached to them so firmly that they cannot be removed without destroying a great number, and they often grow in such a bad shape that they are not of much value in the market. I think, nevertheless, that the nature of the pavement has

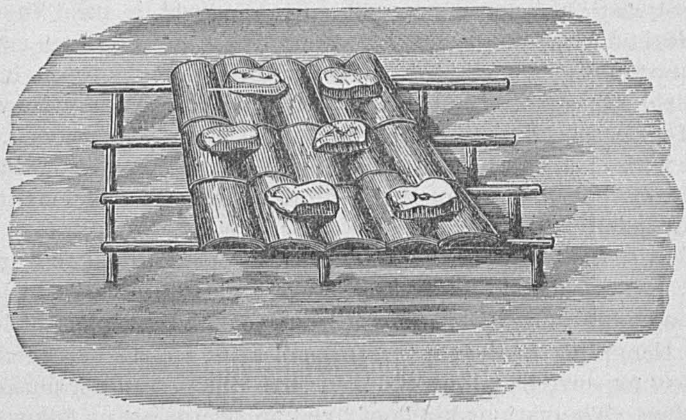

FIG. 12.—Tile collector, simple form.

much to do with the first of these two defects, and that, where one can make use of soft stones, such as limestone and pudding-stone or fragments of coral, the adhesion of the shells might be easily overcome, and in this case the pavement collector, as being economical and easy to use, would give most satisfaction. Those misshapen oysters, on the other

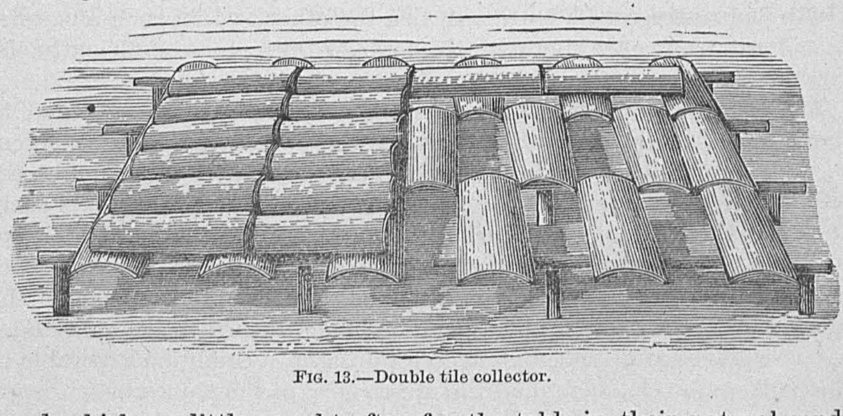

FIG. 13.—Double tile collector.

hand, which are little sought after for the table in their natural condition, can be used without disadvantage in making pickled oysters, or preserved in any other manner, and thus supply a constant and remunerative demand.

Second. *Tile collector.*—In regions where rocks are scarce, and also to avoid the disagreeable features mentioned above as pertaining to the pavement collector, one can make use of curved tiles, similar to those employed in certain countries upon the roofs of houses, to gather the young oysters. For this collector lines of stakes are driven into the ground, over a space of 15 to 20 centimeters of the surface of the bed whence it is desired to take the spawn. Upon these stakes transverse stringers are fastened, along which tiles are placed side by side, with the concave side down (Fig. 12). Here and there heavy stones are placed upon the tiles so that neither the current nor the waves can raise or displace them. But this disposition of the tiles is not the only one; many others can be adopted which multiply the surfaces of attachment for the young. Thus the tiles can be disposed in two superimposed and crossed layers (Fig. 13), forming a double tile collector, or again, as in Fig. 14, they can be set up obliquely between the trestles, which in this case may be placed nearer together; the tiles form an angle of about 25° to 30° with the surface. Still another method, in which the wooden trestles are dispensed with, is to arrange the tiles in the form of a tent, or pointed roof, kept in place by stones placed between the rows

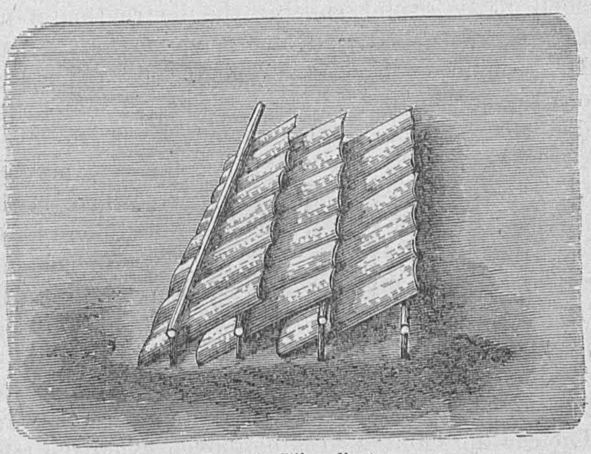

FIG. 14.—Tile collector.

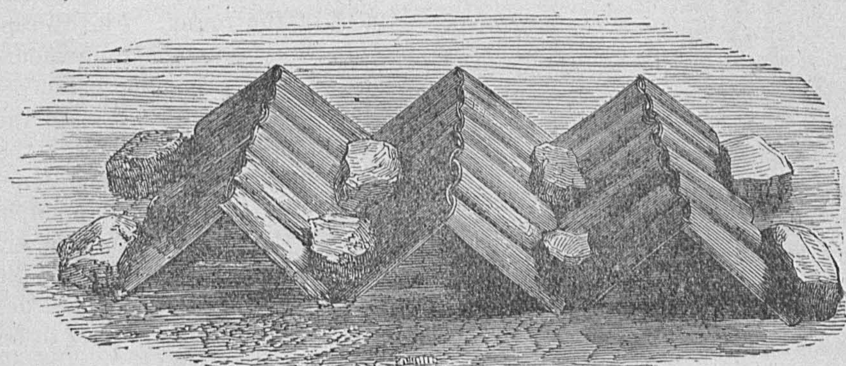

FIG. 15—Tile collector, tent form.

(Fig. 15). This last disposition is the most simple, the least expensive, and moreover not a bad one, for it offers a very large amount of surface for the attachment of the young. Whichever style of tile collector may be employed the concave surfaces of the tiles become covered at the spawning season with the young growth, which develops there under excellent conditions and which can be easily detached when the size of the oysters is such as to fit them for the parks, or for the bottoms where the mother oysters live.

To Dr. Kemmerer, of the island of Ré, is due the credit of numerous ingenious contrivances in the arrangement of tiles as collecting apparatus. The tile is in fact the fixed collector par excellence, except that, like the pavement, it affords too firm and complete an attachment for the shell of the oyster, causing the destruction of numerous animals when they are detached, and also often giving a defective form to the shell. Dr. Kemmerer, in order to remedy these defects, covered the tiles with a coating of cement, composed of water-lime, four parts of water and one of defibrinated blood. This cement dries rapidly, hardens under water, but remains sufficiently brittle to enable the oysters to be detached without difficulty. Or, if desired, the entire layer of cement can be taken off in a single piece, when the young oysters are sufficiently grown, and in this manner transported to a distance to stock depleted parks or territories, while the tile can be recovered with a coating of cement and used a second time. The coating mentioned is employed when the labor of preparation can be performed at home, but when it is necessary to make repairs, or coat the tiles at the parks or preserves, then a coating is used of water-lime and Grignon or Vassy cement, very hard plaster, or water-lime and pounded brick. The presence of the lime seems, moreover to have, a very favorable influence upon the deposit of the young. Fig. 16 represents the various arrangements preferred by Dr. Kemmerer for his cement tiles. No. 3 represents the tile pierced by a simple hole, 4 the tile with its coating of cement alone, and 1 and 2 the cemented tiles with fragments of grape-vine and shells embedded in the cement. Fig. 17 represents the best methods of arranging the tiles so as to give a large exposure of surface and sufficient solidity to the pile. The various forms of apparatus we have just described are not the only ones in use, nor are they the only ones to be recommended.

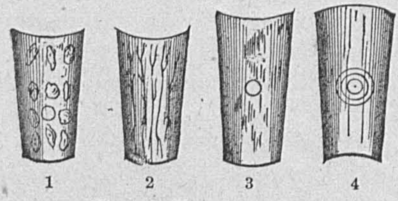

FIG. 16.—Kemmerer tiles.

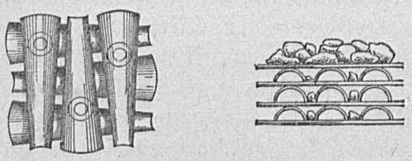
FIG. 17.—Tile collectors.

The essential condition which should be fulfilled by all collecting apparatus, that of offering proper and extended surfaces for the attachment of the young, is so simple that the mode of constructing apparatus can be varied in a thousand ways. The fundamental principle being once comprehended, the oyster-culturist, by using the above described collectors as models, can vary the form, the disposition, and the material according to his means, the resources of the locality where he labors, and the price of the component parts. We will leave this subject, then, to his ingenuity, trusting we have said enough, so that he need not run any risk or labor in the dark in this first stage of the oyster industry, in which the collecting apparatus is an instrument of prime importance.

CHAPTER III.

PREPARATION OF THE BOTTOMS.—CONSTRUCTION OF CLAIRES, PARKS, LIVE-PONDS, ETC.

All bottoms are not equally adapted to the culture of the oyster; some, even, are entirely opposed to it and can be modified only by completely changing its nature. It is, then, of primary importance for the oyster culturist to know how to rightly estimate the value of the soil which he wishes to work, as to its aptitude for the production and growth of this mollusk, and to be able to modify it according to the needs of the case. This is the subject which we propose to treat of in this chapter.

The type of marine bottom especially adapted to the growth of oysters is offered to us at several points along our coast, particularly in the Bay of St. Brieux. The bottom there is firm and suitable, covered with a rather thin layer of fine sand, formed by the *débris* of shells ground up by the action of the sea and the natural wearing of one shell against another, with large fragments or whole shells scattered here and there over the surface. There also occurs here a thin layer of marly mud, similar deposits of which exist nearly everywhere, but it never increases in this locality so as to become injurious, for at every tide the water, which comes in from the ocean with great velocity, carries the greater portion of the mud off with it as it retires. Moreover, the water of this bay is singularly well adapted to the development of all kinds of marine animals, from its vivifying properties, brought about by its ceaseless dashing and breaking upon the numerous rocks which line the coast, and by its constant renewal through which it maintains a favorable mean temperature. We will take this sort of bottom as a type and model, and indicate by what means those places which differ from it in some respects can be modified so as to produce nearly as favorable results. It can be said, in general, that all soils are or can be made suitable for the culture of oysters, although in different degrees; the only ones to be excepted are those formed of large deposits of mud, so deep and so constant in its renewal that there is no hope of its being carried away; and those constantly shifting sand-banks, which change with every spring or very high tide and every heavy sea, covering up upon one side as much as they uncover upon the other. The impossibility of any previous preparation of such soils will prevent any desire or attempt at working them. We shall not, therefore, treat of such bottoms, at least not in this chapter, but confine our attention to oyster culture on those bottoms which are naturally solid, and only altered by superficial deposits.

Muddy bottoms.—As is well known, mud is the result of the deposition of pulverized material of any kind which is held in suspension by the water, having been gathered from the bottom of the open sea during stormy weather, or produced by the decomposition of animal and vegetable forms, or by the erosive action of the waves upon submarine rocks. So long as the water is in constant agitation these materials remain in suspension, and no mud is deposited; but whenever the water becomes quiet, these fine particles, being denser than the water, drop to the bottom, resulting in the formation of mud; however short a time the stagnation favorable to this deposit continues, so long as it lasts the layer of mud goes on increasing in thickness until the entire bottom is rendered completely sterile. The first thing to be done, then, in order to render a muddy bottom suitable for the growth of oysters, is not only to clear the bottom of the mud, but especially to prevent its future deposition. The most certain and most economical method is to make the water itself remedy the evil which it has produced, and prevent its return. One very simple observation will be a lesson in this direction. A deposit of mud is never found at the foot of a rocky cliff, or distributed over a bottom covered with reefs or ridges, since in such localities the water, even in the calmest seasons, is never in perfect rest, but always in motion, and broken into thousands of little streamlets and currents by the many obstacles which it encounters. Although pure, the water of these sections is always charged with infinitesimal particles taken from the mineral substances of the bottom, or ground up from the organic *debris* which is found here. These particles can be recognized without trouble when the rays of the sun penetrate down into the water, just as in a chamber the particles of dust in the air mark the ray of light which penetrates the room. In a word, in sections of this character the water makes mud but does not deposit it. It is this natural effect which it is desirable to have produced artificially upon bottoms covered with mud, first to clear the mud away, and secondly to prevent its return. In order to accomplish this a wall of broken and irregular fragments of rocks so disposed as to produce the greatest number of obstacles and checks to the action of the waves is built along the edge of the shore, at the extreme inner limit of the mud. The next day the success of the movement becomes apparent, the sea comes rolling in and breaking against the rocks, lashing them upon all sides; it stirs up the mud from the bottom and retires loaded with the sediment which it bears off with it, until all the mud along the base of the wall is gradually borne off to sea. A gain of ground having been thus accomplished, a second wall of breakers is formed outside of the first, and when the space in front of this is clear of mud, a third line is run around the second, and so on, breaker after breaker; by gradually driving the mud farther and farther into the sea, solid and permanent ground is obtained, which is visited by pure and aerated water, where oysters can be planted and where they can flourish unmolested; often upon such places a self-planting takes place, that is, the young, floating in the water after having escaped from some natural bed, finding the place in excellent condition for their reception, attach themselves to the rocks and form a new colony. When the deposit of mud is once completely broken up, the rocks, by the aid of which this result has been accomplished, will serve to prevent its return, and as all the rocks will not be required for this purpose some of them can be used as fixed pavement collectors, the advantages and disadvantages of which have been noticed upon a previous page. Certain of the walls may be entirely removed and shells and valves of diverse mollusks, found in abundance nearly everywhere, can be scattered about in the intermediate zones, or other collectors, either fixed or movable, may be employed in the spaces between the lines of breakers.

Sandy bottoms.—Sandy bottoms, if the sand forms a comparatively thin layer resting upon a sure and solid subsoil, so that the action of the currents, tides, and heavy seas is never intense enough to produce great changes, capable of covering up the oysters which may be placed upon them, are the best and may be worked without any fear. All that is necessary, when the oysters are planted, is to distribute a layer of shells over the bottom, and these shells sinking slightly in the sand will give it a certain degree of fixity, and, gradually consolidating by the attachment of oysters to them, will soon transform the entire bottom and even change it into a bed of great value.

Bottoms of grass or weeds.—Certain bottoms become invaded by an abundant submarine vegetation consisting of grass, various kinds of sea-wrack or algæ, including the *maërle.* In their natural condition these regions cannot be utilized for the cultivation of the oyster. By their presence these plants serve to entirely stifle both old and young oysters, and they moreover give refuge to multitudes of crustaceans, mollusks, and polyps, which gain their nutriment principally by feeding upon the young of other marine animals, or in the case of some mollusks, furnished with a boring tongue, they pierce the shell of the oyster and gradually eat out the soft animal parts contained within it. It is necessary, then, if one wishes to cultivate these bottoms and raise oysters there, to commence by dragging up all the parasitic vegetation upon them, and then, to prevent their reappearance, the entire bottom must be covered with a thick layer of shells and broken fragments of rocks, which must be pounded down nearly, if not quite, to the subsoil. But even then it will be well to keep a constant lookout over these bottoms, for marine vegetation has a strong tendency to reproduce itself in the same places, and holds its ground for a long time by means either of subterranean roots or of seeds. It is only by perseverance that they can be finally eradicated. Only after this has been accomplished can oysters be planted without danger of losing both the young and future harvests. What we have just said in regard to marine plants applies equally well to mussels when it is desired to replace them with oysters. Frequent dredgings will be necessary in order to remove the greater number of these animals, whose presence, moreover, nearly always coincides with a muddiness of the bottom, and necessitates, in this case, a cleansing of the bottom as indicated above. But the mussel is essentially rustic, if I may be allowed the expression, and accommodates itself to nearly all conditions of bottom, so that when the mud has been taken away and the mussels have all been scraped up, it will be none the less necessary to pay frequent visits to the collecting apparatus and carefully remove all the groups of mussels, large or small, which may be discovered. When the multiplication of the oyster is well assured, and it covers all the bottom without leaving any vacant places, this vigilance may be relaxed a little, for although the mussel, when it can invade a locality, is a redoubtable enemy to the oyster, the reverse is also true; and the presence of a bank of oysters in fine growing condition is sufficient to keep the mussels from such preoccupied grounds.

Emergent and non-emergent bottoms.—Finally, the marine oyster territory can be divided into *emergent* and *non-emergent* bottoms. The first are found all along the shores of the ocean and the British Channel, and consist of those lands which are left uncovered, either at every tide or at the spring-tides, thus exposing for a length of time to the air and light, which may amount to several hours per day, the marine animals which inhabit them. The second or non-emergent lands lie on the ocean coast and join the emergent lands. They are never exposed by the withdrawal of the water. Upon the coast of the Mediterranean and other inland seas, where the action of the tide is scarcely felt, all the lands are non-emergent. Both kinds are suited to the cultivation of the oyster, but to a variable extent, dependent upon circumstances. The emergent lands, since they are frequently uncovered, have the great advantage of facilitating all the labor necessary to their management, the sorting, the arranging, and the gathering of the oysters, all being done without trouble when the surface is free from water. But the oysters ought not to be arranged indiscriminately, old and young together, for a long sojourn in the air, exposed to the fierce heat of the sun in summer and the hard frosts of winter. The young oysters would surely perish by a too prolonged exposure where older oysters might exist without special damage. One should then, if possible, arrange to have in connection with his emergent lands a certain amount of territory which is never entirely exposed, and upon which the collecting apparatus with the young growth can be placed, and the younger oysters also deposited. Then as these oysters acquire a suitable size and the power of resisting external conditions they can be moved forward, first to that portion of the territory which is uncovered only a short time each day, then to where the water leaves it for a little longer period, and so on gradually advancing, until the oysters shall be arranged in a series according to age and size; the oldest, those destined for consumption, at the extreme inner limit attained by the sea, and the youngest at the farthest point cultivated, where the bottom is never exposed.

As the collectors furnish each year the germs necessary for the restocking of the outer zones, the young oysters in these zones, about one year old, should be passed to the next inner zone, and a rotation thus inaugurated, which would simplify and at the same time facilitate the labor. As for the lands which are never uncovered, and in this number are included all those of the littoral zone of the Mediterranean, oysters can be raised upon them, but they are more easily covered with mud, on account of the stagnation of the water at a certain depth, and it is on this account, or at least this is one of the principal causes of the absence of oyster beds along the coasts of this inland sea, except at certain places, as in the Gulf of Lyons, where the continuous agitation of the water, caused by the strong currents of this portion of the sea, prevents the deposition of mud. Of lands of this character one should choose those in preference where the water is not very deep, from one to two meters at the most, and employ the system of preparing the bottom recommended for muddy lands, in order that the obstacles placed in the way of the moving water may produce a constant agitation which will renovate the water and prevent all deposit.

There are a great many places in the Mediterranean where oysters can be raised with great success, and many of these require no previous preparation. I might mention, among others, the entire coast from Cette to Toulon, the coasts of Corsica and Africa, and the large salt lakes in the neighborhood of Montpellier and Cette, which seem to be vast natural basins especially constructed with a view to this industry.

But for all of these regions it will be necessary to add from three weeks to a month to the period already described as the spawning season, and the time for placing the collectors, &c., since the higher temperature and earlier season of this latitude cause the young to be hatched much sooner.

However, the non-emergent lands in general have a great disadvantage over the other, and the cultivation of the oyster can never attain the same perfection as upon emergent territory, since more labor and greater expense are demanded in the former than in the latter case. In fact, since they are always covered with water, all the previous labor of preparation, the management of the collectors, and the planting of the young oyster, in a word all the manipulations, must be made under water, which render the execution difficult and costly, if not impossible in many cases. Neither could the supervision be very effective, and the oyster-culturist would be obliged to leave his charges almost entirely to themselves, from his inability to cull, change, or distribute them at pleasure or when necessary. Only at the time of gathering could he obtain any exact idea of the success or failure of his undertaking, or the richness of his harvest. Concerning such lands as these, however desirable their cultivation may be from all points of view, it is best, perhaps, that the small oyster-culturist, to whom this book is especially addressed, should look to these bottoms only for his germs, and carry on the breeding and fattening entirely in parks or live-ponds, where, master of the water which fills them, he can easily follow his products in the successive phases of their development, and give to them, from time to time, and without very much trouble, all the care they may demand. The cultivation of the constantly submerged bottoms belongs properly to the State.

ARTIFICIAL BASINS.

Claires, live-ponds, parks, &c.—For a long time past the breeders of Marennes, at the mouth of the Seudre, have employed, for fattening and perfecting oysters, artificial basins called *claires*, a description of which we now propose to give. Recommended by a long experience, they seem to us, save for the necessary improvements which we shall mention, the best model to follow in the construction of artificial breeding-ponds. The claires are basins of variable form and extent, but generally with an area of about two to three hundred square meters (about the same number of square yards). Situated at a short distance from the sea, and with the waters they contain at a higher level than the mean height of ordinary tides, it is only at the period of the spring-tides, or at each new and full moon, that the sea rises to their level and supplies them anew with water. "The best claires are those which receive water periodically from the sea, during about three days before and three days after each highest tide. This period of renewal for the claires is that which experience has found to be the best, and it determines the maximum altitude above the sea for the construction of these reservoirs.

Around each claire is built a levee or dirt-wall, called a *yard*, about one meter in height and thickness. This yard retains the water filling the basin, and upon it the workmen pass to and fro in inspecting and working the claire. A flood-gate closes a sluice in one side of the wall, by means of which the sea water is admitted to the basin. This gate also regulates the height of water within the basin, and if desired, the basin can be entirely emptied by opening it wide. All around the inner circumference of the yard a continuous trench is dug, to receive the mud deposited in the basin from the stagnant water, for if this mud should be left in the basin the oysters would soon be smothered. In order to facilitate the clearing away of the mud into this ditch, a slight slope is given to the bottom of the basin, circumscribed by the ditch, from the center towards the borders, so that the surface is sensibly convex. Some breeders dispense with this ditch; in which they are probably wrong, for if it does not prevent the deposit of mud, it at least retards it and lessens its effect. Its use cannot be judiciously dispensed with, unless the water has a long distance to run from the sea and is given a chance to settle before being admitted to the claire.

so as to enable it to part with the greater share of the mud which it carries.

In order to prepare the ground of the claire for the reception of oysters, it must first be cleared of stones and all vegetation which may cover it, and then the necessary slope from the center towards the sides may be given it. The ditch is next dug and the yard thrown up. Then with the sluice-way made and the gate in place the claire is ready to be filled with water during the first high tide. When the basin is full the gate is closed and the water retained after the sea has returned to its ordinary level. The sea-water soon penetrates the soil of the claire, saturating it with salt, destroying all injurious germs, and transforming it, in a word, into a marine bottom. As soon as it is supposed that this effect is produced the gate is opened and the surface paved; that is, it is first smoothed over, and then pounded until it has the even, compact appearance of a threshing-floor. In about two months the bottom of the claire will be ready for the reception of the oyster. The breeders to supply these claires have, up to the present time, had recourse to oysters taken directly from the sea, either from banks near at hand or along the coasts of Brittany, and brought in bulk in coasting vessels. In order that the products should be of a good quality and that the regimen of the claire should have a beneficial influence upon the oysters contained therein, it is necessary that they should not be older than from fifteen to eighteen months, or larger than from five to seven centimeters in diameter (about two inches). The breeder culls them, cleans them, chooses the best-shaped ones, and then scatters them with a shovel over the surface of the basin. Afterwards they are all arranged by hand so that nothing shall hinder their development or interfere with the opening of their valves. In this manner about 150,000 can be accommodated upon a hectare (about 2.41 acres) of surface. The claire is then filled with water, which is maintained at a uniform depth of 30 to 35 centimeters. This water, as has already been said, is renewed only at the spring-tides, and at this time the water in the claires is necessarily very much raised in level, and consequently the most active supervision is necessary, for the heavy pressure upon the dikes may produce breaks or fissures which it is necessary to repair immediately or widespread disaster may result. During cold or hot weather or sudden changes of temperature the breeders maintain the water in the claires at a higher level than the ordinary, in order to obviate the destructive action of the frost in winter or the rapid evaporation and heating of the water in summer. Nevertheless, the construction of the claires does not always permit of accidents from these causes being guarded against, and sometimes the result is an enormous mortality and the ruin of the breeders. Moreover, the water by remaining in the same basin necessarily deposits there a certain amount of sediment which continually accumulates, being added to at each high tide, and especially during the equinoxial tides, thus placing the oysters in no slight danger. To remedy this evil, since it is impossible to prevent the deposit of mud, the breeders always have certain unoccupied claires into which they transfer the oysters from the muddy claires while these are being cleaned. After a thorough cleansing they are left empty until it becomes necessary to clean the other claires, when the oysters are transferred back to their old quarters. But certain of the breeders, not willing to allow portions of their land to lie unproductive, content themselves by cleaning the bottoms and then replacing the oysters in their old inclosure, always soiled with mud. It is useless to enumerate the defects of this practice, which can only produce inferior results both as to quality and numbers.

Such, in a few words, is the industry of the breeders of Marennes, and it is this which we shall take as a guide, if not as a model, for debarring certain imperfections, it presents the most rational and best combined principles. If the breeders were in the habit of obtaining the germs necessary to restock their claires from the claires themselves, if they had constructed their ponds so as to be able to raise the level of the water contained in them from one and one-half to two meters, and had subjected the water from each tide to a certain amount of stagnation before entering the claires, so that it would carry with it as little mud as possible, there would be nothing lacking in their methods; it would simply be necessary to copy them. Let us profit, then, by all that is valuable in their industry, such as it is; let us borrow from the claires all that can be borrowed, all that long experience has proved efficacious, and then add the improvements suggested by our recent studies, and with these elements combined we shall have an excellent guide for the future service of breeders in constructing and working their claires and live-ponds. A claire or live-pond can be established upon any ground where the altitude above the level of the sea is sufficient to enable it to be covered by the tide, not every day, which would expose it to a too frequent deposit of mud, but at least twice per month and during five or six days each time. And as a breeder should never be content with one claire, however small his establishment may be, a series of basins can be made, either in one or two rows parallel to the coast, along the surface sloping to the sea, and all having the same level. It would not be prudent, however, to have so many that it would be necessary to place them at different levels, or in the form of steps, since in this case the lower ones would receive water more frequently, and even be submerged and exposed to a more frequent deposition of mud, while the upper ones would receive very little water. But if it becomes necessary to construct claires in a series of steps at different levels, either because of a restricted amount of surface, or to utilize pre-existing basins, they ought never to be used indifferently for oysters of all ages, because the conditions offered by the upper basins would be much more favorable for young oysters, and only when they have attained a certain size and a greater degree of vitality should they be placed in the lower apartments. The soil of the bottom of the claire demands, according to its nature, different kinds of treatment. If it is argillaceous or muddy it should be cleaned and leveled, leaving the central portion higher than the borders, then pounded to give it solidity, and finally covered with water until the bottom is thoroughly saturated, when the water can be allowed to run out, and the bottom once more pounded while it is drying. If the bottom is sandy it is necessary to render it impermeable, so that the water may not leak out, and also to consolidate it. To accomplish this the ground is worked over and covered with a layer of coarse gravel or fragments of shells, upon which is laid a layer of clay 30 to 40 centimeters (10 to 12 inches) in thickness, which is then treated as already mentioned for the marly bottoms. A bed of concrete answers the same purpose, and while it is more costly it is more durable. A pavement of blocks of sandstone or porphyry, &c., similar to those which are used in the pavements of certain of our cities, carefully pointed with clay or hydraulic cement, will also make an excellent bottom. But the clays, especially the reddish clays and the bluish marls, should be preferred in all cases where one wishes the oysters to possess the greenish tint to which the oysters of Marennes owe their celebrity. Surrounding the ground thus prepared are built the dikes which are to retain the water in the basins. These should be at least 2 meters in height above the bottom, so that a depth of water of from 1.50 to 1.80 meters can be maintained over the oysters, not all the time, as generally a depth of from .35 to .50 of a meter is best, but when it is very cold to prevent the injurious effects of frost, and when it is very warm to prevent the water becoming too salt from evaporation. These dikes should be constructed very solid, so as to resist the great pressure which is brought to bear upon them at every spring-tide, and should also be covered upon the inside, the same as the bottom, with a layer of clay or hydraulic cement, so as to prevent all leakage, which is very disastrous in these basins, since the water is renewed only at long intervals. Since these earthen dikes are liable to be injured, making it necessary to go to the expense of frequent repairs, it would be best, in my opinion, to construct them at first in masonry of rough stones and cement, and give them solid foundations. The upper portion of the larger of these dikes should be sufficiently broad and firm to permit the workmen to traverse them easily and without danger, for all the necessary manipulations of working and inspection. If the height of the ground permits, these claires can be formed by excavating in the solid earth, in which case it will only be necessary to cover the slopes of the banks with a layer of stones set in cement. This system moreover will allow of the utilization of lands slightly above the level of the tides, so that by uniting the two systems one can arrange three or even more rows of claires all upon the same level.

As to the expense of construction, I judge it will be about the same for the two methods, the excavation in the one compensating for the masonry in the other. Finally, to avoid or at least retard the deposit of mud, resulting from the stagnation of the water, the claire should not receive a new supply of water from the sea without giving it a chance to deposit the greater part of its sediment, which can be accomplished by keeping it for a certain length of time in a special basin. These basins themselves might be made of service by providing them with gates and sluices, and using them as breeding or fattening ponds for mussels or other marine animals. Fig. 18 gives a bird's-eye view and

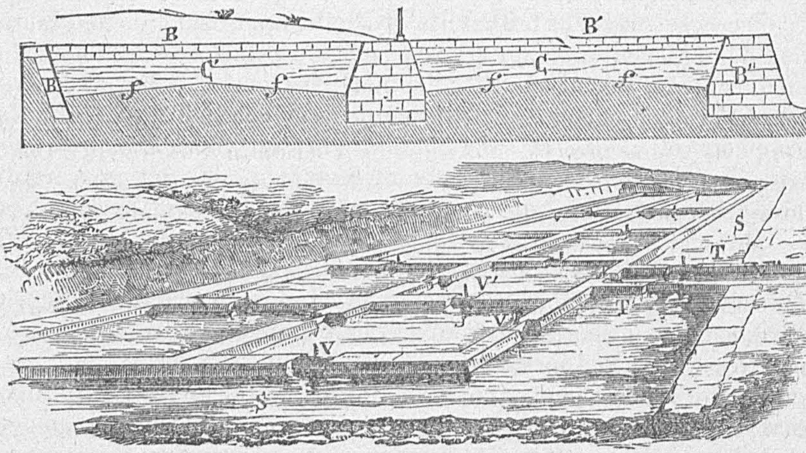

FIG. 18.—Claires. Vertical section, and bird's-eye view.

also a cross-section of two rows of claires with their feeding and purifying basins. The following explanation will sufficiently explain all the details given. C, C′ represent two claires seen in section, the one dug into the bank, the other on the same level but nearer the open water. The sides or slopes of the former, B, B, consist of a layer of rough stones cemented together; the sides B′, B′ of the second are formed of thick walls, about two meters in height above the bottom of the claire, and about 1.40 meters in thickness at the bottom and .75 to .80 of a meter at the top, with an equal slope upon either side, *f*, *f*, of the bottom of each claire, the center being higher than the sides by about .30 of a meter.

V, V, sluices and gates for the entrance of water from the sea.

V′, sluice and gate between two of the claires, to allow the entrance of water into one, only after remaining a certain time in the other, and to establish the same levels in both compartments.

S, basin for the deposit of the sediment contained in the sea-water which enters through the gate V″. It can also be used, if desired, as a supply reservoir, for the claires during the intervals between the spring-tides. In this case it should be constructed in the same manner as the claires themselves, so as to retain the water stored in it. Otherwise it will only be necessary to make the dikes of dirt. In any case it ought to be proportioned in size and capacity to the claires which it supplies.

T, T′, canal through which the water enters from the sea.

By the aid of the sluice-ways and gates in this canal the water can be admitted directly into the claires without entering the outer basin at all. This could be done in case the outer basin were utilized for the rearing of mussels and there was danger of the spawn of the mussels entering into the claires at the period of reproduction.

CHAPTER IV.

METHODS OF WORKING THE CLAIRES.

Now that enough has been said in relation to the apparatus for collecting the young growth, and the construction of the breeding-ponds, there remain only a few words to be said concerning the method to be followed in commencing and continuing a profitable artificial oyster culture. First, it is necessary to construct the breeding-ponds which, for the sake of greater precision, we call *claires*, taking as a basis for their extent the proportion of 1,000,000 oysters to the hectare or 100 per square meter, a proportion which, if it is desired simply to raise oysters, can be carried to 500 or 600 per square meter, or 5 to 6 millions per hectare; this is the proportion in the parks of the island of Ré. During their construction, and in order to stock them as soon as they are completed, the young growth is procured by means of the collecting apparatus already described, or by some of the other forms, preference being given to that which will answer best for transportation, &c., according to the distance to be traversed from the spawning locality to the breeding-pond. As six months of time at least must elapse after the young growth have become attached to the collectors before they can be transported with safety, the two operations, of constructing claires and gathering the young, ought to proceed simultaneously. It is in June that this work should be undertaken in the ocean and a little earlier in the Mediterranean. When the claires are finished, and have a layer of pure and fresh sea-water over the bottom, the oysters which have been brought upon the collectors should be distributed as evenly as possible with a shovel, and afterwards arranged by hand, so that they may not form piles in certain places, and be entirely wanting over other sections. As the oysters should not remain in the same basin during the entire period of their growth, and as the young detached from the collectors are very small, they can be easily so arranged that three or four hundred can be accommodated upon a square metre of surface, and afterwards, as they increase in size, they can be separated, so as to give more room to each. The time of this labor should be chosen so as to end, if possible, at the period of a spring-tide, in order that the young oysters, placed upon strange soil and in strange water, may be promptly refreshed by the incoming tide, and covered with a layer of water sufficiently deep to prevent any abrupt change of temperature. During the entire first year it will be well if the water never has a less depth than about one meter, and a strict guard will be necessary to maintain the dikes in good condition, repair all breaks, look out for the deposit of mud, and if any takes place change the oysters to another claire without delay. Later, in proportion as the oysters increase in size, and are less affected by external changes, this constant oversight can be relaxed to a certain extent, but not entirely, and the level of the water may be lowered to from .50 to .30 of a meter, always taking care, however, to increase the depth to 1.50 to 2 meters during very cold or very warm weather. It will be readily understood with how much caution the level of these basins should be lowered, when it is remembered that it is only possible to fill them again at quite long intervals, eight to ten days generally, during which time, especially in spring and autumn, great changes of temperature may take place, exposing the oyster to evils against which there is no remedy. For young oysters, and especially during their first years' growth, the most formidable enemy is mud. We have already spoken of transferring the oysters from a basin where the mud has accumulated or is being rapidly deposited to another which is free from mud, but this measure, which is excellent for oysters somewhat advanced in size, is not always satisfactory for the very young individuals; and besides, at certain seasons of the year the temperature would render such a change impracticable. I would counsel the breeders then to use for the first year frames of galvanized iron, about two square meters in superficial area, covered with a netting of galvanized iron or zinc wire, having meshes of such a size that the young oysters could not fall through. These frames could be supported upon four or eight legs from .20 to .30 of a meter in length, and arranged side by side in rows over the bottom of the claires, thus forming a double bottom with a space between the frames and the soil sufficient to accommodate the mud, which would then never trouble the oysters upon the frames. They could be left in this position the entire year, without disturbing them. After this time they should have sufficient natural vitality to be handled without danger, and could be placed upon the bottom of a fresh claire. Thus in the rearing of oysters, since five years are required for an oyster to become of marketable size, it will be necessary to allot five claires to the rearing of one generation, and to establish a series which shall render the production continuous. One claire in five should, therefore, be provided with the wire tables mentioned above. The necessary expense of their construction and introduction would be compensated by the decreased cost of manipulation and attention, and the greater production from the claires. The employment of these frames would be nearly indispensable for basins along the shores of the Mediterranean, which, nearly always covered by the sea, are more liable than others to be covered by a deposit of mud, which can be cleared away only at considerable expense. During the first three or four years of such an enterprise one should, in order to procure the young growth necessary to restock the claires left vacant by the preceding generation, have recourse, as at first, to the movable collectors and bring the young from some natural bank; but as soon as a generation of oysters becomes adult, and consequently capable of reproducing the species, the claires themselves ought to produce all the young necessary to furnish the ponds with a constant supply of animals. To accomplish this, about one month before the spawning season collectors are disposed in those claires containing the adult oysters, it having first been ascertained that these oysters are nearly ripe. The collectors are chosen at the convenience of the breeder, according to the means and resources of the country where the claires are situated, and become charged with young just the same as over the natural beds at sea, since before being taken from the ponds for market the adult oysters leave there a numerous progeny to replace themselves; as the germs produced are always vastly more numerous than the oysters which produced them, if the breeder does not desire to extend his industry and increase the number of ponds, collectors need be placed only in one or more of the ponds containing adults, so that the demands of commerce can always be satisfied during the five or six months required to charge the collectors. Experience proves the efficacy of this process. Many times, despite the defective condition of their claires, the breeders of Marennes have witnessed their basins, depleted by a wide-spread mortality, unexpectedly repeopled from a few oysters which had survived the disaster, the young developing upon the shells of the dead oysters; the shells in these cases acted as collectors to retain the germs which otherwise would have perished or been carried off by the first spring-tide.

It is perhaps to be wondered at, and even regretted, that such facts should not have caused the breeders to see the immense advantage of making their basins places of production and growth, as well as fattening establishments. To-day, thanks to the light thrown upon this question by the researches of M. Coste, the oyster industry can be raised above the condition in which it has been kept up to the present time, by routine and indifference, and spread along our coasts, which have been threatened with misery and depopulation; the consequences will be an eminently remunerative industry and a permanent source of labor, which will attract to our coasts numerous and robust men, the future hopes of our naval and commercial marine. A few figures, not chosen by chance, but selected as a possible minimum, may serve to prove to my readers that I have not exaggerated in qualifying the new industry as highly remunerative, especially when it is called to mind that the lands upon which this industry is carried on are nearly valueless and unsuited to any other sort of cultivation.

The price of a hundred oysters of the Marennes variety varies from 1½ to 6 francs. Let us then adopt the price of 3 francs, which is less than a mean, as the average price per hundred. Upon a square meter of surface in a claire we can raise from 60 to 80 oysters, and if we take the minimum at 50 it will give us upon a hectare of surface 500,000 oysters, which, in about five years (average time of growth), would be worth, at 3 francs per hundred, the sum of at least 15,000 francs, making a yearly revenue of 3,000 francs.* Admitting what is evidently above the truth, that the expense of labor, repairs, supervision, &c., absorbs three-fifths of this revenue, then the net profits would be 1,200 francs per hectare, or for the five years 6,000 francs. But these calculations are based, as will be recognized, upon mean numbers, which are probably lower than facts would demand. It will readily be seen, then, that in five years a landed property of the value of at least 6,000 francs a hectare per year can be established upon lands which before were unproductive and of no value. I think it can be said without danger of exaggeration that there are few, if any, rural occupations which in so short a time will give equal results.

As to the decrease in price of oysters consequent upon the increased production of this mollusk there is nothing to fear at present.† Thanks to steam, the oyster can cross our entire continent without becoming dry on the way. Our coasts are called upon to answer the demands not only of all France, but of other countries. The demands for a long period have been greater than the supply, and we are too far as yet from the time when the supply shall equal the demand to include this among the risks.

CHAPTER V.

CULTIVATION OF MUSSELS.

In the preceding chapters, in treating of the rearing of oysters we have said, that the only bottoms upon which such an enterprise could not be prosecuted with chances of success were those where the mud was so deep and well established that there could be no hope of getting rid of it. These places, very numerous upon our coasts, in the coves and small bays formed at the mouths of many rivers, where the mud is deposited both from the waters of the sea and from those coming from the land, can nevertheless be made of service. Unfit for the home of oysters, they are very well adapted to mussels, which, aided by certain simple and inexpensive processes, can acquire there a size and flavor very much superior to those of the sea-mussel. For this industry, as for that of oysters, we have the experience of the fishermen of the Aiguillon, where this industry has existed since the thirteenth century, when an Irishman, named Walton, was shipwrecked upon the rocky point of

* In 1863, on the island of Ré, a sailor named Moreau sold the first gathering from his park, which contained only 500 square meters, for 1,300 francs, making the revenue 26,000 francs per hectare.

† On the island of Ré the first sales were made at 15 to 20 francs per thousand; to-day the price is 30 to 35 francs for the same quantity.

Escale, near the port of Esnandes, and founded here the first *bouchot* or fishing-crawl. Thrown by the tempest upon a barren coast, among a scattered and indigent people, without hope of again seeing his native land, Walton at once sought means of existence by hunting marine birds. The bay, or rather cove, of Aiguillon is only a great mud-flat, a vast lake of mud, where, at low tide, one cannot travel with safety. It was on this bottom, nevertheless, that Walton made his domain. In order to traverse this flat without danger and at all seasons, he constructed a sort of "pirogue" or wooden box 8 or 9 feet long, bent up in front, square behind, and flat upon the bottom. This "acon," or flat-bottomed boat (Fig. 19), is still used by the fishermen, successors and imitators of Walton.

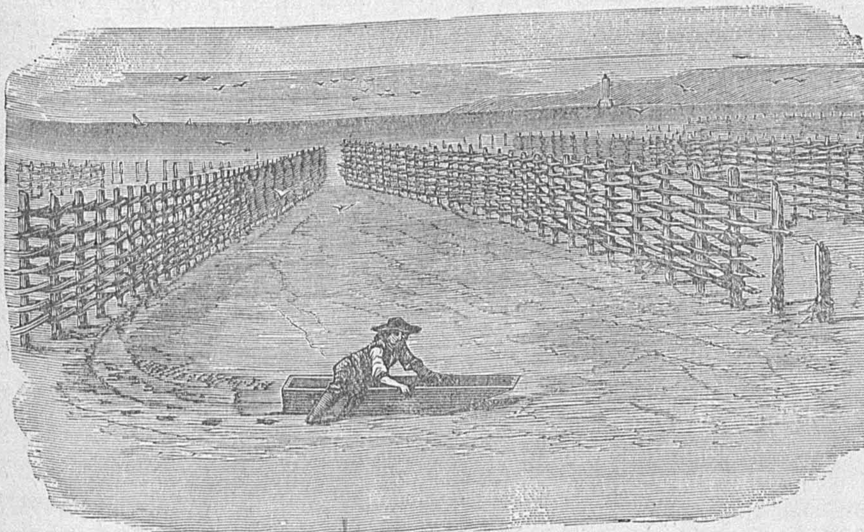

FIG. 19.—Fisherman in his "acon."

In using this boat to travel in various directions over the flat, the fisherman places one knee in the boat near the hind end, and then with his hands upon the sides he pushes himself along with his other leg, which is covered with a long stout boot, and remains outside the boat, acting as a pole to impel it over the mud. In this manner the fishermen can proceed very rapidly in any direction where their labor may require them. In the vacant portion of the box he places his tools, or necessary materials, and whatever he may have gathered in his labors, and transports them without much fatigue. Furnished with this ingenious apparatus for locomotion, Walton planted stakes about in the mud, by means of which he spread vast nets, in whose meshes he caught those aquatic birds which in skimming over the flats flew across these lines of nets. But soon Walton noticed that the stakes which sustained his nets became covered upon those portions just above the mud which were under water at every tide, with great numbers of mussels, which very rapidly attained a size much superior to those in the mud only a short distance away, and also a much superior flavor and delicacy of meat. This was a revelation to Walton. Thence to the establishment of the first of the five hundred crawls or mussel-frames, the revenues from which have brought ease and comfort to those countries, was but a step; and it is the crawl of Walton, for it is constructed to-day just as he constructed it, that we shall take as a guide and model in the study forming the subject of this chapter. If, as in the cove of Aiguillon, the raising of mussels is undertaken upon emergent lands belonging to the domain of the sea, the arrangement of apparatus adopted by Walton is the best for the purpose, since it gives sufficient stability to enable it to withstand the shocks of the waves and boats, and the force of the wind. The apparatus is in the form of a V, with the point turned towards the sea. Each wing is built of a row of stakes interlaced with a wicker-work of flexible branches or strong pieces of osier or chestnut. The stakes are trunks of trees in their original condition, 4 to 5 meters long and .30 of a meter in diameter, driven into the mud half of their length, and placed at a distance apart of from .50 to .60 of a meter. Together they form a palisade from 2 to 2.50 meters in height above the mud. The branches forming the wicker-work, and for which as long branches as possible are chosen, are woven upon the stakes like the osiers of a basket or gate. This wicker-work covers the stakes without leaving any vacant spaces from the top to within about 15 to 20 centimeters of the bottom, in such a manner as to allow, during ebb and flood tide, a free circulation of the water at all times, so as to avoid the deposit of mud at the base of the stakes.

The points of contact between the branches of the wicker-work and the stakes constitute the only support or fastening between these two parts, and to make this fastening as firm as possible, so that there will be no sliding of the wicker-work down the stakes, care should be used in spacing the stakes, and the branches of the wicker-work should be woven as tightly as they can be drawn. But they should not, nevertheless, be brought too close together, for they would thus present too many obstacles to the movement of the mud and thus cause deposits, which, by their rapid increase, would very soon seriously interfere with navigation and endanger the apparatus itself. The mean distance of from .50 to .60 of a meter is the best. The length of the palisades or wings of the V can be varied at will.

The length of the crawls of Aiguillon is, upon an average, from 200 to 250 meters; but this length, which is justified by the condition of the surface upon which they are built, ought to be regulated so that the sides of the V shall occupy about one-fourth of the distance between the extreme limits reached by the water at high and low tides. Upon all emergent lands those portions nearer the sea are much less often uncovered than those toward the shore, so that while the former are covered every day with a layer of water several meters in depth and are dry for only a short period, the latter are covered by a layer only a few centimeters in depth and remain dry for many hours. Hence there are diverse conditions of life for the animals which inhabit these different zones, and there results the necessity of constructing the crawls or palisades in series along the slope of the shore so that the sea will visit them less and less in proportion as they approach the inner limits of the water. The fishermen of Aiguillon call those crawls which are farthest out in the sea, and which are uncovered only by the lowest tides, low crawls; the two next inner rows are called false crawls, and those nearest the land, and consequently uncovered most frequently, high crawls. The outer line is generally formed of single posts (Fig. 20), without any wicker-work whatever, and the posts are somewhat nearer together than in the line of palisades. They serve especially as collectors of the young growth. In fact, at the spawning period they arrest, in the zone in which they are planted, the young which are being swept out by the tide, and offer to them, owing to their nearly continuous immersion, a more secure and appropriate protection than the other collectors, where they would frequently be left out of water.

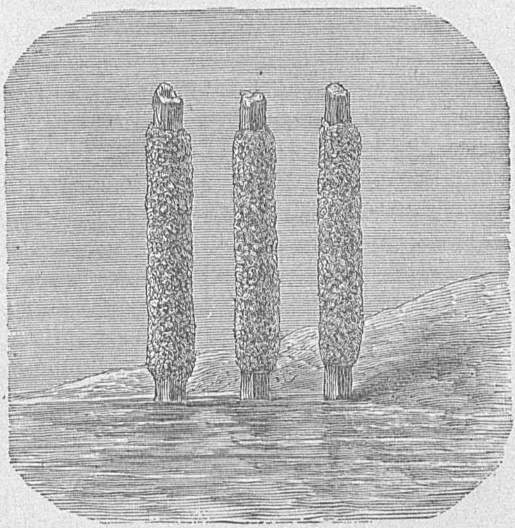

FIG. 20.—Low crawls. (Bouchots d'aval.)

The fishermen thus resort to these outer posts for the seed necessary to supply the false crawls. To obtain this the workmen go about the month of July, at the beginning of the spring-tide, to detach the young, which are about the size of a bean, having been spawned in February and March. They are detached from the posts, in bunches, by means of a hook-shaped instrument, and are gathered into baskets and transported in the small foot-boats to the false palisades, to which they are then attached. In attaching them, the bunches, formed by the adherence of the byssus to the shells, are inclosed one by one in a bourse of old twine and then tied in the interstices of the wicker-work, being equally distributed, so that nothing shall interfere with their future development. Soon the net which incloses the mussels disappears, but it has become useless, the mussels being by this time firmly attached by their byssus to the branches of the wicker-work. In a short time, by a continuous and rapid growth, the mussels cover the entire palisade or trellis in a dense layer of clusters, in which one can scarcely find a vacant space (Fig. 21). When, finally, this increase in size threatens their further development, they are detached, and transferred to palisades still nearer the shore, for by this time they have acquired sufficient vitality to endure frequent exposure to the air. They are fastened in their new positions in the same manner as at first, or, perhaps, only saddled upon the branches, where they remain until they have attained a marketable size, which takes place in about a year after this last change. At this period, when they are strong enough to endure an exposure of several hours every day, they are transferred to the high crawls, to give place to the next generation, and also to have them at hand to supply the demands of consumers. Thanks to this system, the reproduction, rearing, gathering, and sale go on simultaneously and without intermission. But it is from July to January that these transactions are carried on and the mussel is most esteemed as food. In February the spawning season begins, after which they are poor, tough, and not desirable. Those mussels are also much superior in quality which grow on the upper portion of the hurdles, while those which grow close down to the mud are more like the sea-mussels in flavor. Such, in a few words, is the history of the industry founded by Walton upon the flats of the bay of Aiguillon, an industry which has continued to the present time and extended gradually to all portions of the bay, occupying an area of 8 kilometers, with a length of hurdles of 225,000 meters, averaging 2 meters in height, and bringing ease and comfort to the surrounding communities of Esnandes, Charron, and Marsilly.

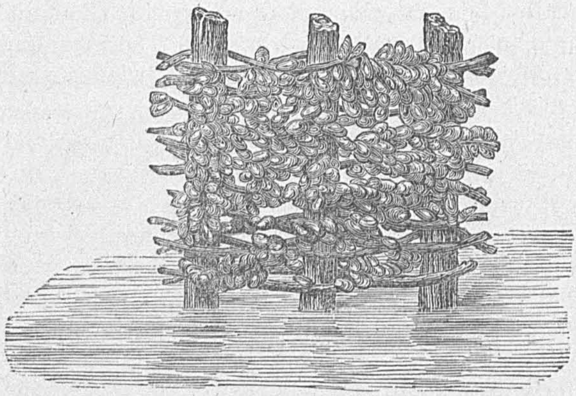

FIG. 21.—False crawls (bouchots bâtards) loaded with mussels.

According to M. D'Orbigny, the elder (*Les habitants des communes de l'anse de l'Aiguillon*, &c., La Rochelle, 1835), each crawl or double hurdle costs for construction 2,049 francs; the demands for labor, supplies, and inspection are 1,136 francs, and the production each year from the sale of mussels 1,500 francs, making a yearly gain from each crawl of 364 francs, upon a yearly capital of 3,185 francs, the legal interest of which at 5 per cent. would be only 159 francs.

It must be admitted that there are few classes of labor where the return for capital invested is at the rate of $11\frac{1}{2}$ per cent. The methods invented by Walton, and imitated by his successors, are so simple, so rational, and so well adapted to the nature of the lands occupied, that it would be somewhat difficult to find anything to change or improve upon. All possessors of emergent lands can thus, by carefully imitating these methods, arrive at the same or similar results, and there remains nothing for us to say in addition to the preceding description. But the emergent mud-flats are not the only ones upon which the rearing of mussels can be successfully undertaken. As a rule, this ought to be accomplished upon all bottoms and in all basins, whether natural or artificial, where the deposit of mud renders the cultivation of oysters impossible, and it is not only possible but advantageous to combine the two methods or kinds of culture, especially when the rearing of oysters is carried on in the claires described in a preceding chapter. This would be an excellent method of utilizing the stagnant basins, in which the water from the sea frees itself of sediment before being admitted to the claires, and which as a result of this use are necessarily muddy. In these basins, and in all of those which are dug for the purpose of rearing mussels, the hurdles would not be exposed, as in the bay of Aiguillon, to the fierce action of the sea and to the thousand other conditions which demand attention. Hence it would no longer be necessary to arrange them in the form of the traditional V, but they might be placed in parallel lines according to the shape of the basin, leaving between each two rows sufficient space to pass in working them. A gateway in the basin would permit the regulation of the height and the renewal of the water at pleasure, or allow it to run dry when necessary to aid in working the hurdles. By combining this culture, with that of the oyster, the breeders could more than cover the expense, always considerable, of digging a basin for purifying the water and a canal to lead this water to the basins, an expense which the breeders with reason often shrink from, yet which ought to be considered indispensable to complete the breeding arrangements. In case the two kinds of cultivation are united, that of oysters in the claires and that of mussels in the purifying basin and entrance canal, the only precaution to be taken, to avoid injury to the first by the second, will be at the spawning time of the mussels to avoid using the water from the outer basin to supply the claires, for in such a case the claires would become filled with great numbers of mussel-germs, which would thus tend to supplant the oysters. This result can be easily obviated by arranging upon the sides and outside the basin of purification a small body of water communicating upon one side by a gate with the entrance canal, before its entrance into the basin of the mussels, and upon the other with a claire, which, during a certain period, can play the rôle of basin of purification. (See explanation to Fig. 18, page 54.)

In Fig. 18, the purifying basin surrounds the claires and each one communicates with it by a sluice and gate. If it is desired to raise mussels in this basin, these gates can be placed between the canal and the basin and between the canal and one of the claires, so that with the gates of the basin closed the claire can be used as a basin of purification for the time being, and the spawn from the mussels prevented from entering where the oysters are. This arrangement will be necessary only during the spawning period of the mussels, that is, from the end of

February to the end of April, two months and a half at the most, and this portion of the year in France is generally cool and rainy, so that the claires, frequently refreshed by rains, need then less than at any other season a renewal of water. Moreover, if one is under the impression that the too frequent use of the canal causes deposits of mud in the claires, it need be employed only when it is absolutely necessary. The use of wood, such as osier or chestnut, for the wicker-work generally gives excellent results, and its renewal is not relatively very expensive. It may be, however, that from its scarcity, or from having to be brought too far, or from the presence of boring animals in the water, its use is not advisable; in such cases the wood can be replaced by frames of galvanized iron, covered with a trellis of iron or zinc wire, woven coarse or fine according to the age and size of the mussels which are to be placed upon it. In order to fasten the frames it is well to attach them to two posts firmly driven into the ground at a distance apart equal to the length of the frames; or better, the frames can be entirely immersed in the water and suspended vertically by means of floats, or held by chains or ropes stretched from one side of the basin to the other and worked by capstans, so that they can be raised or lowered at will according to the level of the water and in order to facilitate the labor of caring for them. This method presents this great advantage that all the manipulation, the building of the trestles or frames, the changing and gathering of the mussels, &c., can be effected without letting the water out of the basin. When desired the frames can be partially raised from the water by means of the cables, and then taken on board of a boat carrying the workmen, and after they have been either loaded with or deprived of their mussels they can be placed in the water without any derangement of the neighboring apparatus. Moreover, the mobility and independence of each frame will considerably facilitate all changes, cleaning, or repairs which it is necessary to make.

It is, perhaps, unnecessary to remark that this system is equally applicable to frames made of wood and filled in with wicker-work. When such frames are used it will only be necessary to anchor them with stones fastened to one side, so as to maintain them vertically under water. The fundamental principles of this kind of culture once fairly understood—and the preceding descriptions have, we hope, been sufficient for that—nothing can be easier than to modify the apparatus as to form and material to accommodate it to the thousand various conditions of each particular locality. But here we must leave the breeder and allow his ingenuity full sway, guided by the experience which he will acquire after a few years of labor, and which will be of much more help to him than the superabundance of details with which we might fill the rest of this chapter. We will only add a few words upon the different methods of procuring the young animals necessary at the start, and of renewing each year the young stock needed to enable the basins to meet the demands of consumers by the sale of the adults.

The sea is the place to go for the germs, and the most simple collecting apparatus is the low crawls or solitary posts employed by Walton. Stakes are planted towards the beginning of the spawning season in those sections where mussels are known to exist. Then, after several months, the stakes are pulled up and the groups of young mussels covering them used as the first supplies for the hurdles or frames. If upon the coast where the basins are built or where it is desired to establish this industry, mussels are so rare that there is no hope of gathering a sufficient number of young ones upon the stakes, a circle of stakes can nevertheless be formed, planting them from 10 to 15 centimeters apart, upon that portion of the bottom which is uncovered perhaps only twice per month, and then suspending to them, at a short distance above the ground by means of netting or twine, clusters of adult mussels which have been gathered from the sea just before the spawning season. The mussels thus imprisoned within the circle of stakes will spawn just as plentifully and in better condition than if left upon the sea-bottom, and the spawn as it encounters the stakes, which prevent its dissemination throughout the water, becomes attached to them; in this way a numerous progeny can be gathered and transported to the prepared hurdles when they have reached a suitable size for handling.

After the basin has been once planted it may be made henceforth to furnish its own supplies, and this it will do with much more certainty since all the spawn is obliged to remain in the basin; thus if one utilizes the purifying basin for mussels all communication between the claires and the basin must be cut off during the spawning season of the mussels. Stakes planted here and there will suffice to collect a sufficient quantity of the young, and the hurdles or frames to which the adults are attached will also be covered with a young growth, for in these artificial basins the water is nearly always at the same level, and the hurdles are never uncovered, as happens at sea; hence the spawn will not be liable to perish from too long an exposure to the air, but will thrive wherever it may become attached.

One can also make use of a very simple and ingenious apparatus which fills the double office of collector and hurdle or frame. It consists of a raft (Fig. 22) formed of a variable number of pieces of wood, according to its size. To this raft between the stringers and in the direction of the length of the frame are attached, like the slats of a blind, pieces of planks, or, better still, wicker-work frames, about 30 to 40 centimeters in breadth (10 to 12 inches). They can be made to turn upon their axes so as to take any desired inclination, or they can be suspended by one end, as shown in the figure. After floating a raft of this kind, with the planks or hurdles suspended vertically, in the water where the mussels are spawning, it can be carried into the breeding basins when it has become covered with germs, and the rearing go on without any other care than to replace the planks or wicker frames lengthwise of the raft, and change their inclination now and then to remove the mud which may have settled upon them. The only disadvantage of this system is that the planks or frames, the latter especially, decay quite rapidly by a continuous stay in the water, frequently causing the breeder the loss of his harvest or obliging him to entirely renew his apparatus.

And here one cannot replace the wickets with metal, since the spawn of these mollusks will not voluntarily attach themselves to metal. So this apparatus will have to be used simply as a collector, and in numer-

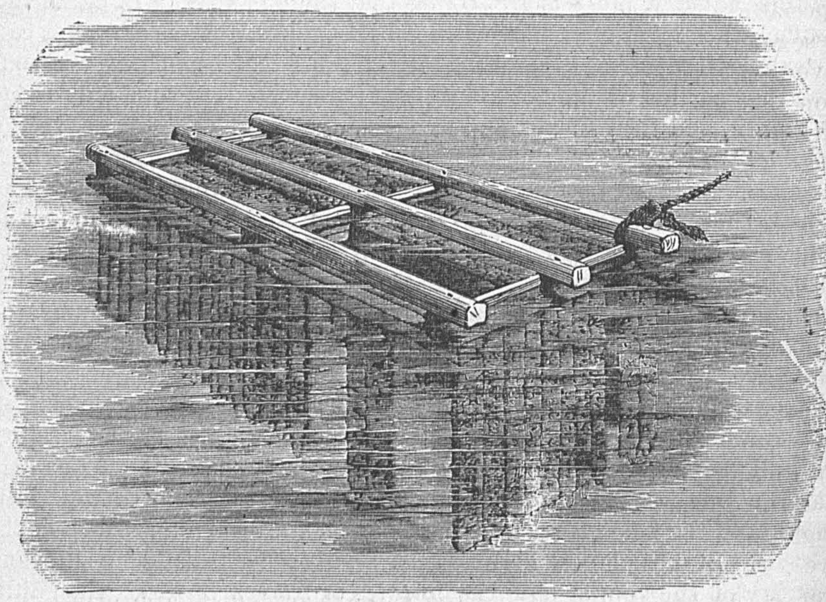

FIG. 22.—Raft collector.

ous cases it can be of great service to breeders, when, for example, the requirements of navigation do not permit the use of fixed apparatus. It can also be employed with success in the culture of oysters, when, because of the deposit of mud, they cannot be placed upon the bottom of the claires. In this case the rafts, covered with young during the spawning season, can be floated at the surface and the mobility of the frames or slats will allow of the oysters being kept free from mud while the condition of light and heat may be varied at will.

CHAPTER VI.

REARING OF LOBSTERS AND OTHER CRUSTACEANS.

In order to accomplish the task which we have undertaken, it now remains for us to speak of the processes which can be employed in the multiplication of crustaceans, such as crabs, lobsters, and the like. While the efforts at artificial reproduction and multiplication of crayfish in fish-ponds may be successful, and while the fecundated eggs of the cray-fish deposited upon wicker frames in hatching-ponds and constantly bathed with a stream of pure running water, may give birth to hundreds of little cray-fish, which need only to eat and grow, we cannot advise the same methods for the reproduction of the larger marine species, like the rock lobster and the common lobster.

We have already said, and we repeat it now, that these species reproduce in the sea in sufficient quantities to supply all the demands of consumers, especially now that, by reason of the reports of M. Coste concerning these affairs, already cited, the laws governing the fishing of crustaceans have been modified in such a manner as to respect the females at the proper season, and prevent the destruction of young individuals until after they may have exercised, at least once, the function of reproduction. Thanks to these modifications, while the numerous natural causes of destruction will always exist, as they have existed throughout all time, without having caused the disappearance of crustaceans from a single point of our coast, it is more than probable that the preservation of these species is henceforth assured.

There is, moreover, no incentive, unless it may be from a purely scientific point of view, to undertake their artificial rearing, which would probably find a great obstacle in the vagrant and especially pelagic character of the germs of the lobster during their first transformations. But among those taken in the nets of the fishermen there are always a certain number which, although of regulation size, are so much smaller than the others that they sell in the market per dozen at the price of a single one of twice the length, and this price is far from being remunerative. Moreover, the fishing, formerly allowed throughout the entire year, is now prohibited during the three months of March, April, and May, the spawning period, and if the incessant demands of commerce would allow, it should be extended through the entire period when the sexes meet.

There are, then, two important improvements to be introduced into the regulations concerning these crustaceans: first, to preserve alive those lobsters which are too small to sell profitably and keep them in suitable places for continuing their development, so that they can be sent to market when they are large enough to command a ready sale and a good price; second, to establish depots or live-ponds, in which, during the fishing season, all those individuals, over and above what are needed for immediate use, can be stored and held to supply the market during the period when no fishing is allowed. These improvements can be readily made, and far from being incompatible with the labors described in the preceding chapters, they can be readily carried on in connection with them. Previous to the labors of M. Coste in regard to these subjects, an ordinary fisherman, the Pilot Guillou, had succeeded in acclimating crustaceans and marine fish in artificial basins of very limited extent. He very soon recognized that the restricted quarters and the care which these animals received were in nowise unfavorable to them;

that their growth continued as normally as in the open sea, and that they reproduced the same; he also noticed, what is more curious than important, that some species were capable even of being tamed and would come to recognize the hand that fed them; they could be handled and would even touch the hand in their evolutions. From these experiences of Guillou, made in restricted ponds, and since repeated by M. Coste upon a grand scale at Concarneau, it is evident that the immediate sale of lobsters and certain fish, the turbot, &c., when their size is such that they cannot command a remunerative price, is to-day an act of blamable prodigality and evil administration which is of profit to no one. It is the case of the farmer who would wastefully cut all his wheat because a few early stalks show ripe heads. The dwellers along our coast should, therefore, construct basins where the conditions of the open sea may be realized as nearly as possible, and where the water can be renewed often enough to remain fresh and pure; then after every fishing trip the catch should be culled, all the lobsters which can be sold immediately and at a good price being taken out and the remainder of an inferior size being placed in the basins to continue their development. From the basins they should not be removed until after they had attained a suitable size, and at such times as fishing could not be carried on, either from stress of weather or in observance of special rules for the marine fisheries. These basins should be constructed upon the model of claires, except that the renewal of water should be made more frequently, providing there is no danger of too rapid a deposit of mud, although in this case the mud may not produce such evil effects as in the rearing of oysters. One might also appropriate to this use the basins of purification, where the water is held for a time before being admitted to the claires, and this could be done without abandoning the cultivation of mussels in the same basins. Those places should vary in depth from one-half a meter to three meters, and have artificial rockeries, built up of irregular pieces in such a manner as to form numerous cavities and crevices where a multitude of species could find protection out of the way of mud and undisturbed by heat or cold. The summits of these rockeries should reach a certain distance above the maximum level of the water to benefit those animals which at certain periods come out of the water into the air. Sand-banks should also be constructed at the level of the water, and, in a word, we ought to have here, so far as is practicable in the limited extent of these basins, all the diverse conditions of depth, bottom, light, &c., which are met with in the sea where the different species live. In order to do this it will be necessary to observe the nature of those submarine localities which each species frequents by preference. But however frequent may be the renewal of the water it is impossible to prevent stagnation to a certain extent, which has the effect of diminishing the aeration of the water and increasing the production of noxious gases. To prevent this result, which would in a short time be fatal to the inhabitants of the ponds, it will be necessary to establish there, as far as the necessary working of the ponds will permit, certain forms of submarine vegetation, which should be planted upon the rock-piles and bottoms of the ponds. As a rule plants of a green color should be chosen. Marine plants act in the water in the same manner that land plants do in the air. While men and animals absorb oxygen in breathing, and throw off carbonic acid, a noxious and suffocating gas, land plants, on the contrary, absorb the carbonic acid gas and decompose it, assimilating the carbon and exhaling the pure oxygen. In the same manner aquatic plants absorb the noxious gases produced by the respiration of aquatic animals and the fermentations going on in stagnant water, decompose them, and while storing up the carbon exhale the oxygen, which by dissolving in the water gives it its vital properties. It is necessary, however, to exercise some choice in selecting marine plants, since some of them grow with such rapidity and spread to such an extent that they would soon interfere with, if not destroy, the culture they are designed to promote. To prevent this extension with such plants as may be chosen, it is well to introduce into the ponds some of those univalve mollusks which feed exclusively upon marine vegetation, and they will keep in check any excessive growths.

One can also divide the basins into compartments, to separate the different species and facilitate their capture at the time of sale. In fact the claires themselves can be used simultaneously for different species of crustaceans or other animals, excepting always those like the crab, &c., which would feed upon the oysters.

One single example will suffice. The morass of Kermoor, converted by M. de Cressoles into a salt lake about 70 hectares in extent and surrounded by salt meadows or lands formed by the mud dug from the lake, contains at the present time seventy thousand adult lobsters, which flourish in this miniature ocean as well as could be desired. There are also in this same lake hundreds of turbots which prophesy by their size and rapid growth a complete success for this magnificent experiment. In a word, and to sum up the various advantages of this kind of labor, so far as regards marine species, the owner of claires is in the same position as the agriculturist with his farm, his stables, and his meadows. He can multiply, rear, and fatten a large majority of the edible marine species, and, like the agriculturist, he should, as a good administrator, allow no portion of his domain, so far as is possible, to remain vacant or unworked. He should draw a revenue from everything, and while we have spoken here only of those species which are of considerable importance as marketable commodities, yet there are thousands of other marine species, fish, crustaceans, and mollusks which form only a restricted branch of commerce in those sections where they are taken, and which the possessors of claires might cultivate. By the rapid means of transportation to all the markets of France, they would become important sources of profit. Despite the immense impulse which M. Coste and his followers have given to this science, it can hardly be considered as yet more than in its infancy, at least from a practical point of view, thus leaving much to be done by those who wish to devote their time and skill to this labor. But at the same time it is to-day removed from the domain of speculation, for experience has demonstrated the excellence of the principles upon which it is founded and the methods it employs; hence the laborer can proceed successfully without fear, and acquire wealth in return for his trouble and expense. Imbued with this idea, I have wished to coöperate, to the extent of my feeble means, in popularizing this humanitarian science. Have I succeeded? If this book shall instruct those who are ignorant and guide those who are laborers in this field, then will my most ardent desires be satisfied.

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XXIX.—REPORT ON THE OYSTER AND MUSSEL INDUSTRIES OF FRANCE AND ITALY.*

By M. Coste.

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A.—ARTIFICIAL OYSTER BEDS OF LAKE FUSARO.

At the inner end of the Gulf of Baia, between the beach and the ruins of the city of Cumæ, may still be seen, far inland, the remains of two ancient lakes, Lucrin and Averne, communicating in olden times through a narrow canal, one of which, Lucrin, gave access to the waves of the sea through an opening in the embankment over which passed the Herculaneum road; tranquil basins they were, which an eruption of this volcanic soil has almost completely filled up, and where, as the poets said, the sea appeared to repose. A crown of hills, covered with primeval forests casting their shadow upon the waters, had made of it an inaccessible retreat which superstition consecrated to the gods of the infernal regions, and where Virgil conducted Ænéus. But about the seventh century, when Agrippa had despoiled them of that gigantic vegetation, and the subterranean route was dug (the grotto of the sibyl), leading from Lake Averne to the city of Cumæ, the unveiled myth disappeared before the works of civilization. A forest of splendid villas, built and

* Extracted from "Voyage d'Exploration sur le littoral de la France et de l'Italie, par M. Coste, membre de l'Institut, professeur au Collége de France. Deuxième édition, suivie de nouveaux documents sur les pêches fluviales et marines. Publiée par ordre de S. M. l'Empereur sous les auspices de S. Exc. le Ministre de l'Agriculture, du Commerce et des travaux publics. Paris, Imprimerie Impériale, MDCCCLXI," pp. 89 to 193.

ornamented with the spoils of the world, took the place of these dark groves. Rome gave herself up to this place of delight, attracted by a soft sky and an azure sea. The warm, sulphurous, aluminous, saline, and nitrous springs which run from the top of these mountains formed the pretext for the emigration of the patricians who were driven from their homes by *ennui*.

Commerce exhausted its resources to accumulate around them all the enjoyments which their indolence sought, and among those who devoted themselves to this enterprise, Sergius Orata, a wealthy man of agreeable manners, and possessed of great credit, conceived the idea of organizing oyster beds, and of bringing this mollusk into popular favor. He had oysters brought from Brindes, and persuaded everybody that those which he raised in Lake Lucrin contracted there a flavor which rendered them better than those of Averne, and even those of the most celebrated countries. His opinion gained ground so rapidly that, in order to meet the demand, he finally occupied all the circumference of Lake Lucrin with constructions destined to receive oysters, encroaching thus upon the public domain with so little discretion that it was necessary to bring a lawsuit to dispossess him of his usurpations. At the time this misfortune overtook him, to express the degree of perfection to which he had brought this industry, it was said of him in allusion to the suspended receptacles, of which he was also the inventor, that if he was prevented from raising oysters in Lake Lucrin *he would become wealthy by making them spring forth from the roofs.* Sergius, however, was not destined to organize oyster beds. He had created a new industry, of which the methods are still applied some miles distant from the place where he had carried it on. I hope, however, to show this further on.

Between Lake Lucrin, the ruins of Cumes and Cape Misène, there exists another salt pool about one league in circumference, from one to two meters in depth over the greater portion, and with a bottom of blackish volcanic mud. This is the Achéron of Virgil, and bears at the present time the name of Fusaro. At intervals around its entire border one sees spaces, generally circular in outline, occupied by stones brought there from away, but there is no possibility of determining when this industry was begun. These stones resemble a kind of rocks, which have been covered with oysters from Tarente in such a way as to transform each of them into an artificial bed. About forty years ago, the sulphurous emanations from the crater occupied by the waters of Fusaro became so great, that the oysters of all these artificial beds died, and to replace them it was necessary to restock the beds. Around each of these artificial mounds, which are generally 2 or 3 meters in diameter, stakes are driven rather near together, and so as to surround the space, in the center of which are the oysters. These stakes project a little above the surface of the water, so that one may easily seize them with the hands and raise them when it becomes necessary. There are other stakes, also, arranged in long series, and united by a rope from which are suspended bunches of brushwood intended to increase the growing individuals which are awaiting collection.

In the spawning season, which is ordinarily from June to the end of September, the oysters lay their eggs; but they do not abandon them, as happens with a great number of marine animals. They protect them during incubation in the folds of the mantle, between the gills. There they remain immersed in a mucous substance, necessary to their evolution, and in the midst of which they acquire their embryonic development. The mass of eggs resembles thick cream in color and consistency; and moreover, the oysters at this time, owing to their appearance are called, *milky oysters* (*huîtres laiteuses*). But the whitish tint so characteristic of the eggs when first deposited assumes little by little, as the process of development advances, a shade of clear yellow, then of dark yellow, changing by degeneration into a brownish gray, or a very decided violet gray. The entire mass, which, at the same time, loses its fluidity, probably in consequence of the progressive reabsorption of the mucous substance enveloping the eggs, presents then the appearance of compact mud. This stage indicates that the development has reached its limit, and is a sign of the approaching expulsion of the embryos and of their independent existence; for, already, they thrive very well without the protection furnished by the maternal organs.*

The mother soon ejects the young ones hatched in her mantle. They go forth furnished with a temporary apparatus for swimming, which enables them to seek a fixed body to which they may attach themselves. This apparatus, discovered by Dr. Davaine, and described in the remarkable work which he has undertaken and executed under the auspices of M. Rayer, my associate in the Academy of Sciences, consists of a sort of ciliated cushion, provided with powerful muscles, by the aid of which the animal can at will protrude the cushion from the valves or retract it. When the young oyster has become attached, this cushion, which is henceforth useless, is lost, or, as is more usual, atrophies in position and disappears by degrees.

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* It would be interesting, especially in a commercial point of view, to know whether embryos which have arrived at this stage of development, and which have been placed in a pond, or recess of the sea previously prepared, would survive this premature and forced hatching, attach themselves, and continue to grow. An experiment, incomplete it is true, but which I propose to enlarge upon, would seem to show that their organization is sufficiently perfect to permit them to be born prematurely, and, if I may be allowed the expression, outside of the medium in which their evolution is accomplished. Thus, young oysters extracted from the mantle of the mother, and placed in a little vessel filled with sea-water, still preserved all their activity at the end of the fourth day; 24 hours later some were motionless; the sixth day all were dead. In fact, the water of the vessel had not been renewed, and had acquired too great a percentage of salt, and too high a temperature, which very probably hastened their death. I am led to believe that under other circumstances, care being taken to change the liquid of the vessel every day, this experiment would give results which one would be able, perhaps, to apply to the industry.

The number of young thus thrown out from the mantle of a single oyster at each spawning is not less than from 1,000,000 to 2,000,000; so that at the time when all the adult individuals composing a bed set free their offspring, this living mass escapes like a thick cloud, which moves from the center whence it emanates, and which the movements of the water disperse, leaving upon the parent stock but an insignificant portion of that which it has produced. All the remainder wander, and if these animalcules, which wander here and there by myriads at the mercy of the waves, do not meet solid bodies where they can fix themselves, their loss is certain; for those that do not become the prey of lower animals which subsist upon *Infusoria*, end by falling into a place unsuited to their subsequent development, and often by being engulfed in the mud.

One could, therefore, render the industry a great service by furnishing a means of preventing these immense losses, and of securing nearly all the crop. The methods of Lake Fusaro, if we knew how to extend their application, would present this advantage. The stakes and fagots by which the artificial beds are surrounded are precisely for the purpose of preventing the escape of this spreading mass, and of presenting surfaces where they can fix themselves, like a swarm of bees to the shrubs which they encounter on going out from their hives. They attach themselves there, and grow so rapidly that at the end of two or three years each of the original living corpuscles becomes edible.

The facts which the fishermen in charge of the operations at Lake Fusaro brought to my notice confirm what I advance here. The propagating stakes, which have stood around the artificial beds for about thirty years, were drawn out before me covered with oysters which one could assign, notwithstanding the numerous variations of size, to three distinct periods. The largest, resulting from the first spawn which became attached to these stakes, were from 6 to 9 centimeters in diameter, and were, for the most part, marketable; those of the middle size, ranging in diameter from 4 to 5 centimeters, were only sixteen or eighteen months old, and were the products of a second season; some of the smallest were of the size of a 2-franc piece, others that of a 50-centimes piece; the remainder, finally, were of the size of a large lentil, that is to say, from 6 to 8 millimeters in diameter. The age of the first, according to the testimony of the fishermen, was about six months; that of the second, three; while that of the last could not have been more than a month or forty days. Their growth would appear rapid enough if we would consider that at the time of their expulsion they were but the fifth of a millimeter in diameter.*

When the collecting season arrives they withdraw the stakes and the

*According to M. Dureau de la Malle (Acad. des Sci., 19 avril 1852), the young oysters placed in beds established at Cancale grow very rapidly. In a year and a half they reach the size of 9 centimeters, while upon the bank of Diélette they would require five years to attain that size.

fagots, from which all the oysters considered marketable are taken successively, and after having picked the fruits of these artificial clusters, the apparatus is replaced, to remain until a new generation has arrived at maturity. At other times, without touching the stakes, they simply detach the oysters by means of a hook with many prongs. The source from which these generations are derived therefore remains permanent, perpetuating and renewing itself constantly by the annual addition of a small minority which never desert their place of birth.

The products of the collecting, heaped up in wicker baskets of a spherical form and with large meshes, are provisionally deposited, while awaiting sale, in a reserve or park established in the same lake by the side of the royal pavilion, and constructed of piles, which support a platform of open work furnished with hooks to which the baskets are suspended.

I said at the commencement of this work that the industry of Lake Fusaro was known to the ancients, and that probably Sergius Orata was the inventor; there are two historical monuments which prove that it began, probably, in the time of Augustus, or, as Pliny says, at the time of the orator Crassus, before the war of the Marses. These monuments consist of two funereal vases of glass, discovered, the one in Pouille, the other in the environs of Rome. They have the shape of antique bottles, with large bodies and long necks, and are covered on the outside with designs in perspective, in which, notwithstanding their crude representation, we recognize fish ponds adjoining edifices, and communicating with the sea by arcades. However, if we should entertain doubts of their purpose and meaning, the inscription which accompanies them would fully explain their character. We read upon the vase from Apulia, illustrated by Sestina: *STAGNUM PALATIUM (a name sometimes given to a villa upon the banks of Lake Lucrin, owned by Nero), and lower down: OSTREARIA. The other vase, which is preserved in the Borgia Museum at Rome (at the present time that of the Propaganda), and of which M. G. B. de Rossi has given an excellent interpretation,† bears the following words, written under the objects designed: STAGNUM NERONIS, OSTREARIA, STAGNUM, SYLVA, BAIA, which plainly shows that the figures have been drawn from edifices, and from places of the famous shore of Baïa and Pozzuolo.

What is most striking in the view of the fish-ponds represented upon these funereal vases is the disposition of the stakes crossing one another in divers directions, and arranged in circles, stakes which were evidently there only to receive and protect the progeny of the oysters.

The industry of Lake Fusaro is simply a practice invented by the ancient Romans, and continued by their descendants, and which for Sergius Orata, *luxuriorum magister*, as Cicero ‡ called him, was the source

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* *Illustrazioni di un vaso antico di vetro trovato presso Popularia*, Firenze, 1812.

† *Topografia delle Spiagge di Baia, graffita sopra due vasi di vetro.* Bullet. Arch. napolitano, nova serie, anno primo, Napoli, 1853, p. 133, tab. ix.

‡ *De fin.*, l. ii.

of immense profit; for, according to the statement of Pliny, it was not only for pleasure, but for love of gain that he pursued this business: *Ostrearum vivarium primus omnium Sergius Orata invenit in Bajano, ætate L. Crassi oratorio, ante Marsicum bellum: nec gulæ causa, sed avaritiæ, magna vectigalia tali ex ingenio sus percipiens.**

This curious industry, all the details of which I have been able to study with care, thanks to the obliging co-operation of M. Bonnuci, inspector-general of the royal monuments, who kindly accompanied me during my exploration of the gulf, gives to the civil list, despite its restricted application, a revenue of 32,000 francs; but it would be still more lucrative if, from the disinterested hands of the prince, the proprietorship of the lake should pass into those of speculators. Introduced into the salt ponds of our sea-coast, the trade of Lake Fusaro would then be a real source of wealth to our population. Extended, with modification, to the cultivation of the natural banks which exist in the sea, it would assume the proportions of an enterprise of general utility. I will explain how this may be done.*

In comparing the methods of Lake Fusaro with the methods of cultivating the natural sea banks, it is not difficult to perceive that if the mode of treating the latter is not abolished the source of production will certainly soon be exhausted. Speculation, in fact, without taking any care of new generations, which it would, however, be so lucrative to retain and preserve, only occupies itself in perfecting instruments to be used in securing oysters for the market from the artificial beds where they lodge. This class only exerts itself, therefore, to render the means of destruction more efficacious; for these beds are precisely those where the young ones which, in their infancy, did not abandon their place of birth, increase. Or, since it attacks with equal power of destruction the old and the young, it follows that any bed is surely destined to be destroyed by the hands of the very person who cultivates it. Yet we would be able to produce more abundant crops without ever touching the stock which originates them, or, in other words, that which now forms the sole resource of the industry.

In order to attain so important a result it will be sufficient, in introducing the processes employed with such success in Lake Fusaro, to simply modify them in accordance with the demands of the place where it is desired to operate. We should have the frame-work weighted by stones put in at its base, formed of numerous pieces, covered with stakes solidly attached, secured with props, &c.; then, at the spawning season, this apparatus should be lowered to the bottom of the sea, either above the oyster beds or around them. There they should remain until the young were produced and had covered the different pieces of the frame-work; ropes, indicated at the surface of the water by a buoy, would permit of their being drawn up when it is considered desirable.

These movable beds, so to speak, could be transported to localities

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* *Hist. nat.*, l. ix, c. liv.

where experience has shown that oysters grow rapidly, and acquire an agreeable flavor, or they might be carried to some small lagoon, where they would always be easy of access, as in a laboratory.

Already M. Carbonel, struck with the depression of the industry, has endeavored to call the attention of the government to the necessity of creating new beds upon our sea-coast. This useful project certainly deserves to be taken into consideration, but the question of the permanency of this restocking can only be definitely determined by the adoption of a mode of operation analogous to that which has been practiced from time immemorial in the Gulf of Naples, and by making the salt ponds, such as the basin of Arcachon and the lagoons of the Mediterranean, contribute to the production.

But this useful undertaking can only be accomplished by a careful initiative on the part of the government. Upon the government alone devolves the duty of awakening attention to the preservation and development of this source of food; for the domain of the seas is common property.

It is well that the administration of the French marine seems to understand the question, since it takes such great care to prohibit the working of the natural beds during the spawning season, and to compel the fishermen to throw into the sea the young oysters which have not reached the lawful size—a measure full of wisdom, which has already produced the happiest results; but it should not limit itself to this intervention. It is necessary that the hydraulic engineers should prepare a topographic chart of the bottoms to be protected from invasion, and that the vessels laden with the edible mollusk, which it is so desirable to multiply, should distribute the seed on these appropriate grounds.

However, before beginning this work we would have to exterminate the mussels, the presence of which is, perhaps, a difficult obstacle to surmount.

Thus the oysters from the ocean will, when we have chosen beds suitable for them, be transported by degrees from the fresh waters into the waters of the Mediterranean, and from the Mediterranean into salt ponds which line the shores. The administration of the marine has in its hands all the instruments necessary to undertake this great work, and to accomplish it without hinderance, to the advantage of a grateful population. I do not, therefore, hesitate to advise it to enter heartily into this scheme, and I know that in giving this advice I point out an object which is in the minds of intelligent men charged with this part of the service.* It is only to be regretted that the maritime guards appointed by the administration are not numerous enough, nor sufficiently paid, so that one may count upon their efficient watchfulness.

*Since the publication of the first edition of this work, artificial oyster beds have been created, according to my proposition, in the bay of Saint Brieuc, through the efforts of the administration of the marine. (See, in the appendix, two reports on this subject addressed to the Emperor.)

This is a question to which I beg to call the favorable attention of M. the minister of the marine. His active solicitude for the interest of these modest workers, and his desire to utilize their zeal, will inspire him with the thought of bettering their condition.

A question of some importance naturally suggests itself here: it is that of ascertaining whether the process actually in use for breeding fish in fresh water can be applied to oyster culture; in other words, are oysters susceptible of being propagated by artificial fecundation? M. de Quatrefages thought so, and he advises the industry to have recourse to this process, which he has not experimented upon, but which he believes would be efficient from the anatomical researches which he has made upon the structure of the generative organs of these mollusks. I quote *verbatim* the note which this naturalist has published upon this subject, in order that all the elements of the question with which I am occupied may be brought together before the mind of the reader.

"It is generally admitted," said he, "that in oysters the sexes are united. Observations which I made some years ago led me to accept a contrary opinion. More recent researches, due to M. Blanchard, have confirmed these first results, and I believe that we should consider these mollusks as having the sexes distinct. Experience has taught me that, among mollusks which present this condition, artificial fecundation readily succeeds. Thenceforth we would be able to apply this process to the raising of oysters as well as to the raising of fish. Even in cases where the sexes might be united, I believe that the process would be perhaps a little more difficult, though equally applicable, and I am convinced that the industry would find here, in this application of physiology, a new source of profit.

"Several of the oyster banks upon the cultivation of which the fishing population of Mancha depends for its livelihood are so poor that it is necessary to abandon them. Left to themselves, the restocking is always very slow; in a short time a bank is so completely exhausted as to entirely disappear, when, as soon as we know localities favorable to the development of oysters, it would be easy, by resorting to artificial fecundation, to obtain a prompt restocking, for certain facts which I have had the opportunity of observing have taught me that oysters, once fixed, grow rapidly.

"To stock an exhausted bank with oysters it would be necessary to convey the fertilized eggs to the very bottom, in order to avoid the losses which the currents and waves would inevitably cause. To this end, I believe we ought to carry on fecundation in vessels containing a sufficient quantity of water, and then, with the aid of pumps, the pipes of which should be sunk to a sufficient depth, spread the eggs over all the places which were formerly richest. We understand, however, that although artificial fecundation permits of the restocking of these oyster fields at will, it would be useless to plant an entire bank more than a league in length.

"Independently of these natural banks which we would be able to support and cultivate, I believe that the raising of oysters, in ponds and artificial reservoirs, would become easy by means of artificial fecundation. Experiments and researches are here necessary, however, to indicate the best processes to pursue; I will simply recall the fact here, and prove by the document, that oysters do not appear to dread a certain quantity of fresh water. Thus we find these mollusks in considerable quantities in Reance, for instance, at such a distance up that, at dead low tide, they are bathed by nearly pure, fresh water."*

Such are the opinions advanced by M. Quatrefages.

The most careful researches undertaken upon the reproduction of oysters indicate that in all individuals, without exception, the spermatozoa and eggs are met with in the same organ, and develop there together. The cells in which the former are developed are the first to arrive at maturity, and the elements destined to effect fecundation break from their inclosures when the eggs, which they are to fertilize, begin to appear. These mollusks are, therefore, hermaphrodites, since they unite in one and the same organ the attributes of both the male and the female sexes; this is henceforth an incontestable fact.

If oysters are hermaphroditic, fecundation must take place within the body of the animal, that is to say, either in the ovary, which is the more probable way, or in the canals [oviducts] which conduct the eggs from the ovary into the folds of the mantle, where they are to develop. Experience proves, in fact, that it is thus accomplished. When the eggs have arrived at the place of incubation, they present all the indications of development which imply a previous fecundation. Impregnation is then an internal phenomenon accomplished before the spawning, I might say even before the eggs are detached from the ovary.

To prove it, it is sufficient to remember that in the oyster the testicle and the ovary are one and the same organ; that in this organ the fecundating elements arrive at maturity and disappear long before the ovules break from the ovarian capsules which inclose them. But, if these fertilizing molecules disappear before the extrusion of the eggs, their action upon the latter must have been anterior to that extrusion; it is therefore while the eggs are still in the tissue of the ovary that impregnation is accomplished. They remain buried in the tissue of that organ a long time after this influence is exercised, and grow there considerably, only disengaging themselves when they have attained a sufficient size to break the walls of the capsules, which they distend.

Ovarian fecundation so long before the time of the extrusion of the fertilized eggs is a fact that ought not to surprise us. We find striking examples of it among birds in general, and among the gallinaceous species in particular. All physiologists know at the present day that even one copulation fecundates 5, 6, or 7 eggs at a time in the ovary of a hen; that among the eggs fertilized at the same time there are some which have

* *Comptes-rendus de l'Académie des Sciences*, Reance du 26 février 1849.

not yet attained one-fifth the size necessary for them to break their capsule and pass into the oviduct; and that they require fifteen days to attain this size, without this *latent fecundation* showing itself by any appreciable sign.

Under parallel circumstances artificial fecundation, such as is practiced among fish, would be impossible; for, to procure eggs, it would be necessary to forcibly extract them from the midst of the torn ovary, and thus remove them from their normal condition. With oysters, the impossibility is still more evident; the eggs and spermatozoa, originating in the tissues of the same organ, could not be extracted and separated from each other in such a manner as to permit of their being afterward united in one vessel. Besides, even in case this operation should prove successful, it would be necessary to place the artificially-fertilized eggs in a suitable medium; and where could this medium be found except within the mantle of the female?

Thus, in whichever way we consider the question, we must arrive at the conclusion that with oysters the natural processes are the only practicable ones and the only ones we ought to advise for this industry. We shall come to see, in treating of the breeding of oysters at Marenne, what advantage the culturists of that locality would be able to derive from the employment of the processes applied in Lake Fusaro.

B.—GREEN OYSTERS OF MARENNE.

The reservoirs in which the culturists of Marenne deposit oysters in order to give them a green color bear the name of *claires*. They are like so many inundated fields distributed here and there upon the shores of the Bay of Seudre, and spread over several leagues of space, forming an immense domain. Here there is carried on a curious and lucrative trade, the development of which is favored by the State by concessions made to enrolled seamen who wish to devote themselves to this kind of business.

These *claires* differ from the fish ponds and ordinary parks in that they are not submerged at each tide like the latter, but only at the periods of the high tides, which occur with the new and full moon, when the waves reach higher upon the land than at other times; too frequent submersion would be an obstacle to the end proposed. They are, consequently, not established on the immediate borders of the sea-shore, as certain authors have erroneously supposed.

Those which are most favorably situated receive water two or three days before and after the high tides; but that depends upon their relative distance from the shore. In this way the water they contain is never entirely renewed, or, if there is a complete renewal, it takes place only at considerable intervals of time. These intervals cannot, however, exceed the period intervening between the epochs of the spring-tides without serious inconvenience to the industry; for experience proves that a *claire* which is only renewed on the eve of the day, or the following day, of these dry periods has less value than one which is inundated by the sea for a longer time; but both are endowed, though in different degrees, with the power of improvement and of viridity.

The *claires* have no regularity of plan, nor uniformity in dimensions. Their size varies, however, on the average, from 250 to 300 square meters. They are surrounded by a bank of earth called *chantier*, about a meter in height and thickness, forming a dike where the *amareilleurs* walk about to keep watch or perform the duties pertaining to cultivation; a dike which offers sufficient solidity to resist the pressure of the water when these pools are filled. A flood-gate fitted to an opening in the wall of this dike permits the regulation at will of the flow and ebb of the sea-water, keeping it at the interval of the great tides at a suitable height to accommodate the business, and allowing it to flow off entirely when they wish to empty the reservoir, to cleanse it, and to place the oysters there to become green.

In a well-arranged *claire* is placed, also, at the bottom of the dike and around its inner circumference a ditch intended to receive the slime thrown by the waves on the central plateau which this ditch surrounds, thus preserving the young from this injurious substance. In order to facilitate the end proposed, the plateau itself is slightly inclined from the center to the extremity, so that by means of this inclination hurtful matter may be carried off; but this arrangement is not absolutely necessary, and is frequently dispensed with.

When everything is arranged, they profit by the first high tide to fill the reservoir, in which, when the waves recede, the flood-gate retains the water. The prolonged stay of these waters in this species of hydraulic apparatus fills the earth with a deposit of salt, which gives it qualities analogous to those of the sea bottom, and purges it from all hurtful products which it may have contained before submersion; then, when they think it necessary that these bottoms should be examined, they empty the clear pools, in order, according to the saying of the *amareilleurs*, to prepare the bottom (*parer le sol*).

This preparation, which can be made at all periods of the year, takes place usually in March, April, and June. It consists in drying out the *claire*, in order to level it like a garden walk or a thrashing-floor; all foreign substances, whether dead plants or growing, are carried off with the greatest care, so that upon this surface, hardened by the rays of the sun, there may be no obstacle to the free development and the acclimatization of the edible mollusk which is proposed for cultivation.

In about two or three months the soil is prepared, that is to say, it has taken the consistency necessary for the oysters to be buried therein. It is advisable then, in attempting to stock the surface, to follow the rules established by old experience; rules which are susceptible of considerable improvement, the introduction of which would greatly improve the quality of the oyster, and at the same time lower its price. Let us see from what source they now procure the shell-fish which are imbedded in these fields of cultivation; we shall afterwards tell how they proceed in the arrangement.

About the month of September in each year, when the spawning season is passed, and the opening of the fishery gives to each one the right to obtain his supply of oysters from the public beds, all the population of Marennes meet there; men, women, and children rival each other in activity to take part in the harvesting. At low tide they are seen running towards the beds which they discover, detaching from them the oysters which the laws permit them to extract, placing them afterwards in store in the spacious live ponds, where they are preserved until the time of sale, or until that of their distribution in the *claires*. At high tide, the deep beds are incessantly raked by the sailing-vessels, which detach from them the oysters by means of a dredge, a kind of iron rake, furnished with a net which collects all that the instrument loosens. But as this mode of operation involves considerable expense, only a few persons are able to practice it.

As they withdraw the oysters from the sea, they place them provisionally, as I have said, in these live-ponds, situated immediately upon the border of the sea-shore, and which differ from the *claires* in being recovered at each tide, which is twice a day. There these oysters live as they do on natural beds; they are kept white, and continue to increase in size. The largest, those which have attained adult age when they are deposited, are ordinarily destined for the use of the surrounding country, where the wives of the fishermen go to sell them. The young ones are preserved for nourishing in the *claires*. But, at present, the natural beds of the neighborhood do not meet the requirements of this trade; about a third of the young which they introduce into these reservoirs come from the coasts of Britanny, Normandy, and Vendée. They are brought by vessels, on which they are loaded in sea-weed, and where they can remain eight or ten days without alteration. But when the voyage is prolonged beyond that time, they are obliged to put them into the water to moisten them (*faire boire*); then they gather them up again, and thus gradually conduct them to their destination.

These foreign oysters never acquire the excellent flavor of those which are taken in this locality. They allow them in vain to stay a long time in the *claires*. The improvement which they undergo in becoming green (*verdissant*) never effaces completely the traces of their primitive nature. They remain tough notwithstanding the new qualities which cultivation gives them, and preserve a certain sharpness which connoisseurs know how to distinguish. It is the same with them as with the adult native oysters. When they attain this period of their existence, their coloration is nothing more, if I may be allowed the expression, than a false stamp, by the aid of which speculation gives to them a higher mercantile value, thus compromising by this fraud, unfortunately too common, the future advantages of the trade. It is not sufficient that these mollusks acquire a particular distinguishing flavor; it is not sufficient that they contract greenness (*viridité*); it is necessary that these qualities be impressed upon them in their early stages of existence by the continued influence of cultivation in the *claires*. That is, in fact, the sole guarantee of their real value.

Thus the cultivators of oysters in Marennes who desire to satisfy their patrons and to preserve a good reputation for their products never admit any except young oysters in their reservoirs, in order that the action of the improving agents, being exerted upon them as they develop, may become constitutional. They choose among those from the storage-ponds the youngest which the laws permit them to detach from the natural beds of the country, that is to say, those of twelve or eighteen months, which are from 5 to 7 centimeters long. The *amareilleurs* in making a choice give the preference to those having the best shape, separating such as adhere together, freeing them from all foreign substances, and making, so to speak, their toilet, before admitting them to this new regime.

When this sorting is finished, they spread them out with long-handled rakes on the bottom of the *claires*, previously prepared to receive them, taking care afterwards to spread them out with the hand in such a manner that in growing larger they will not crowd each other, and, by their mutual contact, interfere with each other in the free movement of their valves and the preservation of their regular forms. The ostraculturist, in a word, imitates the plan adopted by the agriculturist in resetting his plants. He plants about 5,000 to the *journal* of the *claires*, that is to say, in the space of 33 ares. The young colony, installed in this new home flourishes under a covering of water, which is kept at an average height of from 18 to 30 centimeters, is never renewed except at the great spring-tides, and which rises only at these epochs, descending again to its former level after each periodical submersion. The calm and repose which the new-comers enjoy in these tranquil basins are so mantained that nothing more is needful after installation than to provide against accidental causes which may produce some disturbance, and this then becomes the object of constant solicitude.

When the great spring-tides advance or decline, the workers carefully watch the movement of the waters. They see that they flow in and out freely, repairing the timbers which the waves displace, and neglect nothing to insure the proper working of the hydraulic apparatus which each *claire* represents. If they do not take the greatest care to preserve the integrity of the reservoirs, fissures cause leakages which will diminish the mass of water, so that there will not remain sufficient to preserve the oysters against two influences equally injurious, that of great heat, and of rigorous cold. Their vigilance must, then, be redoubled whenever excesses of temperature are to be expected. To secure the water they completely close the opening of the flood-gate, at the first great spring-tide in order that the *claire* may remain full; and, thanks to this measure of foresight, the oysters are placed at a depth where the causes of mortality from which they seek to preserve them cannot so easily reach them. The culturists who are not sufficiently vigilant in this respect soon become the victims of their carelessness. In 1820, the precautions of which I speak not having been taken in time, the colds of the first days of January became suddenly so severe that the waters of these *claires* and the oysters themselves, not having sufficient depth of water, were frozen so that it was impossible to remedy the disaster. The entire crop perished in one day.

If the waves of the sea did not bring in upon the bottoms of the *claires* a mass of slime, the deposition of which is favored by the stagnation of the waters, there would be no more to do, as I have already said, but to leave the oysters in repose on this well-provided bottom, where abundant nourishment is secured for them. They would be brought to perfection under the influence of this clear water; quickly becoming fat, large, and green, without receiving any other care; but the slime, progressively accumulating, threatens to destroy them, and will infallibly become a deadly poison to them, if they are not quickly withdrawn from its influence; and the slime is all the more fatal as it attacks every individual at the same time. Industry has succeeded in protecting the oysters from these unhealthy sediments by transporting the whole population from a *claire* in operation to a *claire* at rest, and by renewing the operation whenever necessary, until the maturity of the crop. To provide for all the needs of the experiment, it is necessary to have at their disposal a greater number of reservoirs than is actually necessary to lodge the oysters while they are perfecting. There are in the environs of Marennes speculators who possess 20 or 30 of these reservoirs, of which 8 or 10 are always at rest, in order that they may put them to use as soon as a *claire* becomes slimy and obliges them to transfer the crops to a vacant one. By the aid of this transfer, several times repeated, they preserve their crops and give them, at the end of a certain time, qualities which those do not possess, in the same degree, which have received less prolonged care.

It becomes necessary to repair the *claires* at the period of the equinoctial spring-tides, which are the strongest and the most injurious on account of the great quantity of slimy matter which they bring; but these periods are not the only times when a change must be made. It may happen that the earthy deposits will necessitate a removal at other seasons; generally it is done only once a year. The producers who have not at their disposal a sufficient number of *claires* are content to cleanse their oysters and replace them on the same bottom, thus carrying on their business under very unfavorable conditions, but nevertheless profitably.

It requires a sojourn of two years in the *claires* for oysters twelve or fifteen months old at the time when they are placed there to attain a suitable size; it takes three or even four years to give them the degree of perfection which characterizes the best products of Marennes. But the greater number of those which are raised in *claires* are, unfortunately for the trade and for consumption, far from having these good qualities. Placed when adult in the reservoirs, they become green in a a few days, and speculators, abusing a property which adds to the mercantile value of their products, carry them to market without having taken the trouble to give them the benefit of prolonged cultivation. Thus they avoid all the expenses of manipulation, and can prepare several crops each year upon the same bed. It is this that enriches oysterculturists.

The oysters of Marennes do not become green in summer, either because during this season the *claires* lose the property of transmitting this color, or because the oysters, having become milky, are then opposed to this influence. Those which had previously experienced the effects blanch by degrees as the time of reproduction approaches, and, when the spawning season has come, lose their color entirely; on the other hand, white oysters deposited at this period of the year remain white. They do not recover from this temporary loss until some time in the month of August, and it is not at all inconvenient for the trade, as the coloration reappears immediately after spawning. This coloring is not general; it shows itself particularly upon the respiratory organs, that is to say, upon the four branchial laminæ. The internal surface of the first pair of labial palpi, the external surface of the second pair, and that portion of the intestinal canal which surrounds the exterior of the great attaching muscle also show visible traces of it. No other organ is affected by it. The liver, it is true, presents a more or less intense greenish tint; but this tint is by no means equal to that of the gills and the labial palpi. The green matter which thus invades the parenchyma of the organs which it prefers, invades the contents of the cells which form the tissues of these organs about the same as the substance which colors the yelk of a bird's egg, or the *corpus luteum* of the ovary of a mammal. Chemical analysis leads us to believe that this matter must be distinct from all green substances, animal or vegetable, studied up to the present day, for reagents do not affect it in the same manner.*

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* I give here the result of experiments which M. Berthelot has had the kindness to make, at my request, with a view to determine the nature of the matter which colors the branchiæ of the oysters of Marennes.

These organs have been treated successively:

First. By water, which has become slimy without being colored or diminishing the color of the gills.

Second. By ether, which likewise had no action upon the coloring matter.

Third. By crystallizable acetic acid, which precipitated traces of a yellowish substance which was neutralized by the yellow prussiate of potash, though it increased considerably the coloring of the gills.

Fourth. By cold potash, which diminished the coloring precipitated by the acetic acid, but without causing it to disappear.

By this series of manipulations the branchiæ lose their coloration in part, and are

Authors do not agree upon the origin of this coloring principle. Some suppose that it is the soil itself which contains it; others that it is an animalcule (*Vibrio ostrearius*), or certain algæ which produces it; others, finally, attribute it to a sort of jaundice or to a diseased state of the liver, whose superabundant secretions tinge with green the parenchyma of the respiratory apparatus of the animals influenced by the treatment to which they are subjected in the *claires*.

Of these three opinions, the one which attributes the power of producing a green color to the nature of the soil would seem most nearly correct. Both the comparative analysis of the soil taken from the *claires* which produce the green color and from those which do not, and the experiments of the commission of pisciculture of La Rochelle,† have at least a tendency to establish this. These experiments prove that the bluish-green marls have, like the soil of Marennes, and to the same degree, the property of coloring oysters; so that, according to the results which this commission has obtained in the artificial basins where they have pursued their experiments, it would be safe to conclude that whenever we can organize clay reservoirs upon our coast, similar to those of which I speak, we will succeed in creating the same industry as upon the shores of the Bay of Seudre.

This industry, extended to districts in which it has not yet been

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disintegrated into viscous flakes, in the midst of which the coloring matter is concentrated.

Fifth. The green substance treated by sulphurous acid in solution is not deprived of color; on the contrary, it is deepened in color as by the acetic acid.

Sixth. Treated by chlorine water the color entirely disappears.

Seventh. Heated to a red heat and incinerated, then treated by a drop of diluted muriatic acid, it gave a blue precipitate with prussiate of potash, which indicates the presence of an appreciable proportion of iron in the incinerated tissues.

We may justly regard this iron as one of the essential elements of the coloring matter, although this substance has not been isolated.

In conclusion, the coloring matter of the oysters of Marennes does not resemble either that of the blood, or the bile, nor is it like most of the vegetable or animal coloring matters. The coloring matter of the blood contains iron, it is true; but the properties of this matter as well as the color are very different.

The earth of the *claires*, which do not make the oysters green, and that of the basins, which do transmit to them this quality, differ notably in the proportions of the elements which enter into their composition. According to the analyses which M. Berthelot has kindly made for me, independently of the ordinary elements of the soil, both are equally colored by the sulphuret of iron, contained in animal and vegetable matter in decomposition, and are impregnated with water containing salt and a little chloride of magnesium; but in the first these elements are much less decided than in the second; the sulphuret of iron is less abundant, and presents less decided tints; the vegetable and animal matters predominate less; the chloride of sodium is found in smaller quantity, and of the salts of magnesia there are only traces. Though these differences, seem of such little importance, may they not be the cause of the differences presented by the products raised in these *claires*? This is a point, which subsequent experiments, made in these places, will doubtless soon clear up.

† *Rapport fait à la Société des sciences naturelles de la Charente-Inférieure, par la Commission de pisciculture, etc.* La Rochelle, 1853.

attempted, simplified and improved by the introduction of the methods of Lake Fusaro, would become the source of a much more considerable and lucrative commerce; but in order that it may make this advance it is necessary to organizé the means of cultivation upon a greater scale; to make the reservoirs deeper in order to introduce a greater volume of of water when the season requires it; to raise and strengthen the dikes in order that they may resist a greater pressure; to connect the flood-gates in such a manner as to easily regulate the circulation of the waters; to establish reservoirs in which these waters can repose and settle in part before passing into the *claires*, and remain in reserve for the needs of the work. Each establishment, thus transformed into a true workshop, where the action of man creates all the influencing conditions and varies them at his will, will perform at the same time the functions of an artificial bed furnishing seed, and of an apparatus for perfecting the crop; so that the oysters which have become green and marketable will be replaced every year in the *claires* by their progeny, which will be carefully gathered and reared in the plâce where they were born; giving thus, by this unceasing rotation, constantly renewed products.

The oysters, in fact, which live in the *claires* become milky there as they do upon the natural beds. They deposit spat with the same profusion, but this spat, finding no solid support upon the soft slime which the sea carries there, inevitably perish, unless they attach themselves to the vertical walls of some structure or the boundary stones, by the aid of which, in certain localities, as at Oléron for example, they mark the limits of submarine fish ponds which are not uncovered until the great spring-tides. These live-ponds are not destined for reproduction, for this kind of industry is not practiced upon any part of the coast of France; but small as is the quantity of spat (*naissain*, as the young oysters are called) which remain on the stones placed there for another purpose, it nevertheless indicates the benefit which might be derived from a mode of cultivation rationally organized.

Collecting, in this way, the progeny of the oyster in the *claires*, as they gather that of mussels within the inclosures (*bouchots*) of Esnandes, stocks these artificial reservoirs with thousands of beings, each of which passes its life there held by an artifice, in order that it may be brought to perfection in adult age; such is the ingenious industry which it is attempted to create, and which awaits its Walton to utilize these immense riches. The products of this new mode of cultivation, obtained by economy, will acquire qualities far superior to those which the present method gives them; for, born in the *claires*, from parents raised therein, they will add to the advantages of education those of inheritance.

The deposit of mud in the waters being the only obstacle to the preservation of the progeny of oysters in the *claires*, a simple means may be found to remedy this evil and save the offspring. This will be to place for the spat at a certain height above the bottom, and in such a position that the molecules of mud cannot encroach upon them nor cover them, solid bodies upon which they may fix themselves. If in supplying these points of support we should follow the example of what is done in Lake Fusaro, and use stakes, it will be necessary to plant them vertically, either at the bottom of the *claire*, or to fasten them to floating rafts, which would hold them suspended without the necessity of occupying a portion of the soil upon which the reproducing animals repose. These rafts would have another advantage: they could carry movable planks, placed obliquely side by side like the slats of blinds, in such a manner as to have one side always preserved from contact with, and from the deposit of, the mud. These movable pieces, when covered with seed, could be disconnected and suspended vertically from the frame of the raft; we would thus imitate the process long since adopted in one of the basins of the arsenal of Venice, by the keeper, who raised mussels there artificially. But there are details of operation which experience will teach us how to vary in practice. The following extract leaves no doubt as to the success of the enterprise.

In 1820 a salt-maker of Marenne, having parked 6,000 oysters in one of the *claires*, an intense cold killed them all with the exception of a dozen, which survived this disaster. But when the reservoir was emptied in order to cleanse it, instead of finding the soil nearly deserted, it was an agreeable surprise to discover upon the shells of all the dead oysters young of considerable size, which restocked the whole reservoir.* The presence of these shells was sufficient to enable the new generation to fix themselves, and prosper there. Art must then only imitate the example which nature offered in this curious circumstance, and it will not be necessary to borrow from more or less distant countries the material for restocking (*renouvelain*), which is now obtained at great expense.

When we have adopted this mode of cultivation, it will be important to find out if, instead of maintaining the dikes in reproductive *claires* low enough for the great spring-tides to submerge them, it would not be better to raise them above the level of the highest sea, in order to prevent the receding waves from washing away a part of the seed. At the eve of each great spring-tide the water of these reservoirs, emptied almost entirely by careful workmen, who leave only a necessary quantity to protect the oysters from injury, will be replaced the next day, so that all the conditions favorable to development will be found combined in the same degree as in the ordinary *claires*. These would be true nurseries from whence could be drawn all the elements of a new prosperity, since they would furnish the live-ponds with abundant seed easy to obtain.

With the help and consent of the administration of marine, an abund-

* Essay upon the green oysters of Marennes, M. G. de la B., president of the Tribunal of Marennes; Rochefort, 1821. (" *Dissertation sur les huîtres vertes de Marennes*, par M. G. de la B., président du tribunal de Marennes; Rochefort, 1821.")

ance of the seed might be gathered, by very simple and cheap means, on the natural beds themselves without ever exhausting them. It would be sufficient to fix upon the beds, some time before the spawning period, by means of anchors or weights, a quantity of bushes tied with ropes, to one or more buoys; these bundles might be taken out five or six months after their submersion, either to be carried to the *claires*, where the sorting of the oysters which may be clinging to them could easily be done, or for the purpose of detaching the oysters of suitable size to be placed in the perfecting basins. The young ones which have not attained sufficient size may be left on the branches, which should again be placed in the reserved part of the pools, or on the beds themselves; here they will grow rapidly, and from them a second and third crop may be taken. I recommend, with all confidence, the adoption of this process, as I have proof of its success. M. Ackermann, commissary of marine at Marennes, having caused some pieces of wood to be drawn out from an oyster-bed, where he had driven in the pickets at my request to receive new generations, found them covered with seed. The young attached to these fragments had collected in sufficiently large numbers to justify the supposition that a few stakes or fagots would be sufficient to stock a *claire*. The commissary at Marennes thus announces the sending of the specimens in question:

"I am happy, sir, to be able to announce to you to-day the shipping of a box containing embryonic oysters adhering to pieces of wood. I have indicated their approximate age estimated by the Oysterman Babeau. The specimens which you will receive come from on the rock called *Bouchot*, which M. Gabion formerly owned, where we had placed stakes; there is no doubt in my mind that oysters can, like mussels, be raised from *bouchots*."

The *claires* of Marennes now furnish annually for consumption 50,000,000 oysters, the price of which varies from one franc and a half to six francs per hundred, which, at an average of three francs, represent the enormous sum of 2,000,000 francs. They are shipped to all the southern villages of France, from Bordeaux to Marseilles, and from the latter city to Italy and Algeria. Those which are intended for the latter countries are deposited in the Marseilles ponds, where they are left at rest some days before being reshipped. Paris consumes very few; they prefer there generally, as in other more northern cities, the white oysters of Normandy, which are furnished in great quantities.

The oyster, therefore, is important as an article of food and of commerce. Many localities along our seaboard owe to it their prosperity, and among those which are most noted, the banks of the bay of Seudre are best esteemed. On the left bank especially, the inhabitants are almost entirely occupied in this culture and enjoy a great reputation on account of the superior quality which the soil gives to the oysters raised there.

To give an idea of the prosperity which this business produces in the country, and to give a vivid description of the habits of the people who follow it, I could not do better than quote from a manuscript work, by M. Robert, a merchant of Marennes, the details which he confided to me with liberty to publish them:

"A stranger, going from Tremblade to Royan, is struck with surprise at the number of buildings which abound along the whole route as in the vicinity of large cities. New houses, tastefully built and luxuriously furnished, rise from the center of rich vineyards; and the progress in building is such that ere long Tremblade and Étante will be nothing more than extremities of a street several kilometers in length. These fine houses, it may be added, are of little use to their owners, who, ill at ease in their splendid apartments, generally spend their time in the least habitable portions, thus condemning themselves to be less comfortably lodged than when they had dwellings suitable to their means.

"At first thought it would seem that the culture of oysters requires but little care; but quite the contrary is true. The men so employed work very hard at certain times. They are, however, not prevented from engaging in other industries, from being salt-makers and farmers; their work is disagreeable, as it is done in the water and mud, when necessary to repair and cleanse the *claires*. The same difficulty occurs in depositing and collecting the oysters.

"The women take no part in this kind of work, except to assort the oysters before putting them in the ponds. Their principal work consists in selling the shell-fish. Towards the end of August, or early in September, as the heat decreases, great numbers of women and young girls can be seen going in all directions to live until April in the villages which they have selected. Many women sell for their husbands; others buy from the oyster-growers and sell again on their own account. There are also many who are hired, and who receive a certain sum for the season. When they go to their destination, they carry the oysters in wicker baskets carefully closed. Each one has some particular selling place. Some pass the day in the open air, at the doors of restaurants and hotels; others, more favored, have a little stall or corridor to shelter them. They remain there from morning until near night, and it is astonishing to see them enjoy such good health, exposed, as they are, to the cold and to the inclemency of winter. This kind of life gives the young girls much assurance; the stay in the city develops, also, a taste for dress and a certain skill in making it up. Tremblade also, on Sunday, offers quite pleasing scenes. The workers of the week-day, dressed in their holiday clothes, are not recognizable, and these oyster women, with willowy forms, coquettish air, and easy bearing, agreeably enliven the scene.

"The men are vigorous, active, and enterprising, and as the *claires* are their fortunes, they are reproached, with reason, with not respecting sufficiently, in forming them, the interests of the public and of the bordering proprietors. Thus cultivators are often seen contract-ing the bed of the Bay of Seudre, and obstructing the channels of the saline marshes, in order to make oyster beds. The means they employ to accomplish this end is both simple and ingenious. They cut bundles of grass and transport them in boats to the localities selected; then, at low tide, they arrange them in such a manner as to form small dams. Now it is known that the water of the Bay of Seudre contains mud, and in such great quantity that each tide deposits many millimeters of it on the ground which it covers. Ordinarily this mud, stirred up continually by the water, would be carried out again by the receding tide, but being prevented by the dams, it settles, remains where it falls, and the bottom soon becomes sufficiently raised to receive the oysters. In this way dry land will often be seen where a short time previously there was several feet of water.

"Thanks to the watchfulness of the authorities, these culpable encroachments are to-day exceedingly rare, and will no doubt cease entirely. Then it will only be necessary to encourage and protect an industrious population, who have learned oyster culture in general, and they will find profit in the marshes which are otherwise in great part useless."

These details I have thought of sufficient importance to mention, in order to give an idea of the methods of the industry of Marennes and of the means which might contribute to its perfection. The manuscript of M. Robert, and the good offices of M. Ackermann, commissioner of marine of that locality, were of great assistance to me, and I am happy to express my gratitude to the author and the officer. I also owe to M. Chabot, manager of the establishment for fish culture at Huningue, many thanks for information furnished while accompanying me in this investigation.

C.—MUSSEL WEIRS (BOUCHOTS*) OF THE BAY OF AIGUILLON.

The majority of persons who partake of the fine mussels which are daily served upon their tables suppose that they, like the oysters, come from natural beds. They do not know by what skill human industry gives to this mollusk, raised by its care, the size and the flavor which render it so far preferable to the poor, little, acrid mussel, frequently unwholesome and infested by a repulsive crustacean, with which the rocks and mud of our coasts are inhabited. Few authors having treated upon this subject,† it will be useful to describe here the processes and

*A word formed by contraction from *boutchoat*, an expression derived from a mixture of Celtic and Irish, and signifying a wooden inclosure: *bout*, inclosure, and *choat* or *chot*, of wood.

†The work containing the best details of the origin and processes of this curious industry bears the date of the year 1598, and has for its title, *Théâtre des merveilles de l'industrie humaine*, par D. T. V. T., gentilhomme ordinaire de la chambre du Roi, Rouen,

to illustrate the apparatus which 'the genius of a victim of shipwreck and the experience of several centuries have applied to this important enterprise.

In the Bay of Aiguillon, a few kilometers from Rochelle, upon the immense and sterile marsh which forms the extremity of this muddy bay, where up to that time the inhabitants of the coast had been unable to obtain any sustenance whatever, a poor Irishman, thrown thither by storm and shipwreck some eight centuries ago, created a business which now supports at ease over 3,000 inhabitants of the communes of Esnandes, Marsilly, and Charron, to whom he left this legacy, as if Providence wished that he should be able to repay the generous hospitality which had been extended to him in his misfortune. It was towards the close of the year 1235 that this event occurred, which was destined to open up to the country an era of prosperity and produce an abundance where before only want and misery existed.

A bark laden with sheep and manned by three sailors was driven by a terrible northwest gale from the coast of Ireland and thrown upon the rocks at the point of Escale, half a league distant from the port of Esnandes. The crew and the freight would all have been inevitably swallowed up in the sea but for the timely help of the fishermen along the bleak coast. But with all of their efforts they succeeded in saving the life of only one of the sailors; he was Walton, the owner of the cargo, and became the founder of the first *bouchot*, a marvelous invention, the fruits of which have long since enriched one province, and the application of which to other shores will some day cause the once obscure name of its author to be inscribed among those of the greatest benefactors of the human race.

Exiled on this barren coast, with all his fortune gone, save a few sheep rescued from the wreck, which afterwards, crossed with the local breed, produced that splendid variety known in Vendée as *marsh sheep* (*mouton de marais*), Walton applied his inventive genius to the problem of obtaining a livelihood and of making himself useful in his new home. He therefore determined to explore throughout its length and breadth the immense lake of mud which lay before his eyes, and ascertain if it could not be turned to some profit. But to do this he was compelled to walk at low tide through this liquid mud, which slipped from under his feet and formed an obstacle to the realization of his purpose.

1598, chez J. Caillove, Cour du Palais (très-rare). In 1752, Mercier Dupaty, treasurer of France, inserted in the reports of the Royal Academy of Rochelle a *Memoir on the bouchots for mussels*, which he had previously read two years before at one of the meetings of this academy. In 1835, M. C. d'Orbigny, sr., wrote a memoir in favor of the *bouchot* fishermen, containing documents and statistical reports proving the importance of this business. This work has been republished, partially, but with additions giving it greater importance, in the *Annales de la Société d'agriculture de la Rochelle*, for the year 1846, under the title of *Mémoire sur les bouchots à moules des communes d'Esnandes et de Charron.*

In the presence of this first and very serious difficulty, the idea struck him of building a canoe of the most ingenious simplicity, by the aid of which, without other impulse than that of the foot, he could glide over the mud with the rapidity of a trotting horse, visiting remote localities, and being able, thanks to this new instrument, to devote himself from this time to all enterprises which he thought useful. He noticed that the sea birds and land birds, which skim along the surface of the water during the twilight, collected in sufficiently large numbers to form an object of lucrative trade, if suitable snares could be devised for their capture. He used for this purpose a particular kind of net invented by him, and called *filet d'allouret*,* or night net.

This immense net, of two unequal meshes, was 300 to 400 meters in length, by 3 meters in height, fastened upon long stakes driven in the mud to the depth of a meter; it was stretched carefully above high-water level like a curtain, in the meshes of which all the birds flying in that direction would be caught. Walton was not engaged in bird-catching very long before he discovered that young mussels attached themselves in great numbers to the submerged stakes which upheld his net, and he perceived that if they were suspended a certain distance above the mud, they would not only grow larger, but be of much finer flavor than those beneath the mud. This discovery was to him a veritable revelation. He increased the number of stakes, and, like the first, these became covered with young mussels, which increased in proportion to the number of stakes provided for these growing colonies. After the success of such an experiment, he became convinced that the progeny of the native mussels could be gathered and bred in artificial reservoirs, and that this culture might be made a great industry. To this important work he consecrated henceforth all his efforts.

The methods which he applied were so happily adapted to the permanent necessities of the new industry, that after the lapse of eight centuries they are still employed by the people who were so greatly enriched by them. In putting up his structures he seems to have desired that they should serve the most useful purpose to his contemporaries, and at the same time remind their descendants of him, since he gave them the form of the letter V, the first letter of his name, as if he wished that his monogram should be inscribed on all the points of this swamp, fertilized by his genius, hoping, no doubt, that in time a suitable monument would be erected by a grateful public to the memory of the founder. According to the plan described below he constructed his first establishment, upon the model of which the 490 *bouchots* now in operation along the Bay of Aiguillon were built.†

Referring to a document published towards the close of the sixteenth century, we find that it was in the year 1246, ten years after his ship-

Allawrat, or *allaurat*, from which comes *allouret*, is a word compounded of Celtic and old Irish, which signifies a dark-night net: *d'allaow*, obscurity, and *rat* or *vet*, net.

†See plan of the Bay of Agiuillon, on page .

wreck, that Walton began this construction. The scattered stakes which he had used up to that time, but which were often torn up by wind and sea, or broken down by vessels and blocks of floating ice, from which causes he frequently lost in one day the fruit of months of labor, led him to have recourse to appliances more complex, stronger, and less apt to be affected by the action of the tides, and which would offer a large surface to the young mussels. He therefore drew at low-water mark, following an imaginary line running from the Castle of Esnandes to that of Charron, where now are to be seen extensive meadows, a V, the apex of which, partially opened, was turned towards the sea, and the sides of which, extending along the coast about 200 meters, were turned towards the shore, forming an angle of about 45°. On both sides of this angle he imbedded half their length in the mud strong stakes, 10 to 12 feet high and 2 to 3 feet apart, which were joined at intervals by bands of twisted branches so interlaced that they formed solid palisades and resisted the waves of the sea. At the vertex of the angle formed by the two wings he left openings of from 3 to 4 feet, where receptacles were to be placed to hold the fish, which, as the tide flowed out, would follow the way bordered by this double hedge; thus his invention served a double purpose, being at the same time an artificial mussel-bed and a fish-trap. And so even at this day we see the *bouchot* fishermen, faithful to all the details taught them by Walton, going in their canoes (*acons*) before the sea recedes, to station themselves behind the entrance of each trap, in their hands a net called *avenau*, to devote themselves to fishing until the tide leaves their boats, and they can then fill them with mussels, and bring them back to port by gliding over the mud.

It is quite a curious spectacle to witness the return of this singular fleet, composed of hundreds of canoes, gliding here and there through all the openings in the palisades, where they disappear during their work, slipping along the surface of the mud like a flock of birds driven by the tide. It is impossible to describe the grotesque maneuvers of this strange looking fleet. These acons or foot-canoes (*pousse-pieds*) are nothing more than plain wooden boxes, about nine feet long by about 18 inches deep, the front of which is shaped into a kind of prow. The fisherman places himself in the stern, supporting his right knee on the bottom, leaning forward, seizes the two sides with his hands, leaving his left leg, clad with a long boot, hang over the side to serve as a propellor. When he has thus balanced himself, he plunges his free leg into the mud, which serves him as a point of support, withdraws it, then pushes again, and, by repeating this maneuver, he propels his boat easily and guides it wherever his presence is required. By long habit these fishermen have learned to distinguish, even in the darkest night, their own bouchots from those of their neighbors, notwithstanding all the mazes of the immense labyrinth which is formed on the marsh by the 6,000 palisades which cover it.

This was the ingenious though simple device which Walton invented, to explore, at low water, the Bay of Aiguillon, and which enabled him to carry out plans and perform work which, without its aid, he could never have undertaken with such a muddy and mobile surface to contend against. Besides, this apparatus is to this day of prime necessity in the business. The inhabitants of Esnandes, Charron, and Marsilly not only use them to bring in their mussels, or to keep up their colonies, but they also transport in them all the wood with which they build their inclosures and palisades. In such a case a single canoe is not enough; they join three together abreast, tying them in front and behind with cords, which they pass through holes prepared for the purpose, then, loading the stakes and the branches on the middle canoe, they take positions on those at the sides, and push, one with his right leg the other with his left, by their united efforts directing the cargo toward the place of its destination. The alder and the snow-ball (*obier*), one employed for the thatching, the other for the stakes, are the only kinds of wood used in constructing the *bouchots*.

There is one season of the year when it would be very difficult to propel these canoes but for the timely assistance of a small crustacean, the *Corophium longicornis*, which, in following marine worms upon which he feeds, smooths the irregularities and rough places in the mud, which, hardened by the rays of the sun, would otherwise offer great obstacles to the movements of the fishermen.

"What a thousand men," says M. d'Orbigny, sr., "could not effect in the whole summer, is performed in a few weeks by the hordes of these little animals, scarcely 4 lines in length and a line and a half in diameter; they fill up the fissures, and smooth the surface; they loosen the mud which is carried out of the *bouchots* and even out of the bay by the sea at each tide; and, but a short time after their arrival, the marshes present as smooth a surface as at the close of the preceding autumn.

"The *Corophies* first appear towards the end of April; about this time also the burrows of which I have spoken are inhabited by innumerable annelids of many species. All these marine worms, which appear in the month of March, as soon as the tide begins to cover them, hold themselves in readiness at the openings of their retreats to seize the animalculæ which are floating by, secreting themselves and sinking in the mud; but as soon as their enemies come they are seen no more. The *Corophies*, which are very fond of them, wage upon them a war of extermination; they pursue them incessantly, even in their retreats in the depths. Nothing is more interesting for the observer than to see these little crustaceans at the rising tide moving about in all directions, striking the mud with their long antennæ, beating it to discover their prey. Should they meet a *Nereis*, an *Amphitrite*, an *Arenicola*, frequently a hundred times their own size, they unite and seem to act in concert in attacking, killing, and devouring it, continuing the carnage until they have searched everywhere and nothing remains to satisfy their voracity.

"These animals, which seem to multiply during the whole of the warm season, generally quit our marshes towards the end of October; they go all at once, in one night, and spread over the high seas, and not one can be found where a few days before they were innumerable."

Walton realized from his first structure all the success which his experience with the isolated pickets in the first instance had led him to hope for, but still he did not entirely give up for this the use of the isolated stakes. He drove a considerable number on the sea-shore, using them afterwards to fill up the gaps in the wattle fence which the young of the year did not fill up, and in the succeeding spring the fine mussels which he raised in these artificial beds were preferred to all others. His neighbors, struck with the advantages he had obtained through his industry, followed his example with such eagerness that soon the whole marsh was covered with *bouchots*, and at the time these lines are being written a forest of about 230,000 stakes is permanently in use to support 125,000 fascines bending every year under the weight of a crop which a whole fleet of vessels of the line could not carry. These stakes are trunks of trees, measuring 12 feet in height and 6 inches in thickness, which are driven down into the mud half their length, thus leaving 6 feet above the surface; planted about 40 or 50 centimeters apart, they are arranged in double rows, according to Walton's plan, and extend some 200 to 250 meters, each pair forming a V, with the point towards the sea. The upper ends of the stakes, that is, the ends out of the mud, are interlaced with wicker-work formed from the branches of the *obier*, which are not less than 25 to 30 feet long, and by twisting them the long colonnades which support them are converted into solid stockades, covered like basket-work. But the wicker-work does not extend entirely to the bottom, stopping a few centimeters above its level, so that the water may flow freely between, both at the rising and ebbing of the tide. Its lower side does not touch the mud, and the whole weight rests on the poles; they, of course, must be placed sufficiently near each other to offer a great number of points of contact, for without this precaution the wicker-work, weighted by the mussels, would bend in the long spaces between the supports so as to touch the bottom and promote the accumulation of soil by opposing an obstacle to the mud which the tide carries, or, being broken by it, the expenses of cultivation would be so increased as to ruin the business. A distance of two feet is sufficient; a distance of a meter would be disastrous. The question, therefore, is whether narrower intervals will not cause a more rapid filling of the Bay of Aiguillon, and whether, in favoring the culture of mollusks, the interests of navigation, of which the minister of marine ought to be the vigilant protector, may not be put in jeopardy.

A careful exploration of the Bay of Aiguillon during an ebbing spring-tide completely reassured me on this point; I discovered that the ebbing sea encountered just as much opposition from the stakes which hold up the wings of the *bouchots*. Striking against them, the waves were separated, only to fall with greater force on the next ones. If the wind is northwest (which is usually the case in this locality) the struggle between the waves and stakes is plainly visible. A depression of the mud in the direction of these wings proves that the erosions could only be caused by the rushing of the waves against the obstacles in the way; therefore there is no doubt that if the stakes be driven 2 or 3 feet apart they would not cause any deposit of alluvium. If their presence could produce so unfortunate a result, the portion of the Bay of Aiguillon near Charente, where there have been for centuries more than 150,000 stakes, should now be much more filled up than that of Vendée, where there has never been one driven; the fact, however, is quite the contrary. The minister of marine need, therefore, have no scruples in permitting this great industry to be developed to its utmost extent. The pursuit of this industry is not incompatible with the interests of navigation. I therefore join my wishes to those of this industrious people, and call the attention and solicitude of the government to their work, that the watchful protection heretofore given them may be continued.

The palisades which the stakes support are not less than 200 to 250 meters in length each, by 6 feet in height. They are, as I have said, grouped in the form of V's, to constitute weirs or *bouchots*, and these *bouchots* are so arranged as to always present their vertices toward the sea, and prevent the waves from attacking their flanks. These palisades, to the number of thousands, form 500 weirs, and each weir is at least 450 meters long; so that the whole forms a vast wicker-work of 225,000 meters in length and 6 feet high. This immense apparatus extends over a surface of 8 kilometers in the Bay of Aiguillon, occupying all the space between the points of St. Clement and the mouth of the river Marans, in the communes of Esnandes, Charron, and Marsilly.

The majority of the fishermen own several *bouchots*, as some farmers own several farms. The poorest of them have for their whole patrimony only the half, third, fourth, or even the fifth part of one of these structures, which they work in common with their partners, dividing the profits and losses proportionally.

All these structures are arranged in four series, each of which has its different use, according as it is near to or distant from the shore. They are called by the names of *bouchots du bas ou d'aval*, *bouchots bâtards*, *bouchots milloin*, and *bouchots d'amont*, names which refer to the zone which each series occupies in the topographic plan of the bay.

The *bouchots du bas* are the most distant from the shore, and are left dry only at the lowest tides. Instead of being built in palisades, as the others, they are composed simply of stakes driven about a third of a meter apart. These solitary stakes, if I may so express myself, are in the zone most favorable to the preservation of the embryo mussels which attach themselves to them. In other places this spat, composed of exceedingly delicate animals, would too often be left exposed, and could not well resist the prolonged action of the sun or of extreme cold. It is therefore here that all the seed is allowed to grow and accumulate which is intended afterwards, by means of transplanting and rearranging, to replenish the palisades which are empty or too scantily furnished, and the series which the sea uncovers very often; for the inhabitants of the country use agricultural expressions to designate the different operations of their industry they say sowing, planting, transplanting, weeding, pruning, and harvesting the mussels.

Towards the month of April, this seed, fixed in February and March to the solitary lower *bouchots* (*bouchots d'aval*), hardly equals in size a grain of flax, and is then known under the name of *naissain;* by the month of May it has grown as large as a pea, and by July attained the size of a bean, and is then called *renouvelain;* at this time the transplanting occurs.

When the month of July has arrived, and the spat has acquired, in its cradle, the size of the seed-mussel, it is considered sufficiently developed to undergo the change and to acclimate itself to a spot somewhat less favorable, where, before this period of its age, it would have suffered. The fishermen push their boats out to the points in the marsh where the spiles are filled with this seed.

They detach by scraping, with the aid of a hook fastened in a handle, as many shells as they will be able to transplant at low water, heaping up these shells in baskets, and directing their canoes towards the nearest palisades, the bastard weirs (*bouchots bâtards*), which are uncovered after ordinary high tides, and there begin the work of stocking (*la bâtisse*).

Then, taking each parcel separately, they inclose it in a bag of old netting; then they place all these colonies among the branches, one cluster after the other, the individuals of which, bound together by their byssus, form distinct families; filling all the interstices with this stock (*bâtisse*), as a mason would do who inserts plaster to convert open stone-work into a wall; with this difference, however, that here one must always place the families so far apart that the increase of one community shall not obstruct that of its neighbors. The bag in which they were wrapped soon decays, and nothing prevents these isolated colonies from extending their limits by the development of individual members. They grow up in this new abode and finally touch one another; so that these immense palisades, when these clusters completely cover them, resemble the sides of a wall blackened by a fire.

When this state of things has arrived, and the mussels are so large as to touch each other, their resistance to the action of external conditions is much stronger than when in their young state. They may be thinned out, when too thick, to make room for younger generations, and to transfer those which are detached from the bastard *bouchots*, which, as I have already said, are not uncovered during ordinary tides, to the empty fascines in the middle *bouchots*, which are uncovered at low water during all tides. Here the same operation of placing the mussels in bags, which has already been mentioned, is repeated, before assigning them to a new dwelling place, where they may continue to grow and expand without hindrance. They are not, however, so carefully wrapped as when younger and taken from the first series, because their size is now such that they can be put in position more easily and securely without the help of this fastening.

Thus the work of distribution goes on as long as there remain on the solitary stakes of the deep water *bouchots* any young which can be transferred to the wicker-work, taking advantage at all seasons, at all hours of the day and night, of the low tides, the only times when they are able to prosecute this laborious culture. If the scaffoldings, upon which they have so carefully placed their crop, give way or break, they repair the damages, replace the stakes which can no longer be used, change the position of the mussels that are not lying properly, and take precautions for the preservation of the whole establishment.

Ordinarily, after ten months' or a year's residence upon these artificial beds, the mussels become marketable. Then, before offering them to the consumer, and to make room on the intermediate palisades, these colonies are subjected to a third and last transplanting. Those which have attained the desired size pass accordingly into the *bouchots* of the inner series, which are more accessible from the shore, as a sort of depot where they are more easily handled. They live here, though left dry twice a day by the sea, and, thanks to this continuous changing, there is no fear that the crop will suffer or the culture be interrupted.

The mussels thus raised, although developed side by side on the same wicker-work, have not all the same qualities. Those which occupy the higher rows are better than those in the middle rows, and so the latter are preferred to those in the lower rows, which, being nearer the mud, are defiled by it whenever it is disturbed by the action of the waves. Only enough of it arises, on the contrary, into the upper series to furnish the mussels with the nutritious molecules, the infusoria which abound in this diluted mud, and this is really the cause of the difference. However, notwithstanding this difference, the poorest of the cultivated mussels are sufficiently improved by the care bestowed upon them to be far preferable to the best mussels grown in the sea.

This mollusk, on account of its abundance and cheapness, has become the daily food of the indigent classes, and is sold at all seasons of the year. But there is one period during which its flesh is more tender, more savory, and fatter than at any other season. This period begins in July and extends into January. From the close of February to the end of April the mussels are milky (*laiteuses*). They lose, like the oyster during the spawning season and during the period of incubation, the qualities which they previously possessed. Poor and tough, they are at such times less sought after. From July to January, therefore, the business is most important, and the greater portion of the crop is sold.

When it is desirable to supply the neighboring villages or cities not far distant, the fishermen draw their canoes to the shore filled with mussels. The women then take charge of them, transport them first into caves dug in the foot of the cliff, where they keep their implements and building materials. They first wash them and then arrange them in baskets and hampers, which are either loaded on horses or in carts, and then as soon as night sets in, no matter what the state of the weather, they start with their cargoes towards the point of destination, arriving sufficiently early to be present at the opening of the market. Thus they travel to Rochelle, to Rochefort, Surgères, Saint-Jean-d'Angély, Angoulême, Niort, Poitiers, Tours, Mauzé, Angers, Saumur, &c. About 140 horses and 90 carts, making altogether to these different cities more than 33,000 trips, are employed annually in this service.

If, on the contrary, they wish to export to greater distances, and on a larger scale, 40 or 50 barks coming from Bordeaux, the isles of Ré and Oléron, and Sables-d'Olonne, and making altogether 750 voyages annually, distribute the crop in countries which the horses and carts do not reach.

A *bouchot*, well stocked, furnishes generally, according to the length of its wings, from 400 to 500 loads of mussels, that is to say, about one load per meter. The load is 150 kilograms, and sells for 5 francs. One *bouchot*, therefore, produces a crop weighing from 60,000 to 75,000 kilograms, and valued at 2,000 to 2,500 francs; from which it follows that the crop of all the *bouchots* united would weigh about 30,000,000 to 37,000,000 kilograms, which at the figures already given would be worth about 1,000,000 to 1,200,000 francs. These figures and the abundant crops from which they result, give an idea of the food supplies and of the great benefits that may be derived from a similar industry, if, instead of being confined to only one portion of the Bay of Aiguillon, it should be extended to the whole of it, and carried from the locality where it originated to all the coasts and salt-water lakes where it could be successfully carried on. In the mean time the prosperity which it secured in the three communes of which it has become the patrimony will remain as an end worthy of effort; for, thanks to the precious invention of Walton, wealth has succeeded to poverty, and since the industry has been developed here no healthy man is poor. Those whose infirmities condemn them to idleness are cared for in a most generous and delicate manner by the others.

"Twice a week," says M. d'Orbigny, the elder, "the housekeepers of each family carry their bread to be baked at the baker's; the poor people or their agents, often persons in easy circumstances, who take upon themselves the honorable mission when the unfortunate themselves are not able to go to the place, present themselves there with a basket. Each housewife, before putting her bread in the oven, breaks off a piece of dough from each loaf; the baker charges himself with the duty of making all these bits of dough into loaves of bread, gratuitously. Nothing is more interesting, for a sensible and observing man, than to be present on the arrival of the weir-men and fishermen, at the unloading of the fish; a course of lectures on morals would not be worth as much as this lesson of fraternal humanity. Whether by day or night, the same indigents, ranged in rows and furnished with baskets, and stationed near the place of unloading, receive from each of them, according to what he brings, the first fruits of his fishing, one a handful of mussels, another a few fish; this gift is bestowed with politeness, with questions which show the interest each one takes in the unfortunates whom he knows, who, perhaps, are his parents; the fisherman fears that he will bring upon himself trouble by refusing them or treating them rudely; often he even has the gift carried to them on a horse or cart which his wife has brought to the landing place to receive the results of the fishery. Bread furnishes them subsistence; the surplus of fish and of mussels is sold, and the revenue therefrom serves to buy for them fire-wood, candles, in fact everything that they may need.

"This population, entirely Catholic, fairly represents those large establishments in North America and Germany of the Moravian Brothers. Everywhere are found plenty of work, good morals, cheerfulness, contentment; the households are happily managed, quarrels seldom occur; hospitality is here looked upon as a religious duty; honesty is the foundation of all education; and the traveler, astonished at all he sees, almost dreams that he has found a better world."*

We present here according to a statistical report made in 1846, by M. d'Orbigny the elder, the estimated cost at that time of conducting one of these establishments, and the annual expenses and profits of the 340 *bouchots* which were being operated by the three communes of Esnandes, Charron, and Marsilly.

Cost of equipment of 340 *bouchots.*

	Francs.
159,400 stakes driven, at 300 francs per hundred	478,200
90,000 bundles of twigs intertwined, at 150 francs per hundred	135,000
160 canoes with apparatus, at 40 francs each	6,400
160 pairs of boots for fishermen, at 33 francs per pair	5,280
166 *aveneau* nets, rigged, at 15 francs each	2,490
400 *albouret* nets, at 15 francs each	6,000
200 boundary stones (*bournes*), at 20 francs each	4,000
2,000 *bourolles*, at 1 franc each	2,000
600 pairs hampers, at 3 francs a pair	1,800

**Les habitants des communes littorales de l'anse de l'Aiguillon, etc., au Gouvernement, etc.* La Rochelle, 1835, p. 25.

1,000 fish-baskets, at 75 centimes each	750
110 pack-horses, at 350 francs each	38,500
28 cart-horses, at 380 francs each	10,640
28 carts, equipped, at 800 francs each	5,600
Total	696,660

Making the cost of each *bouchot* 2,049 francs.

Annual expenses of keeping up 340 *bouchots.*

	Francs.
Annual interest on 696,660 francs	34,833
Cost and transportation of stakes and brush	64,000
For the repairing of canoes, boots, nets, utensils, &c	11,000
102,000 days' labor of men, at 1½ francs	153,000
42,000 days' labor of women, at 1¼ francs	52,500
Feed for 138 horses, and repairs of harness, carts, &c	41,400
1,800 days of detention in Rochelle, at 50 centimes	900
Hire for lodgings for 140 families, at 60 francs each	8,400
Cost of gathering seed	1,400
Old nets for wrapping, and time spent in placing them	18,807
Total	386,240

Annual expenses of each *bouchot*, 1,136 francs.

Annual revenue in mussels, fish, and game from 340 *bouchots.*

	Francs.
To Rochelle, 60 horses make 18,000 trips annually, at 5 francs	90,000
To Rochelle, 28 carts make 7,000 trips, at 20 francs	140,000
To Rochefort, 12 carts make 840 trips, at 40 francs	33,600
To Surgères, 16 carts make 1,120 trips, at 20 francs	22,400
To Saint-Jean-d'Angély, 28 carts make 1,120 trips, at 20 francs	22,400
To Angoulême, 40 horses make 1,600 trips, at 5 francs	8,000
To Angoulême, 8 carts make 320 trips, at 20 francs	6,400
To Niort, 28 carts make 1,960 trips, at 40 francs	78,400
To Poitiers, 8 carts make 160 trips, at 40 francs	6,400
To Mauzé, 8 carts make 320 trips, at 25 francs	8,000
To Tours, 12 carts make 240 trips, at 30 francs	7,200
To Angers, 4 carts make 80 trips, at 40 francs	3,400
To Saumur, 8 carts make 160 trips, at 40 francs	6,400
To Bordeaux, 32 barks make 128 trips, at 300 francs	38,400
To isles of Ré and Oléron, 4 barks make 480 trips, at 30 francs	7,200
To Sables-d'Olonne, 6 barks make 150 trips, at 30 francs	4,500
Fish caught in the *bouchots* and birds caught in nets	27,500
Total	510,000

	Francs.
Each *bouchot* produces annually	1,500.00
Deducting annual expenses	1,136.00
Net profit	364.00
To which should be added the interest on capital of 2,049 francs	102.45
Total	466.45

The labor of both men and women is included above in the annual expenses.

If this statistical report made by M. d'Orbigny gives a correct estimate of the condition of things, the business must have developed considerably since that time (1846). Instead of the 340 *bouchots* then in the Bay of Aiguillon, there are at present nearly 500; and I do not think I make any mistake in these figures, for, after having taken them on the spot, a letter which I received from the mayor of Esnandes confirmed all my estimates.

M. Belenfant, commissary of marine at Rochelle, by the information he was so kind as to give me, and by the interest he manifested in accompanying me in my exploration, has also contributed a great deal toward the investigation of all the details of this industry.

[APPENDIX TO THE FIRST EDITION.]

D.—DOCUMENTS RELATING TO THE MARINE FISHERIES

1.—REPORT TO HIS MAJESTY THE EMPEROR ON THE CONDITION OF THE OYSTER BEDS ALONG THE COASTS OF FRANCE AND ON THE NECESSITY OF RESTOCKING THEM.

PARIS, *February* 5, 1858.

SIRE: The domain of the sea, like the earth, may be cultivated; but this domain being public property, to the government belongs the duty of applying such methods as science has demonstrated to be the most suitable for the execution of so grand a scheme, and then leave to its grateful citizens the harvests which have been prepared by its care.

I have, therefore, the honor to submit to Your Majesty, according to command, the various plans which promise to promote the success of this useful innovation. I will commence with those which relate to the multiplication of oysters on the shores of France.

The oyster trade has already fallen into such a state of decadence, that, unless a prompt remedy be at once applied, the source of production will soon be utterly exhausted.

At La Rochelle, Marennes, Rochefort, and in the isles of Ré and Oléron, out of the 23 beds lately forming one scource of wealth of that portion of our shores, 18 are completely destroyed, while the others, still furnishing a small supply, are seriously injured by the growing invasion of mussels. The cultivators also in these regions, not being able to find sufficient oysters to stock their ponds and *claires* for greening or perfecting, are obliged to seek them at great expense as far off as the shores of Brittany without being able to supply the demand.

The bay of Saint-Brieuc, so admirably and so naturally adapted to the reproduction of the oyster, and which on its clean, hard bottom formerly contained no less than 15 beds which were continuously dredged, has to day but 3, from which 20 boats could in a few days carry off the last shell, while in the period of its prosperity more than 200 barks, manned by 1,400 men, were annually employed in the business from the 1st of October to the 1st of April, and realized from it between 300,000 and 400,000 francs.

In the harbor of Brest and at the mouths of the rivers of Brittany the decadence has not been so great, because these fertile spots have not been subjected to such constant dredging. But inasmuch as our own fishermen are now compelled to resort to these beds, they, like our own, will soon become exhausted.

At Cancale and at Granville, which are historic grounds for the multiplication of oysters, it is only by good management that they succeed, not in increasing the supply, but in preventing its decline. While this important trade is steadily declining, or remaining stationary, the increased facilities of communication between the sea-board and the interior as steadily augment the demand for these marine articles of food. These products, made costly by scarcity, now bring in our markets fabulous prices, and the inhabitants of the coast, consulting only their immediate wants, and looking only to the present hour, commit depredations which, in the near future, will aggravate their distress.

Now, Your Majesty, there is for this deplorable state of things a remedy, easy of application, certain to succeed, and which will furnish an incalculable wealth of food for the public. This remedy consists in undertaking at the expense of the government, under the direction of the administration of the marine and by means of its vessels, the stocking of the shores of France so as to restore the ruined beds, to revive those which are declining, to protect those which are prosperous, and to create new ones wherever the nature of the bottom is suitable. And when by this generous policy these marine fields shall once more become productive, the dredging may be placed under such restrictions that while certain fields are being operated others may lie in repose; a plan which, for a century, has kept the bays of Cancale and Granville from the destruction which injurious dredging has caused everywhere else.

To give a striking example of the method in which these operations of restocking and of creating new beds ought to be conducted, and of the immense results which may be obtained, I have the honor to recommend to Your Majesty's government that the bay of Saint-Brieuc be set apart for this purpose. There the experiment may be undertaken in a restricted space, supervision will be easy, and in less than six months a fair estimate could be made of the expected results, as from a tree in blossom, provided the artificial beds are planted in March or April, that is, before the spawning season.

The sum of 6,000 or 8,000 francs, placed at the disposal of the commissary of the marine, in that quarter, would suffice for the purchase of the oysters required for stocking the bay. These oysters should be caught in the open sea, and, if possible, carried immediately by a government steamer to the grounds naturally fitted for them. But, when they are unable to collect enough in one day to complete a cargo, they may store them temporarily near Plévenon, a dependency of Saint-Brieuc, in charge of two custom-houses found there, so as not to start them from this provisional storage to the places where they are to remain before they have a full load.

With the aid of this simple means, and at a relatively insignificant cost, it will be possible in a few years, if proper precautions be adopted, to realize a considerable revenue in the bay of Saint-Brieuc alone.

Among these precautions, I put first, that the oysters ought not to be out of the water for a moment longer than is required for their transportation from the place where they are caught to their destination. It is owing to a neglect of this precaution that the failures in the past are due; for, whenever it has been observed, success has crowned the experiments, as is proven by the attempts of M. de Bon in the Rance.

A second and not less important condition is that an intelligent and watchful care be given to these submarine fields, made fertile by science and cultivation; and to the commissary of the region naturally belongs the duty of exercising this care. But in order that the equipment of this officer may correspond with his responsibility, he should have at his command a pinnace, or better still a launch of 8 to 10 tons, furnished with a captain, four sailors, and a cabin-boy, a sufficient crew for all the needs of the enterprise; the launch may serve at the same time to guard and cultivate the tract which is assigned to its care.

The oyster beds created or supported in this way by the government will always be easy of exploration and investigation. Nothing connected with them can occur without the administration being instantly informed of it and in condition to act. If the mud accumulate on the producer's grounds, or if the mussels and the *maërle* invade them, the drag will detach the oysters' enemies or remove the parasites as the plow removes weeds from the ground. If in the vicinity of the established beds they discover other bottoms adapted to the multiplication of oysters, the exploring launch may always be occupied in superintending its domains, will seek everywhere on the natural beds the adult oysters required for stocking these new fields, or will sow there the young oysters, which in the fishing season are rejected in selecting the marketable oysters. So that whether we consider this craft from a supervisory point of view or as a means of cultivation, it will render services which cannot be obtained by any other means.

I am willing, then, considering all things, to follow the example of the chief of the service of Saint-Servan.

These launches would, in the navy, form a sort of agricultural marine, the employment of which would not exclude the use of vessels concerned in the general police of the fishing vessels which are employed in a greater development of the coast. They should be so constructed as to contain a well in which experiments could be made, or in which specimens could be transported alive from one point to another.

Without doubt, when it is necessary to restore the prosperity of the affected beds by delivering them from a general invasion of mussels (*moules*), such as exists now at Marennes, or from the encroachment of the no less injurious *maërle*, as at certain points in the harbor of Brest, the fleet devoted to the ordinary service of the region will not suffice for the emergency; but, on such an occasion, the boats of the fishermen, for whose benefit the enterprise was established, could be pressed into service for the treatment of these beds, by the same rights which the proprietors of communes exercise when they undertake the repair of a public road.

The young oysters and those taken in the open sea form two sources from which the government vessels may secure supplies for stocking the coast; but notwithstanding their abundant reproduction they would never be sufficient to accomplish this vast project unless means are employed to prevent the loss of the myriads of embryo oysters, which, in the spawning season, leave the maternal valves as bees leave their hives; embryos which are nearly all lost in the natural state for the want of something to which they may attach themselves.

To the care of this precious spat the attention of the agents of the government should be henceforth directed.

Each oyster produces not less than 2,000,000 of young. But, if out of this immense number a dozen succeed in attaching themselves to the parent shell it is all that can be hoped for, even in years of the greatest abundance. Those, then, that succeed in attaching themselves are as nothing in comparison with the immense numbers that are swept off by the waves or which are lost in the mud, or which become the prey of polyps, which feed upon the animalcules suspended in the waters of the ocean. The problem to be solved, then, is how shall this inexhaustible seed supply be secured and carried to the grounds which are to be stocked?

In doing this, no notice need be paid to the natural beds formed from the young obtained at each spawning season, although even from them incalculable riches might be obtained. The only thing necessary is to fasten around the beds a species of wicker-work made with twigs and branches of trees with the bark on, imbedded in such a manner as not to interfere with navigation, and held to the bottom by heavy weights. The progeny of the oysters deposited will rise like a living cloud of dust through the branches, and the embryos will incrust every available point of this structure, which will thus be made the recipient of seed.

These receptacles, filled with this microscopic population, should be left on the beds not only during the whole spawning season, but also until the young oysters shall have attained a sufficient size to be used for restocking other localities. The government vessels will then carry the whole structure to the point which may be selected for organizing new beds. After they have been fixed for a short time, the young oysters will detach themselves naturally and sink to the bottom, previously cleaned by the dredge, just like the wheat from a drill on ground prepared by the plow.

This transportation should be effected in February or March, because at that season of the year the spat deposited in the branches, during either the months of September or May, are easily discovered, the first having already attained the size of a 20-sous piece and the latter that of a 2-franc piece. It is then easy to ascertain whether the seed is scarce or plentiful, and in what measure it will contribute to the object in view. Besides, the force of vital resistance with which it is endowed at this age enables it to endure without inconvenience the changed conditions of its new abode.

The possibility of gathering the progeny of the oysters by means of this wooden wicker-work is a fact established not only by the results obtained from time immemorial on the artificial beds of Lake Fusaro, an industry of which I described the methods in my *Voyage sur le littoral de la France et de l'Italie*, but also from experiments made in the ocean itself. Branches sunken on the beds of Brittany by M. Mallet, commanding the Moustique, and on those of Marennes by M. Ackerman, ex-commissary of marine, were taken out a few months subsequently, filled with seed. I preserved them in my collection as a proof of the efficacy of the methods which I recommend. In order to derive from these methods incalculable benefits, it is only necessary to employ them on a large scale.

I make bold to affirm, sire, that if the administration of the marine will draw upon the various sources I have designated, and employ all the means tending to the development of the object which I have had the honor to recommend to Your Majesty, they will very soon convert the whole coast of France, except in such places as are filled with mud, into one long chain of oyster beds. It will be necessary for the realization of this scheme that the agents be encouraged to devote themselves zealously to the service, and that they shall have placed at their disposal all the means requisite for the furtherance of the object in view. As if by enchantment the harbor of Brest, the bays of Brittany, and the mouths of the rivers will extend their isolated beds and unite them, by the creation of new ones, into one vast productive field. The depleted beds of Cancale and Granville will be renewed and extended to a great many neighboring localities whose suitable bottoms will readily respond to the attempts which are made to enrich them. The basin of Arcachon, all that portion of the shores of the British Channel which extends from Dieppe to Havre, from Havre to Cherbourg, from Cherbourg to Granville, will be covered with oysters, and the extinct beds in the neighborhood of La Rochelle, Oléron, Rochefort, Marennes, &c., will be restored to their former prosperity. But here, more than elsewhere, it will be necessary for the government to continue the work of restocking and division, which it fortunately has already begun: that of cleansing, by repeated dredgings, these productive bottoms from the mussels and mud which completely cover them.

This work accomplished, there is no reason why these ruined localities may not witness a return of their early prosperity and an increase of their wealth. The exploration which has enabled me to ascertain the state of suffering, of poverty, and of complete ruin in which most of the beds along the coast are now to be found, also demonstrated to me the fact that the depopulated depths had lost none of their fitness for reproduction. The abuses by excessive fishing, aggravated by the want of care, have alone completed the destruction. Careful culture will soon repair the harm done in the past, and properly taken in charge, fields hitherto sterile will create, by a kind of submarine cultivation, new sources of abundance. But to create new sources of wealth is not sufficient; it is necessary, in order to perpetuate them, to define also the method of their cultivation, and to fix the time of year when it will be best to gather the crop.

The experience of more than a century has already, in the bays of Cancale and Granville, given a solution of the first part of this important problem; regular periods of harvesting are the only means of obtaining from the beds the greatest yield without destroying their fertility. The same general methods should be henceforth applied to the cultivation of oyster beds; they should be divided into zones, so as not to return to any one of them for two or three years, according as the bottoms are more or less suitable for the rapid maturing of the crop; but always taking care to leave a sufficiently large number of adults, so that the spat which they spread during the periods of repose may create new and sufficient harvests. By the general application of this method, the supplying of our markets and the fertility of the beds will be assured.

There is, however, no rule so general, especially when applied to the reproduction of living creatures, subject to all the vicissitudes of the external world, that it may not have exceptions. There may exist unknown causes which will delay for a longer or shorter time the generative function of the oysters of one locality or destroy their spat, and, in this case, the beds found to be affected ought to be kept in reserve until it is certain that they have resumed the regular exercise of their functions. This moment having arrived, they should be included anew in the alternation of regular harvesting.

In the present state, of things, the regulations of the police which supervise our fishing coasts, prescribe the first half of the month of August for the purpose of visiting the oyster beds and designating those which are to be dredged at the opening of the month of September, which is the legal period for commencing operations; but the commissioners charged with this duty cannot at that time form any exact idea of the actual condition of things; for a large number of oysters have not at this period spawned, and the spat of those which spawned in the month of July is scarcely visible to the naked eye. In order to fully recognize them recourse must be had to a magnifying glass, by which they can be distinguished only after drying, and by one accustomed to researches of this kind. To obtain the most satisfactory results, therefore, it is necessary to defer the inspection of the beds until later in the season, that is to say, until the month of January. By the adoption of this measure the government will find that February or March, and not September, is the proper season for the opening of the fisheries, and by this means alone the yield will be increased at least tenfold.

In fixing upon the first of September as the time for the opening of the fishing season, the government has undoubtedly (in a measure) acted wisely, as the majority of the oysters have already spawned, and there is not much danger of taking from the water the parent oysters still containing the spat in their interior. But this progeny, which, before the spawning, forms in the interior of each milky (*laiteuse*) oyster an innumerable family, after parturition spreads itself over the exterior of the valves, incrusts them, and creates a new population on the surface of the old. Now, if at this time dredging be permitted, the harm resulting therefrom will be almost as extensive as though it had occurred at the period of gestation; for, in taking out the adult oyster, the younger generation will also be removed, at least all that have not deserted their birthplace. The dredge would devastate the fields in full germination like a rake drawn through the branches of a fruit tree while covered with blossoms. This is not one of the least causes of the impoverishment of our coasts. To remedy this evil it will only be necessary to change the opening of the dredging season and make it February or March instead of September. By that time the young oysters of the year will have attained the size of seed-oysters (*huîtres de rejet*), and those that still adhere to the parent-shell can be easily detached, and either returned to the beds, as prescribed by law, or preserved in the *étalages*, as is done at Cancale.

It may be said, probably, that in appointing February as the opening of the season there will be only three months for dredging, as in May the oysters become milky, and dredging is then prohibited. But this objection is not well taken, for six weeks of daily dredging would be sufficient to depopulate the whole coast of France. Besides, the question has already been settled by experience: At Cancale, one of the most fertile districts, the season extends only from March to May. The fishermen of Marennes, from what I learned during my exploration of the bay of Seudre, will hail with gratitude such a measure. It will cause their exhausted beds to be once more restocked, will prevent the complete ruin of those which are still dredged, and, as a consequence, will relieve them from the heavy taxes which they pay to other countries from which they are obliged to obtain their supplies.

It will probably be also said that the interval of three months between the opening and closing of the fishing season will not suffice for the consumption of the crop. But the oysters which are eaten at this season are not then taken from the sea. On the contrary, to be admitted to our markets, it is first necessary that they be kept several months in the *parcs*, *claires*, and *viviers*, where they are prepared for their destination. Now, the owners of these *parcs*, *claires*, and *viviers*, in which the oysters are brought to perfection, being always able to accommodate more than can be supplied, it follows that the fishermen will always find a ready market for the stock on hand.

While, by the generous intervention of the government, this industry may be extended to all suitable points along the whole coast, the navy department will be enabled easily to follow its progress, if the agents charged with this work be compelled to keep a register not only of the seed beds, but also of the establishments where the oysters are perfected, such as *parcs*, *claires*, *viviers*, *étalages*, and *bouchots;* if it instructs them each year to give, in this register, a complete description of the beds and to state which are affected and which are thriving; if, finally, it compels them to keep as exact an account as possible of the yield, not only of each bed in particular, but of all the beds contained in their jurisdiction, whether the yield be obtained by dredging or by hand.

This statistical work, which I propose to extend to all the marine products, will form, in the archives of the central administration, a collection of documents from which to ascertain in what proportion these products enter each year into the public food supply, and to determine whether they are increasing or declining: important questions upon which up to this time our knowledge is very incomplete, as I have reason to know from my experience in exploring the sea-coasts.

The methods which I recommend for the creation of artificial oyster beds along the ocean shores are equally applicable to the Mediterranean. While waiting for the special plans which I shall propose for the latter scheme, I think it would be well, sire, to authorize, as a preliminary experiment, the commissaries of the districts in which the ponds of Berre and of Thau lie, to begin at once gathering, from the natural beds of the Gulf of Lyons, in the neighborhood of Cette, a sufficient quantity of seed oysters, to be transported to these ponds, and deposited alongside of each other, on sandy and rocky bottoms, rather than muddy, which will there form experimental beds. These beds, protected from depredation by a rigid surveillance, will constitute the first step toward the further experiments which your majesty wishes to make in the salt lakes of Southern France.

I am, with profound respect, sire, Your Majesty's humble and very faithful servant,

COSTE,
Member of the Institute.

2.—Report to His Majesty the Emperor on the artificial oyster beds created in the Bay of Saint-Brieuc.

Paris, *January* 12, 1859.

Sire: Subsequent to the report in which, in February last,* I had the honor to submit conclusions for your acceptance, Your Majesty, desirous of testing the conclusions I had arrived at, and of ascertaining decisively whether the promises held out by science in regard to the cultivation of marine products could be realized, ordered that the Gulf of Saint-Brieuc be made the theater of the first experiment at oyster culture by the government, executed by means of its vessels, confided to the keeping of its navy, and destined, in case of success, to serve as a model for the creation along the coasts of France of a vast submarine industry, alike profitable in developing the navy and enhancing the prosperity of the coast inhabitants.

The harbor selected for the accomplishment of this undertaking has a solid bottom, naturally clean, composed of shells or coral, thinly covered with marl or mud, with scattered eel grass (*pailleul*), covering an area of 12,000 hectares everywhere adapted to the sojourn of the parent oysters. The current, which at each tide sets from northwest to southwest and from southwest to northwest, at the rate of one league per hour, brings in fresh waters continually, carries off all unhealthy deposits, and gains by rushing upon the rock-bound coast all the vivifying properties which such constant aeration communicates to it.

The excellent bottom, the active nature of the limpid waters which cover it, unite, then, over this immense submarine domain all the conditions favorable to the multiplication and development of this article of food, which I propose to introduce there, and the products of which we are endeavoring to transform into an inexhaustible annual harvest.

But while in its work of intervention and conquest science recommended this as an enterprise of great public benefit, empiricism and old fogyism condemned it in advance as rash and visionary. It is only necessary, sire, to recall the various obstacles which had to be overcome, and the amount of perseverance required for the realization of a scheme, the marvelous results of which I already have the honor to make known

* See preceding report.

to Your Majesty; a scheme which aimed to retain on the spawning beds, by means of a simple device, the seed which in a state of nature is dispersed by the currents, and to create sources of wealth wherever the bottoms are not subject to the invasion of mud.

No region along our coast offered at the same time so vast and so appropriate a theater for drawing public attention to the solution of this double problem; for the bottoms are undisturbed, though the currents rush over them at times with such violence that superficial thinkers prejudged this to be an inevitable cause of failure. Everything there depended on a triumph of art over nature, for it was necessary not only that material from various provinces should be transplanted to a foreign land, but also that the progeny of this exiled population be protected from the perturbation of the waters.

It will not be out of place, sire, for the honor of science, to state here in detail how the dominion of the sea is made accessible to industry, for, in providing new methods applicable to the business, it creates, for its abstract studies, instruments of investigation which extend its range to regions yet unexplored.

The planting of the reproductive oysters, opened in the month of March, closed under my own supervision towards the end of April. In this brief period 3,000,000 of individuals, some taken in the high seas, others at Cancale, and others from Tréquier, were distributed over ten long beds, situated in different parts of the gulf, and together representing an area of 1,000 hectares; beds previously traced on a marine map, indicating the productive fields, and provided with signals intended to facilitate the movements of the vessels engaged in the stocking. But in order that the planting should be done with the regularity of a practical farmer, and that the mother oysters should be sufficiently separated so as not to interfere with each other, a government steam-vessel, first the Ariel, and then the Antelope, towing the launches, and a *basquine* filled with oysters, would make alternate trips to either extremity of the line, where a small boat, placed crosswise, designated the spot upon which operations should begin. Then, steaming to the other end, designated by another boat, it would go around this in following the long axis of the rectangular space designated by the flag signals, and return to the starting point, like a plow which makes two parallel furrows in a field.

While our tow-boat was thus engaged, the sailors belonging to it were placed on board the accompanying launches and employed in emptying the hampers, filled with oysters, which they had previously arranged in rows along the decks, and as they were gradually thrown overboard they sank to the bottom and spread themselves over the surface intended to become stocked by their seed. To insure the success of the work, it was not only necessary that the oysters should be planted under the conditions most favorable to their propagation, but also to build around and above them efficient means of securing the progeny and of compelling it to fix itself on the beds where it had commenced to spread; for the planting took place at the time of the first spawning.

This second end, which transforms the gulf planted into a species of submarine farm, undergoing the various processes of rational cultivation, has been accomplished, by means of two contrivances, the simultaneous employment of which has already furnished immense results, and which in the near future will permit the increase of the supply to any extent that may be desired, provided propagation keeps pace with the demand.

One of the contrivances consists in covering the productive bottom with oyster or other kinds of shells, so that every single embryo that sinks shall find a solid body to which it may cling. The shells which we used for this purpose were gathered on the beach at Cancale, by order of M. de Bon, chief of the maritime service at Saint-Servan, who was kind enough to lend us his assistance, and were brought to the gulf by a special convoy of fishing smacks, and scattered over the artificial beds in my presence. These shells, otherwise useless, which must be cleared away from the beach at great expense every year, so that they may not encumber it, if carefully preserved hereafter, will become, after drying, valuable instruments of culture.

The second appliance, which is designed to secure the embryos carried away by the currents, and to receive them on solid bodies placed under the tide-whirls, which do not extend to their depths, consists of long lines of small bundles, placed crosswise like intersecting bars, from one end to the other of each bed. These bundles, perfect collectors of seed, formed of branches from 2 to 3 meters in length, tied in the center by means of a rope to a stone, which holds them 30 or 40 centimeters above the bottom, were put in position by men wearing cork jackets, who were instructed to place around each stone a few oysters about to spawn. The rope, which the haste of the first experiment made it necessary to use for anchoring this apparatus, will, of course, soon rot, and it may be necessary to replace it in future by chains made of galvanized iron, which can be constructed in our arsenal shops, and which will form a part of the permanent outfit of this new culture.

Bearings, carefully taken, form, on special charts well plotted, the means of identifying the points where each line is sunken, so that there will be no difficulty in finding each one in succession, of raising the bundles and removing the crop of oysters, as easily as the farmer gathers the fruits from his trees.

Two government vessels, the Pluvier and the Éveil, stationed at opposite points in the gulf, one at Portrieux, the other at Dahoflet, visit each day the artificial beds, while a small cutter, which was constructed by Your Majesty's orders, at my request, steams up the gulf and helps to complete the surveillance, besides rendering other necessary assistance in carrying on the work. This little cutter, which is almost indispensable in the enterprise, should be placed under the immediate orders of M. the commissary of the marine at Saint-Brieuc, so that my daily instructions can be promptly executed by a force selected by that agent of the administration. I think, sire, that it is my duty to insist that this essential part of the programme be not forgotten.

These, sire, are the initiative means which have been adopted for the fertilization of the gulf. Hardly six months have elapsed since they were put into execution, and already the promises which were held out by science have become startling realities. The treasures accumulated by the persevering application of these methods in these fully developed fields exceed the most sanguine expectations. The mother oysters, the shells which were scattered over the bottom, in fact everything brought to the surface by the dredge, is covered with spat; the beach itself is thick with them. Never at Cancale or Granville, in the eras of their greatest prosperity, was such a spectacle of immense reproduction witnessed.

The bundles bear in their branches and on their smallest twigs bouquets of oysters in such profusion that they resemble the limbs of our fruit trees, which, in spring, are hidden by the profusion of their blossoms. They look like veritable petrifactions. To believe such wonders it is necessary to be an eye-witness of them.

In order that Your Majesty may judge with your own eyes of the extent of these treasures, I caused to be transported to Paris one of these appliances for collecting the spat, together with specimens taken from the several beds; these will testify eloquently in behalf of our successful efforts. The young oysters which cover them are already from 2 to 3 centimeters in length. They are simply the seed which, in eighteen months, will ripen and yield an immense harvest. On one bundle alone, occupying no more space in the waters than a sheaf of wheat in a field, as many as 20,000 were found. Now 20,000 oysters, when they are of edible size, represent in value 400 francs, the current price being 20 francs per thousand on the spot. The revenue from this industry will therefore be immense, since one may put down as many spat collectors as he wishes, and since each adult individual forming part of the bed will furnish not less than 2,000,000 to 3,000,000 embryos. The bay of Saint-Brieuc will become in this way a perfect storehouse if, by the junction of beds already formed, we convert the whole area into a vast productive field.

All the arrangements necessary for the accomplishment of this great scheme can be promptly executed, sire, if the prosecution of it be entrusted to those from whose intelligent zeal I have received so much aid up to this time. The experience which they have acquired in these first operations is a guarantee that what remains to be done will be brought to a successful issue.

I therefore hope that, in order that I may retain the indispensable assistance of two fellow-workmen, Your Majesty will deign to reward their zeal, and appoint from the list of officers M. Levicaire, chevalier of the Legion of Honor, and wearing the medal of Saint Hélène, who, unites with the best record thirty-nine years of excellent service, and ought to be raised to the rank of commissary of marine at Saint-Brieuc; and that M. Bidaut, lieutenant in the navy, a chevalier of the Legion of Honor, with nineteen years of excellent service to his credit, will be kept in command of the Pluvier, with all his crew, beyond the ordinary period, that is to say, until the scheme that we are now engaged in be entirely accomplished.

With the assistance of these two distinguished officers and the aid of an inspector of fisheries, whose appointment should be immediate, so that the bay of Saint-Brieuc may be placed on the same footing with Cancale, Granville, and Marennes, we hope in less than three years to unite all the beds, and have the whole surface of 12,000 hectares under full cultivation. An annual appropriation of 10,000 francs will suffice to carry on the work of clearing out the bottoms, buying supplies of seed oysters, gathering shells, repairing the structures for holding the embryos, organizing other beds of acclimatization like the one already established at Plevénon, and for the creation of perfecting-*claires*, where the fattened oysters are improved by becoming green. When this project is accomplished, the inhabitants of the sea-board will find in the gulf, as in a very productive field, an inexhaustible supply provided by generous foresight, and will witness on the shores an example of the different methods and practices connected with this oyster industry. It will prove at the same time a lesson and a great benefit.

If Your Majesty consent to this proposition, I shall immediately transmit to the commissary of the marine at Saint-Brieuc, and to the commander of the Pluvier, all the instructions necessary in executing these delicate operations. But to preserve our artificial beds one more measure must be brought into requisition: to order the dredgers to obtain their supplies at greater distances from the beds, where they may rake the bottom without injuring an enterprise commenced under such happy auspices.

To sum up, sire, the experiment made in the bay of Saint-Brieuc has been attended with such decisive success that the lessons it teaches cannot be ignored. It proves, by a splendid result, that whenever the bottoms are free from mud and slime, industry, guided by science, may reap from the depths of the sea, fertilized by its care, more abundant harvests than can be obtained from the earth. I deem it, therefore, my duty to recommend that Your Majesty order the immediate restocking of all our sea-coasts, that of the Mediterranean as well as of the ocean itself; that of Algeria and of Corsica, not excepting all the salt lakes found in southern France, the fruits of which, by multiplying, will become a source of wealth to the poor people who inhabit the shores. But, in order that these operations may be successful, it is necessary that a swift propeller of light draught should be built and devoted exclusively to this service; which vessel, during the spawning season, should be subject to my orders, so that I may visit all the centers of these great phenomena of natural reproduction, where science promises to industry precious revelations.

Captain Isidore Le Roy, known to the government by his studies upon the fisheries, a pilot experienced in the waters which are to be the scene of our work, well qualified in mechanical arts, and officially recommended for the surveillance of the first and second naval districts, could render me much aid if he were invested with the command of this vessel, heretofore mentioned as necessary to the execution of our plans; and in case Your Majesty sees fit to appoint him my coadjutor, he should at once report at the College of France, there to be instructed, under my direction, in all that pertains to the cultivation of marine products.

Among the measures to be taken for the accomplishment of this object, there are, sire, some which experience has already demonstrated to be efficacious, and which, by their immediate application, will produce certain results. But, besides these known facts, there are mysteries which persevering study alone can reveal, and which should be made the object of serious investigation. It will then be necessary to open along our shores vast laboratories, where scientific experiments may be performed, which will furnish new means for the extension of empire of industry. The saline lakes of Southern France, the bays of the ocean, those of Algeria, of Corsica, &c., offer the best opportunities for organizing great districts to be gradually transformed at Your Majesty's desire into supply centers for the seeding and cultivation of the sea.

The different edible species admitted by turns into those zoological gardens, so to speak, would be, like the animals in our stalls or in our parks, under the observant eye of those charged with the duty of studying their laws of propagation and of development, investigators placed there, as a branch of my laboratory of the College of France. It will then be necessary to enlarge the study rooms and increase the *personnel* and endowment. A skilled artist with his brushes will give a representation of each curious discovery which shall be made in this living museum, and thus prepare plates for one of the most important publications with which the annals of natural history will ever be enriched.

The unexpected phenomena which I witnessed at Concarneau, in the small ponds of Pilot Guillou, left no doubt in my mind as to the great serviceability of an establishment which will place in the hands of the government the necessary means for executing a work of public utility.

In the age when, by a sovereign application of the laws of physics, an invisible flame carries thought through conducting wires with which the genius of man has encircled the earth, physiology will exercise its empire over organic nature by an application of the laws of life.

I cannot conclude this report, sire, without expressing my thanks to Admiral La Place, *préfét maritime* at Brest, for the energetic assistance which he gave to our enterprise, by confiding its rapid execution to the combined care of the commandant of the station at Granville and to the chief of the maritime service at Saint-Servan.

I am, sire, with profound respect, Your Majesty's very humble and very faithful servant,

COSTE,
Member of the Institute.

After the above report was made, M. Levicaire was promoted to the grade of officer of the Legion of Honor, and M. Le Roy was appointed to the command of the Chamois, a steam-vessel which was placed at the orders of those superintending the restocking operations. M. Bidaut, lieutenant of the Pluvier, was retained in command of that vessel.

3.—Report to his excellency the Minister of Marine, on the restocking of the basin of Arcachon.

Paris, *November* 9, 1859.

Sir: In the first edition of a work which is now being republished by order of the Emperor, I demonstrated five years ago, by the help of numerous facts observed at Marennes, at Tremblade, and at the isle of Oléron, that oysters reproduced themselves in as great profusion in the *claires*, *viviers*, and *étalages* as in the open sea.

At the sight of these revealed sources of wealth, I announced that, by means of appliances for collecting the seed, all the establishments organized along the coasts would soon be transformed into productive areas, where, without quitting the land, the coast inhabitants would have in their hands the inexhaustible treasure which science offers to labor; and I described the instruments which were to be used in securing the possession.

I hope, sir, in the presence of the wonders accomplished under the eyes of the astonished inhabitants, henceforth anxious to take part in the prosecution of a work in which they, at first, had no confidence whatever, that your excellency will permit me to restate here the means employed, so that it may again be shown that the most abstract knowledge is everywhere the lever employed in attaining most wonderful results, in the great workshop where the genius of man extends its empire over the world. As I said before: "Each establishment, being thus transformed into a veritable manufactory where all the conditions are created by the genius of man, and varied at his pleasure, would at the same time answer the purpose of artificial beds and of appliances for perfecting the yield, giving in this manner constantly renewed products. The deposit of mud being the only obstacle to the preservation of the progeny of the oysters in the *claires*, there is a simple method of saving the spat, which is to place at a certain distance above the bottom, within their reach, and in such a position that the mud cannot interfere with them, solid bodies upon whose surface the oysters may cling. If in building these resting places preference be given to stakes, they should be planted in a vertical position, either driven in the bottom or fastened to floating rafts. These rafts would have another advantage: they could carry movable planks, placed obliquely one by the side of the other, like the slats of a window-blind, so that one side would always be free from contact with the mud. These movable planks, when once filled with seed, could be taken apart and suspended vertically to the frame-work of the raft. These, however, are initiatory details, the application of which may be varied according to the dictates of experience."

The first models of these plank collectors, whose efficiency as a means of collecting the seed has been tested along our whole sea-coast, had certain disadvantages which rendered them insufficient for practical purposes. One objection is, that they offer but a limited surface to adhere to; and another is, the difficulty in gathering the crop, as the young oysters attach themselves to the surface in such a manner that in removing them one part of the valve is frequently left adhering to the wood.

The problem, then, is not whether the spat may be cultivated in new grounds, for that fact has long since been demonstrated by science, and is known to all oystermen, but to discover some economical means of gathering large numbers of embryos in a limited space, and of easily removing them from these temporary repositories. It is necessary, in short, to organize hive-like structures where the mother oyster can deposit her young, like the queen bee, in myriads of cells so arranged that the swarm may be removed and renewed. This apparatus of precision places the work of nature under complete shelter, and carries the business even to man's habitation, where the saline waters, invigorated by a communication with the sea, are retained by artifice. By such means every point will be occupied by the spat, and they may be easily removed and multiplied.

The idea of applying these hive-like structures to the cultivation of the oyster, whether in bottoms sometimes exposed or always covered, has already made a decisive advance in the bay of Arcachon by the combined efforts of Drs. Lalesque and Lalanne, who bring their physiological knowledge to bear upon the new methods. The first named of these park-owners has converted my plank collectors into inclosed spaces, or submerged boxes, where the spawning is as effectual as when the oyster enjoys complete freedom, and so arranged that the young are entirely protected from the currents. The second is applying himself to the problem of *multiplication of surfaces* by doubling the height of the propagating cells, by means of *artificial stalactites* made from a mixture of three parts rosin (*brai*) to one of tar (*goudron*). This mixture, poured while hot on the prepared plank surface, gathers up the pieces of shell with which it is sprinkled, and, in cooling, substitutes for a hard, smooth platform, a rough, jagged, and friable surface, from which the spat can be easily removed and attached to other parts of the seed-plots on the *étalages*.

The collecting appliance thus modified is of a much more practical character, as the artificial stalactites form an inclosure where the oyster can be reproduced, and from whose surface the young can be easily removed. But even with this improvement it will be insufficient for the necessities of an industry which has so suddenly assumed colossal proportions, unless the interior of the structure be filled with fagots and branches, among which the embryos find unlimited space for spreading themselves. Thus sheltered, the branches, kept from contact with the mud, will, as I have already frequently demonstrated, be more abundantly filled with the embryos than if exposed in the open sea. But whether the industry be prosecuted upon the naked planks or in artificial stalactites, whether upon inclosed or open wicker-work, whether upon surfaces sometimes exposed or always submerged, it is still the same industry, furnishing everywhere proofs of incomparable success, and organizing effective appliances for fertilizing all the coasts where its development may be attempted.

Thanks to the rapid progress already made in this industry, it is now possible to retain in a space of a cubic meter in extent more than 100,000 embryos. So that with a simple outfit of twelve or fifteen hives of the dimensions given a million individuals may be obtained, which can be raised in a space of one hectare.

Now these oysters, representing in the pond when they have attained marketable size a value of at least 25,000 francs, it follows that, from the 800 hectares of surface in the bay of Arcachon suitable for this oyster culture, an annual revenue of 12,000,000 to 15,000,000 francs may be derived. What wealth for France, and what a lesson for the people!

A simple arrangement of the productive bottoms, a watchful care, and the necessary appliance for collecting the seed, will give this wealth and this salutary lesson.

Although the entire bay of Arcachon may be transformed into one vast oyster-bed, there are two localities, the point of Germanan and the space comprised between Estey de Crastarbe and the port of the island of Oiseaux (bird island), which are best adapted to the purpose of reproduction. The muddy, pebbly, and uneven bottoms will afford every opportunity for the various methods.

I have, therefore, the honor of proposing to your excellency that the government agents be ordered to proceed at once to the organization of two kinds of model farms, which will be at the same time public storages for seed and great areas for the concentration of the harvests.

The superabundance of seed which the collecting apparatus cannot hold will spread far and wide over the shells and artificial repositories with which the bottom of different parts of the bay will be covered, and will furnish, both to the hand fishery and the boat fishery, a continually renewed source of food. This portion of the harvest will be common property.

Those which develop in the reserved cantonments will be distributed in lots to the most zealous seamen, to whom this loan or generous gift will be a means of cultivating, on their own account, beds, ceded by the government, and thus creating for themselves a first capital, by which they will pass from a mercenary or laboring condition to that of cultivators. *This will be part of the recompense.*

But in order that nothing shall be left undone that is calculated to expand the business, it will be well to admit, to a certain extent, private enterprise to the benefits of the concessions, obliging it to be associated with the fishermen, whose rights will be protected by contracts made before the proper authority. So that, without making over anything, the government can aid the development of the industry and attract those who, witnessing its prosperity, feel disposed to engage in the pursuit.

If your excellency consent to this plan of organization, the commissary of maritime inscription at Teste will have ship-loads of shells taken from the Matoc bank, situated at the entrance of the bay, and carried either by the fishery-police boat or other vessels and deposited in the places designated to receive the spat. But before spreading them over the bay, they should be exposed to the sun a sufficient time to destroy any deleterious animals that may live in or cling to them, so that they will not be deposited in the oyster beds to increase and multiply.

In carrying out the details of this general arrangement, about 1,000,000 breeding oysters, procured either in the channels where fishing is prohibited or in the markets, should be carried during the following months of March or April to the places I have designated for the creation of the two model establishments. These oysters should be submerged, as in the ordinary *étalages*, in parallel rows, between each of which a path must be left for the laboring men, who, during the highest tides, will be occupied in the restocking operations. But in order to avoid the injury incurred by leaving the oysters exposed too long to extremes of heat or cold, such places as are less frequently left dry should be selected for depositing them.

Above each of these level rows boxes 3 meters long, 2 meters wide, and 60 centimeters in depth, built of fir planks, are to be placed in line, end to end, and held at a certain distance above the bottom by means of stakes, to which they must be securely attached. These boxes, divided into two compartments by wooden partitions, something after the manner of a traveling valise, will receive in the upper story as many fagots as can be placed under the cover, which is provided with artificial stalactites; the covers should be arranged on hinges, so that the operations of nature may be watched without interfering with them, and any causes that might prove an obstacle to them be easily removed. By the side of these appliances, placed like bells, receiving in their open lower part the spat which escapes from the *étalages*, a few completely closed should be built, the sides of which should be pierced with holes to allow the free flow of water; and in these pens, filled with branches, a few oysters about to spawn should be placed, in order to ascertain whether these collectors will retain more or less seed than the first.

In other places, the work will consist simply in placing wicker-work beneath planks, fastened by cross-pieces to stakes. The ceiling of this plank structure, being roughened by adhering chips, will furnish to the spat points of support which will replace the artificial stalactites.

I have had constructed by the crew of the Chamois models of these different instruments of cultivation, and will place them at the disposal of the government when it is desired to introduce them.

In the center of each of these school-farms a pontoon surmounted by two rooms will serve as a lodging place for the persons in charge of the apparatus, who will act in concert with the maritime guards of Dauris, Séveillard, and Daillon. These guards are all devoted to the work, and the first named have excited special remark by their ardent zeal. In order, however, that these agents may derive from their employment a livelihood, I hope that their salary may be raised to at least 800 francs, whether in the form of a temporary grant, or as a permanent salary. The watchmen of the two pontoons, two men to a pontoon, will be taken in turn from the crew of the police-boat; for the personnel of the fleet, being under a rigid discipline, offers a guarantee of faithfulness.

In the present condition of things the general surveillance of the bay is insufficient. There are in a circumference of 18 leagues containing 10,000 hectares of surface, three maritime guards, the inspector of fisheries, and a small cutter commanded by a skipper. So limited a force is evidently insufficient to meet the exigencies of the service. I therefore recommend that the maritime guard be increased to six, their pay doubled, and that the inspector of fisheries be promoted to the first class, so that increased responsibility may be rewarded by increased pay. I also recommend that the actual guard be stationed at the far end of the bay towards Gujan, and the employment in addition, of a screw-launch of 25 or 30 tons burden, of light draught, constructed upon the model of those used in the light-house service, and commanded by an ensign or lieutenant.

With these means of action, and the aid of private enterprise, an appropriation of 20,000 francs would be sufficient to transform, in two years, with profit to all and honor to the government which extended its help to the enterprise, the bay of Arcachon into a veritable field of abundance. This bay then would produce upon its stocked depths, by means of appliances prepared beforehand, immense harvests, the extent of which may be calculated in advance by the result which the permanent depots have already begun to accumulate.

But shell-fish will not constitute the only harvest taken from this fertile tract. The government can easily create along the coast a no less precious source of production, by building reservoirs connected by trenches with the sea, through which the excess of fish spawn can be carried into the interior; this question has been controverted, and to its discussion I will in a future report call your excellency's attention.

While awaiting your decision, sir, I beg you to accept a renewed assurance of my respectful consideration.

COSTE,
Member of the Institute.

In accordance with the conclusions arrived at in the above report, two establishments, to be used as models, are already in operation at the designated places in the bay of Arcachon. A second police-boat, the brig Léger, commanded by Lieutenant Blandin, is charged with the surveillance of the bay, and co-operates with M. Filleau, commissary of maritime inscription of that region, in the cultivation of the two beds created by the government. One hundred and twelve grantees (*concessionaires*), associated with registered seamen, now follow this new industry over an extent of 400 hectares which the government has ceded to them.

4.—APPLIANCES SUITABLE FOR THE RECEPTION OF OYSTER SPAT.

Young oysters, after leaving the parent shell, move about in the waters, here and there, seemingly in search of the most favorable conditions for their adherence and their subsequent development, preferring solid bodies, with a slightly roughened surface, protected from the mud. It is for the purpose of creating similar conditions that the appliances, of which a compendious description is herewith given, were invented.

These various appliances, when used in the *parcs*, *claires*, *viviers*, *étalages*, natural beds, &c., which are left dry at each tide, or only during equinoctial tides, should not be put in place more than a week or two previous to the most active period of the spawning season, that is to say, during the first fifteen days of June, or towards the end of that month, if the hot season be early.

THE PLATFORM COLLECTOR.

The platform collector will cover only a limited space, if but one compartment be used, but may be extended over a vast surface if its compartments be multiplied. Its construction is such that the labor of one person is sufficient to manage its different operations. Wherever the oyster is cultivated it may always be used, if it be so arranged that at any time after the young oysters have attached themselves it may be taken apart and transported to such places as may be desirable. It has an additional advantage, in that it protects the embryos from the mud, which would smother them at their birth, and also shields them from most of the animals that feed upon them.

The platform collector, with multiplied compartments (Fig. 1), consists of several series of double stakes (A) separated by a space of 12 to 15 centimeters only; arranged in squares like a chess-board, at a distance of about 2 meters from each other, and divided by passages for convenience of cultivation (E) about 60 or 70 centimeters in width. Two corresponding holes, the first at 50 centimeters from the bottom of the bay, and the other 25 or 30 centimeters above the first, pierce the coupled stakes. A pin (I), either of wood or iron, passed through the lower hole, converts the stakes into a kind of trestle, and serves as a resting-place for cross-pieces made of a single piece of timber (B), at least 2 meters and 20 centimeters in length, and from 10 to 12 centimeters in diameter. These cross-pieces should be solid, because they are to bear the weight of the flooring, consisting of planks (D) supported horizontally at their extremities by the lower cross-pieces, and placed as close together as possible. Other cross-pieces (C), of the same length as those already mentioned, placed above the planks, and held together by pins (J) passed through the upper holes, keep all the planks in place. If it should happen that there be too much play between the upper pins and the cross pieces they hold in position, a wedge (Q) placed between the two will prevent this inconvenience. Wooden wedges (Q′) serve also to fasten such planks as are too movable. Whenever it is desirable to take the planks apart, either to carry them to some other supports, or to turn them and isolate the young oysters, which are large enough to resist the deleterious action of the mud, or to inquire into the state of the crop, or examine the surrounding bottoms, all that is necessary is simply to pull out the upper pin (J′) and remove the cross-pieces (C′) that hold the planks down. The wood best adapted for making these planks is that of pine or spruce; the planks should be from 2 meters and 10 centimeters to 2 meters and 15 centimeters in length, and about 20 to 25 centimeters in width; one side of which is made rough with an adze, the chips to be left adhering to the plank. These chips which project 2 to 3 centimeters, offer a larger and better surface to the embryos, and also make it easier to gather the oysters which adhere to them. The chips may be replaced by a bed of shells of cockles, clams, scallops, mussels, or of pebbles as large as a nut, which can be fastened to the planks with a cement made of tar and rosin. Finally, to increase as much as possible the points to which the spat may fasten themselves, small branches of chestnut, oak, vine cuttings, &c., are tied on to the planks (DD), holes being bored through them for the purpose.

In *parcs*, *viviers*, &c., where the bottom is rocky or hard, and piles therefore cannot be used, stones should be used as a substitute; these (G) should be about 70 centimeters high and 25 centimeters thick, pierced at certain points with holes sufficiently large to receive the cross-pieces (B C), and also a wedge (H) to hold the latter in place, and held in position by masonry or by means of iron clamps.

ROOF COLLECTOR.

The *roof collector* (Fig. 2) may be used advantageously instead of the stones, which serve at some points, for the purpose of keeping the spat in the *parcs*, or it may supplant the wooden collectors where these are subject to the invasion of teredos and of other wood-eating mollusca.

The *roof collector* is supported on trestles made of cross-pieces nailed to stakes, which rise above the bottom from 15 to 20 centimeters.

The number of trestles is increased or diminished according to the area which is to be covered.

The tiles, which are the chief elements of the roof, being susceptible of different combinations, allow the form to be varied at will.

These tiles may be arranged in parallel and contiguous rows, and thus form a simple complete roof.

In all the *parcs* where the action of the water is very strong the different rows of tiles should be secured to one another by means of a galvanized iron wire, or with stones placed here and there over their surface.

A double roof may be formed (Fig. 3), consisting of an open work of tiles covered by a series placed close together.

The tiles may be placed between wooden supports (Fig. 4) in rows, covering, without touching each other, and forming, with the bottom upon which they rest, an angle of from 30 to 35 degrees.

They may also be arranged in the shape of a tent, with both ends open and more or less extended, as in Fig. 5.

In this last combination, the tiles touching the bottom will act as a mutual support to one another, and can be strengthened by placing stones along the line of contact with the bottom; thus the use of wood becomes unnecessary; the apparatus is consequently protected from destructive animals. The embryos can be gathered from this kind of collector more easily and with less loss than from those made of stones.

HIVE-COLLECTOR WITH MOVABLE TRAYS.

The hive-collector with movable trays, although of limited dimensions, offers, nevertheless, to the spat multiplied points upon which to fasten themselves, and the independent collectors, which form the essential elements, offer the most favorable conditions for the complete development of the young oysters.

This apparatus (Fig. 6) is composed of an enveloping part, consisting of a chest made of light wood, rectangular in shape; measuring 2 meters in length, 1 meter in width, and 1 meter in height; without a bottom; with a cover made of several pieces (D), held in position by a cross-piece (T) passed through cleats at the handle (A). The chest is bored at the extremities with a double series of holes, either square or round, corresponding to each other, and large enough to admit beams of 6 to 7 centimeters in diameter (S); it is held together on the sides by battens of wood (R), which correspond to traverses of the same size placed across the bottom (Q). In order that the water may circulate freely in all parts of the structure, the vertical bands (R) should extend some 10 centimeters below the bottom of the chest; the planks that form the partitions ought also to be placed 2 or 3 centimeters apart, or be pierced with a great many holes (O).

In this chest wooden trays of about 4 centimeters in thickness are placed, having two handles opposite each other (Figs. 7 and 8), and furnished on the opposite side with a screen of brass wire with meshes 2 centimeters in size; the bottom is held in place by means of cords, nails, or galvanized iron wire. A median cross-piece (Fig. 7), consisting of two copper rods placed at right angles to each other, fastened at the ends, either to the angles of the frame (Fig. 8) or to the middle of its arms, increases the strength and helps to support the wire gauze.

To make the work all the more easy, the trays ought to be square, of only one-half the size of the interior surface of the chest, so that it will be possible to place two of them on the same supports, as shown in Fig. 9, and there should also be sufficient space between them so that they may be removed or put in place without difficulty.

Finally, shells of different mollusca, of medium size, such as the ordinary mussel, the edible cockle, commonly called *coque* or *sourdon*, of our various species of *Venus*, &c., form an indispensable part of this apparatus.

The method of putting the various parts together is very simple (see Figs. 6 and 9). After having placed the chest on the strips of timber which extend beyond its bottom, and having placed under these a flat stone which prevents them from sinking too far into the earth, some sixty odd selected parent oysters are spread in the vicinity; then, in the lower openings of the ends of the chest the first two supports (SS) are placed, on which two trays are laid, which are previously covered with a bed of mussel or cockle shells, above which other spawning oysters are spread. This first tier being arranged, the second is proceeded with, and then the third, in the same manner except that in the third no mother oysters are admitted.

The whole is then covered with notched planks (D), which are held in place by means of a cross-piece passed through iron handles and tightened with wooden wedges (C). These handles being fastened in two posts solidly attached to the ends of the chest (P), it follows that in holding down the planking the cross-piece also keeps the whole structure together; additional strength can be given to it by nailing to the sides two other independent posts (P′), shorter than the first, but as deeply imbedded in the earth.

Five or six months after the spawning, the young oysters having attained sufficient growth, the apparatus is taken apart piece by piece by an inverse operation, that is, proceeding from top to bottom, and the contents of each frame are carefully placed in some *parc*, *étalage*, or *vivier*, in places least affected by currents and mud.

PAVING-STONE COLLECTORS.

Oyster spat is also gathered upon blocks of stone, such as are sometimes used in parks; this practice obtains in the neighborhood of La Rochelle, and notably at Laleu and the isle of Ré.

These stones, irregularly and obliquely arranged one against the other, serving for mutual support, should form numerous winding caverns, whose arches are protected from mud, and afford numerous large spaces where the young oysters may fasten themselves.

The paving-stone collectors can be constructed at small cost, and each one of them offers, also, the advantage of accommodating two crops; all that is necessary to accomplish this is simply to return the blocks to the same places from which they were taken, and arrange them as nearly as possible in the same position as they originally occupied.

By this operation the oysters fastened to the lower surfaces are placed in a full light, which is a most favorable condition for their growth; while the upper surface of the stones, when reversed, furnishes to succeeding generations shelter and an excellent surface for their adherence.

But while these paving-stone collectors offer incontestable advantages, they are also open to grave objections, made evident by experience. The oysters are apt to fasten one whole side of the valve to the stones, and hence cannot be removed except with great loss; and then again, those that are not attached in this manner are liable to contract defective shapes.

It is not only necessary that large quantities be produced, but also that the product may be easily gathered, and that the oysters have a desirable form.

INDEX.

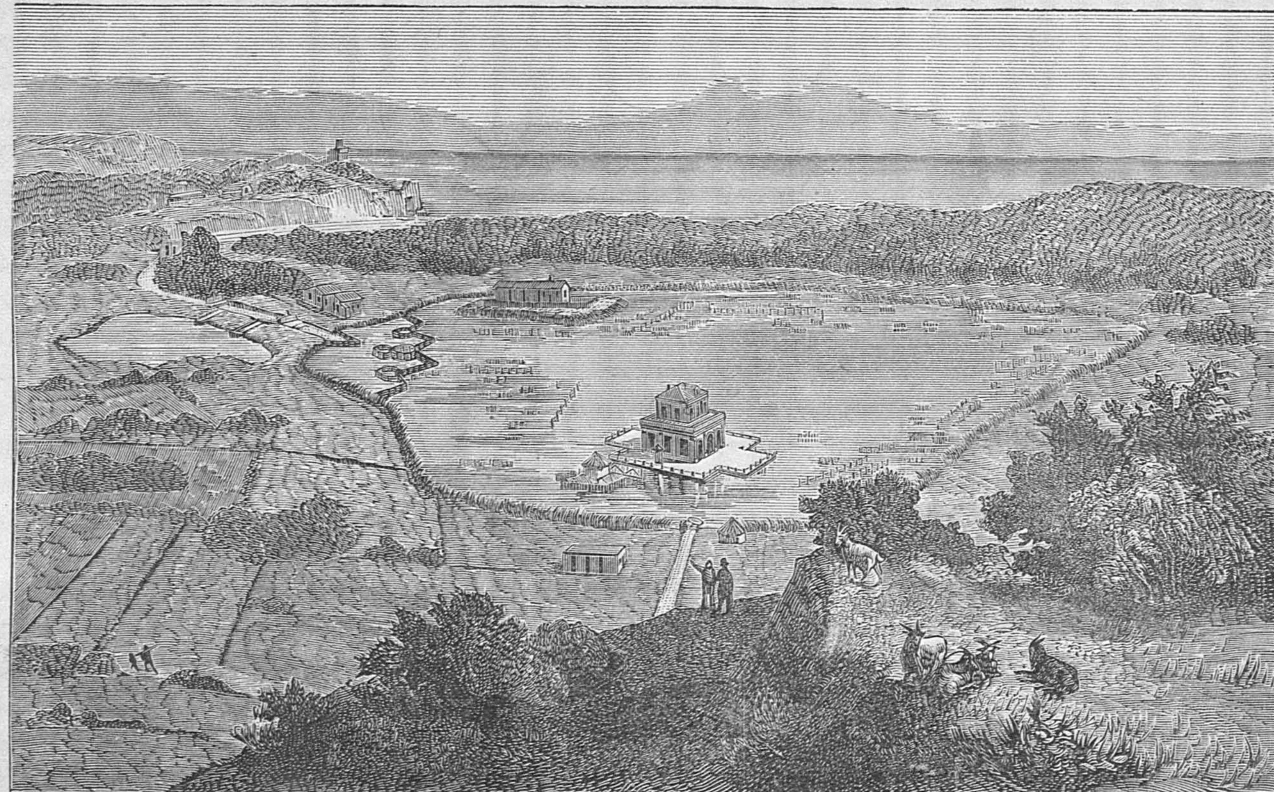


FIG. 1.—General view of Lake Fusaro (*Achéron* of the ancients), showing here and there the stakes arranged circularly around the artificial beds; the single and double rows of other stakes, by means of which the fagots are suspended; and at one of the extremities, the labyrinths in front of which there is a canal two and a half to three meters in width and a meter and a half deep, excavated in part in the sides of a promontory, and connecting the lake with the sea. A small lake, believed to be the ancient *Cocyte*, communicates with this canal. In a pond or reservation there the oysters destined for sale are placed provisionally; it joins the royal pavilion, the residence of the *personnel* charge, with the superintendence and collecting.

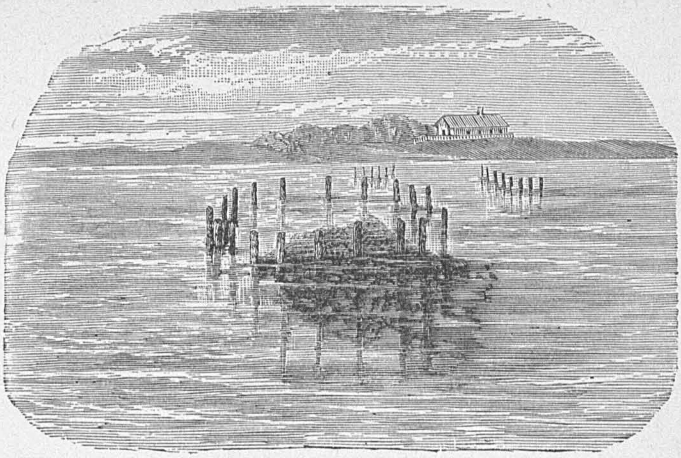


FIG. 2.—Artificial beds surrounded by stakes.

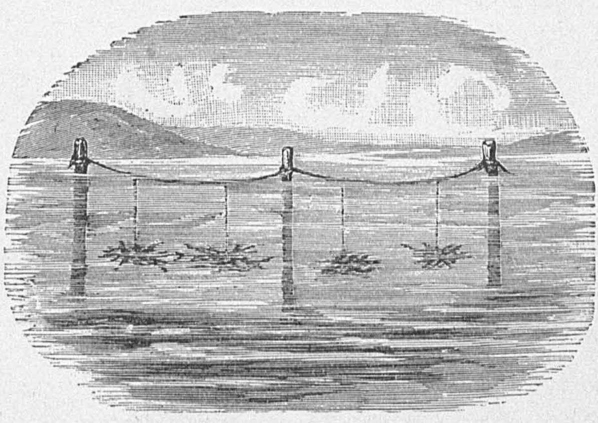


FIG. 3.—Stakes arranged in a straight line and united by a rope to which are suspended the fagots intended to receive the young oysters.

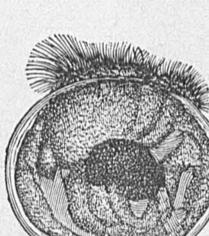


FIG. 4.

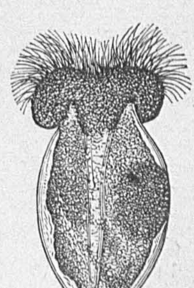


FIG. 5.

FIGS. 4, 5, 6, 7.—Oysters ready to leave the mantle of the parent, enlarged a hundred and forty times. Figs. 4, 6, 7, show one side. In the three last, the cushion, provided with its natatory cilia and the muscles which move it is outside of the shell and protrudes beyond the mouth, which is itself ciliated.

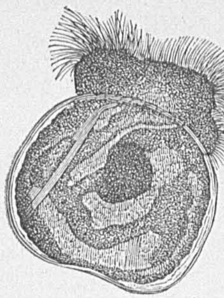


FIG. 6.

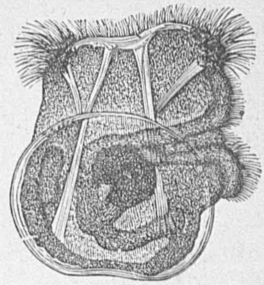


FIG. 7.

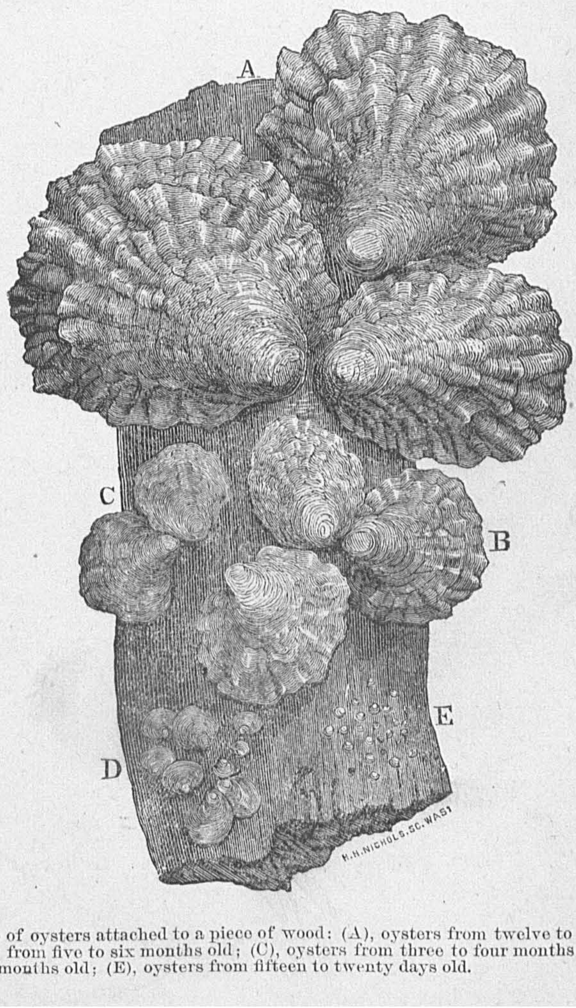
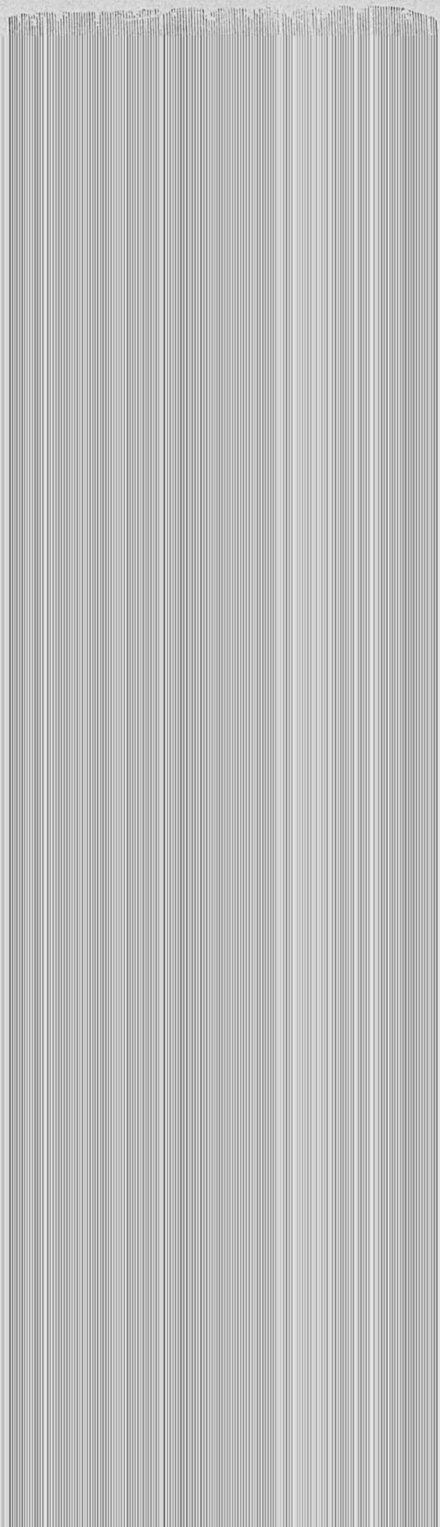


FIG. 8.—Group of oysters attached to a piece of wood: (A), oysters from twelve to fourteen months old; (B), oysters from five to six months old; (C), oysters from three to four months old; (D), oysters from one to two months old; (E), oysters from fifteen to twenty days old.



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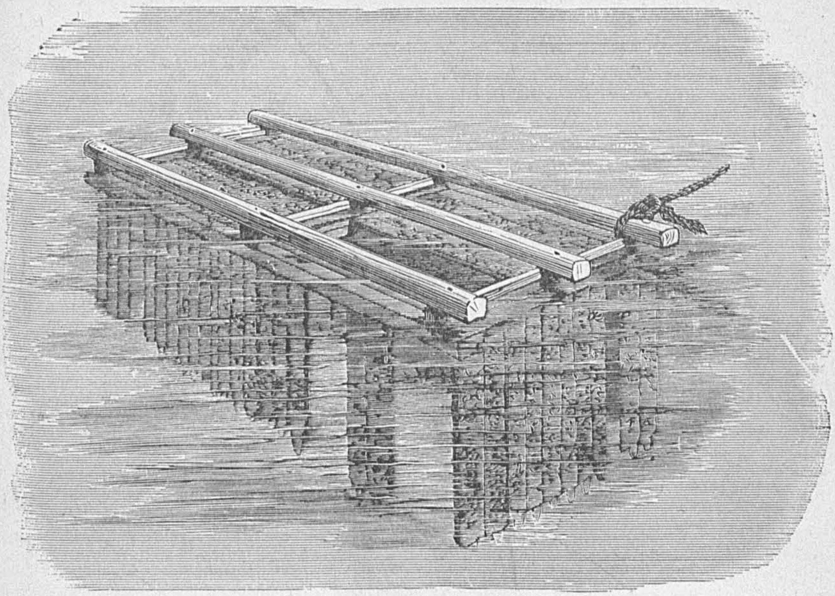


FIG. 11.—Floating apparatus for the artificial culture of mussels, consisting of a double frame formed of beams, on which are fixed, by the aid of hooks, either vertically or horizontally, as the case requires, planks covered with mussels. The horizontal planks, submerged from 15 to 20 centimeters, receive the seed-beds of very young mussels, which attach themselves there, and allow the suspension of these seed-bed planks vertically.

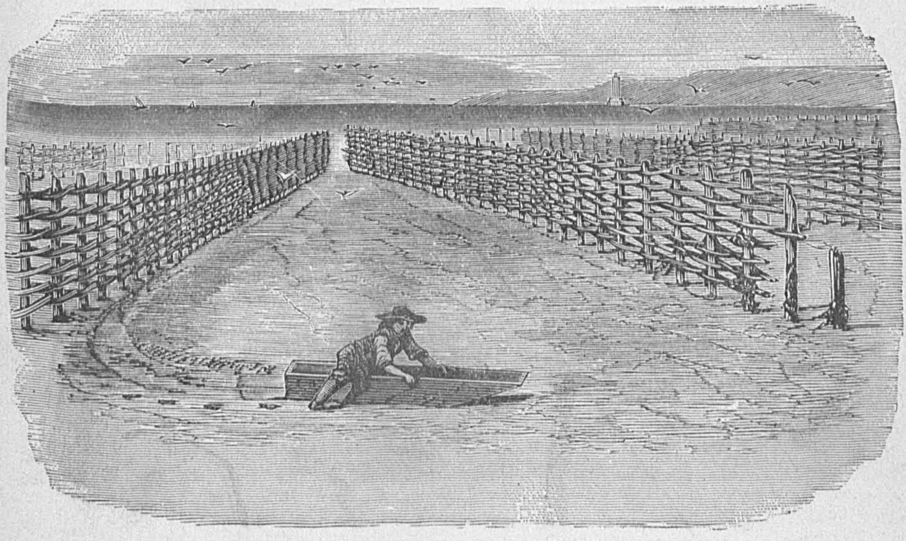
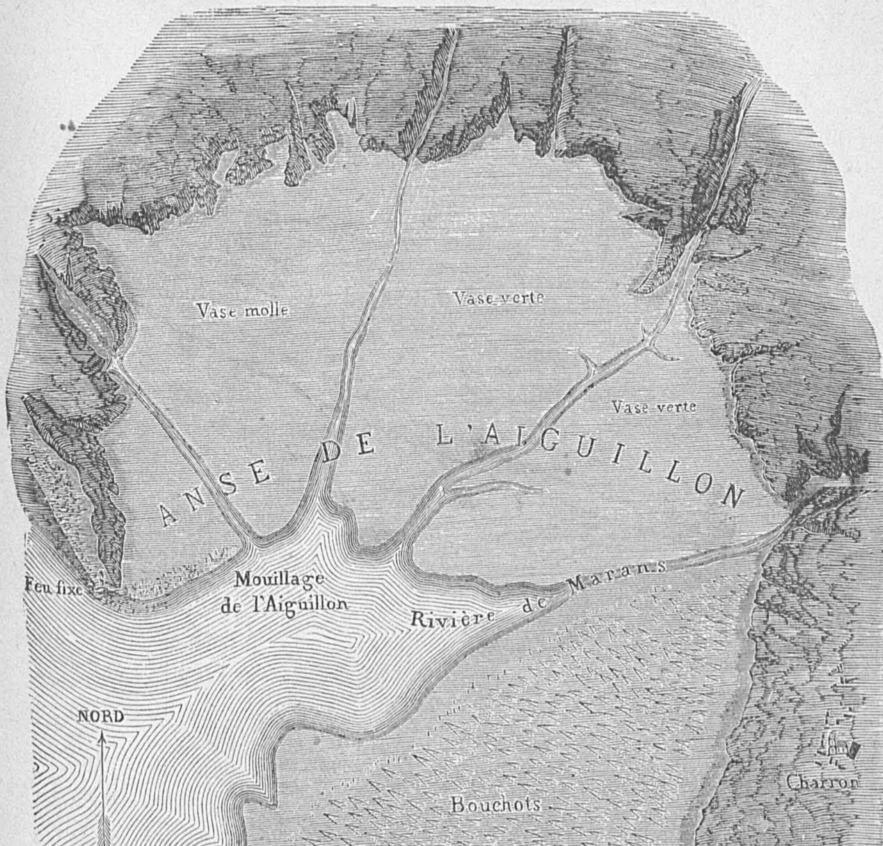


FIG. 12.—"Bouchot fisherman in his *acon*, which he pushes over the mud."


ANSE DE L'AIGUILLON
Vase molle
Vase verte
Vase verte
Feu fixe
Mouillage
de l'Aiguillon
Rivière de Marans
NORD
Charron
Bouchots

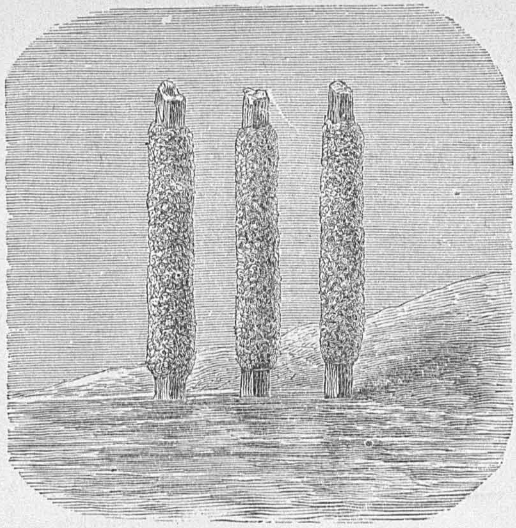


FIG. 14.—Isolated stakes, called *bouchots d'en bas ou d'aval*, covered by the spat (*renouvelain*) or spawn of mussels, which they are especially intended to receive.

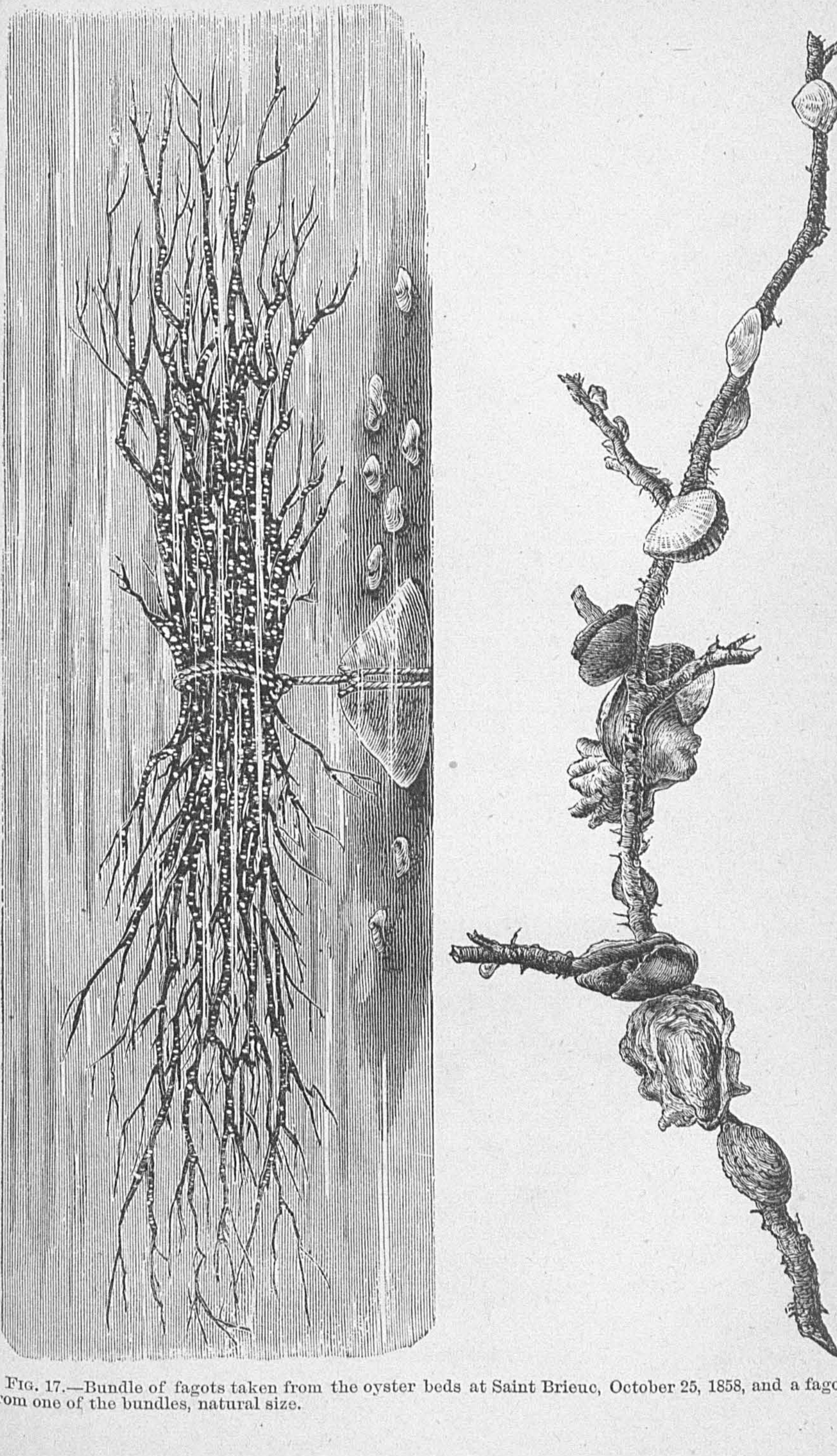


FIG. 17.—Bundle of fagots taken from the oyster beds at Saint Brieuc, October 25, 1858, and a fagot from one of the bundles, natural size.

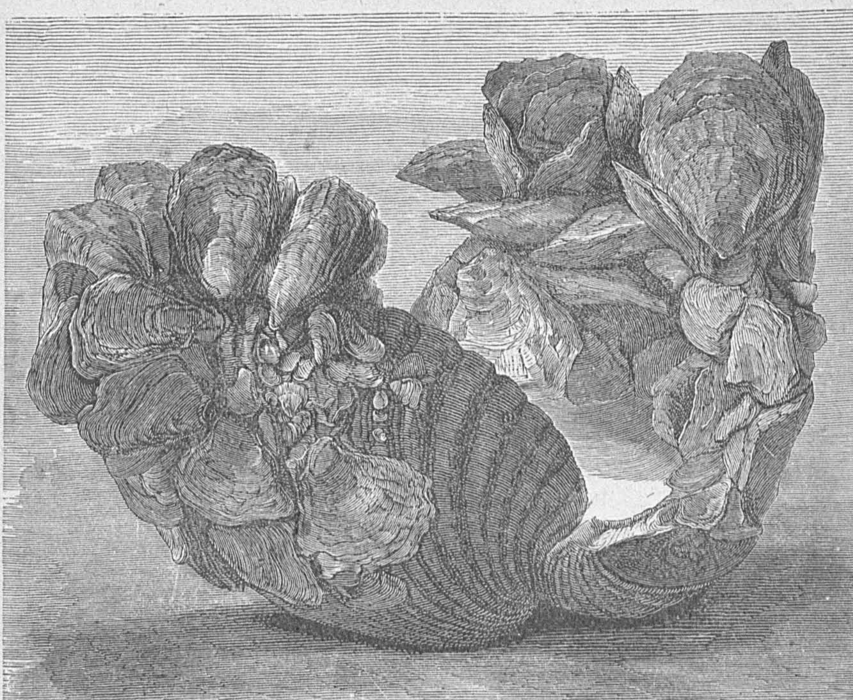


FIG. 18.—Cardium shells covered with young oysters of life size.

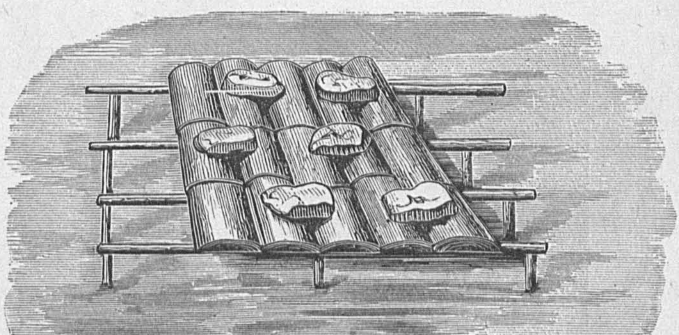


FIG. 19.—Simple roof-collector.

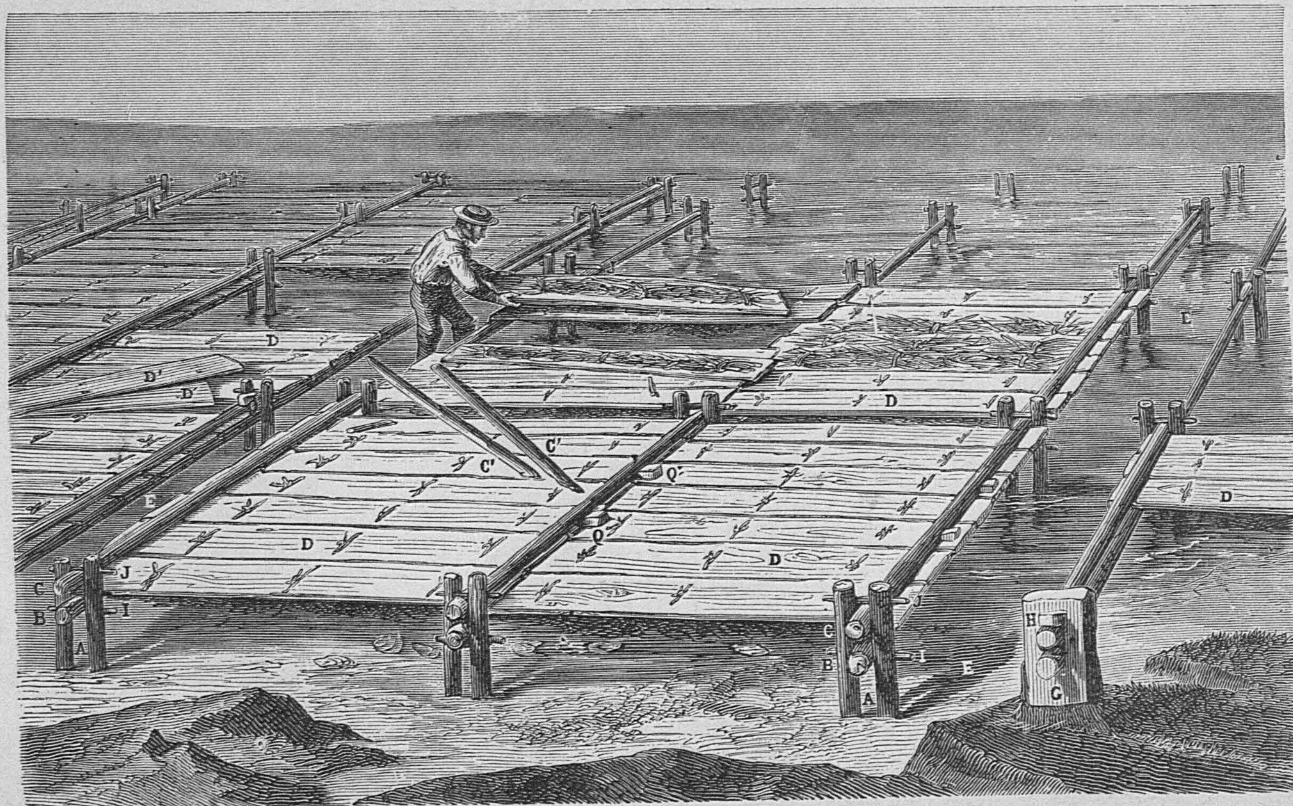


FIG. 20.—The platform-collector with multiplied compartments.

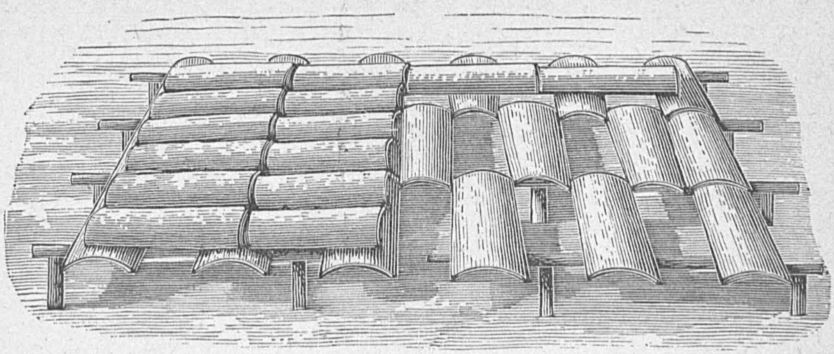


FIG. 21.—The double-roof collector.

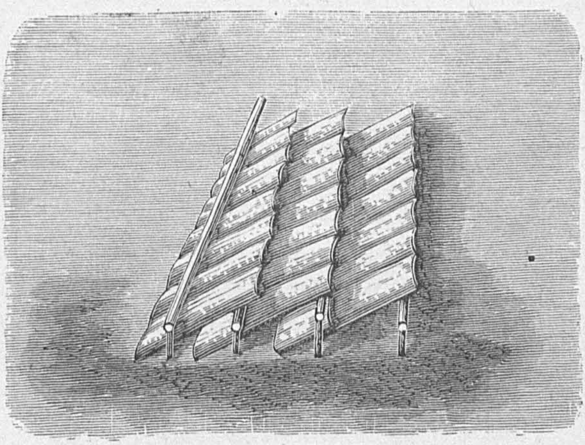


FIG. 22.—The roof-collector in oblique rows overlapping.

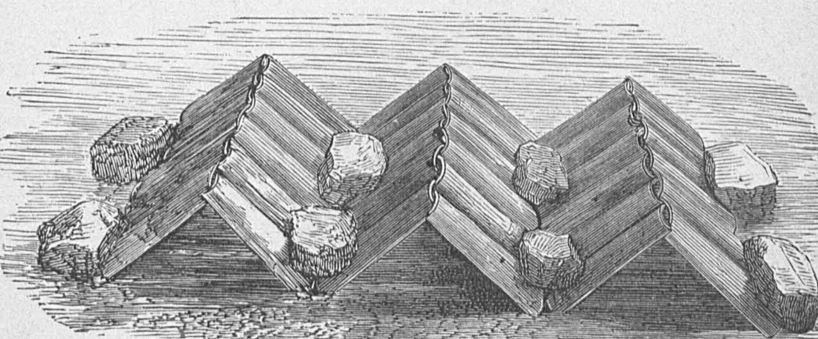


FIG. 23.—The roof-collector in alternate rows opposing.

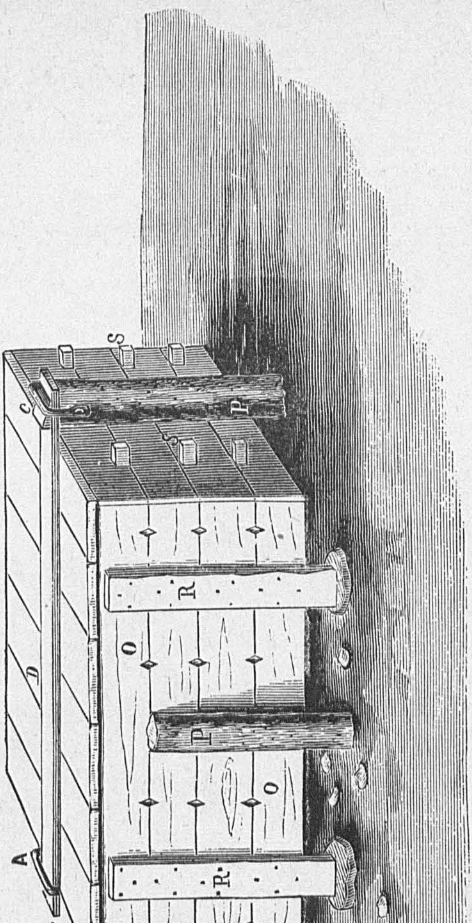


FIG. 24.—The live-collector, complete.

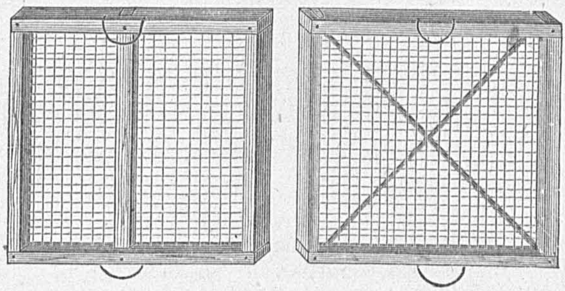


FIG. 25.—Movable frames of the hive-collector.

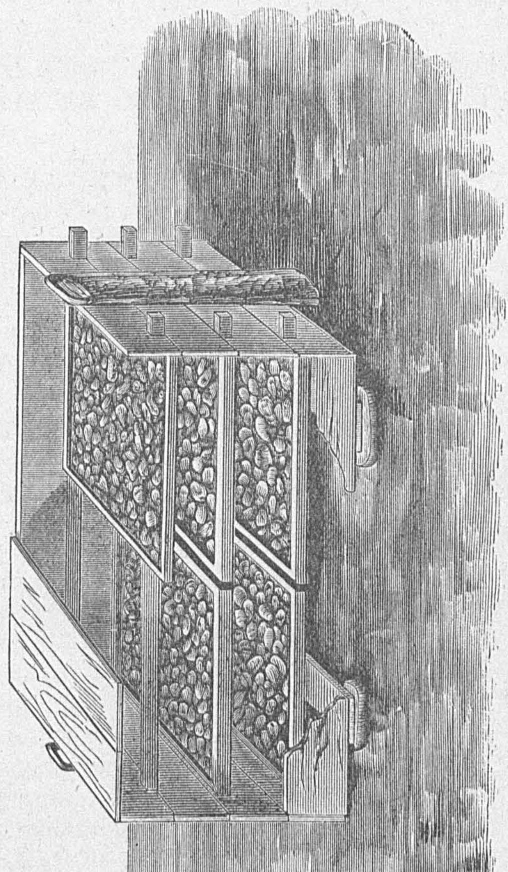


FIG. 26.—Hive-collector with lateral wall removed to show arrangement of the frames.

XXX.—REPORT ON THE CONDITION OF OYSTER CULTURE IN 1875, PRECEDED BY A REPORT TO THE MINISTER OF MARINE AND OF THE COLONIES.*

By M. De Bon,
Commissary-General and Director of Administrative Affairs of the Ministry of Marine and of the Colonies.

REPORT TO REAR-ADMIRAL THE MARQUIS OF MONTAIGNAC, MINISTER OF MARINE AND OF THE COLONIES, BY M. DE BON.

Versailles, *January* 23, 1875.

After a long period of quietude oyster culture has recently made considerable advancement. In the basin of Arcachon, especially, it has rapidly developed since 1870. The practical results attained by the improved methods of work have attracted the attention of all the inhabitants of the basin, have even acquired a great notoriety abroad, and have induced many people to engage in this industry. The demands for concessions of ground have increased to an unusual extent, and at the same time the oyster culturists, already provided with parks, have found themselves much inconvenienced in the establishments they now possess from the lack of room in which to raise the young oysters taken in large quantities from their collectors.

A ministerial decision, published in 1860, reserved for the general fishery quite an extended area in the basin, upon which the establishment of parks was prohibited. The suppression of this area was asked for by some in the interest of oyster culture, but there was also another party, opposed to this plan, according to whom it was not only necessary to maintain the existing reservations, but also to refuse all new concessions, under the pretext that the multiplication of the parks would injure the general prosperity of the basin.

At the beginning of last year Vice-Admiral Dompierre d'Hornoy, then minister, instructed me to proceed to these places in order to ascertain the state of affairs at Arcachon, and to report to him *de-visu*. I returned from this mission convinced that the oyster industry of Arcachon was

*Notice sur la Situation de l'Ostréiculture en 1875; précédée d'un Rapport adressé au Ministre de la Marine et des Colonies, par M. De Bon, Commissaire Général, Directeur des services administratifs au Ministère de la Marine et des Colonies. (Extrait de la Revue Maritime et Coloniale.) Paris: Berger-Levrault et Cie., Rue des Beaux-Arts, 5. 1875. Octavo pamphlet, 27 pp.

susceptible of important developments; that it merited favorable attention from the administration, and that the greater part of the reserved area could be turned over to oyster culture without any inconvenience whatever to the general interests. The minister, in accordance with propositions which I submitted to him upon this subject, decided on the 28th of January, 1874, that all the grounds of the basin yet unoccupied should be placed at the disposal of private industry, and in addition a certain number of natural oyster-beds, which need to be taken care of, as they constitute breeding centers indispensable to the maintenance of the parks.

In executing this decision, the first work of dividing the old reserved area was effected during the year 1874 and received the sanction of the ministry on the 19th of last December. Seven hundred and twenty-eight new parks were thus authorized at one time, and were added to the seventeen hundred and six oyster-cultural establishments already existing in the basin. A second work of the same kind was also approved by the minister, and a third will soon follow. At the same time concessions of ground were daily granted in all other parts of the basin and the great number of demands was not lessened. Furthermore, this progress in oyster culture is not limited to the basin of Arcachon. In Morbihan industry and capital favor it in a nearly equal degree. There also oyster culturists, finding the condition of the soil, climate, and locations propitious, have, little by little, perfected their methods and obtained remarkable results.

From these two centers of activity oyster culture radiates to a greater or less extent in all directions. It has been permanently established in the bay of Mount-Saint-Michel and on the sandy borders of the Vivier. It seems in a fair way of becoming re-established on the coast of the island of Noirmoutiers and the island of Ré, where it had previously given great hopes of success at the time it was first started there; it is more prosperous than ever on the banks of the Seudre. Finally, it has become in many places the object of attempts which will, without doubt, prove partially successful.

Aware of the deep interest taken in the coast fisheries by the Admiral Marquis of Montaignac, who, in 1850, was one of the commission under the presidency of the Count Chasseloup Laubat to prepare the penal laws of 1852, I have thought that at this time, when oyster culture has received a definite impulse, the minister would read with pleasure a detailed report of its origin, its first phases, and its present condition. I have, therefore, by the aid of documents collected at the bureau of fisheries, prepared this report, which comprises the history of oyster culture and practical descriptions of the most perfected methods of cultivation practiced upon our shores.

I have the honor to submit this work to the minister, and should he find it worthy of his approbation, I beg he will give it to the public as an aid in extending the knowledge and facilitating the progress of an industry which is still new and full of promise for the future.

I recommend that this report be published in the Revue Maritime et Coloniale.

Commissary-general of the marine, director of administrative affairs,

Signed: DE BON.

Approved.

Signed: MONTAIGNAC.

AN ACCOUNT OF THE CONDITION OF OYSTER CULTURE IN 1875.

In addition to the taking of oysters by dredging, there exist two very distinct branches of oyster industry, which have hitherto been carried on to a very unequal extent.

The first consists only in the improvement of oysters taken from natural banks. The oysters are taken, so to speak, ready-made, are deposited in localities calculated to give them certain qualities of flavor, shape, or color, and are then furnished to consumers after they have acquired these qualities, which increase their market value. It is a sort of stock-raising, analogous to that of the farmer who buys lean cattle and fattens them before sending them to market.

The second industry consists in taking the oysters when they are in an almost embryonic state, as soon as they have left the valves of the mother oyster; in favoring the first phases of their development by special care, thus saving from destruction a multitude of germs which would perish if left to themselves; and subsequently in increasing artificially the harvest of these productions which nature lavishes with so much carelessness and prodigality. This latter industry has been compared to agriculture, which multiplies the productions of the earth in order to meet the constantly increasing demands of mankind; hence the name *oyster culture*, which has of late been applied to it.

I.—History.

RAISING OF OYSTERS TAKEN FROM NATURAL BEDS.

Ancient origin of this industry.—The rearing of oysters by the first of the two methods just spoken of is of very ancient date. Historians relate that a rich Roman, named Sergius Orata, a contemporary of Cicero, at the close of the Roman Republic, conceived the idea of bringing oysters from Brindes, and of parking them in Lake Lucrine, which communicated with the Mediterranean Sea not far from Naples. This plan resulted very successfully, for the oysters of Lake Lucrine soon acquired an unequaled reputation and the originator of the idea derived considerable profit therefrom. This industry appears to have been perpetuated in the country where it began. M. Coste, the celebrated propagator of the methods of fish-culture, during his voyage of exploration on the coasts of France and Italy found it practiced in Lake Fusaro, a short distance from Lake Lucrine. The oysters employed there are taken from the gulf of Tarente and distributed over various portions of the lake, which have been previously arranged for this purpose. This industry is associated there with methods of oyster culture, properly so called, to which we shall refer hereafter.*

Practices in France—Marennes.—In France the improvement of oysters by parking has been known and practiced for a long time. The productions of Marennes have long been famous. The parkers of that district purchase not only the shell-fish taken in the immediate neighborhood, but they also bring them from the coasts of Brittany and the basin of Arcachon. These oysters are put into *ponds*, where they grow rapidly, and into *claires*, consisting of shallow basins, where they acquire, after a more or less prolonged stay, a particular flavor and that green color so much prized by epicures.

Cancale, Granville, Saint-Vaast-la-Hougue, &c.—The oysters of Cancale and Granville are also parked, either locally at Saint-Vaast or at Courseulles, where they greatly improve and acquire the faculty of preserving in their valves, for a long time after they are taken from the park, the savory water, constituting one of their principal merits.

Practices in America—Importance of the production in that country.—The same method of raising is practiced in America on a grand scale. The coasts of the United States have, almost everywhere, oyster-beds of extraordinary richness. The consumption of oysters among the Americans attains proportions quite unknown on this side of the Atlantic. In 1859 a newspaper of that country estimated the trade in this mollusk in the principal cities of the Union at 20,000,000 bushels; each bushel contains on an average 400 oysters, making the enormous total of 8,000,000,000 oysters consumed in a single year, without counting those eaten on the spot, or those omitted by the errors of enumeration.† Most of these oysters after being taken are parked the same as in France. The parks are usually near the large centers of population, which in America are almost all situated in the vicinity of the sea. The most favorable places are the estuaries of rivers; for it has been ascertained in all countries that a mixture of fresh and salt water greatly develops the edible qualities of the oyster. In fine, the rearing of oysters is an industry of great antiquity, and is practiced almost everywhere where this mollusk constitutes a common article of food.

OYSTER CULTURE PROPER.

The same is not true of oyster culture. We have said before that this industry consists in collecting by artificial processes the spat of the

* Voyage d'exploration sur le littoral de la France et de l'Italie, par M. Coste, published in 1855.

† De Broca: Industrie huitrière des États-Unis, 1865.

oyster at the time of spawning. Some details of natural history will here be necessary.

Spawning of the oyster.—The oyster is hermaphrodite;* that is to say, each individual possesses the attributes of both sexes, fecundates itself, and produces young. The spawning usually takes place from June to the end of September; but the eggs are not immediately expelled; they remain until hatched within the mantle folds of the parent oyster, enveloped in a mucous substance essential to their development. When the proper time arrives the young sally forth, being furnished with a temporary swimming apparatus, which enables them to go in search of a suitable point of attachment. The swarms of embryos are innumerable, each parent giving birth to not less than one or two millions of young at each spawning. "At the time when all the adult individuals composing a bed void their progeny, this living dust issues like a thick cloud, which, leaving the point where it originated, is dispersed by the action of the water, only an imperceptible portion remaining attached to the parent stock. The rest is all scattered, and if the multitudes carried here and there by the waves do not find something solid to which they can attach themselves they are certain to be destroyed, for those that do not become the prey of other forms of life finally settle upon a locality unsuited to their development, and are often swallowed up in the mud."

Recent origin of oyster culture.—The idea of forming special establishments for the purpose of retaining and preserving some of those innumerable germs is a recent one, or, at least, only a few years have elapsed since it passed from the domain of theory to that of fact. The only oyster cultural practices known of somewhat ancient date are those seen by M. Coste in the parks of Lake Fusaro, to which we have already referred. The keepers of these parks had, from time immemorial, been in the habit of collecting the spat upon stakes driven around their deposits, and upon bundles of fagots suspended from ropes stretched above the water. But this industry was an entirely local one; it had not extended to the other districts of Italy, not even to the adjacent ones, and it was not at all commonly known.

First attempts made at Saint-Servan.—It was in France, some twenty years ago, that oyster culture really had its origin. About the time M. Coste visited Lake Fusaro, in 1853, M. De Bon, then commissioner of marine and chief of the service at Saint-Servan, now director of administrative affairs in the ministry of marine, was directed by the minister to attempt the restocking of the old oyster-beds of the Rance and of the roadstead of Saint-Malo, by means of shell-fish obtained from the beds in the bay of Cancale. In observing the results of these experiments, which succeeded perfectly well, he became convinced of a fact which had, until then, been contested, viz.: that the oyster can reproduce itself even after having been transplanted to bottoms which are

*Coste: Voyage d'èxploration, &c.

left bare at each low tide, and on which it has never existed before. He was struck with the facilities thus offered for the obtaining of artificial supplies of spat. He established at Saint-Servan, in the port of Solidor, a sort of experimental park, and commenced a series of experiments to discover means of fixing the spat emitted from the oysters. In the year 1855 he announced to the minister that the question of artificial reproduction was for him definitely settled in the affirmative. In 1858 he asked to be authorized to try in one of the parks at Cancale the system of collecting spat which he had decided upon. It was a sort of floor formed of boards from 15 to 18 centimeters wide (6 to 7 inches), upheld by stakes and placed 20 centimeters (8 inches) above the oysters. Having seen with their own eyes the results of this system, the parkers of Cancale did not hesitate to give it a trial at their own expense during the summer of 1859. The experiment was crowned with complete success. In the month of October of the same year, M. De Bon transmitted to the minister, as a specimen, several boards covered with spat, some from the beds of Cancale and some from the parks of the Rance. His experiments had, moreover, become famous. The prefect of the island of Vilaine had come to pay a visit to the park and had comprehended the scope of the discovery. In pursuance of his advice, M. De Bon sent specimens of the oysters obtained by the new method to a local exhibition which was held at Rennes in August, 1859. These specimens, which were accompanied with a description, attracted much attention, and the jury of the exhibition conferred a silver medal upon the inventor.

M. Coste's share in the introduction of the new industry.—Notwithstanding these satisfactory results, oyster culture would undoubtedly have found difficulty in overcoming the obstacles which prejudice always places in the way of new advances, in attracting public attention and subsequently in securing the costly and persevering efforts necessary to insure its speedy development, had it continued as a purely administrative work, subject to the conditions of prudence and wise reserve which are always imposed upon responsible functionaries. It found in M. Coste a bold champion, who brought to its service his reputation as a man of science, his talent as a propagandist, and the open support of the chief magistrate of the nation, which he had gained by the eloquent ardor of his convictions. Made proficient for this work by reason of his studies on fish-culture, M. Coste had become much impressed by what he saw in Italy, in the parks of Lake Fusaro. He at once conceived the idea of transporting to France the industry which flourished so obscurely near the gulf of Naples. In the report of his explorations, made January 1, 1855, to the minister of agriculture and commerce, he expressed a desire that the same processes might be tried in the salt ponds of the south of France, and also applied to the natural oyster-beds. He proposed to let down over these oyster-beds in the spawning season large wooden frames to collect the spat, which should be withdrawn at the proper time.

His first missions on the coast.—Two years afterwards, in 1857, the Emperor commissioned him to make experiments in maritime fish-culture. Soon thereafter, having received letters of introduction from the minister of the marine to all the maritime officers of the ports, he began to travel along the coast. He visited Saint-Servan in August, 1857. M. De Bon showed him the already decisive results which he had obtained, both in restocking the beds of the Rance and in collecting spat artificially. This was a practical confirmation of his theories, and in many respects a revelation of the means of executing them, for which he was still seeking. He saw with his own eyes the reproduction of oysters upon ground left bare by the tide, a fact which he had long denied and from which he subsequently derived so much advantage. On the 5th of February, 1858, in the first report addressed to the Emperor on the subject of his mission, he asked that a simultaneous experiment in restocking and in oyster culture might be tried on a large scale in the bay of Saint-Brieuc. He predicted its success, and his vivid imagination, entirely given over to the fondest hopes, already saw the coast of France transformed by the same process into an almost continuous chain of oyster-beds, furnishing inexhaustible supplies of food.

Experiments in the Bay of Saint-Brieuc.—This report, which was printed in the "Moniteur," attracted much attention. M. Coste received from the minister of marine all the means that he required. Three million of oysters, purchased at Cancale and Tréguier, were deposited (April, 1858) at various points in the bay of Saint-Brieuc, with the aid of two small steamers belonging to the government, which towed the entire flotilla of boats carrying the oysters. On these improvised beds oyster shells were previously spread, to serve as collectors, and, for the same purpose, long rows of bundles of fagots were let down and anchored at a height of 30 or 40 centimeters (12 to 13 inches) above the bottom. Other boats were permanently detailed to watch and keep the new beds in order. Success seemed insured from the first. At the close of the spawning season the collectors brought to the surface were covered with spat. M. Coste thought that now he was about to see his plans realized. He proposed to immediately undertake to restock the entire coast, and the report in which he announced his results in the bay of Saint-Brieuc (December, 1858) received the same publicity as the former one.

Attempts at restocking on a large scale.—From this time onward oyster-cultural experiments both by the department of Marine and by private individuals developed rapidly. In the month of July, 1859, a steamer called the "Chamois" was placed at the disposal of M. Coste to convey him to such points along the coast as he desired to visit, in order to direct his experiments, and especially to co-operate in the oyster-cultural works under the charge of the commissioners of the maritime inscription and of the vessels guarding the fisheries. In January, 1860, two and a half million oysters were purchased at Cancale and distributed through the bay of Saint-Brieuc in order to enrich its bottom. In May and July of the same year two million more were purchased in England and taken to Bordeaux, by the Chamois, whence they were conveyed to Cette by railway for the formation of oyster-beds in the Mediterranean. This lot was divided between the pond of Thau and the roadstead of Toulon. The roadstead of Brest was restocked, and an oyster reservation, supplied by large shipments from England and intended to facilitate the stocking of the surrounding beds, was established in l'Anse de la Forest, near Concarneau. In the basin of Arcachon, explored by M. Coste in October, 1859, there were established by his advice two model parks to serve as breeding beds for the entire basin and for the trial of the different collecting apparatus thus far invented.* Several millions of oysters were deposited in these parks, and a government vessel, together with a coast guard expressly appointed, were charged with their supervision and with the carrying on of all necessary work.

First advances made by private industry.—Private industry followed the impulse given by the state. On the coasts of Normandy and Brittany, on those extending from the Loire to the Gironde, and in the basin of Arcachon, concessions were solicited from the minister of the marine; oyster-parks were established, and the people engaged with eagerness in experiments at artificial reproduction. Capitalists intrusted their funds to enterprises of this kind, conceived on a grand scale. The success in several localities was very marked. In the beginning of 1861, M. Coste, in requesting the minister to grant further extension to his restocking operations, stated that the bay of Saint-Brieuc, where the first experiments had been made, could immediately furnish a harvest of several millions of marketable oysters; that the coasts of the island of Ré had been converted into a vast and richly stocked oyster-bed; that the basin of Arcachon promised a harvest of incalculable richness; that in the roadsteads of Brest and Toulon the success attained, although less pronounced, was still of a nature to justify the most sanguine hopes; that at La Rochelle and at Marennes the production was equally satisfactory; and, finally, that in the pond of Thau, if the oysters had not reproduced they had at least grown and acquired qualities which would cause that pond to be considered a place for improving their flavor.

Numerous failures—Temporary decline of oyster culture.—Unfortunately numerous and bitter disappointments followed in the course of the succeeding years. The artificial beds of Saint-Brieuc were destroyed by inclement weather, the oysters being scattered and the bundles of fagots broken apart and thrown upon the shore; they never rallied from this

* These parks were formed in 1860, on two of the best oyster bottoms of the basin, called the Cès and Crastorbe. In 1863 a third model park was established upon the crassats of Lahillon. These parks, after having rendered much good, ceased to be useful when private industry had made considerable advancement at Arcachon. In 1872 the minister of the marine granted to the Central Life-Saving Society the right to take oysters therefrom, with certain reservations.

disaster. The roadstead of Brest became again impoverished, in consequence of the imperfect reproduction of the oysters deposited there, and the plundering operations of the fishermen. The experiments made in the Mediterranean failed completely. The parks of the islands of Ré and Oléron and of La Rochelle, after a few years of prosperity, rapidly declined and were almost entirely abandoned. It was the same at Cancale and in the Rance, where the attempts at oyster culture, begun by M. De Bon, resulted unsatisfactorily not long after his departure; the majority of the parkers abandoned the work. Finally, the report of the maritime authorities stated that in the basin of Arcachon, at the close of 1865, the government parks were flourishing, but the natural beds were impoverished, and private industry was prostrated because of the failure to collect spat.

Causes of this decline.—What were the causes of these failures, which seemed to indicate the ruin of all hopes based upon oyster culture? They were manifold: in the first place, ignorance or neglect of the natural laws governing the formation and continuance of oyster-beds; secondly, imprudent attempts at restocking, or cultivation under unfavorable circumstances, quite excusable, however, at the outset of a new enterprise; and, lastly, the inexperience of the oyster culturists, all of whom were green hands at the business, the uncertainty which prevailed as to the choice of favorable localities, the methods to be followed, and the apparatus to be used as collectors.

Action of the department of marine.—While seconding the efforts of M. Coste, the department of marine did not share in his illusions. It rightly considered that the renewal and enlargement of our oyster-beds, exhausted by the excessive drain upon them, could not be accomplished either as speedily or completely as he had anticipated. The department was not, therefore, discouraged by the failures it had encountered. It was this department, in fact, that had really opened the way, both by its experiments in restocking, commenced in 1852, and by the promulgation of the decrees of July 4, 1853, concerning coast fishing, which decrees laid the foundation of a rational system of regulations as to the taking of oysters.

The coast-fishery regulations of 1853 *with reference to the oyster.*—The main features of this system of regulations are the prohibition against taking oysters at times not allowed by the maritime authorities; the determination of the proper time for taking them dependent upon the advice of special commissions that visit the oyster-beds annually; the reservation of beds found to be impoverished or calculated to answer as centers of reproduction; and, finally, the obligation imposed upon fishermen to throw back onto the beds or preserve in parks the young oysters which have not yet attained a certain size. Wherever it has been possible to enforce these rules continuously, and at the same time keep a sufficiently close watch to prevent the plundering operations of fishermen and other people living upon the shore, the marine authorities have succeeded in securing the prosperity of the oyster-beds, provided they were established upon bottoms naturally productive and not entirely exhausted; the success of enterprises whose object is to reconstruct beds, of which not a trace remains, or to create entirely new beds, is much more problematical. In this latter case the lessons taught by experience have not been lost. Since 1865, the department, without refusing to engage in all attempts at starting new beds, has especially endeavored to maintain the already existing ones, to improve them by timely cleansing or by the additions of shell-fish brought from richer localities, and, finally, to strengthen the watch upon them, which is the best method of preserving them. Thus, in several localities they have been gradually raised from the decay into which they had fallen.

Results of the continued enforcement of these regulations.—Oyster culture, properly so called, has advanced continuously, and in the course of its progress there has been brought to light a fact of prime importance, viz., that the artificial breeding of oysters can scarcely be successful excepting in the neighborhood of the natural spawning-beds. Thus the oyster-park of the island of Ré became sterile as soon as the neighboring natural beds which supplied it had disappeared. The abandonment of the attempts at oyster culture at Cancale was contemporaneous with a prolonged impoverishment of the oyster-beds in the bay of Mont-Saint-Michel; these beds are now becoming filled up again, and oyster-cultural industry has reappeared upon the shores of that bay, at Vivier, where it is increasing daily. It is the same at Arcachon and in the rivers of Morbihan. The oyster propagates well in parks, as was demonstrated by M. De Bon, and perhaps at some future time it will be possible by improved methods to collect the spawn artificially produced in sufficient quantities, especially if the operation be performed in a favorable medium; but at present an abundant supply of spat from large natural beds is essential to success.

Progress made by private industry—Improved methods—Revival of oyster culture.—On the other hand, the oyster culturists, taught by their own experiences and by the results attained through the government experimental parks, became more self-reliant; they improved their implements and their methods of work. It may be affirmed that in the two principal centers in which it is now carried on, the basin of Arcachon and Morbihan, this industry then emerged from its period of uncertainty. The great profits realized there during the past few years have brought oyster culture again into favor and turned toward it a current of labor and capital much greater than that which flowed in the same direction after the publication of M. Coste's report. Requests for concessions of parks are received by the minister of marine from all quarters of the coast. Attempts are being made to reconstruct old and abandoned establishments, while new ones are being started in the majority of localities where others formerly existed. Those seeking grants desire particularly the unclaimed localities in the basin of Arcachon and the rivers of the marine sub-district of Lorient, certain that they will receive in the future what is promised by the present.

Rapid increase in the number of oyster-cultural establishments at Arcachon.—At the close of 1871 the parks controlled by private parties in this basin numbered 724 and occupied a total area of 588 hectares (1,450 acres); at the close of 1872 they were 1,133 in number and occupied an area of 1,061 hectares (2,625 acres); at the close of 1874 they numbered 1,706 and covered an extent of 1,733 hectares (4,310 acres), not counting the portion formerly included in the reserved zone but now given over for parking. The denomination "Reserve Zone" was applied to a considerable section of the basin in which parks were prohibited in order to retain a common fishing ground which could be frequented by all. In view of the great increase in oyster culture at Arcachon, both to satisfy the claims of the old parkers, who complained that they were cramped for room, and to meet the new demands which were constantly increasing in number, the minister of marine decided, on January 28, 1874, to open up the greater portion of the reserve zone to private industry. The remainder of this zone, positively withheld from private demands, comprises exclusively the natural beds of the basin with their immediate surroundings, which it is important to protect against all intrusion, as the prosperity of the parks depend upon their preservation. In pursuance of the ministerial decision of January 28, the first work of dividing off the sections for distribution was carried on during the year 1874; a decree has just been issued for the formation of 728 new parks, which, added to the 1,706 now existing, will make a total of 2,434 concessions and an extent of 2,669 hectares (6,625 acres) to be occupied by oyster culture. A second work of the same character has just terminated; a third will soon follow.

Prosperous condition of the establishments at Morbihan.—In Morbihan the development of oyster culture is no less striking. The section of Vannes contains nearly 200 oyster-parks, while that of Auray will soon have 300 and requests are still coming in. Thus, persons in all stations of life are engaging in oyster culture, either by investing their capital in it or by laboring for it. Many of them are without experience in the matter and it, therefore, seems proper and opportune to add to this brief historical sketch a few practical remarks concerning the processes now in use for the cultivation of the oyster. A knowledge of the processes which have the authority of success will, perchance, guide inexperienced oyster culturists in the right direction and prevent mistakes; it may also incite others who are still indifferent or timid.

II.—Practical Remarks on Oyster Culture.

Different kinds of collectors.—The first apparatus used to collect the spat of oysters were the plank collectors of M. de Bon, and the bundles of fagots, stones, and shells of various mollusks, as recommended by M. Coste in his first publications. We have seen that the parkers of Cancale successfully used the plank collector in the summer of 1859. At the close of the same year the parkers of Arcachon also tried it, having learned through the authorities of the success obtained by its use at the former place. In several other localities private oyster breeders, hearing of the experiments made by the chief of the marine service at Saint-Servan, wrote to him direct, in order to obtain information regarding his method of work. In the great experiment at Saint-Brieuc bundles of fagots and shells alone were used, as the plank collectors would not have withstood the violence of the sea in a position so exposed. Stones, slates, and bricks were employed in the more quiet waters. All of these collecting implements are still in use, and are more or less successful according to the locality; but with regard to this there is no uniform rule. At Arcachon, wooden boxes or hives, 4 meters square, and filled with fagots, were employed in the beginning. These were the invention of Messrs. Lalesque and Lalanne, two promoters of oyster culture in that district; but this system was soon abandoned as being of little avail.

The use of tiles.—It was at Arcachon, and in the parks of Régneville, belonging to Mrs. Sarah Félix, that the use of tiles, which has since become very general, was first inaugurated. The tiles used as collectors are concave in shape, being the same as those which are placed upon the tops of walls to protect them from the rain. They were arranged in the shape of a roof at a short distance above the bottom, being held up by means of stakes. They answered well, but presented a serious inconvenience at the outset; the young oysters attached themselves so firmly to them that they could not be removed, without breaking either the collector or the shell.

Improved methods of preparing the tiles.—Dr. Kemmerer, an oyster culturist of the island of Ré, found means to obviate this difficulty by coating the tiles with a layer of hydraulic cement mixed with water and defribrinated blood. The young oysters adhering to this friable outer coating could be easily removed from the tiles at the proper time. This system was greatly improved upon, or rather simplified, by the parkers of Arcachon; the hydraulic cement, which became very hard by contact with the sea-water, was replaced by a less expensive coating—consisting of ordinary mortar, and made by mixing two parts of sand with one part of an inferior quality of lime.

Claires, or water parks.—Another improvement consisted in the establishment of claires, which are basins of slight depth, so built and arranged as to retain the water at low tide, in order to protect the oysters against excessive heat and cold during the period of development. They are in imitation of the method of cultivation that has been used at Marennes and in the Seudre since very early times.

"Ambulances," or preservative boxes.—Finally, as the operation of removing the oysters from their point of adhesion often results in injury to their shell, notwithstanding all the precautions taken, and as their

shells are then too weak to withstand the attacks of crabs and other predaceous animals, the parkers of Arcachon hit upon the plan of placing their oysters just detached from the tiles in wooden or osier boxes, furnished with hinges and lids, in which they were left until they had acquired sufficient size to be deposited in parks or claires without danger. These boxes received the significant name of *ambulances.* M. Michelet, a resident of Teste, who took a notable part in oyster-cultural improvements, invented an improved system which he called "*ambulances ostréophile*"; it is a stone basin with the bottom of bricks, laid in cement, raised upon a strong frame-work of wooden joists, which, in turn, rests upon stakes driven into the bottom. A second frame-work placed above the stones is attached to the first by strong iron bolts. On the inside, at a height of about 10 centimeters (4 inches) above the bottom, are fixed screens of osier or wire cloth, on which the young oysters repose. The covering is formed of movable pieces of wood or wire cloth, or simply of tarred netting having a very close mesh, stretched tightly by means of hooks screwed into the upper frame-work. An opening through the stone side, on a level with the bottom, serves to empty the basin when necessary. The entire structure is surrounded by clay masonry which strengthens the walls.

THE COURSE PURSUED IN CARRYING ON THE OYSTER INDUSTRY AT ARCACHON.

Such are the principal improvements which have transformed the cultivation of the oyster into a regular and methodical industry. It is by the following series of operations that it is carried on. We will take as types the processes employed in the basin of Arcachon, because they are the most advanced, and because that region is now the principal center of oyster-cultural activity.

Preparation of the ground.—The parks of Arcachon are established upon bottoms called *crassats*, which are uncovered at each low tide. These regions are covered by a species of fine grass which gives them the appearance of sea meadows, and those having the firmer soil, composed of clay and shells, are best adapted to the reproduction of oysters. The oyster culturist, having taken possession of a portion of *crassat* as the site of a park, commences by clearing it of the long grass and of all foreign materials which may lie upon it; but he takes care not to pull up the short grass, commonly called *moussillon*, for, although the oyster grows more rapidly on bottoms entirely free of all covering, it is less fecund there and more exposed during inclement weather.

Construction of claires, or water parks.—In the highest portion of the park, claires or water parks are established. These are of two kinds: first, those in which the tiles, still covered with young oysters, are placed, and, second, those for the young oysters after they have been removed from the tiles. The height of the water in the former should be 40 to 50 centimeters (16 to 20 inches), and in the latter from 15 to 20 (6 to 8 inches). Both are dug in the ground to the required depth. The sides are formed of boards held in place by strong stakes and supported on the outside by a bank of clay. Their bottoms are covered with sand and fine gravel. A small sliding door or a mere hole filled up with potters' clay suffices to empty them when necessary. The claires are in general from 30 to 40 meters (100 to 130 feet) long by 4 to 5 meters (13 to 16 feet) wide, and it is advisable to divide them into several compartments by wooden or tile partitions, in order to prevent the wind from agitating the surface of the water too strongly, to the injury of the walls and young oysters.

Construction of "ambulances."—After the claires the parker prepares his *ambulances* as we have before described them. The *ambulance* of stone and brick belonging to M. Michelet forms quite an extensive building, and cost in the neighborhood of 600 francs ($120). The parkers usually content themselves with wooden boxes 2 meters (6½ feet) in length, 1 meter (3¼ feet) in width, and from 12 to 15 centimeters (5 inches) in depth. The bottom of these boxes are now covered with wire netting, and the tops also sometimes with the same. Constructed in this manner, however, they are liable to be invaded by mud which passes through the meshes of the netting. Coverings made of boards or of tarred cloth seem to be preferable and are much more economical. The oysters in the *ambulances* should always be covered with water. The boxes are generally placed in claires and fastened upon stakes which sustain them at an elevation of 10 centimeters (4 inches) from the bottom.

Choice and preparation of collectors.—These preparations being completed, collectors must now be arranged. Notwithstanding the predominance of tiles, boards, fascines, and strings of shells are still used at Arcachon. But, whatever may be the kind of collector employed, there is one precaution which is never neglected, and that is to scatter over the bottom, as thickly as possible, oyster and other shells, which offer at slight expense one of the best means of retaining and fixing spat. In order to prepare the tile as a collector, it is coated over with a substance destined to facilitate the removal of the oyster. It is plunged several times into a bath of hydraulic cement and water, and when it is sufficiently dry it receives in the same way a layer of ordinary mortar (one part of lime and two parts of fine sand), which should be from 2 to 3 millimeters ($\frac{1}{12}$ to $\frac{1}{8}$ of an inch) in thickness. Some parkers substitute a second layer of hydraulic cement for the mortar; the advantage claimed being that the tiles are made smoother, are less easily soiled, and retain the spat much better, while they do not need to be cleansed to fit them for use the following year. On the other hand the use of mortar renders the separation easier.

Barges.—The organization of a park is generally completed by the accession of a barge, containing two rooms for the guard, and the purchase of a small boat for communication between the park and the shore.

Arrangement of the collectors.—By way of commencing operations, the oyster culturist first supplies his park with adult oysters, purchased either from the dredgers at the time of collection or from other parkers. The collectors must next be put in place, and it is very essential that the proper time for arranging them should be ascertained, for the spat will fasten to clean and smooth bodies only; and if the collectors are put in place long before spring time they will become covered with mud, algæ, small shells, &c., and the harvest will prove a failure. The oyster spawns earlier or later in the season according as the average temperature ranges higher or lower. The proper time for placing the collectors varies, therefore, according to the latitude of the place and the relative temperature of the season for each year. In the basin of Arcachon the collectors are usually placed the latter part of May. The locality chosen for this purpose is the lowest portion of the park, in order that the apparatus may be under the sea for as long a time as possible. The strings of shells are placed in the dampest places, especially in the natural excavations of the bottom, where some water always remains.

Arrangement in piles.—The tiles are arranged in piles called "hives" (*ruches*). In the first place, there is placed upon the bottom a wooden frame, formed of two parallel beams about 2 meters (6½ feet) in length, 30 centimeters (11 inches) apart, and connected by two short cross-pieces upon which they rest. The tiles are placed in successive layers above the frame, with their concave sides downwards, the tiles of each successive row being arranged alternately parallel with and at right angles to the beams of the frame. The whole is held in place by means of ropes, or, better still, by wire, and sometimes even by a circle of stakes, if from the situation of the park the apparatus is exposed to the force of the waves. In the latter case the lowest hive is also protected by reducing the number of layers of tiles, which may vary from five to nine. The hives should be at a distance of 2 meters (6½ feet) apart; if there are several lines of them they should be arranged in the form of a quincunx, in order that the current may pass through them so as to form eddies at intervals, enabling the spat to become the more easily attached. They should not be brought together in too confined an area, for then they would become filled in with mud, and, from the desire for too rapid gain, all would be lost.

Removal of the collectors—Detaching of the oysters, &c.—The hives remain in their places until October, the spawning season continuing until the end of September. They are then taken apart, the tiles are placed in large claires prepared for the purpose, and the work of detaching commences. This operation, which is usually performed by women, consists in cutting into the coating of the tiles around each oyster, by means of a chisel. The young oysters when detached are placed in *ambulances* or preservative boxes, in piles 3 to 4 centimeters (1½ inches) high at the most. They spend about two months in this place, during which time the parker frequently visits them in order to keep them clean and supply them with air, by opening the boxes when the weather will permit. They are then conveyed to the breeding-claires and scattered over the bottom, where they should be placed as far apart as possible, in order that they may become the better developed. The claires are protected by means of fine mesh nets against the attacks of the various animals which prey upon the oyster; these nets cover or surround the claires. The water is kept at a height of 20 centimeters (8 inches) above the oysters during the extremes of heat and cold, but during mild weather this height is lessened, so that the oysters may come more directly under the influence of the air and light. When this cannot be done it is well to change the oysters from one claire to another once or twice a year, placing them in well-cleansed basins, the bottoms of which have been renewed by allowing them to remain unused for several months.

Final care to be bestowed upon the oysters.—After two years of this treatment the oysters have attained an edible size, but before being taken to market they must be accustomed to remain without water. The parker, therefore, at each low tide for a certain length of time, drains the claire containing the oysters to be sent to market; these oysters gradually acquire the habit of retaining the water within their shells by not opening their valves, and become able to stand a journey of several days without losing their freshness.

Another method.—According to another method the oyster is not separated from the collector to which it is attached, until it has attained the age of eighteen months. Two sets of tiles are necessary in this case, the first remaining in the claires until the time of detaching, while the second is made ready to receive the spawn of the next season. According to this system the waste is very small, because the oyster is much stronger when it is separated from its point of adhesion. When allowed to remain too long upon the collectors, however, they often become malformed, and this diminishes their market value.

Oysters produced upon the bottoms of parks.—The oysters produced upon the bottoms of parks, or upon the shells deposited there, are easily separated from one another, or from the collector to which they have adhered. They are scattered in grassy places and are taken up from time to time in order to secure those which are marketable, the others being returned to the park. Sometimes, with a view to diminishing the waste, they are placed in claires, where they are raised like those on the tiles.

USUAGES AT THE PARKS OF MORBIHAN.

Such, in brief, is the manner in which oyster culture is conducted in the basin of Arcachon. The methods of breeding are nearly the same everywhere, with some exceptions rendered necessary by the climate and nature of the soil or water of different localities. Thus, in the district of Auray, the plank collectors succeed perfectly and are much used.

They are especially employed upon bottoms consisting of soft mud. They consist of rude deal platforms, placed one above the other, at a certain elevation, and separated by interspaces whose height is equal to the cross-pieces serving as supports. In order to retain the structure in place and prevent its being carried away by the waves, it is either surrounded by a line of stakes or the upper platform is loaded with stones. The objection to this style of collector is, that the oysters do not adhere to it very firmly, but are easily detached and swept off by the currents. This defect is remedied by a coating of lime like that given to the tiles, for a very different purpose, however. On hard bottoms the parkers of Morbihan prefer tiles arranged in hives, as at Arcachon. They also suspend the tiles from stakes by means of iron wire. The tiles are pierced by a single hole at each extremity, and through these holes an iron wire is passed so as to maintain the tiles in a nearly horizontal position. The ends of all the wires are then fastened to the top of the stake. By this means veritable quagmires can be utilized, which are otherwise unproductive and inaccessible to persons on foot. In Morbihan the collectors are not usually put in place until the beginning of July; but there, as elsewhere, it depends upon the temperature, and the prudent oyster culturist should, before proceeding, make certain that the mother oysters of the natural banks are about to spawn. The preservation of the spat is now the principal question in this region. Many claires are constructed for the reception of the young oysters, which are usually detached from the collectors at the age of nine months; but suitable grounds are not always within reach of the breeding-park, and amends are sometimes made for this by using boxes, whose four sides consist of wire netting.

USAGES AT THE PARKS OF VIVIER.

The collectors which have produced the best results on the shores of Vivier, near Cancale, are slabs of schist and birch screens. The slates, although favorably regarded in the beginning, have been discarded on account of their expense, and for the reason that they cause the oysters to assume a flattened shape, which reduces their market value. The screens are divided into sections, from 5 to 6 meters (16 to 20 feet) long, to facilitate their removal and cleansing; they are fastened to stakes, 5 centimeters (2 inches) in diameter and 66 centimeters (24 inches) high. Being arranged in the direction of the current, they form parallel lines, stretching the entire length of the park, and at a distance of 4 or 5 meters (13 to 16 feet) apart. Between these rows are placed horizontal cross-pieces of wood, raised 20 centimeters (8 inches) above the bottom, on which are fastened slabs of schist, 50 centimeters (20 inches) long by 25 (10 inches) wide, and 15 (6 inches) thick, supported one upon the other at their extremities. In some parks the stones are retained in a vertical position by means of stakes driven into the ground on both sides of them. The latter arrangement is more favorable for the collection of the spat, but it is also more expensive. The parkers of Vivier place their apparatus during the months of May and June. They have not yet constructed claires in their breeding-parks, but several have obtained grants in the harbor of Roteneuf, a small well-sheltered bay, situated between Vivier and Saint-Malo, where they will doubtless meet with more favorable conditions for the formation of breeding-parks, the indispensable complement of all well-regulated oyster-cultural enterprises. Moreover, the revival of oyster culture in the subdistrict of Saint-Servan is of quite recent date; the establishment at Vivier and those at several other places are still few in number, and the methods employed have not been so much perfected as at Arcachon or Auray.

CONCLUSION.

The foregoing statements will give an idea of the new industry which has already taken firm root in some of our coast districts, and which will probably be established in other localities wherever there are men of enterprise and intelligence. Let us add that, according to the common estimates, the establishment of an oyster-park, such as we have described, with an extent of one hectare (2½ acres), requires an expenditure of from seven to eight thousand francs ($1,400 to $1,600) for the preparation of the ground, the purchase of the various implements and the first expenses of preparation, &c. As to the results obtained, they necessarily vary greatly, according to the more or less favorable character of the locality selected, the skill and care displayed by the oyster culturists, and the abundance of the spawn; with regard to the latter item there are considerable variations from year to year. The oyster culturist who happens to commence during an unfavorable season should not be discouraged at the ill success of his first efforts. The parks of the basin of Arcachon and those of Morbihan were severely tried at first, but the fruitful years which followed have made ample amends for the early losses; with a gain in experience the inequalities of the different years will doubtless be less sensibly felt in the future. Everything tends in this direction; the constant improvement in the means of transportation will facilitate the sale of the excess of production during certain years, while the multiplication of claires and breeding-parks will render it possible to store up richer harvests and preserve them for times of scarcity.

The part devolving upon the administration—Supervision.—It may also be relied upon that the marine authorities will not fail in the proper discharge of their duties, the importance of which is better realized now than ever. They will take special care to preserve the natural oyster-beds, the sources of present prosperity and the pledge of future development. Already, thanks to their incessant watchfulness, and to the reservation of important sections of the bays of Granville and Cancale, the restocking of these regions, formerly so prolific in oysters, is progressing favorably in the vicinity of Cancale, where, during a few low tides last season

(1874), the dredgers obtained oysters valued at 900,000 francs ($180,000), which result will be exceeded in 1875. There is, moreover, a fact full of significance, which observation has most clearly demonstrated. It is as follows: If the bottoms which supply the parks produced oysters naturally, the latter return to the natural beds a portion of what they have received from them. An interchange of germs between them therefore ensues, which is a further guarantee of their common prosperity. The basin of Arcachon is an illustration of this. Since the increased development of oyster culture in that locality, the natural beds have become enriched to such an extent that, although they were only open to the public during a few hours at the close of the month of November, 1874, still they yielded a harvest of 40,360,000 oysters to the 8,500 persons engaged in taking them. An examination of these beds, made after the dredging had ceased, indicated that that enormous and unprecedented catch had not exhausted them. Very many of the oysters taken were purchased by the oyster culturists of the neighborhood, who placed them in their parks, so that they will still further contribute to the general fertility of the basin.

Dissemination of information and encouragement.—The second aim of the authorities is to disseminate information concerning oyster culture, and the methods of conducting it in districts where this industry is still hampered by the ignorance or prejudices of the people. Early in 1874 the minister of marine instructed the maritime authorities to examine such points within their districts as promised favorably for the procuring of spat by means of collecting apparatus. At Cancale, where the fishermen have little sympathy with the oyster culturists of Vivier, at Granville, Tréguier, Paimpol, and in the vicinity of Sables d'Olonne, in the bay of Bourgneuf, on the coasts of the island of Ré, and in other places, small breeding-parks were created in accordance with the orders of the ministry. These attempts are of such recent date that it is as yet impossible to form a correct idea of the probable results. The department of marine aids them with the appropriations at its disposal. These appropriations, when wisely managed, suffice for the essential services which they have to render, and it is by their aid that it is possible to continue, or resume, when necessary, the experiments started by the department twenty years ago; to maintain the oyster reservations upon which depend the future prosperity of certain localities; to form new reserves; to pay the expenses of the special supervision in the most important oyster districts; and, finally, to encourage labor favorable to the progress of oyster culture. It is for private interests to do the rest. The path is now marked out and a beginning has been made. We hope that the zeal of our oyster culturists will not diminish, and that this industry will become, through a continuous and rapid development, an abundant source of wealth to our country, where it originated.

INDEX.

XXXI.—A REPORT ON OYSTER-CULTURE IN THE MEDITERRANEAN.*

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OYSTER-CULTURE IN ITALY.

It is to Italy we are indebted for the idea of establishing in France that branch of industry, so flourishing at the present time, known as oyster-culture. The Romans were the first to engage in the cultivation of the oyster, and their methods, inherited by the Italians, have come down to us without any modification. The method of cultivating this mollusk at Tarente to-day is the same as that practiced in the time of Sergius Orata. In 1853 M. Coste visited Fusaro, and from that remarkable journey of scientific exploration, it is said, he brought back the elements of the new industry to which science has assigned general rules that have since been improved upon by practice. But if, prior to that time, an exceptionally fine flavor was given to the precious bivalve at Marennes, Courseuilles, and Cancale, by a special treatment, we were still ignorant of the processes of taking the spawn and of supplementing the loss occasioned by the continued impoverishment of the beds on our coast, the sources of production which had formerly been erroneously supposed to be inexhaustible.

Oyster-culture, properly so called, is carried on in Italy in only one locality, Tarente. The celebrated Lake Fusaro, to which I will devote a few words hereafter, has become sterile and has been abandoned. The oysters consumed in Italy, beyond those received from Tarente, come from the gulfs of Genoa and Naples, from the coasts of the Adriatic, and from the ponds of Corsica.

The Gulf of Genoa produces small and delicate oysters, which are

* Rapport au Ministre de l'Instruction publique sur la Pisciculture en France et L'Ostréiculture dans la Méditerranée, par M. Bouchon-Brandely, Secrétaire du Collége de France. Paris: A. Wittersheim et C^{ie}., Quai Voltaire, 31, 1878, (Extrait du Journal Officiel des 16, 17 et 18 Mai 1878.) small 8 vo. pamphlet, pp. 103. Only that portion of the report devoted to oyster-culture in the Mediterranean (pp. 45–103) is reproduced here.

held in high repute. At Naples, near the rocks of Castel, and in other deeper parts of the gulf, oysters similar to those of Genoa, are still found, which are designated, scientifically, under the name *Ostrea plicatula*. At neither Genoa nor Naples are the banks sufficiently well stocked to permit the use of the drag, with profit, in gathering oysters. The fishermen take them by hand, sometimes at a considerable depth. The products of this fishery are entirely consumed in the vicinity. Rome, Florence, and the large towns of the peninsula receive a part of their supplies from Brindisi and Venice, at which places some natural beds exist. The oysters from these beds belong to the common Mediterranean species (*Ostrea edulis*).

LAKE FUSARO, NEAR NAPLES.

There is no necessity of our entering here into a retrospective examination of the industry of Lake Fusaro. M. Coste, in the learned report he has published concerning his mission to the shores of the Mediterranean, has performed this task better than I could do it. But I have thought it proper not to leave Naples without first endeavoring to ascertain the causes which have occasioned the sterility of this ancient lake and the loss of its secular industry. The principal cause, as well as the oldest and most incontestible one, which has at all times occasioned the greatest disasters, results from sulphurous emanations arising over certain portions of the bottom during the eruptions of Mount Vesuvius. At such times as these all of the inhabitants of the lake are imperiled, but shell-fish suffer most because of their inability to get out of harm's way. At various periods of eruption the oysters of Fusaro have been very nearly exterminated, but so great has been their fecundity that only a few years were required to enable the lake to recover its normal productiveness. In addition to this natural and inevitable cause, there are others of more recent origin and less extent, among which may be cited: (1) the accumulation of vegetable and animal refuse which has fouled the bottom; (2) the too extensive cultivation of mussels; (3) the excessive saltness of the water; and (4) the insufficient supply of fresh water. Finally, in 1856, the Neapolitan Government, with a view to rendering Lake Fusaro more healthy—as its marshy water propagated the malady so common in certain parts of Italy, viz., malaria—caused a new canal to be dug at the extremity of the lake, in order to secure, to the greatest possible extent, the renewal of the water. It is claimed that this work hastened the decay of Lake Fusaro. The contact of this new current with the old resulted in the stirring up of the materials that had been accumulating in the lake for many years. Sands were brought down by the current, thus changing the nature of the bottom. The oyster-culturists, after vain endeavors to overcome this new misfortune, abandoned their concessions, and in the year 1869 the last oysters disappeared from Lake Fusaro.

TARENTE.

From the earliest times the maritime population of Tarente has busied itself in the cultivation of oysters and mussels. This industry is carried on in salt ponds which border the city on the west, and to which the name of "Little Sea" has been given. Being connected with a roadstead or open sea, by means of a narrow channel, sufficiently large, however, to insure the renewal of the water, the Little Sea (*piccolo mare*) presents the most favorable conditions for the production of shell-fish. The productiveness of this portion of the coasts of the Ionian Sea is proverbial; fish and shell-fish of all kinds occur there in abundance, and in addition to the species which are also common to the Mediterranean and the Atlantic coast of Europe, it likewise possesses certain other varieties peculiar to itself. The Little Sea, which is quite well sheltered from the sea winds by the eminence on which the city of Tarente stands, is also protected against the winds from the interior by the range of hills in the midst of which it lies. It measures twelve miles in circumference, and is six miles wide in its broadest part, that is, from the gate of Naples to the convent of San Francisco (*Battentiere*). Its waters are pure; the bottom is composed of calcareous sands, and the shores at intervals are covered with sea-weed, which the fishermen do not molest, and in which many different species of fish come to spawn and find shelter. The depth of the Little Sea is relatively great and its shores are narrow. In its deepest part it measures 17½ to 18 meters (about 55 feet). At 2 or 3 meters from the shore (6½ to 10 feet) it is about 1 meter (3¼ feet) deep, and thence it gradually deepens until at 200 meters (650 feet) from the shore it is about 6 meters (19½ feet) deep. Seven small streams whose sources are near at hand flow into the Little Sea, five into the upper part and two into the lower. The most important of these are the Galésio, the Oro, so called from the particles of gold brought down by it, the Battentiere, and the Adeja. The Little Sea receives, moreover, the waters of submarine springs, one of which, the Citrello, has been pointed out by geographers and is very well known; it rises nearly in the middle of the sea at a great depth, but with such force as to agitate the surface over a space more than 100 meters (325 feet) in diameter. The quantity of water supplied by this spring must be considerable, and it is even conjectured by some to be a veritable river which rises there. It is these bodies of fresh water that insure the prosperity of pisciculture; for during the months of July and August the heat is so great at Tarente and the evaporation so rapid in the Little Sea, that the water would soon become too salt for the oysters to live in it.

The temperature of the water in the Little Sea rises in summer to 27° and 28° C., and even higher at times; on the 15th of September, at 7 o'clock in the morning, my thermometer indicated 25° C. Its density varies greatly, according as the examinations are made near to or at a distance from the places where the fresh water enters; three or four hundred meters (975 to 1,300 feet) below where the Citrello emerges I found the hydrometer indicated 2¼°, while over the oyster and mussel parks it marked from 2¾° to 3°; in the roadstead, which likewise receives the fresh water of the Citro, and near which are situated the oyster beds that furnish the young oysters, I found an indication of 3°. It was not without astonishment that I became convinced that oysters could live and thrive in water as warm as that of the small sea of Tarente; for it had generally been admitted that their preservation was impossible in water exceeding 23° or 24° C.* In support of this assertion it was customary to refer to the oysters of Lake Fusaro, which died in large numbers whenever the temperature of the water reached such a height as this. But in reply it may be argued that the oysters of Lake Fusaro die rather in consequence of the action of volcanic emanations, or of sulphurous gases, which, under the influence of a high temperature, escape from the decaying animal and vegetable remains accumulated at the bottom of the lake. From this fact it is evident that the heat of the water on the French Mediterranean coast is not as insurmountable an obstacle to the establishment of oyster parks as has been asserted.

The Little Sea of Tarente is leased by the city to a company that pays for it an annual rental of 38,000 francs ($11,600). The oyster and mussel parks are situated in the lower part, where the currents unite, always bringing with them fresh nourishment and an ever-changing supply of water. They are thirty-five in number, twenty-one for oysters and fourteen for mussels. Each oyster park measures from three to four hundred paces on each side. The mussel parks are much more spacious, their extent equaling from two to three times that of the oyster parks. The latter are farmed out by the company to the fishermen, who devote themselves to the culture of the mollusks, at the rate of one franc (20 cents) per seven palmes (about 6 feet). All concessions are marked off by strong posts driven into the bottom. In the spaces included within this first line of division there are other parallel lines of posts, arranged at intervals of fourteen palmes (about 12 feet). Of their uses we shall hear more further on.

MUSSEL-CULTURE.

Bouchots are entirely unknown at Tarente; and it is even doubtful whether they would yield favorable results in the sea at that place. The larval mussels are gathered on the spot by means of cords arranged horizontally very near to the spawning mussels, which lie on the bottom and are connected by slight agglomerations. This reserve is placed, as nearly as possible, in the most suitable location for it, and where it is least liable to suffer from the encroachment of mud. It is also necessary to avoid placing it at too great a depth, for mussels will not repro-

* Professor Oronzio Gabriello Costa, Del Fusaro.

duce deep down in the water. From time to time, as the mussels increase in size, the reproducers are changed for others which the fishermen get from the crop of each season. The cords used to gather the young mussels are made from rushes or "alfa"; each of their extremities is fastened to a stake, and their length depends upon the depth at which they are to be immersed, it being required that the tangent of the arc which they describe should lie close above the bed containing the reproducing mussels.

The mussel spawns in March or early in April, and reproduces so rapidly that the cords used as collectors soon become loaded with young ones. The collectors are allowed to remain down six months before they are taken up to make a selection, the object of which is to remove the mussels when they attain the size of a small almond. Those selected are then interlaced, either in bunches or singly, with the strands of the ropes, and these ropes are fastened to others stretched horizontally between stakes placed at suitable distances apart, so as to fall vertically into the water.

In selecting the mussels from the collectors, those which have not yet attained the required size are allowed to remain, and the collectors are thrown back into the water. The following season these will have grown large enough to serve as food. The rearing places are in deep water; parks even are utilized which extend eight or nine hundred meters (2,600 or 2,925 feet) into the sea; the cords bearing the mussels are also sometimes nearly forty palmes (about 30 feet) long; so that, at least as regards Tarente, breeding may be well accomplished in shallow water, while the rearing should be carried on where the depth is greater.

The little sea of Tarente produces two kinds of mussels, the common mussel and the red mussel (*Modiola barbata*). The latter is preferred, and is much more valuable. The red mussel and the white mussel multiply and abound in nearly equal proportions; nevertheless it would seem that the white mussel is endowed with greater fecundity, and can be kept fresh, out of water, for a longer time. A park will furnish, on an average, from four to five hundred quintals of mussels every year, the wholesale price of which is 11 francs ($2.20) per quintal.

OYSTER-CULTURE.

The arrangement of oyster parks is like that of the parks for mussels, with this difference, that they do not generally extend quite so far into the sea. Beyond certain depths oyster culture presents great difficulties and entails great expense. These parks are divided by stakes into equal squares of fourteen palmes (12 feet) on each side. They are entirely devoted to the raising of oysters. Breeding cannot succeed there on account of the large quantity of mud brought down by the current into the lower part of the Little Sea. Nevertheless, the adult oysters accomplish their generative functions there; but the young ones, on leaving the mother oyster, do not find collectors suitable to receive them and fall down upon the muddy bottom; the stakes of the parks and the cords which they sustain are speedily covered with a thin layer of mud, which prevents the young oysters from adhering. Moreover, in the upper portion of the Little Sea isolated oysters, called "horse-feet," are sometimes found in the natural state, and these seem to leave traces of their spawning, doubtless on account of the purity of the water and the cleanliness of the bottom. But these mollusks are constantly displaced by the currents, and it would be quite hazardous to count upon a regular harvest of young ones. This kind of oyster, which is still found in very small numbers in the roadstead, is highly esteemed by the Tarentians, who sell them for 15 to 50 centimes ($\frac{3}{4}$ to $2\frac{1}{2}$ cents) apiece. The beds near which the oyster-culturists of Tarente have placed their collectors are situated in the large sea. It is not known whether these beds are of large extent or merely small aggregations; their exact limits as well as their actual situations are unknown. In the month of May the fishermen submerge fascines about two miles from the shore to serve as collectors. Stones attached to cords serve to keep them down at a suitable depth in the water, and they are found and recognized by means of pieces of floating cork. The fascines are examined fortnightly or monthly. Those which do not have a sufficient quantity of young oysters upon them are returned to the water after they have been cleaned of the mud that may have collected between the branches, and of all parasites which may have grown thereon, by leaving them exposed, for one or two days, to the heat of the sun. Those, on the contrary, on which the young oysters have attached themselves in large numbers, are immediately transferred to the parks of the Little Sea.

The spawning season in the Gulf of Tarente is of exceptional length; it begins early in May and does not end until the close of September; and the yield, dependent upon the character of the year, may be abundant either at the beginning, at the middle, or at the end of this period; there is nothing fixed as regards this. Upon their arrival at the park the fascines are suspended from cords stretched from one stake to another, and kept in the water at a depth of one, two, or three meters (3 to 10 feet). After having been there six months, the young oysters have already attained a length of two or three centimeters (about an inch). The time has now come to give them more space, and to place them under more immediate oversight; the fascines are untied, the branches taken apart, and those bearing oysters are placed between perpendicular cords similar to those used for mussels. The young oysters which are detached during this operation are placed either in baskets, on screens, or in nets suspended from the horizontal ropes, but never on the bottom. This system of breeding avoids general mortality. At least every four months the cables and other apparatus carrying the young oysters are taken up and examined. Those oysters which have become large enough to sell are removed, and advantage is taken of this opportunity to give those which ought to remain some time longer in the park the cleaning and care which they need. The growth of the oyster takes place rapidly and regularly; from two to two and a half years suffice for the young oysters to reach a diameter of from 7 to 8 centimeters (about 3 inches).

The oyster of Tarente is of good growth; its shell is usually rather thick, this being due to the great amount of calcareous matter contained in the sea-water. This peculiarity, however, in no way impairs the regularity of its form.

The number of oysters obtained each year from the parks of Tarente is estimated at about 10,000,000. Before forwarding them they are exposed to the air for twenty-four hours, in order that they may be the more easily cleaned afterwards. The sale of oysters is absolutely free, whatever may be their size, or the season. But it is unnecessary to state that during the summer, the period of gestation, oysters are never sold. It is, moreover, to the advantage of the fishermen that their oysters should have attained a good size before being offered for sale.

The prosperity of the fishermen of Tarente is, unfortunately, disturbed from time to time. From a volcanic excavation situated below the convent of Saint Antoine, and which is obstructed during long periods of time, surges sometimes a boiling sulphurous spring, which flows down into the Little Sea. As soon as this phenomenon manifests itself, consternation spreads among this population of ten thousand fishermen, who live exclusively upon the products of the sea. The Little Sea then takes a reddish tint; the water of the springs, lighter than that of the sea, is rapidly transported by the currents. The fish are able to flee from this pest, but the oyster, the mussel, and shell-fish in general are quickly poisoned. When the water is in this state the fishermen call it "the sea of blood." This fortunately happens only at rare intervals; but, nevertheless, within the past twelve years it has taken place twice; formerly it had become almost a legend, for it had not occurred within the memory of man.*

* OYSTER-CULTURE IN NORWAY.—The work lately undertaken in Norway by Lieutenant-General Wergeland, formerly minister of war, enables us to further extend the comparative study of the methods of oyster-culture in the different seas.

There are remarkable differences between the processes in use in the Mediterranean and in the ocean, but these differences can only be the more sensibly realized if we go as far as the North Sea. Hitherto, Vivier-sur-Mer, in the bay of Mont-Saint-Michel, seemed to be the most northern limit where oyster culture assumed all its phases, for, if at certain more northern points on the Norman coasts, and at a few stations on the southern and eastern coasts of England, young oysters have been taken by the aid of scientific appliances, the means of preserving the spawn are still to be discovered and these experiments have not been practically applied.

Considering the latitude of Norway, the intense cold which prevails there during a large part of the year—cold so intense that sometimes the spawning of the oyster on the natural banks is without results for several seasons; and, moreover, considering the distance of Norway from those countries from whose experiences she might profit, and from which she might obtain information, it will be readily seen how numerous are the difficulties to be overcome in the establishment of oyster culture on the shores of Norway. General Wergeland was not deterred by these obstacles. After carefully consulting works relating to oyster culture which had been published in foreign coun-

TOULON.

The roadstead of Toulon presents, on first examination, most favorable natural conditions for the cultivation of oysters, mussels, and edible shell-fish in general. All the edible species common to the Mediterranean occur there, and it produced, moreover, in the early part of the present century, very fine oysters. Gradually, however, the exhaustion of the natural beds there began to be felt, as was the case with most of

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tries, and procuring exact data from M. Théodore Soelfeldt, who had come to Paris to study the French industry, he resolutely set to work in the month of April of last year.

Various circumstances appeared to him encouraging: first, the presence of the oyster in the North Sea; second, the small amount of salt contained in the water of that sea; third, the favorable influence of the Gulf-stream on the climate of these regions, and finally, the ease with which shelter may be found in the numerous *fjords* which cut into the shores of the peninsula of Norway. A bay situated a few leagues from Christiania (toward the fifty-ninth degree of north latitude) was the spot chosen for the experiment. It was necessary to guard against the inconveniences resulting from the early setting in of winter, from the slight rise and fall of the tides, which at the sysygies rise but a foot or a foot and a half, and from the violence of the storms which sometimes displace a volume of water more than 7 feet in depth. On the arrival of winter in Norway, that is to say, toward the beginning of September, the young oysters are still too young to resist the shocks and sudden changes of temperature. It was, therefore, of the greatest importance that they should not come into contact with the outer air. These difficulties were surmounted in the following manner: In the upper part of the establishment a supply reservoir, fed by a pump, worked by wind, was dug. Immediately beneath, within a house which protected it from the rigor of the cold, was placed a basin for holding the eggs, measuring 8 meters (26 feet) in length by 6 meters (19 feet) in width. A leaden conduit, furnished at its upper part with a grating fine enough to stop the passage of harmful fish, and in its lower part with faucets to regulate the supply of water at will, brought the two reservoirs into connection with one another. This tube took several windings and passed through an inclosure filled with water, which could be heated when necessary so as to maintain the water supplied to the hatching basin of a nearly uniform temperature. The level of the water in this latter basin was regulated by means of a tube, the opening of which was covered with a filter to prevent the escape of the young oysters. In this basin 2,200 female oysters were placed at the commencement of the season, and, although they had undergone the fatigue of a long journey, they emitted such a quantity of spawn that it was found upon the collectors by which they were surrounded.

This first experiment, as will be seen from the above, succeeded well, and the system invented by General Wergeland for obtaining larval oysters in inclosed places could be developed to any desired extent. The General intends to try and obtain the spawn of free oysters, if the season be mild enough to permit, by surrounding with fascines a natural oyster bed that has been recently explored. He proposes subsequently to inclose the young oysters in floating preservative boxes, and to raise them on the spot.

The labors, works, and schemes which I have just explained are due to the initiative taken by General Wergeland, whose laudable ambition it is to render to his country the same services which M. Coste has rendered to France. He is now engaged in restocking by means of pisciculture the large and beautiful lakes of Norway. If he succeeds, as there is every reason to believe he will, his country will be indebted to him for the introduction of a branch of industry for which there is a great future in store.

the banks along our coasts, and the deposits which had been of considerable importance were speedily exhausted. The oysters now taken at Toulon are isolated ones found in the crevices of the rocks.

Did the ruin of these banks arise from excessive and unlimited fishing, or must we attribute it, as at Brest, to the successive transformations which the submarine soil must have undergone, in consequence of the great works performed in the bay, and the repeated dredgings which stirred up the sand and the mud, and covered up the solid objects to which the oysters might have attached themselves? All have, doubtless, contributed to this result; but it is certain that at the same time the oysters disappeared, several other edible shell-fish, the mussel, for instance, became rare, and certain migratory fish which usually visited the shores of Toulon, as well as some stationary species, deserted the coast. This state of affairs aroused the solicitude of the marine administration. The labors of M. Coste had just then been meeting with great favor in France. Numerous attempts to introduce into our waters the oyster-cultural methods, brought by that gentleman from Italy, were repeated at various points along our sea-coast. The task of renewing the oyster banks of the roadstead of Toulon, and of making oyster-cultural experiments there, was confided to M. Coste about the year 1859. He proceeded in the following manner: Spawning oysters, with which he hoped to accomplish the restocking, were brought from England and Arcachon, and planted, some at points that had been previously explored, and found to be most favorable for the preservation and increase of the mollusk, especially near Seyne, the others in suspended baskets. Collectors, consisting of fascines or pieces of wood, were placed around the reproducing oysters. The oysters distributed in the improvised parks and those contained in the baskets acted differently; the latter spawned abundantly, and grew rapidly during the entire summer; the others spawned but little, or at least their spawn was without vitality; they thrived miserably during the season following their spawning, and finally perished. This was the fate of them all. This result, though not a negative one, having been deemed unsatisfactory, the experiments were, too hastily perhaps, abandoned.

In order that the fatal influences should not always exist as a check to oyster culture in the Mediterranean in the future, it is expedient to seek the causes that have led to them. In the first place, it must be remembered that M. Coste could not do everything. He had charge, simultaneously, of the attempts at oyster culture in the ocean and the restocking of our fresh-water streams; he was organizing a model fish-cultural establishment at Huningue, at the same time that he was pursuing in his laboratory at the College of France scientific researches, which he afterwards made known in his lectures; finally, he was engaged in the preparation of interesting reports. He was thus unable to observe with all the necessary assiduity the different phases of the experiment, to watch its progress, and to modify it in case of need. Notwithstanding the zeal and activity displayed by the persons to whom he had given his instructions, were they competent to fill the place of the master? Secondly, would it not have been preferable to choose as reproducers oysters from the Mediterranean, instead of the English oyster, whose fine quality and powers of rapid growth and fattening were incontestable, or the "*gravette*" of Arcachon, with its fine shape and exquisite flavor? These oysters being accustomed to the waters of the ocean, which differ greatly both as regards saltness and temperature from those of the Mediterranean, it could not be expected that they would become acclimated without difficulty, and that the regularity with which reproduction took place in their native water would not be interrupted. The proof that these oysters were not suited to this place is the fact that no trace of them now remains there, while the indigenous kind, although few in numbers it is true, has survived. It has been objected that the varieties may have become confounded in one type, or, that those planted at Toulon may have become transformed and have acquired the character of the native oysters.

The first objection is very easily refuted. It is probable that the foreign variety may have undergone some modification, but this could not have been great enough to have deceived the experienced eye of a naturalist.

From these facts it must not be inferred that the acclimation of foreign oysters is neither possible nor advantageous. There are precedents which demonstrate the contrary, and it will be sufficient to remind the reader that the American oyster (*Ostrea virginiana*) has prospered well in the basin of Arcachon; that the Portuguese oyster (*Ostrea angulata*) now reproduces naturally in the lower Gironde, just as it does at Arcachon, and that it does not suffer from its forced residence in the parks of Saint Vaast-la-Hougue, where the water is very considerably colder than it is at the mouth of the Tage, of which this oyster is a native. In the third place, some indispensable precautions had been neglected. Thus, when the oysters were immersed, instead of being distributed and separated from one another, they were piled up in thick layers in the parks. It is known that the accumulation of too many individuals at one point is disastrous, unless the conditions for aerating the water are exceptionally favorable. The spawning oysters were also exposed to many other dangers. First, their habitation was soon invaded by mussels. This is by no means of rare occurrence; it takes place whenever the oyster and mussel are brought too near together. In the next place, on account of the difficulty of keeping the place of experiment perfectly clean, owing to the absence of tides in the Mediterranean, the mud and sand, constantly kept in motion by the currents, accumulated by turns, and the reproducing oysters which suffered at the outset, as shown by the small development which they acquired in their parks, finally perished. It is the opinion that this experiment should not be considered as decisive of what can be done in oyster culture upon our southern shores. I think that if it were tried again with the more certain methods now employed the results would doubtless be encouraging. It is private enterprise, however, that should take the initiative, for to that in large part is due the great progress realized in the ocean, and the creation of oyster culture in France.

As I have before remarked, two varieties of oysters live naturally in the roadstead of Toulon.* First, there is the *Ostrea plicatula*, which also occurs at Genoa, Naples, and on the coast of Africa; and, second, the common Mediterranean oyster found at Narbonne, Port-de-Bouc, Aigues-Mortes, in the inclosures of Leucate, as well as at Tarente, and in the Adriatic at Brindisi and Venice. The first is a small oyster, which lives isolated or in groups attached to the rocks. It never forms, however, what is known as an oyster-bed; at least none are known on the coasts of France and Italy. The shell is small, rough, and irregular, seldom exceeding a large walnut in size. Its interior is pearly and of a slightly greenish tint, and the lower valve is very deep. This oyster is of an exceptionally fine flavor, which causes it to be much sought for. It is quite uncommon at Toulon. The second, if it were carefully parked and cared for, would not, as regards fineness and quality, be inferior to the best on our ocean coasts, and might compare favorably with the oysters of any region. The oysters of the pond of Leucate, the very rare ones taken at Narbonne and in the vicinity of the islands of Hyères, with those of the roadstead of Toulon, are the finest and best furnished by the Mediterranean. When properly cared for in a park they attain a size of from 10 to 12 centimeters (4 to 4¾ inches). The shell becomes light, translucent, hard, and well enameled on the inside; it emits a sound like crystal upon being struck. The lines of growth are indicated on the exterior by slight and delicate tubular folds. The oyster is well shaped, without being too large or too fat, and its exquisite flavor has earned for it a great reputation among the people of the south, a reputation which would not be merely local if oyster culture was in favor in the Mediterranean. Finally, I will add that between the Quimper oyster, which is excellent and of high repute, and the oyster of Toulon or Leucate, there exists the greatest analogy.

PENINSULA OF GIENS.

ESTABLISHMENT OF MESSRS. GASQUET.

Messrs. Gasquet were the first to seriously attempt putting into execution the happy idea of cultivating other shell-fish than the oyster and mussel, and the experiments which they have been making, with the most painstaking and laudable efforts, since the beginning of the year 1877, on the north coast of the peninsula of Giens, deserve to be made

*It is pretty generally admitted that the oyster called the "Pied de cheval" does not constitute a distinct species. It is supposed to be a common oyster that has grown old and large.

known. The oyster and the mussel are also among the mollusks raised at Giens. This marine establishment has been founded on the banks of a concession, measuring not less than 10 hectares (25 acres). The shores slope gently, and the sea-weed, with which they are almost everywhere covered, converts them, as it were, into marine meadows, similar to the "*crassats*" of Arcachon, which are known at Toulon by the name of "*mates*." The soil is formed of a mixture of clay, sand, and calcareous deposits. The proximity of aquatic plants for the raising of shell-fish and other fish offers undeniable advantages, particularly in the Mediterranean. In the ocean the breeding parks are, at times, almost entirely uncovered, and the tide furnishes them with well ærated water. The tide also brings to the shell-fish confined there abundant and fresh food from all directions. The case is different in the Mediterranean. At less than 50 meters (160 feet) from the shore, except during storms, the bottom is never brought into contact with the outer air, and the animals which have not the power of locomotion are forced to feed on little else than what grows upon the bottom within a very restricted area. But in the present case aquatic plants tend to render less noticeable the effects resulting from the absence of tides. They always set free a small quantity of oxygen and produce multitudes of microscopic insects, which furnish food to other animals. These were not the only considerations which induced the Messrs. Gasquet to establish themselves on the peninsula of Giens. The numerous kinds of shell-fish which took refuge in the gulf and the fine oysters occasionally found there were indications of the possibility of success.

In connection with the experiments of acclimation which the Messrs. Gasquet have made on the shell-fish brought from Cette, experiments which have given the most favorable results, I have thought it would be interesting to make known the chemical composition of the waters of the breeding-parks. The following is an analysis made in the laboratory of M. Schutzenberger, a professor in the College of France:

Sodium and potassium	11.02
Chlorine and bromine	21.61
Magnesia	3.03
Sulphuric acid	5.12
	40.78
Residuum for 1 liter (about 1 quart—61 cubic inches)	41.28

With some slight differences, the water at Cette resembles that at Giens. This fact must be borne in mind, for it shows that the acclimation of foreign species can only be obtained without difficulty, when the medium whence those species are taken closely resembles that in which they are to be placed. The water of the roadstead has a density of 3° by the hydrometer; its temperature is very variable; it attains, and even exceeds, 24°. This is not, however, an unfavorable condition. Under the action of the heat and the beneficial influence of the rain-water, the shell-fish rapidly develop.

The industry of Messrs. Gasquet consists in the breeding and rearing of the following species: the oyster, the common mussel and the red mussel, the "double *praire*" (*Venus verrucosa*), the "simple *praire*" (*Cardita sulcata*), the "*clovisse*" of Toulon (*Tapes decussata*), and the "*clovisse*" of Cette (*Tapes texturata*), the edible sea-urchin (*Toxopneustes lividus*), and the "*violet*" (*Ascidia cynthia*). The products of the sea are generally much relished by the inhabitants along the Mediterranean coasts. All marine animals that serve as food and cannot be classified as fish are called by them "fruits of the sea." The people of Toulon have a marked predilection for the *praire*, and esteem it as highly as they do the oyster. The average-sized double *praire* sells at Toulon at from 1 franc to 1 franc 25 centimes (20 to 25 cents) per dozen; if of large size, it brings as high as 2 francs (40 cents); the simple *praire* is worth a little less. The red mussel has a delicate flavor, and, like the *praire*, is eaten raw. The *clovisse* is, perhaps, less appreciated by epicures, but is universally eaten throughout the south. "One year, at Marseilles, the *clovisse* disappeared from the port, and desolation was general among the inhabitants. The magistrates took a generous initiative and had large quantities of the best quality brought from a distance. These were thrown by the basketful into the place which since that time has been known as the 'Reserve.'"*

The sea-urchin (*Toxopneustes lividus*) is sought after by many of the natives of Provençaux. The *violet* also has its partisans. Many of the southern people like it because of its somewhat high flavor. It sells at Toulon from 5 to 25 centimes (¼ to 1¼ cents) apiece.

As we see, the industry which the Messrs. Gasquet are attempting to create has an economic bearing, for it supplies a demand. The parks on the peninsula of Giens are all surrounded by stakes driven into the bottom, and to these hurdles are attached. This kind of inclosure serves the double purpose of presenting an obstacle to the waves, which beat on the coast, and of acting as a collector or place of refuge for the spat of the shell-fish. Within the parks have been placed other collectors, consisting of stones and tiles covered with a coating of hydraulic cement, which renders it possible, when the time has arrived, to remove the oysters from the place of attachment; this may be accomplished without the slightest difficulty.

The oysters which Messrs. Gasquet have introduced into their concession came from Arcachon; the largest, on their arrival, measured about 4 centimeters (1½ inches) in diameter; the others were still attached to the collectors. They were imported and parked in the spring of last year, and at once rapidly grew to be one centimeter in size. But since the manifestation of this first growth, until the month of September, at which time I visited the establishment at Giens, they had remained stationary, and moreover had given no signs of reproducing. There is nothing strange in this, for it must be considered that these oysters, which were

* Note sur la praire double (*Venus verrucosa*) par M. Charles Bretagne. Extract from the Bull. de la Soc. d'acclim., 1863.

still rather young for spawning, had, besides, undergone the fatigue of a long journey; the time they have taken to recover themselves coincides precisely with that of their growth and spawning. It is also necessary to add that a drier year than that of 1877 has been rarely seen. During more than four months the water of the roadstead of Giens, naturally salt, has not received the slightest addition of rain-water. In spite of this fact very few oysters have perished. This is important and promises well for the future.

Messrs. Gasquet, like practical men, do not propose to limit their experiments to the oyster of Arcachon; this year they are going to obtain a supply of Portuguese oysters and of oysters native to the ponds of Corsica. They have taken advantage of the winter season to make important improvements in their parks. Having learned of the excellent results obtained by distributing shells and sand over the bottom of the parks, they have, like Messrs. Mauduit and Solminihac, at Belon, carried calcareous sand mixed with clay to that part of their establishment where the young oysters are to be quartered. Boxes, such as are agreeable to the fry, ingeniously arranged, have been constructed to receive the young oysters and other valuable shell-fish, whose small size would expose them to the attacks of their enemies. If in the experiments made at Giens nothing conclusive has been decided as regards the oyster, mussels have succeeded perfectly. They have grown very large during the past year, and have multiplied in a large proportion. Their spat was so abundant that it was found attached in quantity to a net several hundred meters (a meter is 3¼ feet) from the breeding beds. The hurdles surrounding the park and the slates which served as collectors were also well covered with them.

In order to further extend this branch of their new industry, Messrs. Gasquet propose soon to establish *bouchots* made on the model of those used in the cove of Aiguillon. It is also desirable to mention the success obtained with the double *praire*, both as regards propagation and growth. The *praire* is a bivalve of nearly oval shape, with deep, hard valves which are concentrically ribbed. It may attain a maximum size of from 7 to 7½ centimeters (2¾ to 3 inches). The animal is plump and of a whitish color; it fills its shell so completely that a *praire* of average size is at least equal to a good-sized oyster. It is found in the ocean and in the Mediterranean; the Mediterranean form is preferable as regards flavor, and its reputation would have spread beyond the limits of Provence, were it not for its tendency to disappear from the southern shores. It usually lives in water ranging from 1 to 4 meters (3 to 13 feet) in depth; it is fond of a sandy bottom and sometimes penetrates from 8 to 12 centimeters (3 to 5 inches) into the sand. Like many other mollusks, it seeks the vicinity of fresh water. In the month of April, 1877, *praires* of all ages and sizes from the roadstead of Toulon were placed in the parks of Giens. The place chosen for this deposit was a sandy and somewhat clayey bottom, where a few tufts of marine seaweed grow.

Their growth was apparent during the whole of last year, and it was also observed with satisfaction that they had propagated. I, myself, found some very young ones on the cords of tunny-nets. It is thought that the spat of this mollusk floats freely in the water, until it is stopped by some obstacle, to which, however, it does not adhere; it remains free in the interstices which have received it. As soon as it becomes more developed, it leaves its place of refuge, where it found neither the food necessary to its growth nor the protection it needed against its enemies, and settles in the sand or among the vegetation. The name simple *praire* has been improperly given to the *Cardita sulcata*, for it is neither the parent nor the congener of the double *praire*, but belongs to a distinct species. The simple *praire* does not exceed in size the cockle (*Cardium edule*), which, as regards its shell, it strongly resembles; its flesh, however, is of a reddish color and has a rich flavor. When placed in the same parks as the double *praires*, they have gone on reproducing their kind from the first year of their introduction. By digging in the sand on the shore, and as far out as the ropes of the tunny-net (*madrague*), we found some that measured from 5 to 7 millimeters (¼ inch) in diameter, as early as the month of September. The fishermen say they had never previously found this mollusk on this part of the shore of Giens. The acclimation of the simple *praire* is now an accomplished fact, and shell-fish culture cannot but be benefited thereby.

The *clovisse* of Toulon and Cette have also increased much in size during the past summer. Indications of their spawning have been found near where they are located, and still more abundantly on the ropes supporting the nets of the *madrague*. In autumn the new generation had attained a size of from 10 to 12 millimeters (about ½ inch).

The *clovisse* of Toulon, which has a dark and hard shell, lives in limpid waters and on a sandy bottom. The *clovisse* of Cette, whose shell is thinner, more tender, and lighter in color, lives in less pure water and on more earthy bottom. I will relate, simply for the sake of recording the fact, an observation made at Giens, which it is difficult to explain, regarding the manner of reproduction of the shell-fish in question and their well-defined characteristics. It would appear that the *clovisse* imported from Cette has a tendency to resemble the *clovisse* of Toulon; that is to say, to borrow from it something as regards shape and color. Although the possibility of a crossing may be contested, it must be admitted that the bottom on which the *clovisse* from Cette now lives, and the quality and nature of the food which they find there, may have caused the modifications to which I have just referred. At all events, it is proved that after a very short sojourn in the parks at Giens, they have acquired the flavor peculiar to the native variety. There is another fact to which it seems proper to call attention. It was observed that the spat had particularly sought out the ropes of the tunny-net (*madrague*) at considerable distances from the concession. In the beginning of winter, when the *madrague* was taken up from the water, some of the ropes were so covered with these little shell-fish that Messrs. Gasquet thought best to immerse them in the park in order to allow the young ones time to grow.

Is not this indication calculated to put shell-fish culturists in the way of an improvement in the processes and methods to be employed in collecting spat? It is not right to attribute to chance alone, or to the mere influence of the currents, the preferences which these young animals seem to have for this sort of collector rather than for the hurdles by which they are surrounded, or the aquatic plants of the shore. Have not the fishermen of Tarente, who have carried on their industry for a long period of time, always used, and do they not use still, horizontal ropes as collectors? At all events, the observation is worthy of note.

The edible sea-urchin is common on the coast of the Mediterranean. At Marseilles, Toulon, &c., it is largely consumed. It is also found in the ocean, but a very serious difficulty stands in the way of its artificial propagation there. It spawns below low-water mark, so that its progeny may not be exposed from a lack of water at low tide. In the Mediterranean it propagates on the spot where it is found, which renders its culture possible in such places. The sea-urchins preserved in the park of Messrs. Gasquet propagated last summer, and in September I saw some ten or twelve young ones, of the size of hazel-nuts, collected round a couple of adults, which had been isolated for observation and had evidently given them birth.

The *violet* (*Ascidia cynthia*) is not considered edible by all the inhabitants of the sea-coast. Nevertheless, those found in certain localities on the Mediterranean possess remarkably fine qualities. The ancients were very fond of these *ascidians*, and ate them prepared in vinegar, with green or raw mint seasoned with vinegar.* Before the fishermen had devastated our shores with their drag-nets *ascidians* were not uncommon in the roadstead of Giens. They are now almost unknown, and Messrs. Gasquet are right in seeking to bring about their increase. It appears from the observations made by these experimenters that this *ascidian* is fond of rather deep places, those, for instance, ranging in depth from 1½ to 2 meters (5 to 6½ feet); it seeks localities where there are seaweeds to furnish it with food, and there it establishes itself permanently. In default of aquatic plants it attaches itself to any stable body. It does not dislike water but little salt or even slightly muddy. Like the sea-urchin, the *ascidian* has thrived at Giens, and will now, no doubt, continue to exist there, as it has a tendency to grow and multiply in the parks where it has been planted.

Such is the result of the fortunate experiments made by Messrs. Gasquet in their marine establishment at Giens. If, as it is to be hoped, shell-fish culture comes to take its place among the new industries, to them will be due the honor of having taken the initiative and of having marked out the path to be followed.

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* Docteur Ozenne, Essai sur les mollusques.

BERRE, CARONTE, THAU, LEUCATE, AND AGAY.

In view of the large extent (20,000 hectares (50,000 acres)) of water known as Lake Berre, it is astonishing that human industry has not yet taken possession of this little sea, which, in many respects, is to the Mediterranean what the basin of Arcachon is to the ocean. By its situation and close proximity to large centers, which would afford a market for its productions, and by the richness of its marine fauna, Lake Berre would seem destined to occupy an important place in fish culture. The astonishment which I express is shared by a large number of persons, and it is asked what are the reasons that have retarded the use of this lake for the cultivation of marine animals. One of the principal reasons, to which I cannot call attention too strongly, for it is essential that it should be correctly viewed, is the lack of success which has attended a majority of the attempts at shell-fish culture made in the Mediterranean, which lack of success has given rise to doubt and discouragement in the minds of those who are disposed to undertake the cultivation of marine animals. There is another matter which cannot be considered too seriously, viz.: that at the time the experiments were commenced, our knowledge of fish culture was still in a rudimentary state, and yet the results obtained, as is apparent from what I have said concerning Toulon and shall have to say further on in speaking of Lake Thau, were not of a nature to wholly justify these discouragements.

In the ocean it has not been without uncertain groping; without the efforts of individual enterprise; and above all, without sacrifices on the part of the administration of the marine, that the prosperous state has been reached, which I am sure will manifest itself at the Universal Exposition. The solicitude of the minister of marine and of M. Coste has been extended with equal favor both to the Mediterranean and the ocean, but private industry has been less persevering on the southern coast than on the western.

Lake Berre presents the best conditions for the breeding of edible shell-fish and other fish. The *clovisse*, the *praire*, &c., live there naturally; mussels of an excellent quality are sufficiently abundant to make it profitable for forty boats to spend a large part of their time in fishing for them. Nor is the oyster a total stranger to this locality, for some were formerly found there, and in the neighborhood, near Port-de-Bouc, very fine ones still exist. The shores are formed of shell sand, very rich in lime, and in many places are covered with marine plants common to the most fertile oyster-cultural stations of the ocean, such as Marennes, Tremblade, the island of Oléron, &c. The lake receives several streams and rivers, and numerous pure and fresh springs are found on its banks. Its water, which is neither too salt nor too fresh, never attains an excessive temperature so as to endanger the life of the aquatic animals which industry might confide to it. Its density is very variable; in the month of October, 1877, towards the center of the lake it ranged from 2°.8 to 3°, and on the banks it was about 2°.5 to 2°.6.

Lake Berre would not, however, in all its parts serve for the culture of shell-fish or for the establishment of fish-cultural reserves; in the first place those localities must be excepted which are too deep, or at too great a distance from the shore, and those in which such violent currents prevail as to render it impossible, as shown by experience, to maintain there pieces of apparatus, and, finally, the localities which are most exposed to the northwest winds. But there are to the west some sections of coast where violent winds and currents rarely prevail, and it is on one of these that the commissioner of maritime registry at Martigues has established a park, by way of experiment, to attempt the acclimation, breeding, and raising of oysters. The experiments are still in their infancy, but they promise a successful issue. The oysters that have been used were taken in the vicinity of Port-de-Bouc. They were first placed in baskets submerged at a suitable depth, quickly attained great vigor, and soon lost the salty and somewhat muddy taste which they had on leaving the sea; but still more important, not a single loss occurred. The experiment was made only with reference to the oyster, but an incident occurred which leaves no doubt as to the possibility of artificially cultivating the mussel in the lake of Berre. The baskets in which the oysters had been imprisoned, when placed in the water, at spawning time were covered in a few days with small mussels.

Let us seek to discover then, (for it cannot require a great deal of time or money), the apparatus to be used in Lake Berre in order to collect and preserve the spat of this mollusk: let the system of ropes which is used at Tarente and Fusaro with so much success again be tried, if, in this case, the crawls and the rafts do not succeed, and when the proper apparatus shall have been found there is a strong probability, not to say certainty (as is proved by what I have said above, especially if the rational rules which have been pointed out by science and practice be observed, and if suitable localities be chosen), that mussel culture will be established there, and attain all the prosperity which has been attained by the sister industry, oyster culture, at Arcachon and in the sea of Morbihan.

Below Lake Berre is Lake Caronte, as rich in shell-fish and other fish as the first named, and finally Port-de-Bouc, where oyster-cultural experiments were made by M. Viand; but a dry summer coming, the oysters all perished. Since Caronte and Port-de-Bouc were placed in more perfect communication with Lake Berre, however, the fishermen have remarked that certain kinds of edible shell-fish which had become very scarce have reappeared in large numbers.

Of the section reaching from the gulf of Fos to Lake Thau there is nothing to be said. In the latter, in 1865 and in 1866, M. Coste caused oysters to be placed at points chosen by himself. He wished to restore to these fine sheets of water the oysters which had disappeared from them, and to make Lake Thau an adjunct of the basin of Arcachon. M. Coste had analyzed the water and found its composition to be favorable. The first result did not deceive his expectation. The oysters soon attained a large size and acquired strength and flavor. They propagated perfectly, and the spat attached itself to the fagots arranged for that purpose and to a central rock, which became covered with them. I will remark in passing that the breeding of the *clovisse* has been very successful there. It is, therefore, an established fact that the oyster is capable of living and multiplying its kind in Lake Thau. How does it happen, then, that private industry has not been induced to come there also by the success of this first attempt, and that it should have forsaken a work so full of promise? It would, in the future, receive compensation for its labors there.

Among the other maritime stations where it would seem oyster culture might be profitably carried on, I will mention Lake Leucate, which has already been pointed out by Messrs. Coste and Gerbe as likely to become an oyster-cultural center, and where, not long ago, there were well-stocked oyster-beds, producing splendid oysters of rare beauty and delicacy of flavor, the finest, perhaps, to be found in the Mediterranean.

The waters of this lake, a large portion of which is sheltered from the winds, is mixed to a suitable extent with fresh water. The soil is rich in lime, and shell-fish of all kinds abound. But the level of Lake Leucate is not always constant; according as there is a drought or freshet its extent varies from six to eight thousand hectares (15,000 and 20,000 acres). It would, therefore, be necessary to take every precaution to prevent the inconveniences that would result to the oyster culturists from the changes in level.

Retracing my steps I will pass abruptly from the shore of Languedoc to that of the farther Provence. I will mention, as a reminder merely, the gulf of Saint-Tropez, where M. Coste made unsuccessful attempts, which may be tried again some day. Then I will stop at a little station which I particularly noticed in the course of my mission, and which seemed to me to unite all the natural conditions desirable for new and decisive experiments in oyster culture in the Mediterranean, namely, the bay of Agay. It is not surprising that it had escaped the attention of M. Coste in his explorations, for at that time it was far removed from all lines of communication, and frequented only by the fishermen of that section, or visited by barks in distress. Now it is on the line of the railway that connects Marseilles with Genoa. The water of the bay of Agay extends into a locality where it is protected from the northwest and north winds. As it communicates with the sea through a narrow entrance it is likewise protected on that side from the south winds, which are so terrible in autumn. A stream brings into it a tribute of fresh water, thus increasing the chances of success. An experiment made at a given point in the bay of Agay, with selected oysters, suited to the nature of the water, a park well arranged, well kept, and well watched, an experienced man to follow up with attention and perseverance the various phases of this experiment, would show definitely, I think, what might be obtained by oyster culture on our southern coasts. If the experiment was successful, as there is every reason to suppose it would be, it would form a starting point of information, calculated to establish oyster-cultural industry in the Mediterranean.

CONCLUSIONS.

Last year I stated with legitimate satisfaction that the industry of oyster culture in the ocean, although in its infancy, was in a flourishing condition and secured the existence on our shores of a maritime population of 200,000 souls. What a different spectacle is presented between Port Vendres and Marseilles. At the former place it is the picture of a commercial life asserting itself—the dawn of prosperity. I have seen an entire fishing population engaged with indefatigable activity in all the labors demanded by the culture of the mollusks, certain of finding there the reward of their efforts. At the latter one sees barren lakes, a deserted beach, and an impoverished sea.

The causes of the decadence of our southern shores are extremely numerous and varied, and it is not for me to examine them all. The principal causes are doubtless geological ones. The alluvium transported by the rivers flowing into the gulf of Lyons, the total volume of which exceeds 20,000,000 cubic meters (705,600,000 cubic feet) per annum, has caused a displacement of the shore line, the formation of lagoons, their progressive filling up, and their transformation into marshes which have become hotbeds of dangerous fevers. The fish, whose spawning grounds were constantly buried beneath the mud, sought a more stable shore, and man finally was obliged to flee from its pestilential atmosphere. Now the general situation is daily improving. The direction and the place of deposit of the alluvium is known, the portions of the shore which must be abandoned to the geological phenomena have been circumscribed, and engineers are successfully resisting the filling up of the lagoons. Many marshes, moreover, have disappeared through the action of time, and man has dried several. The influence of the marshes has diminished in intensity since then ; and the laws of hygiene now better understood renders it possible to combat more effectually the paludal poisoning. Thus the reclaimed lands are beginning to be peopled again, but the population is exclusively agricultural. It is useful, doubtless, to bring these shores, which have been reclaimed from the water, under cultivation, with a view to rendering them healthy, and rescuing them from sterility. But why not open a yet larger field to the activity of the people, who never fail to improve every new source of making a fortune, and give them these aquatic fields, which, like the land, can receive seed and yield a harvest? Does not the sea support multitudes of creatures which man may utilize as an important part of his food, provided he knows how to apply them to his use, not only by maintaining them under his hand, but, also, by encouraging their growth and multiplication according to well-known laws?

Reasons of the greatest importance, especially in view of their relation to the public maintenance, impose upon us daily more and more the necessity of placing under a regular system of cultivation the domain of the fluvial and maritime waters. As regards the rivers and streams, this necessity was long ago made known, and the art of cultivating fish is not unknown to us; whereas maritime fish culture, properly so called, has as yet received no attention. I desire, therefore, to call public attention to the subject of restocking the lagoons by fish culture, as well as to the necessity of restocking our rivers.

Oyster culture in the Mediterranean does not seem to me to promise so brilliant a future as on the Atlantic coast, although some stations seem to offer all the conditions recognized as indispensable to success. Mussel culture, however, might be profitably carried on there. So many places along the coasts resemble Tarente and the cove of Aiguillon. The mussel furnishes nutritious food, and is, by reason of its cheapness, accessible to the majority of the people. Neither the south nor the west can produce enough to meet the demands of consumers. One-half of the mussels eaten at Paris are sent there from Belgium.* Another branch of fish culture, the breeding of small shell-fish (*praires*, *clovisses*, &c.), would probably be profitable. The people of the south are very fond of these *sea fruits*, as the Italians call them, and would pay a good price for them.

I hasten to pass on to maritime fish culture, which seems to me to be the true industry suitable to these regions, and their natural conditions. Geographers have pointed out the striking resemblance existing between the delta of the Rhone and that of the Po; the alluvium tends in the same easterly direction, there are the same lagoons and the same marshes produced by the deposits of the river. The lagoons of Ferrare, Comacchio, and Venice may be compared to Leucate, Thau, and those of Aignes-Mortes. The inhabitants of the shore, however, have derived great benefit from these salt lakes, and in this no parallel can be drawn between the two. Whilst on the French side nothing but solitude and neglect† is seen, the Italians have not allowed to be lost the teachings in the art of cultivating the sea which were transmitted to them by the ancients. If, in the south, they practice oyster culture as in the last days of the Roman republic, along the Adriatic and in the Sardinias they have applied themselves to the breeding and preservation of sea fish.

At Comacchio fish culture has from time immemorial furnished ma-

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* Maxime Du Camp, "Paris, ses organes, ses fonctions et sa vie."

† The average annual yield of the fisheries in Lake Thau amounts to 300,000 francs ($60,000). This is an indication of a certain activity. (Lenthéric, Villes mortes du Golfe de Lyon.)

terial for a large export trade, and fisheries are numerous in all the lagoons of the coast.

This is the example to be followed—a profitable business, in which one can engage without doubt of success. The soil, the climate, the water being the same in the Gulf of Venice as in the Gulf of Lyons, the processes need not be sought for anew. The Italians succeeded with them: why not apply them upon our Mediterranean shores? They might be speedily tested at little expense, and if found imperfect in any way they could be quickly improved, just as were the oyster-cultural processes brought from Fusaro by M. Coste.

Let it not be forgotten that the number of fish brought to our market is constantly diminishing. A part of the north of France is dependent upon foreign countries for its fishery supplies; in the south, fish of fine quality would be unknown if the coasts of Corsica and Sardinia, which are still prosperous, did not furnish their quota. The native fishery is insufficient to satisfy the demands of a market which increases day by day, in proportion as railroad communication becomes more extended. It can with great difficulty furnish Paris with a little more than half the fish consumed there, and still fresh sea-fish are considered the favorite article of food; a gale of wind is sufficient to deprive Paris of its supply.* It is apprehended on all sides that the time will arrive when fish, other than preserved fish, will be a luxury which the rich alone can afford. This situation demands a prompt remedy. It has seemed to be my duty to point out where it might be found.

* Maxime Du Camp, *loc. cit.*

INDEX.

XXXII.—AN ACCOUNT OF THE PORTUGUESE AND FRENCH OYSTERS CULTIVATED IN THE BAY OF ARCACHON.

By J. Renaud.*

A.—AN ACCOUNT OF THE PORTUGUESE AND FRENCH OYSTERS.

The oyster (*Ostrea edulis*) is a mollusk belonging to the class of *Lamellibranchiates*. To form an adequate idea of its admirable conformation, it is necessary to study it with the microscope.

The oyster is widely distributed in nature, each marine province counting one or more species in its fauna. Usually grouped in places most favorable to their development, they form considerable accumulations, known under the name of *Banks*. The immense consumption of this mollusk, principally in Europe and America, may give some idea of its fecundity, for its abundance does not seem to diminish in spite of the large quantities taken from the sea.

The oyster which we now call the Portuguese was known to, and esteemed by, the ancients; the citizens of Athens regarded it as a dainty, and used its shell to write their votes upon. Subsequently, among the Romans, we find Pliny congratulating one of his friends on being at Marseilles, where he could have fresh oysters.

The shell of the oyster is especially recognized by its irregularity; living attached to sub-marine bodies it takes the imprint of them, and individuals of the same species are infinitely modified in consequence of the numberless accidents of position which they assume on the bodies to which they are attached. It is, therefore, necessary to examine a large number of individuals in order to recognize a species and learn its distinctive characteristics. One characteristic of oysters is the inequality of their valves, the one which adheres to foreign bodies being always the larger. These valves have received the name of upper and lower, in consequence of the usual position of the oysters; the lower valve is the larger, the upper one is also called the operculum. Nevertheless, in the study of this mollusk, I shall follow the rule laid down by zoölogists for the study of bivalve shells in general, that is to say, I will suppose the animal to be standing upright before me. In this position the large valve is on the left, the small one on the right, while the

*Notice sur L'Huitre Portugaise et Française cultivée dans la Baie d'Arcachon. Arcachon, Imprimerie E. Faure et V. Aumassanne, 1878. Quarto pamphlet, 33 pp.

upper edge, comprising anteriorly the hinge which unites the shells, is extended as two somewhat conical prominences called umbos or beaks. The beaks in the Portuguese oyster are unequal in the two valves; the left one is always the larger. They are each marked by a groove, varying in size, in which an elastic ligament, for opening and shutting the valves, is firmly fastened. This groove is also frequently marked with ridges and furrows, of greater or less width, which follow its direction and indicate the successive lines of growth.

The edges of the valves in the Portuguese oyster present very considerable variations; sometimes that of the larger valve is undulated, striated, or denticulated. If the oyster is an old one, the smaller valve partakes of the modifications undergone by the larger one, so that it often happens that the shells are marked by corresponding indentations. Their interior surface is smooth, almost always white, and often pearly toward the center; a little back of and above the center, however, there exists an oval depression. This is the point of attachment of the central muscle which connects the valves together. In studying the structure of the shell of the Portuguese oyster, it is sufficient to saw or break the shell in two, in order to become convinced that its structure is foliaceous, that is, formed of successive layers. There are two reasons why the specific gravity of this shell is not high. The first is, that rather broad spaces often intervene between the laminæ of which the shell is formed; the second is, that the laminæ themselves are to a large extent composed of a white, porous substance whose specific gravity is exceedingly low. In the Portuguese oyster the laminæ, which are irregularly distinct, are piled upon one another like partitions. This laminated structure arises necessarily from the organization of the animal, and it is known that the interspaces contain an acrid water, resulting from a depuratory secretion. This phenomenon is, moreover, common among the mollusks.

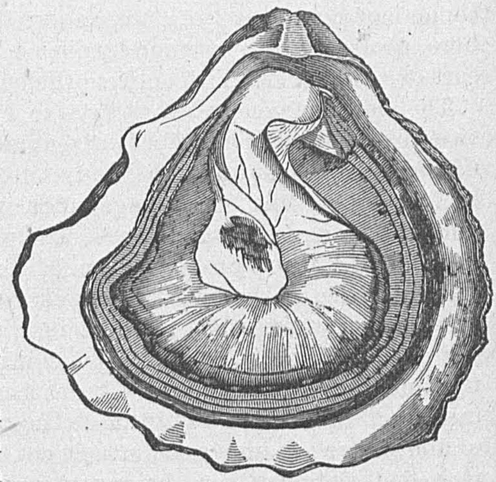


FIG. 1.—The Portuguese oyster.

Let us now carefully open the Portuguese oyster. In the first place we must break the solid, dark-brown ligament which, like a hinge, attaches the two valves together. But even now the valves do not separate. A sharp instrument must be inserted between them, so as to cut the cylindrical muscle connecting them near the center.* The ani-

[* This is not the way oysters are opened in America. The process is reversed; the muscle is first cut with a knife when the hinge is broken apart.—ED.]

mal then appears to have nearly the form of its shell, being usually oval in shape, and with its anterior extremity towards the narrow part of the shell. If after death, it is placed in water, so as to allow its parts to float, one sees in the center a mass of organs, separated by the contractor muscle noticed above, around which are attached large striated and whitish laminæ, which may be compared to the gills of fishes. Finally, the entire body is covered with a thin, transparent skin, whose edges are blackish in color and thickened, and correspond to the edges of the shell during the life of the animal. This membranous envelope, which is called the mantle, has its edges free and detached throughout almost the entire circumference of the body. On the sides it adheres to the principal organs constituting the abdominal mass. It serves at the same time to cover the oyster and to secrete its shell. Its thickened edges are of a muscular nature, and are also provided with secretory glands. Its main portion is formed of two very thin membranes united by a vascular tissue, which, when injected, presents to view a beautiful network of fine ramifications. In that portion of the mantle which is in contact with the shell there is also to be seen an organic web, in which calcareous granules are secreted in great abundance. It is these secretions, which, becoming detached, together with the organic matter enveloping them, increase the thickness of the shell, forming one by one the laminæ above described. If one tries to open the mantle he can turn back its lobes as far as the central muscle, but from here inwards to the anterior extremity, where the mouth is, it forms a sort of cowl inclosing the other organs of the mollusk.

The mouth is recognized at once by its transverse position and by the two thin membranous lobes accompanying it. These lobes are continued on each side of the body into a pair of narrow, lance-shaped labial palps or lips, which are smooth on the outside and marked with oblique striations on the inside. The mouth is a simple opening, which the animal can contract by means of a small sub-circular muscle; it is followed by a very short œsophagus ending in an ovoid pouch with membranous walls (the stomach), into which open the bile ducts from the liver. A more important opening near the lower extremity of this stomach is the entrance to the pylorus. Here begins a slender intestine, which descends through the thick portion of the liver, in front of and somewhat under the muscle connecting the valves together; then it ascends obliquely towards the back, passes above the stomach till on a level with the mouth, and finally, bending upon its course, returns, passing over the upper side of the muscle, at the middle of which it terminates in an anus, situated between the lobes of the mantle. The liver, which is the principal organ of the oyster, constitutes a considerable portion of the visceral mass and is easily recognized by its dark greenish color. The organs of circulation and respiration can only be examined after they are injected with mercury. The heart is easily distinguished by the blackish color of its auricle, and from the fact—very rare among acephalous mollusks—of its being entirely independent of the digestive system; although placed in the ventral region, it has no connection with the intestines. The gills, or breathing organs, four in number, are in the shape of large laminæ nearly equal in size and with transverse striations; they are arranged symmetrically, two on each side of the body. When viewed from behind, four rows of large and perfectly regular quadrangular openings are seen. These openings pass through the gills in the form of canals, in which the fecundated eggs accumulate at the spawning time, in order to undergo a sort of incubation.

The organs of reproduction consist of an ovary placed along the sides and upper portion of the head end of the body, and which finally, as it becomes developed, almost entirely covers the abdominal mass. The oyster is hermaphrodite, that is to say, combines the two sexes in one and the same individual. The organ of generation, which is scarcely visible during the winter, is nevertheless distinguishable in the form of a milky spot covering a portion of the liver. In the spring almost the entire upper portion of the creature has assumed a whitish color; the zoosperms appear; and their presence effects fecundation. The oyster yields from 50,000 to 60,000 eggs, more or less.* They are spherical and can only be seen by the aid of a microscope The embryo develops rapidly, is soon provided with vibrating cilia at the anterior end and swims round and round; finally it settles upon some solid object, perhaps on an oyster shell, to which it attaches itself and begins to grow. At this time the body of the oyster, being extremely soft and its shell very thin, the valves take the impress of the body upon which it happens to fall and fix itself, and preserves the shape so assumed ever after.

B.—A NEW MIXTURE TO BE PLACED UPON COLLECTORS.—PRESERVATIVE BOXES.

Without wishing to repeat what is already known or to treat of a subject which has been handled by others, I shall in a few lines render homage to those intelligent and laborous workers who by the rational application of new methods have greatly contributed to the development of oyster culture. I propose to speak of the new collector or apparatus for collecting the "fry," as soon as it is set free by the parent oysters and preserving it from destruction.

It is but a few years since the only methods in use were the following: In Lake Fusaro, in the province of Naples, where the oldest artificial oyster banks were established, and on our coasts of Brittany, Cancale, Saint-Brieuc and Arcachon, the oysterculturists did nothing to collect the spat beyond placing bundles of whitewashed fagots in the water, anchoring them by means of stones. The spat lodged upon these fagots, after which the breeder had only to take them from the water, when as

[*Now known to yield a much greater number.—ED.]

they were shaken many of the young oysters fell off. I leave it to the reader to imagine what quantities must have been lost in this primitive and imperfect practice. Stone blocks were also used, as were tiles, slates, and wooden shingles, but all these collectors were defective and insufficient. It was almost impossible to detach young oysters adhering to a very hard body without breaking them, or at least doing them much damage; wooden collectors present contrary disadvantages; the point of attachment of the oyster being too weak renders them too easy a prey to the crab, their most dreaded enemy, which, with its very delicate instinct, always attacks this mollusk in its most sensitive part.

Mr. Michelet, an oysterculturist of Arcachon, and a thoroughly practical man, wishing to remedy these two serious inconveniences, conceived the idea of covering the collectors with a mortar, consisting of lime and sand mixed with a small amount of cement. In this mixture half-cylinder tiles are soaked until they are covered with one or more layers of it. These tiles thus prepared are dried for several days in the sun, and are then carried to the park, where they are placed in five or six rows, forming hives of from fifty to sixty tiles; these hives are surrounded by strong stakes, which are firmly fixed to prevent their being overturned or carried away by the rapid currents. The water passing through these tiles is arrested there and an eddy formed, which permits the young oyster to attach itself to the collectors by means of its little vibrating cilia. There the embryo becomes developed, increases in size, and attains the adult age, which is a year and a half, and not three years,

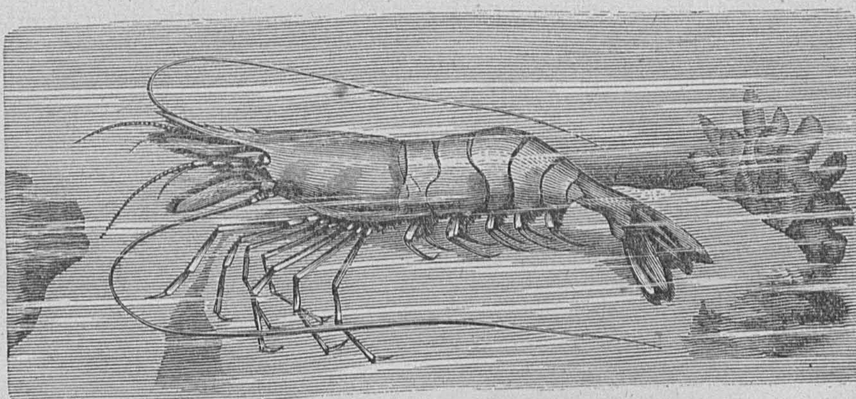


FIG. 2.—The shrimp (*crevette*).

as has been stated by certain parkers, whose opinion in the matter (as we know from numerous and thorough experiments) is entirely erroneous. Towards the close of the year women detrocate them (this term, when used in oyster culture, signifies detaching the oyster) by means of knives designed for this purpose, which they very carefully insert between the young mollusks and the tile to which they are attached. The young oyster, thanks to the covering of mortar, is easily loosened without suffering much damage. When this industry was in its infancy, and especially after the first trials of these implements, before hard experience had yet taught its costly lessons to the imprudent, a great many producers threw these young oysters, improperly detached, into their basins. Either because the tiles were not properly covered, or because the oyster had been injured in detaching, a majority of the persons engaged in this industry lost almost their entire work through the ravages of the crab, the *cormailho*, the shrimp, the *vive*,* and the numerous other enemies of the oyster.

In view of these serious disasters, numerous experiments were made by the various oysterculturists, but generally without success. After many attempts and trials, M. Michelet fortunately invented a wooden box, about one meter in length, by half a meter in width (3¼ by 1⅝ feet), covered at the top and bottom by a rather fine metallic netting, which permitted the water to circulate freely, and bring to the oyster sufficient nourishment while protecting it against the voracity of its numerous and dangerous enemies. In this connection we will reproduce a few lines taken from a work on oysterculture, printed in 1866, with which, on this point alone, we are entirely at variance. This passage, which we will quote in full, asserts that the enemies of the oyster are innumerable, but that they can do nothing in the face of the immense power of reproduction of the oyster. Many oyster breeders might reply to this assertion by figures, showing conclusively the serious and irreparable losses resulting from these numerous enemies of the oyster, which the following lines appear to disregard, although certainly without reason.

M. Davaine says, in a treatise which we have before us, page 78: "Of mollusks, *Nassa reticulata*, *Murex tarentinus*, and probably several other

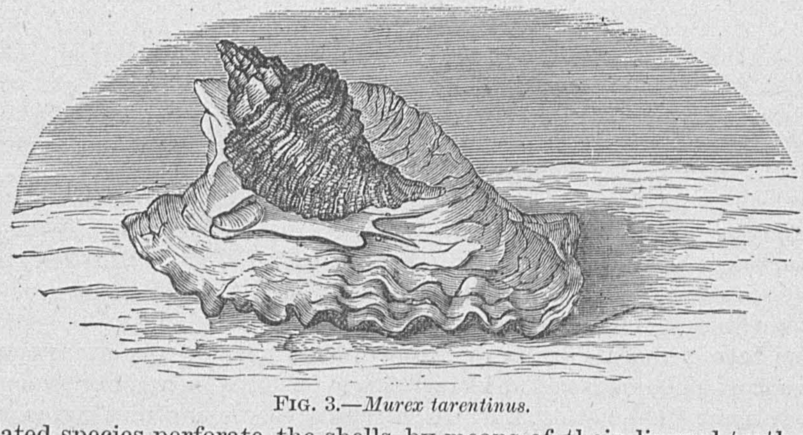


FIG. 3.—*Murex tarentinus.*

related species perforate the shells by means of their lingual teeth, introduce their proboscis and suck the oyster through this little opening; the latter becoming sick or weakened partially opens its valves; the crab comes * * * and others with him, and all disappears.

[* Probably *Trachinus draco*, Linn.—ED.]

"Now, let us at once declare that these numerous, implacable, and bitter enemies are not to be feared; they neither increase nor diminish—they are always the same, to-morrow as to-day, as yesterday; they will devour in vain, for they will be powerless to stop the prodigious multiplication of the oyster.

"Their number can only be compared to the grains of sand on the sea-shore, yet the spat is infinitely more numerous.

"Moreover, every imaginable means that could be used against these enemies would be illusory and powerless. It is in vain to struggle against a natural law.

"The evil does not exist."

In 1866 when the above lines were written, this theory might perhaps have been admissible, and it was possible for an oysterculturist to express himself thus; but now, in 1876, the progress and extent of oyster-culture, the invention of the covering for collectors, and of preservative boxes, are the most direct refutations that we can array against the passage quoted. In order fully to convince the reader and to prove to him that we are right, we will say a few words concerning the boxes and their use. M. Michelet calls his boxes *ambulances ostréophiles*, their principal object being to serve as infirmaries for the oysters that may have been injured by the knife of the clumsy *detrocatrix;* and by isolating them, to permit them to repair the damage done to their shells. After remaining for a few days in these reparative boxes, the oysters are thrown into basins called *claires*, where they grow until the time for selling arrives, when, leaving their protective asylum, they go to enrich the tables of the epicures of Europe and America, who, when tasting them, little think of the amount of care and labor which they cost their producers before reaching the palace of the gastronomer.

C.—THE PORTUGUESE OYSTER FROM A COMMERCIAL AND OYSTERCULTURAL POINT OF VIEW.

The Portuguese oyster has already become of great importance as an article of food and of commerce.

Not long ago Messrs. Garrelon, Grenier and Dasté, oysterculturists of the basin of Arcachon, all of whom are now known as maritime culturists at the head of the basin, were engaged in its cultivation on a large scale, and derived great profit therefrom. Several have been so pleased with their success in this line that they have said to me within a few days, "if the Portuguese Government would send us a few cargoes of oysters, we could, after selling them, give them a fair share of the profits." These words, which are from very competent oysterculturists, demonstrate sufficiently, that in spite of its detractions the Portuguese oyster is sold in large quantities and with profit, since the great quantity raised is insufficient to meet the demands of its numerous consumers.

This oyster, when young, differs in taste from the French oyster, that is to say, from the oysters of the basins of Cancale, Saint-Brieuc, and Arcachon; but it is nevertheless highly esteemed and much sought after in the interior of France, and in many districts in which the culturists have sold and are still selling considerable quantities. We might cite, for instance, a culturist of Arcachon, who, a few years ago, had buyers at Lyons, Limoges, Marseilles, Grenoble, and at all the great centers, whose purchases amounted to 27,000 francs ($5,200) during the oyster season, that is, during a period of six months. The Arcachon oyster has a finer and perhaps richer flavor, but the Portuguese, according to the testimony of physicians, contains more compounds of iodine and operates upon delicate and diseased chests more speedily and more beneficially, especially in the case of the various physical affections. It may, according to epicures, be seasoned and cooked in various excellent ways.

In oysterculture this oyster offers to breeders great advantages over the French oyster, as it speedily attains the adult size, and is thus sooner fitted for the market. In short, while the French oyster cannot be sold to consumers until it has reached its third year, the Portuguese oyster in two years attains the size and quality most favorable for its sale, for at that age it is always above the prescribed size of five centimeters (2 inches), and having become adult its flesh then is fine and delicate. In addition, it results from this rapid growth that at the age when the French oyster has still everything to fear from its natural enemies, such as the crab, *cormailho*, shrimp, &c., the Portuguese oyster has a shell of sufficient strength to protect it from the attacks of these animals, and there is no need of resorting to artificial means of protection, which are always so costly. For these reasons, the Portuguese oyster offers to breeders at least double the advantages of the French oyster.

Finally, allow me to pay it a tribute of gratitude in this little book. All oysterculturists know that during a period disastrous to our industry, the bays of Arcachon and Brittany were, from various causes, depopulated, oysters became scarce, and could hardly be obtained at all. Then France had recourse to the coasts of Portugal; we went there and obtained the precious mollusk in large cargoes, in order to restock our depleted oyster-beds. If, therefore, our parks are now so richly stocked, we owe it in a great measure to the Portuguese oyster, which, coming to the aid of the French oyster during the oystercultural season of that time, rendered it possible to restock our oyster-beds.

No one is ignorant of the fact that the shell of the Portuguese oyster is very useful for manufacturing purposes; it furnishes mother-of-pearl in abundance, from which beautiful fancy articles are made; it is also very serviceable to agriculture as a superior fertilizer, inasmuch as it contains a large quantity of phosphate of lime.

D.—PROTECTION OF "CLAIRES," OR OYSTER BASINS, BY MEANS OF OVERHANGING STRIPS AND WIRE SCREENS.

A large number of oysterculturists lose the greater part of their young oysters, or find them often endangered, from the want of proper means of protection. When spring arrives the *tère*, *thouy*,* and many other rapacious fish which are fond of oysters, invade our bays, and create great havoc. "But," some will say, "we have done everything, and our efforts have proved powerless against the numerous and voracious enemies; nothing can save us from them." After many attempts, I have just devised a method of protection, which may be easily arranged, and which serves to shield the mollusk from the attacks of crabs and other oyster-eating animals. The following means are apparently the best, and I will briefly describe them:

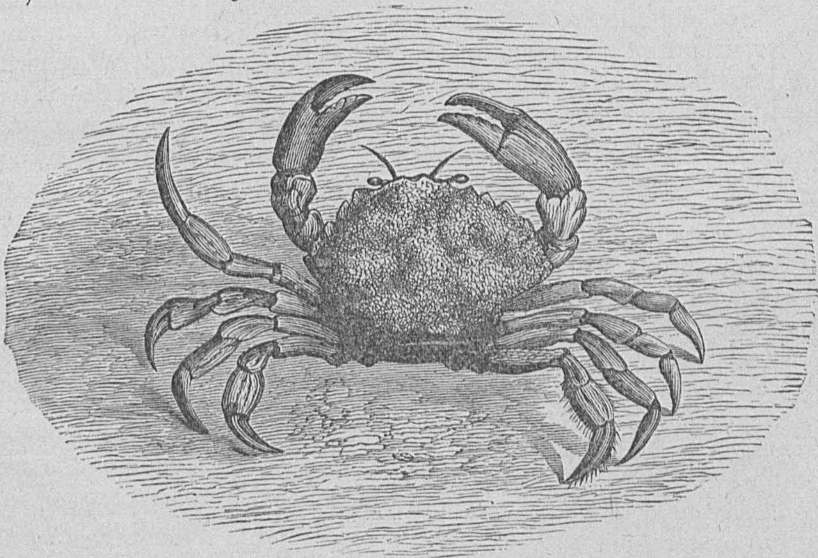


FIG. 4.—The crab.

Over the walls of my *claires*, which are built of tiles and a very resisting clay, I fasten from the base to near the middle boards, about twenty centimeters (7½ inches) in height, bound together on the inside by means of strong stakes driven in at a distance of a meter (3¼ feet) apart; and in this way I arrange a block of five or six *claires* touching one another, the continuity not being interrupted either below or between the boards. Along the upper edge of the boards, and jutting outward from them, I fasten a strip of zinc about eight millimeters (one-third inch) wide, which is firmly held in place by a small lath. The crab,

[* I have not been able to identify these fishes from their vernacular names.—ED.]

attracted by the young oysters in the *claires*, climbs along the board, but meeting with the little projecting band of zinc on which his claws can get no hold, he slides off and is precipitated outside the claire; he exhausts himself in vain efforts to enter, and the oyster meanwhile flourishes, secure from his attacks. This contrivance may be made either of wood or of zinc, according to the desire or means of the breeder; but zinc, although more costly, is far preferable.

But even now, protected from the crab, the oyster harvest is not yet sure; for there is much to fear from the predacious fish already referred to. These other enemies do not crawl, but swim; and at high tide pass over the obstacle just described; coming in large schools, they devour millions of young oysters in a single night; alas! we have just had a sad proof of this in the Arcachon basin. In order to arrest their invasion, I arrange small iron hooks along the zinc band at intervals of about twenty centimeters (7½ inches), and also at the same distance apart upon the two longitudinal sides of the *claires*, which are opposite to one another. The keeper of the park, bearing a large roll of galvanized iron wire upon his arm, attaches the extremity of the wire to the first hook; a second workman, unrolling the wire, carries it to a third upon the opposite side; the latter attaches it to the corresponding hook which is before him, and then fastens it securely to a second hook; the man with the wire carries it back to the keeper, who repeats the operation. This work is continued until all the *claires* are covered with this metallic net-work.

Oysterculture is still in its infancy, and it is only after many fruitless attempts that we have been able, by a slow course of study, to discover, successively, the collectors, the proper coverings for the tiles, the preservative boxes, and the different methods of raising and breeding, which have served as the fundamental basis of our oyster industry; and it is by pursuing the same course that we have demonstrated the immense advantages presented by the use of the zinc protector and metallic network for *claires*. In fact, the results we have just described are not the only ones secured by these arrangements, for they serve, not only to prevent the oyster from being devoured, but also from escaping. Many persons are tempted to consider this assertion as a pleasantry, yet nothing is more true. During the prevalence of extreme heat the basins are covered with a greenish growth, called "*gouëmon*," or "*Arbre de mer*" (sea tree), which becomes attached to the mollusk. This seaweed increases in size, and finally, by reason of its specific gravity floats, carrying with it the oyster to which it adheres, and transferring it from our basins to a neighboring park, or to the bottom of the channel outside. The metallic net-work prevents this escape; the *gouëmon*, or sea tree, raises the oyster as it did before, but, meeting with the wires which cover the *claire*, it attaches itself there, becomes dry in the sun or air, at low tide, and having no longer strength to retain its prey, the oyster falls back into the *claire*, leaving it for the waves to carry off its ravisher at the next high tide.

To complete the enumeration of the advantages of our system, we will remark that there is still another one, not less important, to which we would call the attention of our readers; it is, that theft is rendered very difficult, if not impossible; oyster thieves can no longer dredge the *claires;* in order to rob them, they must cut or saw the metallic wires, which operation would require much time, would make a noise, and give the alarm to the guard, thus enabling him to defend the property entrusted to his care; a robbery of this kind would, moreover, come under the head of burglary. We will mention, as another advantage, the protection which the seaweed, stopped by this net-work, gives to the oyster by shielding it from the violence of the sun during the extreme heat of summer; for the heat of the sun may cause the loss of a great number of oysters, both large and small. We therefore persist in saying, and our own experience has sufficiently demonstrated the fact, that the zinc bands and the metallic net-work for *claires* are destined to become two efficient adjuncts of all the various kinds of apparatus which have thus far been used in oysterculture in our basin of Arcachon.

XXXIII.—OYSTER CULTURE IN MORBIHAN.

*A REPORT PREPARED IN THE NAME OF THE COMMISSION OF THE COMPETITIVE EXHIBITION AT VANNES.**

By A. E. HAUSSER,
Engineer of Roads and Bridges.

TABLE OF CONTENTS.

* L'Industrie Huitrière dans le Morbihan. Rapport dressé au nom de la Commission du Concours de Vannes par A. E. Hausser, Ingénieur des Ponts et Chaussées. Publié sous les auspices de M. le vicomte de Rorthays, préfet du département, par le Conseil général du Morbihan. Avec vignettes et 5 planches. Paris; Dunod, éditeur. Quai des Augustins, 49. 1876. 12mo. 152 pp.

CHAPTER V.

Measures required to insure the prosperity of oyster culture.

INTRODUCTION.

The oyster, whose edible qualities are so remarkable, formerly abounded upon our coast, and has always been in great demand. Successful attempts at its cultivation date back to remote times, and Coste has given an exceedingly interesting description of the ancient industry of Lake Lucrin. In the days of the greatness of ancient Rome, the proconsul, C. Sergius Orata, attained such success in the cultivation and improvement of the oyster, that a liking for the pleasures of the table, no less than for the attractions of picturesque country life, drew every year numerous patrician families to the environs of Lake Lucrin, upon the pleasant shores of the bay of Naples.

Among the *débris* discovered about certain Roman camps, oyster-shells occur abundantly, and history proves that everywhere among the many productions serving as food for man, shell-fish in general, and oysters in particular predominate. This has resulted from the remarkable hygienic properties possessed by this class of animals, and to judge from the prescriptions of American physicians, one might be led to believe that the flesh of the oyster bore the character of an universal panacea.

We do not intend to plead here the cause of the oyster, or argue in favor of its increased use. The consumption has already attained such proportions as to form in itself the strongest argument in its behalf. When we consider that in America nearly ten thousand millions are eaten yearly, that in the city of New York alone the annual sales amount to from seven to eight millions of dollars, and that, according to M. de Broca, more money is expended there for oysters than for meat, some idea may be obtained of the consumption in that country, and of the important position occupied by this mollusk in the public welfare. Taking into account the valuable nutritive properties of this product, and the importance of making it a common article of food, one can understand our regret at seeing it disappear from some of the most important of the French beds. We do not need to seek the cause of its disappearance from the French coast; the fact is evident, and it is the fact that we should bear in mind. Coste, whose name will ever be remembered in connection with the great attempts of the past fifty years, in advancing fish culture and the cultivation of marine products, has, with the characteristic glance of a man of genius, embraced the entire question, in all its bearings.

It is indispensable that we should, in this connection, review the plan of work of this learned man, together with his principal ideas. Whenever oyster-cultural enterprises are to be undertaken, it is Coste, and Coste alone, who should be consulted, and whoever desires to make oyster culture practical must reflect upon the failures of Coste and deeply ponder their causes.

We give here, in a few words, the course pursued by the master. M. de Quatrefages has contended that the artificial fecundation of the oyster is possible; Coste has shown that the oyster is hermaphrodite, that the eggs and spermatozoa originate in the tissues of the same organ, and that the mantle of the parent forms the only favorable medium for the process of hatching. In 1860, he wrote the following words, which are full of truth: "In the case of oysters, the natural processes are the only practicable ones to be followed in connection with the industry."* This discovery, therefore, totally precluded the artificial fecundation resorted to in fish culture, rendered the crossing of species impossible, and led to a study of the natural development of the functions of the oyster, without the hope of controlling it. The fecundity of the oyster is very great. Each individual is capable of producing from 1,000,000 to 2,000,000 eggs, between the months of June and September. Hatching is accomplished, as already stated, in the mantle of the parent. The eggs, which are white at first, change in color, and when they have assumed a bluish or slaty gray tint, it is an indication that the embryos have arrived at maturity, and they are then expelled.

Impressed by what he had observed at Lake Fusaro, convinced, after his trip to the little bay of Seudra, that cultivation might improve the oyster and give it valuable qualities, persuaded, by the results of the mussel industry in the bay of Aiguillon, that man might exert a powerful influence in increasing the abundance of these mollusks, Coste conceived a comprehensive plan. He asserted that breeding was possible in basins or claires; he made a study of the spat-collectors, sought to collect all the spawn produced by the parent oysters, and affirmed that nearly all our shores might be planted and transformed into fertile regions of production. He insisted upon the duties of the department of marine, in connection with the enterprise. "The administration," he said, "will see, as if by magic, the isolated banks of the entire harbor of Brest and of the bays of Brittany, with the mouths of the affluent rivers, enlarged and united, by the formation of new ones, into vast areas of production. The depleted beds of Cancale and of Granville will be renewed, and will spread out towards very many localities, where the depths are such as to readily favor the attempts made to enrich them. The basin of Arcachon, all that section of la Manche, extending from Dieppe to Havre, from Havre to Cherbourg, and from

*Voyage d'exploration, Industrie du lac Fusaro.

Cherbourg to Granville, will become covered with oysters, and the extinct beds of the districts of Rochelle, Oléron, Roçhefort, and Marennes will be brought back to their former prosperous condition."*

Such enthusiasm in a man of science, who based his propositions upon indisputable observations and upon the very judicious application of the principles of embryology, would naturally be communicated to others and create numerous adherents.

The first attempt at oyster culture on a large scale was made at Saint-Brieuc. Over the spawning oysters deposited upon the bottom, fascines were arranged and held in place by means of weights. The spat attached itself abundantly, and at the end of a few months, the first lot of branches, covered with young, were carried triumphantly to the palace of the Tuileries. "I consider it my duty," said Coste, "to propose to your Majesty that you order the immediate restocking of our entire coasts, including that of the Mediterranean as well as those of Algiers and Corsica, and not excepting the salt lakes of Southern France. * * * In this age, in which, by the efficacious application of the laws of physics, an invisible force carries thought along the conducting wires, with which the genius of man has encircled the globe, physiology shall exert its power upon organic matter, by an application of the laws of life."†

Coste did not doubt the result; failure seemed to him impossible; he foresaw the complete transformation of the sea-coast, and exclaimed, in his letter of March 20, 1861, to the Emperor: "I thank your Majesty for having placed me in the front ranks of the greatest enterprise of the age, in connection with animate nature." Attempts were multiplied, but progress and success seemed more and more retarded and lessened in the course of time. The bay of Saint-Brieuc was swept by a tempest. At Arcachon discouragement seized upon those who, in the beginning, were most enthusiastic; for little or no spawn was collected. Coste heard the name of charlatan sounded in his ears; his work was ridiculed even by those whom, in the expectation of success, he had loaded with favors, and our modern Athenians were lavish in criticisms, in which neither sarcasm nor bitterness was spared. Enfeebled by his labors and deprived of sight, Coste struggled on. He hoped against all hope, and maintained that the application of his principles would even change the social conditions of the sea-coast communities.‡ His views were met only by incredulity. He died at his post, despondent, greatly discouraged, and to the last hour misunderstood by that multitude, who treat with contempt all great ideas which do not meet with immediate success. While others were occupied in criticising, a few men labored faithfully, and in a few years, between 1868 and 1875, the production and cultivation of oysters made remarkable progress on the shores of Morbihan.

*Rapport à l'empereur du 5 février, 1858.

†Rapport à l'empereur du 12 janvier, 1859.

‡See the preface to the work of M. de la Blanchère, Culture des plages maritimes.

In 1875, a local fair was held at Vannes, in one of the departments of France. Those who visited the section of practical oyster culture were convinced that the enterprise was not only practicable, but had even grown to the rank of an industry. Fifty-four oyster-culturists responded to the invitation of the prefect of the department, and displayed specimens of their productions, in a tank prepared for the purpose. In addition, they thought it appropriate to exhibit their materials and tools, and the methods of using them. A first glance sufficed to show that this branch of industry had its principles, its methods, and its utensils, elaborated and adapted by study and experience.

Two grand prizes, in addition to the ordinary awards, were specially offered for oyster culture. The first was to the culturist who, by his perseverance and success, had contributed most to the development of this special branch. The second was to the author of the best memoir on the general subject. The second prize was not given, but the first was doubled and divided between M. Chaumel and M. le Baron de Wolbock. Through the efforts of the prefect of the department, a special commission was organized, under the honorary presidency of the prefect of marine. The labors of this commission, consisting of the study of the memoirs presented by the competitors, the examination of the parks, and the discussion of the processes in use at Morbihan, excited a lively interest. Furthermore, it was decided that, in a general report, the commission should set forth the condition of oyster culture at Morbihan, in 1875, its progress, its prospects, and its demands. This was the consummation of its labors.

Appointed to edit this report, we have attempted to perform this delicate and arduous task to the best of our ability. If this memoir contains any valuable ideas, their merits should be attributed to the oyster-culturists of Morbihan. We assume the responsibility of the imperfections that may be found, and invoke the indulgence which we hope will not be refused to good intentions.

A. E. HAUSSER.

LORIENT, *July* 25, 1875.

CHAPTER I.

BREEDING PARKS IN GENERAL.

Time of spawning; extent of the parks.—The determination of the exact time when the oyster becomes milky and its ovaries become charged with millions of eggs, is of such importance that we must devote some lines to the subject.

When the parent oyster, by a series of contractions, throws out about it that whitish cloud, so rich in life, it leaves to the forces of nature and to the instincts of its progeny the entire care of providing for the fixation and development of the embryo. The works of M. Coste and his followers, among others M. Fraîche and M. de la Blanchère, illustrate the structure of the young oyster, with its embryo shell and prominence armed with cillia, which, remaining in a state of perpetual vibration, constitute a temporary swimming apparatus. The young oyster, by this latter means, sustains itself in the water, until it finds a suitable object for its attachment. Then, the temporary swimming organ disappears, and soon afterward a little shell may be distinguished, about the size of a lentil, firmly attached to the side of the collector.

It has been noticed that mud is not suited to the newly-hatched oysters, which require a hard and clean surface for their attachment. But it was not known when to place such objects in the water, when to offer the embryos a suitable surface upon which they could live, for a short time at least.

Many culturists, observing that the oysters became milky in April and May, thought to prepare their collecting apparatus at that time. They were entirely deceived, and, in an industrial point of view, unsuccessful. It was this failure, experienced by Coste himself, which discouraged the first attempts.

M. Chaumel, in an interesting memoir, has given to the commission the series of experiences by which he succeeded in meeting the difficulty. "The situation in 1862–'63," said he, "was very trying. M. Coste, in discouraging letters, did not disguise from me the fact that he was on the eve of seeing his functions as inspector-general suppressed, and urged me on to a success which I already began to foresee, and for which I tried to make him hope.

"I was, in fact, convinced that the principle was good, but that he did not yet know how to apply it, and it was towards this end that all my efforts were now directed.

"I, as well as the greater number of oyster-culturists, had already noticed that the young oyster never attached itself to any but the cleaner portions of the collectors, and also that apparatus which had been even fifteen days in the water was already salt.

"It, therefore, became absolutely necessary for me to ascertain the exact time of spawning, which would, consequently, be the proper time for placing the collectors. Upon this success depended. I made many attempts to arrive at this desirable result; but what turned out the most successful were the most simple.

"At Pénerf and Auray, I arranged new collectors at every high tide after the month of April, and at the same time I opened a few oysters, to ascertain the condition of the ovaries. I noticed that the spawn, at first white in the ovary, deepened in color as it passed through the gills, becoming yellow and violet in turn, as the time of incubation approached, and finally assumed a bluish slate-color. When this hue appeared, I discovered several young oysters upon the last collectors put in place.

"The conclusion was easily deduced; the blue tint announced that the spawning time was at hand, and that we should hasten to arrange the apparatus. I announced to M. Coste the happy result I had obtained, and predicted a complete triumph."

This result, which to-day may seem of slight importance, had considerable weight at the time of its publication, ten years ago. When it became known that about the 1st of July, the time when the milky hue changes to the bluish color, was the commencement of the spawning season, then it was evident that one might with certainty, and without danger of interference from sediment, make ready the collectors to receive the young oysters.

From the time when this matter was determined, the problem of the arrangement of the collectors was solved.

In this way, moreover, judicious observations conduced to progress, and divers experiments were made. Attempts were made to collect the young oysters by keeping the spawning oysters shut up in basins furnished with sluices, and also by simply placing the collectors in the water. This last method produced magnificent results.

It was now well understood that the spawning season dated from about the 1st of July, and it was also known that the best results had been obtained in the deeper water; but it had not yet been ascertained that there was a classification to be made, and a judicious method to be followed.

To Dr. Gressy, of Carnac, is due the following observations: "The collectors should be placed in the shallower areas from June 15 to July 10, and in the deeper areas from July 10 to August 1.

"If, during the first-named period, the collectors are set in the deeper areas, polyps will grow over them, and they will receive only an insufficient number of embryo oysters. Polyps are never observed on the collectors in the shallow areas, because the young are unable to resist the heat, when exposed at low tide, but they are most abundant upon those which are seldom uncovered, or only at the spring-tides. Nothing can be more easily proved in the breeding parks. The deeper down we go, the more numerous and more luxuriant will we find the polyp growths, suspended over the collectors.

"By the 10th of July, the polyps have about finished spawning, while the oyster spawn is still very abundant; hence, after this time, the young oysters may attach themselves to the collectors, without fear of being smothered by the growing polyps. This physiological law, which I have observed in my parks, has not hitherto been made known."

It will, therefore, be seen that, before placing the apparatus intended for the attachment of the embryo oyster, it is necessary, not only to await the month of July, so as to escape the deposit of sediment, but also to follow a methodical order, and work in the shallower areas from the middle of June to the middle of July, and in the deeper ones from the middle of July to the first part of August.

Ill-success of breeding in parks; the currents.—The idea, at first, was not to collect the embryos at the mouths of rivers or along the shores. Aware of the extraordinary fecundity of the oyster, and knowing its period of spawning, it was supposed that all that was necessary was to transfer the adult oysters to basins, arrange collectors near them, and leave the rest to nature.

This method, which led many culturists to employ clusters (*ruches*) of tiles, where the spawning oysters were fastened upon shells or other collectors, was recommended by Coste. If one adult oyster produces 2,000,000 embryos, thousands of such oysters would yield the thousands of millions, required to satisfy the public demands, and that too within a very restricted area. Such was the reasoning employed, which appeared as striking as it was logical.

The method of proceeding is described in all of Coste's letters, regarding the industry at Marennes. "Each establishment," he says, "thus transformed into an actual factory, where man controls the influencing conditions and varies them at will, performs the double function of an artificial oyster bank, supplying spawn, and of a perfect collector for the attachment of the spat; in this manner, those oysters which have become adult and marketable will be replaced each year by their own progeny, carefully brought together and bred in the place of their birth; thus, by this indefinite rotation, a constant renewal is produced."

The attempts made to carry out this process at Morbihan resulted in completely upsetting this plausible theory.

Breeding in basins was found to be unprofitable. Such was the conclusion then arrived at, and this conclusion is to-day considered indisputable. What is the cause of it? The question is one which it would be quite useful for us to solve; for, in order to progress in so delicate a matter as the breeding of oysters, it is necessary to study all the phenomena, and even those which, at first sight, appear to be of secondary importance. We have said above that the young oyster, with its embryo shell, when first set free by the parent, is furnished with a temporary swimming apparatus, which enables it to move about and remain suspended in the water. In a closed basin, the young oysters, when they issue forth, fall to the bottom, and whether there be any mud or slime there or not, or anything beyond the proper bodies arranged to receive them, but a very small proportion attach themselves. Certain culturists, among them M. Charles, who own important breeding establishments near Lorient, attribute the ill-success to the saltness of the water in the basins, and its temperature. Besides, according to the latter, the oysters when they are placed in the basins are not in a healthy condition; being transported, handled, and moved about, during the period of fecundation, conception takes place under unfortunate circumstances, and the issue is but an abortion, producing still-born offspring. According to others, and Coste foresaw this difficulty, it is impossible to have a basin without some mud and ooze, in which the young oysters perish. While granting to these several causes effects more or less important and decisive, we must seek others, and arrive at one of the most important subjects in oyster culture, the action of currents. We are convinced, and our opinion is founded upon the statements of the principal oyster-culturists of the department of Morbihan, such as MM. Chaumel, Gressy, and De Wolbock, that a current is indispensable to the life and welfare of the embryo.

On the sea-coast, the tides vary in their movements according to the location. Near the shore, in the coves and mouths of rivers, the undulations, due to the tides, produce currents, which are called tidal currents. The rivers also have their currents, which on the flood tide carry the sea-waters towards the interior, and on the ebb come back laden with sediment.

There is something peculiar about these currents, which is that they are unequally distributed, and often, when there is an inward or flood current at the surface, the water is flowing outward below, and *vice versa*. It is now known that the parent oyster does not give out its spawn, excepting at the beginning of the flood tide. "How admirable!" exclaims M. Chaumel. "Never does the parent oyster, doubtless from the fear of having its young left upon dry land to perish, give them forth at the last of the ebb; all of the emissions which I have witnessed have taken place at the first of the flood, when the oysters begin to be well covered by the rising water, but never, never when the sea was about to leave them dry."

We can readily admit the instinct of the mother oyster, especially as we shall have later to speak of the instinct of the embryo; but we must also take into account the fact that the water is less pure and vivifying on the ebb than on the flood tide, and thus, in the former case, the conditions are much less favorable for the oysters. After remaining some length of time under the influence of the ebbing waters, they feel the contact of the incoming tide, under the revivifying action of which they throw out their spawn, for some distance around.

Whether we take into consideration solely the action of the tides in connection with the spawning of oysters, or study their effects upon development in general, the result is always the same, as determined by careful observations, that the tides are necessary for the oyster and indispensable to its normal existence. If the oyster becomes fat and of a greenish color, it is an indication that it has been living under abnormal conditions, and it is well known that all animals confined in parks or basins, where they fatten, are not favorably situated for reproducing. Thus, in locations where the current is wanting, the oyster, even though performing its natural functions, reproduces very imperfectly. But, however important the tidal current may be for the mother oyster, it is still more necessary to the embryo, which has not the power of transporting itself to any distance, by means of its temporary swimming organs. The area which it can traverse of its own free will, so to speak, is very limited. In a single drop of water its vibratile cilia cause it to move freely about in all directions, but it has not the power to stem a current, nor to swim far in a perfectly quiet sea. It is the current alone that transports it, preserves it, and places within its reach everything essential to its growth and existence, and it is the current alone that enables it to become readily attached to the collectors. "I feel certain," says M. Chaumel "that the organs of locomotion serve, at the same time, as organs of respiration, sight, and hearing, by means of which the embryo is able to find a suitable place for its attachment."

It is evident, therefore, that, if the idea of breeding oysters in a closed area must be abandoned, it is because the parent oyster, from the lack of a current, gives issue to imperfect offspring. The embryo, also without the means of moving about, is exhausted from the time of its birth, and generally falls to the bottom, where it perishes within sight of the collectors. These conclusions only apply to inclosures of medium size, having a superficial area ranging from 1 to 2 hectares (2½ to 5 acres). In more extensive basins, of 15 to 20 hectares (37 to 50 acres) each, special phenomena come into play, producing changes both at the bottom and at the surface, in the former case by the renewal of the water, and in the latter by the action of the wind, permitting to a certain extent more favorable results.

Taking everything into consideration, however, it is now admitted, at Morbihan, to be preferable to entirely renounce both the small and large inclosures, and depend upon the natural movements of the water, in the channels, coves, and rivers. This plan is the most economical one and the results are more certain.

We cannot do better than quote, in this connection, the remarks of M. Chaumel, who is one of the best authorities on the subject. "I regret," he says, in speaking of the works established in the river Trinité, "to see such extensive reservoirs, built at so great an expense, in which it is expected breeding can be successfully carried on. I know full well that it has been found possible in some places to collect embryo oysters in artificial basins, and an example is cited where shells, thrown upon the bottom, have become covered over with young oysters. I am, therefore, convinced that I was mistaken in what I had all along held to be the case, that the shells were really covered with the young, without its being noticed, before they were placed in the basins. The temperature of the water in these narrow basins, under the action of the sun's rays, attains that of a warm bath, and must, at least, present a serious obstacle to the operation of breeding. Reservoirs for the breeding of the young and walled parks are fundimentally wrong in principle. It is necessary to avoid placing any obstructions in the way of the currents, which are very essential to success."

The muddy deposits of the shores of the Department of Morbihan.—The currents, so important and so necessary to the life of the oysters, carry along with them, what is considered by many culturists a very destructive element, one of the most deadly enemies of the oyster; this element is mud. "Mud is a deadly poison to the oyster, whether large or small. * * * What then is essential to the prosperity of the oyster? Very little, indeed; a solid object, and water, devoid of mud."* We might multiply these citations from Coste, Fraîche, and others; upon this point all seem to be in accord. It may, therefore, appear paradoxical when we state that, upon the coast of Morbihan, the oyster thrives only where there is mud; the fact is incontestible; reproduction succeeds only in the muddy estuaries, and good parks exist only in the sheltered places, almost covered over by slime. This assertion would appear improbable did it not admit of an explanation.

With these preliminary remarks, we will proceed to a consideration of the conditions required of a shore in Morbihan, in order that it may answer for the general cultivation of the oyster.

The sea bottom consists, for the most part, of mud, as is evidenced by the many soundings that have been made, and by the results of various explorations. It is also known that, in many of our rivers, as at Auray and in the Scorff and the Blavet, there are sloping shores, which, when the tide goes out, appear above the water as immense areas of a black or brown color, and into which one can easily sink up to his neck. Whence comes this fine flocculent mud, which has seemed, at times, to threaten the port of Saint-Nazaire, and whose action has been so difficult to resist. Does it come from the rivers, or is it produced by the constant disintegration of the rocks and shores? Why does it invade the mouths of all our rivers and all our bays and creeks? Some good may arise from our pointing out general causes, at least, if not by the determination of all the questions, and this is all our subject demands.

The constant wearing of the rocks, as in ages past, by the action of the sea upon the headlands, gives rise to three principal kinds of material: gravel, sand, and mud. These materials are carried along by the action of the waves. Gravel is moved only in times of heavy storms, when, lifted by the force of the waves, it is moved gradually along, until it finds a region of comparative shelter, where it remains buried. Sand is more frequently moved than gravel, but the strength of the waves is required to raise it and carry it along, and it needs a greater calm than the gravel, in order to fall to the bottom again. Mud, on the contrary, being fine and light, acts more as though it were in solution in the water, and remains suspended in it for a long time; carried along by the currents, which have no power over sand and gravel, it penetrates into coves, estuaries, and rivers, where it is deposited in the eddies, constantly raising the level of the shores. With regard to the movement of the sea alluvium, we are able to make the following deductions: Whenever we desire to determine whether a bay or estuary is a region of actual calm, we have only to examine the character of the bottom. If the bottom is muddy, the region is a quiet one; if sandy, it must be

* De la Blanchère, Culture des plage maritimes.

subject to more or less disturbance; and if gravelly, it is certain to be the scene of much commotion in stormy weather.

The first condition to be sought for, as favorable to oyster culture upon a coast, is one of rest. However rich the bottom of a region may be in the elements essential to the oyster, it cannot serve for the breeding of oysters if it is not a quiet one. Consequently, to mark out on a chart of Morbihan the regions covered with mud, would be to indicate the bottoms where oysters can be cultivated, and, without visiting the region, one is able to affirm, by reference to the chart contained in this volume, that oyster culture is only possible in the Scorff, the Blavet the bay of Gâvres, the river Saint-Philibert, the river Auray in the gulf of Morbihan, the estuary of Pénerf, and the entrance to the Vilaine. It is precisely at these places that the oyster-culturists have located. Oyster culture cannot be carried on at the entrance to the river Étel, about the peninsula of Quiberon, and in the many bays possessed by the islands Groix, Belle-Ile, Houat, and Hœdick.

It may be objected, with reference to our own statements above, that if the mud collects in sheltered situations it will cause an elevation of the bottom, against which the culturist of Morbihan will have to contend. An equilibrium is, however, finally established, and this fact is of so much importance to culturists as to warrant mention here. It appears as though, during the geological changes which resulted in our present coast line, the mouths of our rivers were given a size, quite out of proportion to the importance of the rivers. The Scorff and the Blavet, both humble rivers, unite majestically in the roadstead of Lorient, whose great depth caused it to be chosen as the great central station of the India Company, and more recently as a naval station. Ten kilometers from their mouths, these rivers lose their importance, from their small size, and farther up, the Scorff especially, dashes through narrow granitic valleys and becomes the haunt of trout. These two streams play no part in the role of rivers, so to speak, while at their mouths all the conditions are strictly marine. The valleys through which they flow, in the interior, give rise to no alluvium for them to carry down, and the only phenomena observable are those produced by the sea.

As we have stated before, the water enters the broad mouths of rivers, charged with mud, and, if it encounters perfect stillness there, the mud sinks and the bottom is gradually built up; but this elevation of the bottom has a limit. An equilibrium has already been established between the tendency to build up the bottom and the wearing action of the tidal currents, and at present both the landward and the seaward currents go, charged with mud, without producing any change in the level of the bottom. Two equal and opposing currents are thus represented as annulling each others actions.

We insist upon this point, because of its important bearing upon oyster culture, and the breeding of oysters in particular. A state of equilibrium having been established with regard to the beds of our rivers, it follows that, whenever this equilibrium is disturbed, one or other of the forces we have described must come into play. If the rivers are dug out, the depth being increased, mud will be rapidly deposited until an equilibrium is again established between the actions of the two contending forces, one bringing in the alluvium, the other sweeping it out to sea. Then the deposition of mud will cease. If, on the other hand, liquid mud should be poured into the channel, causing a temporary elevation of the bottom, the currents would naturally clear it out again, and in a short time the mud accidentally deposited there would be carried away, and the bottom cleaned. Finally, if fixed obstacles are placed in the river, eddies will be produced, and, consequently, a deposition of mud, of which it is easier to affirm the existence than determine the intensity and scope. From the very beginning of oyster culture in Morbihan, we have, therefore, encountered these two elements, the currents and the deposit of mud, the actions of which are controlled by natural laws, and to which the culturists have been obliged to submit. It is not without some hesitation and many experiments that these results have been attained.

The difficulties met with and the failures and losses at the beginning, sometimes considerable, which have been sustained, all go to prove that one cannot, with impunity, oppose the action of natural phenomena.

Whenever nature's laws are violated, she knows how to avenge herself, and it is, therefore, much better to submit to them and avert the danger.

Dr. Henri Leroux, an excellent and intelligent observer, remarks as follows: "We reckon ourselves among the active partisans of science, but ask of it only the application of practical discoveries. We should consult science in order to ascertain the greatest advantages to be derived from our field of labor, but it is very dangerous to struggle against nature."

Science and work, study and observation are required of all the culturists of the department of Morbihan. Now, that the importance of the currents and of the deposits of mud are understood, we can appreciate the entire worth of our culturists, who have labored under great disadvantages from more than one point of view; but success has finally been attained, thanks to the persistent energy so characteristic of the Britons.

...... Labor omnia vincit
Improbus.

The general character of a shore, with reference to breeding parks.—For the purposes of breeding, therefore, the culturists of Morbihan do not hesitate to establish themselves upon the muddy shores of the rivers Trinité or Auray. They know that, by the processes we are going to describe, they can collect a goodly number of young oysters. They seek to group themselves, as nearly as possible, in the neighborhood of natural oyster banks, over which the marine authorities watch with a solicitude, worthy of all praise.

The site being chosen, they endeavor to locate between ordinary low-tide level and the level of low water during the spring-tides. Collectors placed in these situations are only exposed during spring-tides, and remain almost entirely covered at ordinary low water. There is a great advantage in keeping as near as possible to the channels, and to the natural oyster banks, for there are to be found fewer eddies, more currents, and a greater number of embryo oysters.

M. Henri Leroux, to whom we have already had occasion to refer, sums up in the following just and brief manner, concerning the conditions which a shore should possess, in order to fit it for breeding purposes:

"Up to 1867, it was supposed that breeding could be carried on most successfully in those portions of the river where the water was most tranquil, but quite the reverse is true. Nowhere do the collectors become more fully covered with the young, than in the currents produced by the ebb and flood tides, and above all at the level of low water. Parks situated in a region of eddies are poorly located. In 1867, it was still conceded that the embryo oysters, leading as they do a wandering life for several days, must scatter themselves more or less equally throughout all parts of the rivers, where natural oyster beds exist. At present we are given to understand that, at a distance of 500 meters from an oyster bank, in the direction of the mouth of the river, no embryos are to be encountered; whereas very many oysters will attach themselves to the collectors arranged in the bottom of the river, above the oyster bed, these being carried up by the flood tide.

"The parturition of the oyster seems to take place rather at low water than at high water. It is essential, therefore, that the breeding parks be established in as close proximity to the oyster beds as possible, and also in the course of the tidal currents; at any rate, they will have no chance of success, if exposed to the violent action of the sea."

These ideas present to us an example of the foresight of private industry, which is more powerful in its results than the wisest rules. One cannot always locate close by a natural bed, and again natural beds may die out, as experience has unfortunately taught us. Hence the culturists are always careful, when not breeding, to retain about their breeding parks a strong reserve of adult oysters. M. Alphonse Martin, who has such a well-managed establishment at Kergurioné, keeps 30,000 oysters in reserve, and the Baron de Wolbock has 50,000 at Kériollet. Thus, when they fear a scarcity of young, from the exhaustion of the beds, this reserve series becomes of the utmost importance. MM. Leroux and Leroy have a supply of 800,000 oysters, whence their supply of young is derived. So perfect a system cannot fail to produce good results.

Natural oyster beds, bordering the parks where oysters are kept in reserve, increase the richness of the results. The quantity of young produced will be augmented, and, in consequence of this prolific interchange, the richness of the oyster beds will be insured for the future.

CHAPTER II.

COLLECTORS—LIMING—FORMATION OF BREEDING PARKS.

Collectors.—After the selection of a site comes the choice of collectors—that is to say, of the apparatus for the attachment of the embryo oysters.

The word *park* conveys to the minds of many persons the idea of an inclosure; but breeding parks are never inclosed. It is, therefore, important to define the terms in use in oyster culture, in order to prevent confusion.

A *park* is any bank or shore, where spat collectors are used in connection with the spawning oysters; a *claire* is an inclosure surrounded by low walls and covered by the water at high tide, and serves as a depot for collectors, and for raising; and, finally, a *basin* is an inclosed area, protected from the influence of the tides, in which, by means of hydraulic apparatus, water-gates, or sluices, the height of the water may be regulated at will. Coste's attention was first directed to the subject of collectors, which, from the beginning, have been made the object of much study.

Most authors who have written upon oyster culture have contented themselves with reproducing Coste's note, which occurs in the supplement to his Voyage of Exploration. We will call attention, simply as a matter of interest, to what have, until to-day, been considered as the best collectors. Wood and tiles are the most important materials for the construction of collectors. Wood is used either as fascines, submerged and held in place by means of weights, or else as platforms; tiles are utilized in the greatest variety of ways. Coste recommended—

1. The simple roof collector.
2. The double-roof collector.
3. The roof collector with oblique rows.
4. The roof collector with opposed rows.

As a more complicated apparatus, he advised the "hive" collector, a large wooden box, open at the bottom and containing movable frames. On the latter, the spawning oysters and cockle-shells are disposed in layers—the one supplies the spawn and the other the means for its attachment. Finally, he suggested the use of stone, although, at the same time, he acknowledged the difficulty of removing the young oysters from it.

Study and experience in breeding have failed to discover any other substance suitable for collectors, but the method of using collectors has been greatly perfected.

Stone, which sinks so easily in the mud, cannot produce good results. M. Liazard, one of the culturists of Morbihan, who, since 1861, has not hesitated to continue his labors in the difficult branch of oyster culture, has given numerous details of the failures in the use of stone. It would be needless to enter here into a long argument upon this subject; this kind of collector does not seem likely to come into general use. At Pénerf, however, limestone has been employed with some good results.

With wood there is not the same difficulty, and it is even now used, either in small rectangular pieces about the size of a tile, and half an inch thick, or made into platforms, such as are in use especially in the river Auray.

Fascines have been experimented with, especially by M. Chaumel, and, as they may answer for some sections, it may be useful to give some idea of their construction. The following account is by M. Chaumel:

"For the construction of good fascines, it is necessary to procure branches of some hard wood, with the bark as soft and smooth as possible; cherry, for example, answers perfectly. It is a great error to suppose that the embryo oyster attaches itself more readily to rough surfaces than to smooth ones, for precisely the contrary is true.

"After the wood has been prepared, the branches are arranged alternately, with the large end of one branch next to the smaller end of the adjoining one, so as to prevent their lying too close together and leave interspaces between them; then at each extremity, under the cord which binds them together, a large wedge is introduced, the object of which is to prevent compression when the bindings are tightened. In this manner, the fascines have plenty of light and water about them, and the embryos have ready access and may attach themselves to any part of the branches. It now simply remains to attach the fascines to a small chain, at intervals of about two yards, by means of pieces of wire, like those used in binding the extremities, care being taken, however, to fasten the wire around not more than one or two branches, in order not to draw them together.

"Fascines are the best collectors I know of for use at the bottom, and the oysters may be detached from them, to some extent, even with the fingers, especially after the lapse of a year. By this method not a single oyster is lost; they may perhaps be a little defective in form, but to so slight an extent as not to affect their sale. It is a singular fact that fascines which become uncovered give but poor results."

We do not believe that, along the shores of Morbihan, fascines are destined to play an important part as collectors. Planks will also become less and less used; made into platforms they have been employed in the river Auray, and M. Liazard gives the following description of those in use by him:

"My platforms are constructed of four, five, or six thin boards, according to their widths; they are joined together by three bars, about three inches high. Those which I shall construct this year will consist of only four thin boards, as I wish to leave a space of about an inch and a half between each two boards, so that the mud, deposited upon them, will run off at each side and not collect upon the top."

Tiles, however, are the apparatus *par excellence* for collectors, and they are now generally employed. Dr. Henri Leroux sums up as follows, regarding the efforts made to employ tiles successfully and in the most effective way:

"The tile," said he, "has the right of priority, but this is not its sole merit. Its cost is moderate, it is easily handled, and its weight tends to keep it in position in the water.

"The sea, however, is subject to so many unexpected movements, and the oyster bottoms are so covered with shifting mud, that the culturists had to struggle against great difficulties for many years.

"The tiles were first arranged in piles, in a manner pleasing to the eye, and it was hoped that the heavy stones, placed as a weight upon each pile, would give the requisite stability to these structures; but at the first high tide, a portion of them were overthrown and the work had to be done again.

"Upon a solid bottom, two tiles are placed upright, and upon the tops of these a third is laid crosswise, to separate those which are to follow. A considerable number of rows may be arranged and held in place by means of flat stones, laid in front of, above, and behind them. In this manner the tiles are sufficiently well secured, and may readily become covered with young oysters. A hard bottom is not often found, however, and generally occurs near the shore, where, at low tide during the summer, the sun destroys a large share of the young, the remainder finally succumbing to the cold dry winds of September and October. If, on the other hand, the tiles are placed upon level bottom, the obstacle they present to the action of the sea soon leads to a deposit of mud or sand, which may cover them, either entirely or in part.

FIG. 1.— Bouquet collector.

"In 1868, in order to preserve the tiles from contact with the bottom, we had a number of boxes made, capable of holding about four hundred tiles each. The desired object was attained, but the young oysters did not develop except upon those tiles which received air and light. These groups of tiles served as haunts for star-fishes, crabs, and other marine animals, which found there an abundance of provender. In fact, the construction and maintenance of the boxes led to an expense, out of proportion to the results of the harvest.

"The best method of arranging the tiles is unquestionably by means of stakes. The tiles, pierced with a hole at each extremity, are united in little piles of twelve or fourteen, by means of wires, firmly fastened to the head of the stake, which is from three to five feet long, and implanted in the bottom in such a way that the lower tile is about six inches above it. Each of these clusters of tiles bears the name of 'bouquet' or 'mushroom.'"

Tiles arranged in "bouquets."—In the principal breeding parks of the river Trinité, they have settled upon the use of tiles arranged in "bouquets," as represented in our design. At Morbihan this is also considered a very rational system. It has this great advantage, that the apparatus can be entirely prepared on land and so arranged that the setting up will consume but a very short space of time.

This is an excellent idea, as will be understood from what has already been said, and the details we have given concerning the deposition of sediment will indicate its bearings.

Whenever, in a river, subject to depositions of sediment, the nature of the bottom is modified, if only by a wooden stake, a deposit of mud is induced, which elevates the level of the bottom. One will gain some idea of the rapidity with which the deposit of sediment is formed, on learning that, in the military port of Lorient, after the alterations which modified the bottom, the deposition reached a depth of from twenty to

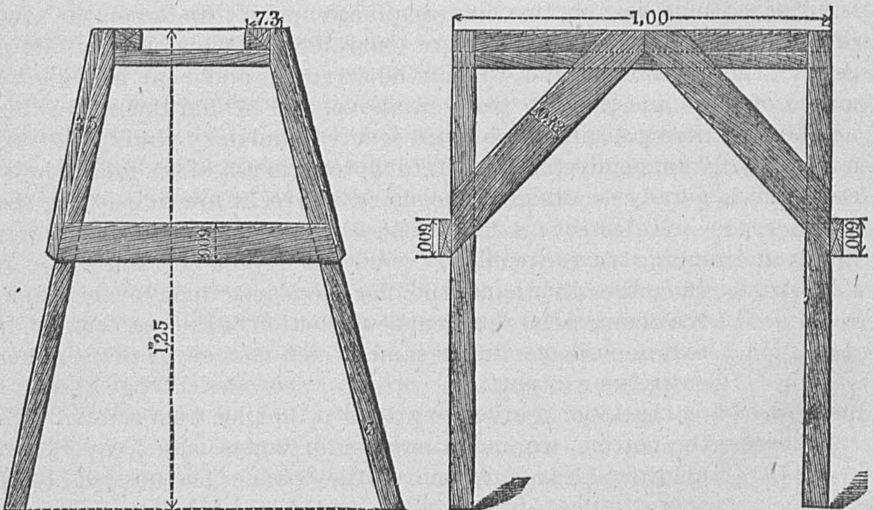


FIG. 2. FIG. 3.

Frames for supporting "Bouquet" collectors on a hard bottom.

twenty-eight inches a year, the average being twelve inches. In the commercial port the case is identical, and several spells of bad weather, accompanied by a southwest wind, are sufficient to produce the muddy deposit. Culturists should not forget that the water is not charged with sediment, excepting when it is agitated. At such times, the waves washing upon the muddy shores become charged with mud, which is deposited at those points where the equilibrium of the bed has been modified, in one way or another.

The cluster of tiles fastened to a stake, if arranged above the muddy bed of a river in July, has been placed at the proper season, and from then until the month of September causes but a slight deposit of mud. Whatever may be the extent of the deposit produced, at the moment when the stake is withdrawn, in order to secure the oysters attached to the tiles, the current resumes its normal action, sweeps away the accumulated mud, and restores the bed to its original condition.

We repeat, that, after having carefully examined the action of the current upon these bouquet collectors, we must assert that the greatest progress made in oyster culture, in Morbihan, consists in the discovery and reducing to pratice of this system. The honor of this progress belongs to M. Eugène Leroux, one of the most indefatigable and persevering culturists of Morbihan. It is very interesting to note by what a succession of attempts Mr. Leroux arrived at the important result we mention.

"On May 31," said he, "I began to arrange the tiles in my parks. I constructed a wooden framework, and upon wires attached to the top of it I placed two tiles, followed by two others placed crosswise upon the first, this operation being continued until a dozen tiles were thus disposed of. When this arrangement had been completed, I saw that my tiles would not remain in place, since the currents tended to continually displace them. I, therefore, thought to retain them, by passing a wire around my little scaffolding, which made everything very secure.

"I did not finish the placing of my five thousand tiles in the parks until towards the end of June. It was a lengthy undertaking, as we could work only at low tide, and I will add that it was both laborious and expensive.

"I had read in the works of M. Coste that after every high tide it was necessary to remove from the tiles the sediment which formed there, from one tide to another, so I scrupulously set to work to wash mine, one by one; we were obliged to stand in the water up to our knees, and when the tide left us to continue our work with buckets of water, and then to carefully replace all the tiles.

"This troublesome operation continued until September; I considered it the work of a Roman, and saw the impossibility of undertaking it on a large scale.

"As soon as I discovered that my tiles had embryo oysters upon them, I discontinued the washing; I contented myself with rearranging the the collectors that became displaced, and thus passed the winter.

"I determined to develop my undertaking on a larger scale. I ordered from Nantes 30,000 tiles, which were received in the month of May, 1867, and then I set myself to work distributing them in the parks. This necessitated a new arrangement. Planks were first placed flat upon the mud, and on these I arranged the tiles, four in width and ten in length, making forty tiles placed side by side in one layer. Upon this layer five other layers were arranged, making six in all, the last layer being covered with boards, holding stones heavy enough to act as weights, to keep the entire structure in place, and prevent the movement of the water from causing the tiles to fall into the mud.

"The results in 1867 were fair, but did not equal those of the first year.

"I observed that tiles placed upon the bottom did not remain as clean as when placed above it. Here, therefore, was another point to be considered.

"In the month of November, 1867, I bored a hole at each end of my tiles. But, before doing this, I measured off the points where the holes should be, in order that they might correspond exactly in all the tiles, and permit of the tiles being joined in pairs opposite to one another. The wires, with which the tiles were strung together, measured each about 46 inches. Two tiles were first strung together, by means of a wire passing underneath and through the two extremities. Two more were then arranged in the same manner, but opposed to the first, and the series continued up to twelve. This work being finished, I passed a stake, about fifty-three inches long, through the middle of the bundle of tiles, and wound the four ends of the wires firmly around the top of it, which projected about five or six inches above the uppermost of the tiles. In this manner they were firmly fastened to it.

"I proved that my new invention was entirely successful and would resist the action of the sea. These collectors also had this additional advantage, that they could be placed in the water without the necessity of wading through the mud; from the boat in which they were carried we could set them up in the parks. This system has been so highly appreciated that all the culturists have adopted my invention, and it is the only one in use to-day."

Being as practical as it is reasonable and as judicious as economical, this system has given excellent results. The mode of arrangement varies but little in the different parks. M. de Wolbock perfected the system, by slipping very thin pieces of board between the tiles; but this addition, which is an excellent one, does not in any way alter the principle upon which the apparatus is constructed.

Coating the collectors.—If bare collectors had always been used, the greatest difficulty would have been experienced, when it came to the delicate operation of removing the young oysters from them. Coste, himself, when he rejected stone, simply followed the idea that the oyster, when it adheres too strongly to the surface of the collector, is wounded by the operation of removal. When breeding was first attempted at Arcachon, as well as at the Ile de Ré, and along the coast of Morbihan, numerous trials were made, and finally, after many drawbacks, the only rational system was arrived at, by applying unconsciously, perhaps, a principle which, had it been proclaimed in the beginning, would probably have averted many a failure. The science, to which M. Gressy and M. Henri Leroux appealed, plays an important part in oyster culture, and must always be taken into account, whenever it is desired to arrive at practical results.

In giving some details concerning the coating of collectors, a method now in universal use, we desire to have it understood that, in oyster culture, this subject involves a principle, fully as important as those which relate to the action of the current and the deposition of sediment.

About 1858, a mason of the Ile de Ré, named Hyacinthe Bœuf, prepared a park with great care, and inclosed it with walls. After having filled up the bottom with various materials, and among others straw, he was surprised to find that the young oyster, instead of adhering to the bottom, preferred the calcareous stones of the inclosure. So he took his wall to pieces, stone by stone, and thus obtained a more or less abundant harvest.

At this time, no one investigated the reason why the oysters had shown such a preference; the fact was noticed, but nothing further was done.

Many observers remarked that, upon submarine walls of masonry, constructed with hydraulic cement, even in basins and in places distant from oyster banks, there were always found a considerable number of oysters, persistently seeking the joints of the masonry. The thing was considered as accidental, exceptional, and still, at the same time, numerous attempts were being made to facilitate the removal of the oysters from the tiles, by dipping the collectors in a material, soft enough to permit of the oyster being easily removed, and hard enough to offer an adhesive surface to the young.

Dr. Kemmerer, of the Ile de Ré, the veteran oyster culturist, whom Dr. Henri Leroux calls the *savant*, who studies with feet and hands in water, was the first to find a remedy for the too persistent adhesion of the young oyster to the tile. He began by soaking his tiles in the following composition: Hydraulic cement, 1 part; water, 4 parts; defibrinated blood, 1 part.

The results obtained by the use of this composition were excellent, as compared with those resulting from the old misunderstanding.

Defibrinated blood is not much used, and for those establishments scattered along the coast, far from great centers, it is very difficult to obtain. Efforts were made to dispense with it, and Dr. Kemmerer himself succeeded in making a mixture with lime as a basis.

In the report which he sent to the fair at Vannes, he expresses himself thus:

"The oyster attaches itself to all natural bodies, but nature cannot equal industry. Nature created the oyster beds, and as soon as the demand for oysters became more pressing, from the increased facility for transportation, afforded by our modern means of communication, the beds disappeared.

"The oyster culture of Coste does not, therefore, present the apparatus necessary for the purpose, since it cannot produce the oyster seed.

"I designate as seed the young oysters which, having remained from seven to nine months upon the collectors, are ready for removal and planting in beds, where they may grow and develop. The first principle of the industry had been discovered, but the means of producing this seed were still wanting.

"Then it was that I invented the cement for collectors, the formula of which I have given.

"Between the collector and the oyster there should be interposed a calcareous substance, hard enough to withstand the action of the sea, and soft enough to permit of the easy removal of the oyster at any time. I had proved that cleanliness was the first necessity of a good collector, and soon I added that the collector cement alone had the power of renewing that cleanliness, at the will of the oyster culturist. From that day oyster culture was an established fact."

The success attained by coating the tiles, that is to say, by dipping them in lime or cement, has been complete and very characteristic. Several culturists, wishing to observe what the difference might be, have placed a certain number of tiles, some coated and others not, under the same conditions as regards cleanliness. The former had about three times as many young oysters upon them as the latter. The trial was therefore decisive.

In 1866, when M. de la Blanchère was seeking the principle in the case, he wrote:

"A principle should govern the employment of all collecting apparatus, not only as regards the time for setting the collectors, with reference to the spawn, but also as to the special state of cleanliness of the apparatus itself."

With Dr. Kemmerer, the principle was an easy removal of the oysters from the tiles; with M. de la Blanchère, it was cleanliness.

Without wishing to enter into the domain of the critic, we venture to say, however, that the principle had not yet been found.

While seeking a means of easily detaching the oysters from the tiles, and almost without being aware of it, there was discovered the attractive element, indispensable to a good harvest, the bait, so to speak, of the oyster—that is, lime in an easily assimilated state.

Such is the principle; we will proceed to explain it:

When the young oyster passes from the mantle folds of the parent, out into the sea, what does it instinctively seek? A place to which it can easily attach itself, and where it can readily defend itself against its enemies. It could readily attach itself to any substance, but in order to defend itself, it must be able to develop its shell, which serves as a protective armor. As lime is the predominant element of the shell, the preferable collector must have a basis of lime.

The young oyster seeks calcareous substances by instinct. Nature is certainly very provident. If calcareous material is wanting in the collector, that extremely perfect laboratory, contained within the infinitely small body, constituting the embryo oyster, will withdraw it from the surrounding waters; but there is a question of instinctive preference, which must not be forgotten. This is the reason why Hyacinthe Bœuf found young oysters upon his walls, and not within his pen; this is the reason why we find oysters upon the joints of the masonry of the quays and other structures, in our ports. Wherever a calcareous solution has exuded, and then hardened upon the outside, there it is most readily dissolved and assimilated. Nevertheless, to Dr. Kemmerer is due the honor of having first introduced the process of liming into oyster culture. It will be said of him, perhaps, that he carried a torch by which he himself was not lighted. We may consider that he was looking for India and discovered America. He deserves the gratitude of all oyster culturists.

What is most remarkable concerning liming is the fact that both quick-lime and hydraulic cement are decomposed by sea-water. Hydraulic cement hardens in fresh water; but salt water, although it permits of a first hardening, in the course of time produces complete decomposition.

This change is favorable to the removal of the young oyster, and to the assimilation of lime by the young.

By combining these two substances, hydraulic cement and quick-lime, the oyster culturists of Morbihan, in all cases, attain the desired results, so far as this particular point is concerned.

If some of our culturists still seem to ignore the existence of a principle in the use of lime, as necessary for the attachment of young oysters, there are others who, without strongly insisting upon it, still affirm this truth. We may cite a few instances: "Quick-lime," says M. Alphonse Martin, "always retains a little moisture, thus placing at the disposal of the oyster all the materials which it needs."

"A coating of lime," says M. Gressy, "not only permits of the easy removal of the oyster, but also constitutes a substance eminently favorable for collecting the young. This fact is so well known, that no one to-day would place a collector in the sea, without having first dipped it in lime."

Finally, Dr. Henri Leroux writes as follows: "We will not now insist upon the necessity of coating the tiles, in order to obtain a good supply of oysters, as experience has sufficiently proved this fact. The tiles, covered with lime, will give three times as many oysters as those without it."

This principle being admitted, the liming is done in two very different ways, at Morbihan, according to whether it is intended to entirely free the oysters from the tile, or to allow a portion of the tile to remain attached to each shell.

When we come to speak of the removal of the oysters from the collectors, we will make some remarks concerning the matter of leaving a portion of the tile attached to the young. For the present, we will merely state that, under that system, the tile is cut, leaving a portion adhering to each oyster, forming a sort of heel.

Some of our culturists, such as M. Gressy and M. Henri Leroux, who breed oysters in this manner, cover their tiles with a slight coating of hydraulic cement. The young oyster attaches itself to the cement, but the coating, being very thin, is soon worn away, leaving the oyster quite firmly fixed to the tile.

Others, on the contrary, who, six months after the collectors have been set, prefer to separate the oysters entirely from the tile, with the blade of a knife, generally cover the tile with two layers, and proceed in a different manner. We cannot do better than to give their method of procedure in their own language:

M. Eugène Leroux says: "I procured some quicklime, which was slacked just as it was to be used, and was put, while still in a state of ebullition, into a large vat, where two-thirds the same quantity of sand had been placed. My men stirred the mixture, until it had attained the consistency of clear broth. The collectors had been made ready, and, held by the lower end, were dipped into the vat. One immersion sufficed, after which the women took them in hand-barrows and exposed them to the air to dry, before setting them up. This excellent coating should be prepared with fresh water only; sea-water prevents its adhering for any length of time to the tiles, and if it comes off the labor is, of course, lost."

M. Liazard states: "It was necessary to find a substance which, placed between the outer coating and the tile, would decompose, after remaining long in the water, and thus leave the coating almost free. I tried different pastes, all of which gave good results, but it was necessary to select the most economical. I was satisfied with a mixture made of flour and a small quantity of the scrapings of potatoes, boiled in a sufficient quantity of water to produce a thin paste. The tiles were dipped in this, and after they were dry they were passed through a bath of hydraulic cement. I have always succeeded with this mixture; it is quickly made and costs but little. Every time I have neglected to use it I have regretted it."

M. Alphonse Martin says: "I first plunge each tile into a milk of quicklime, and when this coating is quite dry, I again dip the tile into a bath of hydraulic cement."

M. de Wolbock generally uses two layers of hydraulic cement.

It seems to us rational that, when not intending to leave the oyster attached to the tile, we should resort to two layers, the first of quicklime, which will not adhere very firmly, and the second of hydraulic cement. The first facilitates the removal of the oyster and the second, the adherence of the young.

Pursuing this idea, Dr. Kemmerer, in his report, makes the following proposition:

"In oyster culture, not a single oyster should be lost. I anticipate this result from the removable cement for collectors. Saturate your tile with water, cover the concave portion with wet paper, leaving the edges bare, then spread on the layer of cement, which must cover both the paper and the edges, so that when the edges are scraped off, the entire concave surface can be removed, without damage to the adhering oysters.

"If the paper is not spoiled, it can be used a second time, or it may be replaced by the large leaves of some plant.

"The collector with a removable coating, applied to the industry at Arcachon, will offer the following advantages: it will prevent a loss of 20 per cent. and much labor may be dispensed with. The cement, bearing the young, may be transferred directly to the claires, without passing through the boxes. The oysters will grow and the cement may be easily broken into pieces, even with the hand."

It is useless to insist further upon the practice of liming; we have stated the principle and supported it by several illustrations.

At Morbihan, it is easy, in all cases, to settle whatever difficulties may arise. The question has been studied, and the path to be followed clearly pointed out.

Arrangement of the collectors and of the breeding parks.—We have reviewed the system of collectors and of coating the tiles; it is now in order to say something about the arrangement of the collectors and of breeding parks in general.

One principle also governs this question, and imposes itself upon each culturist. It is the transportation of mud in rivers, which are influenced by the tides. The culturists of Morbihan study the currents and the deposition of mud; they arrange their collectors along the shore in such a manner as to prevent their being covered up with mud, during the period when they remain in place. The principle being understood, the question of application is determined in each case by observation, it being impossible to formulate any general rule.

We will state, however, that the majority of culturists arrange their collectors in rows, at right angles to the shore. This system, which produces a sort of dam opposed to the current, must be modified in a certain measure, so as not to offer too much resistance to the general current. It might, perhaps, be preferable to arrange the collectors in rows parallel to the channel; this is an experiment yet to be tried. We repeat that the culturists of Morbihan pay considerable attention to the action of those natural forces, which produce the currents and the deposition of mud. In proof of this, we have only to refer to the judicious observations of Dr. Gressy.

"The 'bouquet' collectors, whether of tiles or of thin boards, when placed near together, will cause a deposit of mud in the parks, by reason of the obstacles which they oppose to the current.

"To obviate this inconvenience, I was the first to originate the idea of grouping the bouquet collectors in series of three rows each, placed in juxtaposition. Between each series I left a space of from five to six feet, so as to permit the current to flow freely, and by the force of the rising and ebbing sea to sweep out the deposit of mud, which might accumulate among the collectors in calm water. This system is universally followed in our river.

"The number of collectors to be arranged within a given area varies, and no absolute rule can be laid down regarding this point. The force of the current and the degree of impurity of the water should guide each culturist, in determining the number of collectors he may be able to accommodate in his concession. Whenever mud begins to accumulate at the base of the collectors, the culturist finds an experimental proof that there is not sufficient space between them, and that, consequently, he should decrease their number.

"The first I have upheld, and even to-day, against the general opinion, I still maintain that the concessions are overloaded with collectors. My own concessions contain, in proportion to their extent, many less collectors than those of my neighbors.

"I consider it very necessary to prevent the deposition of mud. I cannot forget that, on the Ile de Ré, oyster culture had to be abandoned, because the concessions became filled up, after having succeeded admirably for several years.

"The space to be left between each group of the bouquet collectors varies also, according to the length of time which they are to remain in place.

"It is evident that the culturist, who leaves his collectors in the water eighteen months, should separate them more in order to prevent the deposition of mud than he who removes them in November of the same year in which they are placed, that is to say, after an interval of only four months.

"In this latter case, the mud has not sufficient time to form a deposit, and the current, after the collectors have been removed, sweeps everything away, during the winter season."

The method described by Dr. Gressy is practiced by all his associates in oyster culture, with various modifications.

For instance, in the parks of the Baron de Wolbock we find groups of from twenty to twenty-four "bouquet" collectors, separated by interspaces of about six and a half feet; they are arranged in rows both parallel with, and at right angles to, the channel. MM. Gressy and Eugène Leroux have their collectors arranged in series, running at right angles to the channel, and formed of rows of "bouquets," each row containing three "bouquets." The series are separated from one another by a passage-way, about six and a half feet wide.

We have already had occasion to state that the principal advantage to be gained by the use of the "bouquet" collectors is that everything can be prepared on land, and the collectors set up in the parks almost on a fixed day, by merely sinking the stakes in the mud.

One can judge of the truth of this by the following statement of M. Eugène Leroux:

"In 1871, I had the use of a large barge, which was very flat and drew very little water; it was about thirty-two feet long and nearly ten feet wide. I could load it with a large number of collectors, and it also had other advantages. When this loaded boat reached the parks, where the water was only about three feet deep, my men could set up the collectors in

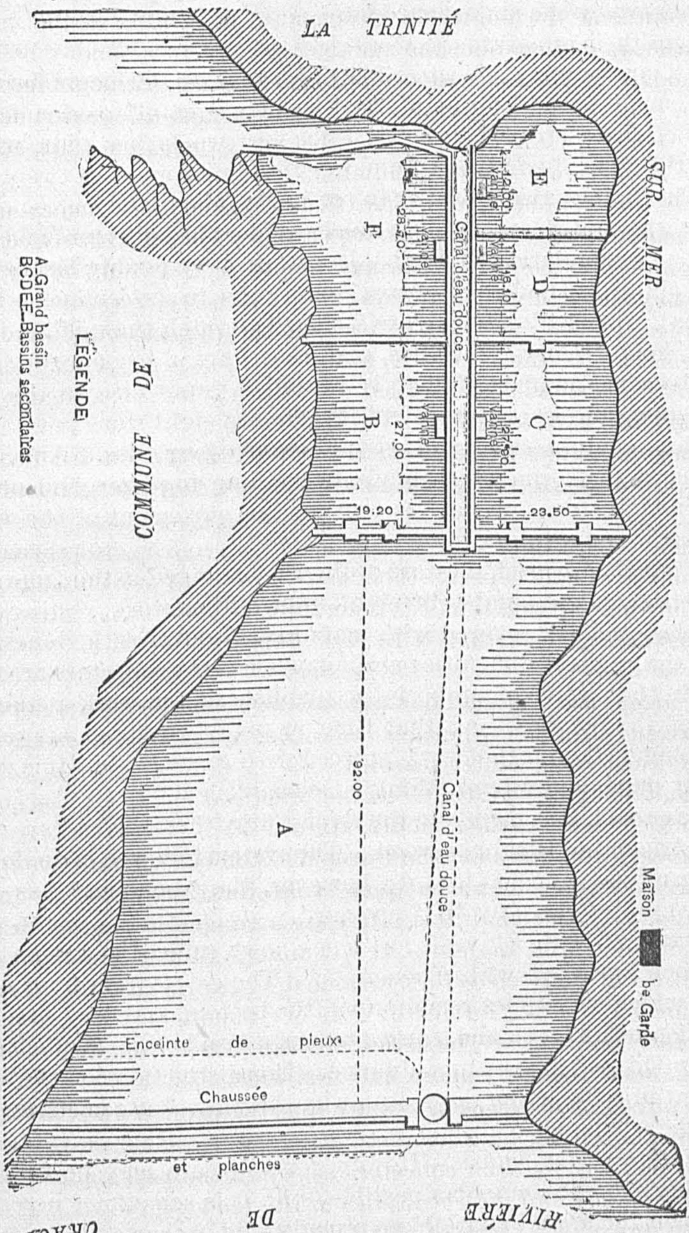


FIG. 4.

the mud from the boat, and were no longer obliged to stand in the water, sometimes at the risk of their health. Moreover, this method was much more expeditious, for I could place twelve thousand tiles in one day."

The stake has this great advantage, that it dispenses with all complicated apparatus and is both easily and rapidly set up. Those culturists who do not employ the stakes encounter many difficulties in the matter of setting up their apparatus.

"When I arrange my collectors," says M. Liazard, "I begin by placing three small horses of rough wood upon a sort of wooden frame, composed of three strips $1\frac{4}{10}$ inches thick by two inches wide, which, including the laths, furnishes a framework, to build upon, of twenty-six inches. The horses rise from six to ten inches above the bottom, thus permitting the water to circulate freely under the collectors and preventing the accumulation of mud. In certain very muddy localities, I have been obliged to make the horses from twelve to sixteen inches high. I first place a row of tiles, which are fastened through the middle. The frame will hold twenty-eight tiles, and, therefore, a second row, composed of the same number of tiles, is arranged transverse to the first, and this operation is continued until there are eight rows in all. My clusters thus contain two hundred and twenty-four tiles. Above the tiles I place a platform, which binds everything together, and on the platform enough stones are laid to prevent the movement of the water from displacing anything.

"When panels are used, they are ordinarily arranged in the same manner as the tiles, to the number of eight, upon a framework, resting upon three trestles, and are covered with mats loaded down with stones."

"One of the greatest difficulties arising, when many collectors are to be placed, is in the matter of properly accomplishing the work at the two low tides of the Syzgies. At that time, as many workmen as possible should be engaged, and the work proceed with great haste. It is sometimes badly done, and often nothing is accomplished."

As we have said, it is mainly in the river Auray that "hives" are used, either constructed of tiles or of wood. The system followed is analogous to that described by M. Liazard; however, the "bouquet" has been judiciously applied there by M. Thevenard.

Parks arranged with "hives" are much more subject to a deposition of mud then those set with "bouquets." The *débris* from frames and platforms, which sometimes remain upon the bottom, may lead to a serious elevation of its level, and, consequently, a firm bottom is much more suitable for "hives" than an unstable one. This distinction must be taken into account in considering the reason why the "hive" is sometimes preferred to the "bouquet."

Consolidation of the bottom.—However much care may be taken to avoid muddy shores as much as possible, still, it is sometimes necessary to work upon them, and as we have already said, in some places a man would sink into the mud up to his neck. A means of visiting the parks without sinking into the mud was, therefore, sought. It was a difficult problem, and all the culturists declare, that, if there had been long to wait for the simple and economical solution which has been found, oyster-cultural attempts at Morbihan would have ended in failures.

To lay small strips of wood in the passage-ways through the parks, would have been expensive in the beginning and useless in the end. Fixed obstacles would have created eddies, and the eddies would have induced a deposition of mud. The desire to examine the oysters would, consequently, have resulted in their being destroyed by the mud.

Then arose the ingenious idea of covering the parks with coarse gravel, such as the shores afford. This gravel partakes of the well known property of sand, in distributing pressure over a large area. Slightly compressed mud is elastic, and vibrations are carried through it in great undulations. These two properties of distributing pressure and of elasticity have been judiciously utilized.

Dr. Gressy was the first to employ this mode of consolidating the mud:

"The first attempt at macadamizing," says he, "were made in my parks. It is effected by spreading over the mud, to be hardened, a layer of sand, varying in thickness according to the softness of the mud. The sand becomes incorporated with the mud and thus transforms it into firm ground. I thus converted into excellent oyster bottom some soft mud, upon which the workmen had refused to work.

"The macadamizing of mud by means of sand is, in my opinion, a discovery of great importance for the future. I call the attention of the commission in a special manner to this question, of which the oyster culturists have not yet understood the importance."

The Baron de Wolbock, who encountered the same difficulty, expresses himself thus:

"Before utilizing the basins, it was sometimes necessary to excavate the rocks, and sometimes to harden the shifting mud, especially in the great basin of Keriolet. This was considered an impossible undertaking; nevertheless this result has been completely attained, by the use of sea gravel, spread upon the surface to be hardened. Put on in layers, from four and a half to six inches thick, this sand or gravel mixes with the mud, which it hardens, forming a sort of mortar, and this without changing the original level of the bottom. After this operation one can move about, and even place heavy loads upon the bottom, where previously both men and apparatus would have disappeared, swallowed up in a short time."

Reverting to the properties of mud and sand already indicated, it will be seen that the consolidation with gravel has the great advantage of causing no modification in the section of the bed, which assumes greater consistency without change of level. The other means employed for the same purpose, such as fascines, which we have examined at the Spanish fort, in the river Auray, are inferior both in effect and result. It is true that the particularly unstable nature of the bottom there may justify the use of fascines, but gravel and sand have such remarkable properties that, when judiciously employed, they are of a nature to bring about the most excellent results in almost all cases.

CHAPTER III.

REMOVAL OF THE YOUNG OYSTERS FROM THE COLLECTORS—THEIR PRESERVATION—ENEMIES OF THE OYSTER.

Attached and freed oysters.—In well arranged breeding parks, where care has been taken to employ the means previously mentioned, both as regards the choice of collectors and their arrangement, about the month of August, small yellow spots will be noticed. These are none other than the newly hatched oysters, which attach themselves to the tiles and develop there. In the earlier experiments it was decided to wait two or three years, before removing the oysters from the tiles. But oysters left to grow upon the collectors assume imperfect shapes. Upon stone or wood they grow very flat, and upon tiles they become distorted and a portion of the young are stifled. Furthermore, when oysters remain for several years upon the collectors, it is impossible to regulate, according to necessity, the care which they demand.

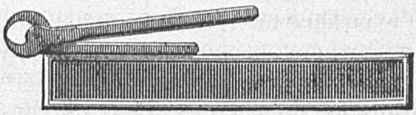


FIG. 6.—Pincers for cutting the tiles in preparing the attached oysters. One-tenth the ordinary size.

Where there are good raising parks, it would be well to remove the oysters at an early date, so as to allow them to grow under better conditions; but the best course to pursue in the matter of raising oysters has not yet been determined upon, at Morbihan, as the different methods in use will decisively show.

When a young oyster is removed from the collector, the valve by which it adhered is exceedingly delicate, and, notwithstanding the existence of a calcareous appendage, resulting from the calcareous covering of the tile, still the surface of attachment presents a very weak point.

By attacking it from this side, its enemies are able to destroy it, and, therefore, all the proceedings during the first stage of raising are directed toward protecting the recently detached oyster from its foes, while at the same time its growth is going on.

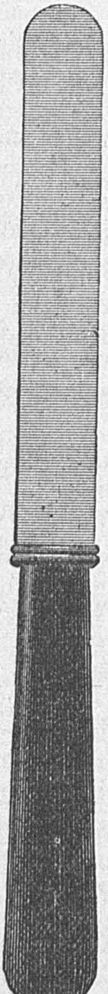


FIG. 5.—Knife for detaching the young oysters, reduced to one-half the ordinary size.

Two principal systems are followed at Morbihan.

The first consists in cutting up the tile, so as to leave each oyster with a fragment of tile adhering to its shell. By so doing, there is no weak surface exposed, to be attacked by an enemy.

The second consists in shutting the young oyster up in cases, the sides and top of which, being made of wire gauze, permit the action of the air, light, and current, while they present an insurmountable obstacle to the entrance of such enemies as the crabs and shrimps.

These two systems are criticised and defended with equal vigor, and both tend to favor industrial results.

In order to throw light upon the subject, without attempting to completely elucidate it, we should, necessarily, make known the different opinions of the various culturists.

"Some desire to preserve their tiles," says Dr. Henri Leroux, "and so cover them with a thick coating of lime, which they remove every year with the young oysters; others spread only a thin coating of lime over their tiles, which the young oysters soon absorb to their own gain, and thus fix themselves firmly on the tile itself.

"In the first instance, the labor of removal will be much easier and less expensive, and the plastered tiles will be as good as new for the next year. These advantages are very tempting; but at the age of six or eight months the young oyster, separated from the surface upon which it had fixed itself, is flattened, and the valves become very delicate, especially the lower one, which is transparent.

"In this condition, the oyster is without protection, and is exposed to the voracity of its enemies. A lot of forty thousand, exposed in this way, disappeared in the course of two weeks. This has twice been our experience.

"If, in order to avoid such a disaster, the culturist puts his oysters in basins, he exposes himself to the same dangers; we have seen quite recently, in a basin measuring something like two thousand square yards, more than a million oysters disappear, stifled under the sand, stirred up by crabs and black worms.

"We must, therefore, have recourse to boxes, covered with wire gauze, in order to save the oysters; but should we not consider the expense of this, when there are several millions of oysters to be preserved?

"If, on the other hand, the tiles are kept in the water until the second year, when the oysters will have attained sufficient strength, they will be badly shaped, and the economy in the matter of tiles will become a source of vexation and deception. On the contrary, tiles covered with a calcareous coating appear to us to present much greater security. The preliminary labor is more difficult and more prolonged than in the case of the tile with the thick coating; but the young oyster, adhering firmly to the tile, still remains fixed upon it, even when, with a pair of pincers of our invention, the tile has been easily cut away, into pieces about the size of the young mollusks. Thus placed free from one another in the raising parks, they are in a condition to defend themselves against their greatest enemies (crabs and oyster-devouring fishes), by the weight and strength of the hard tile covering."

To this opinion, which appears to be based upon reasonable and logical conclusions, we will oppose that of M. Solminihac and M. Mauduy, who have a very important breeding park at the Spanish fort, in the river Auray, which supplies their famous establishment at Bélon.

Speaking of the first attempts, when the oysters were left to grow upon the collectors, these gentlemen express themselves thus:

"In the months of March and April, the oysters being then two years old, we thought them strong enough to be transplanted, and we removed them. This method gave us results which, if not satisfactory, were at least assuring. Considerable expense and some inconvenience were encountered. The great number of tiles required for the proper growth of the oysters demanded a great deal of space. Our possession, which we had been obliged to crowd, suffered great mortality, and also a large number of young oysters, having been completely deprived of light, scarcely grew at all.

"We tried removing them earlier, that is, in May and June, and then placing them in our parks or floating basins, where the water was renewed every day. The oysters placed in the parks disappeared completely; those in the basins succeeded better, but their development was so insignificant that we thought it best to put them into the parks in the month of August. We preserved about one-third of them. We tried at the same time some boxes of thin wood, which gave but poor results. At this time, M. Coste induced us to try wire cages, such as were used at Arcachon. Of these we had three hundred made, after the model sent us. In these cages, arranged in different parts of the river, and in close proximity to the current, we placed four million young oysters, taken from our stock of 1873, at the Spanish fort.

"These cages, set at different periods of the spring and summer, gave us magnificent results, in spite of the great number of oysters placed in each one. The mortality was very insignificant. We obtained from them more than half a million oysters, measuring from two to two and a half inches; the remainder measured from an inch and a quarter to an inch and three-quarters. These oysters were put into the market in very good condition.

"For us, at the present time, the problem of the collection and raising of young oysters has been solved, and, profiting by the experience resulting from prolonged and arduous efforts, we are convinced that the crop of 1874, at which we are going to work next spring, will give us results superior even to those of last year. Satisfied of the importance of this method of operation, we are having five hundred new boxes made with wire gauze."

As indicated by these statements, the conclusions arrived at are quite opposed to one another, and this difference occurs everywhere in neighboring parks; M. de Wolbock abandons the method of leaving the shell attached to the tile, while M. Gressy retains it. If we wished to solve the difficulty, we would have to take into consideration the location of each park; for it should be remembered that in the industry now being discussed there is no universal method of procedure, and from this arises both the difficulties and the dangers. The saying that "what is true on

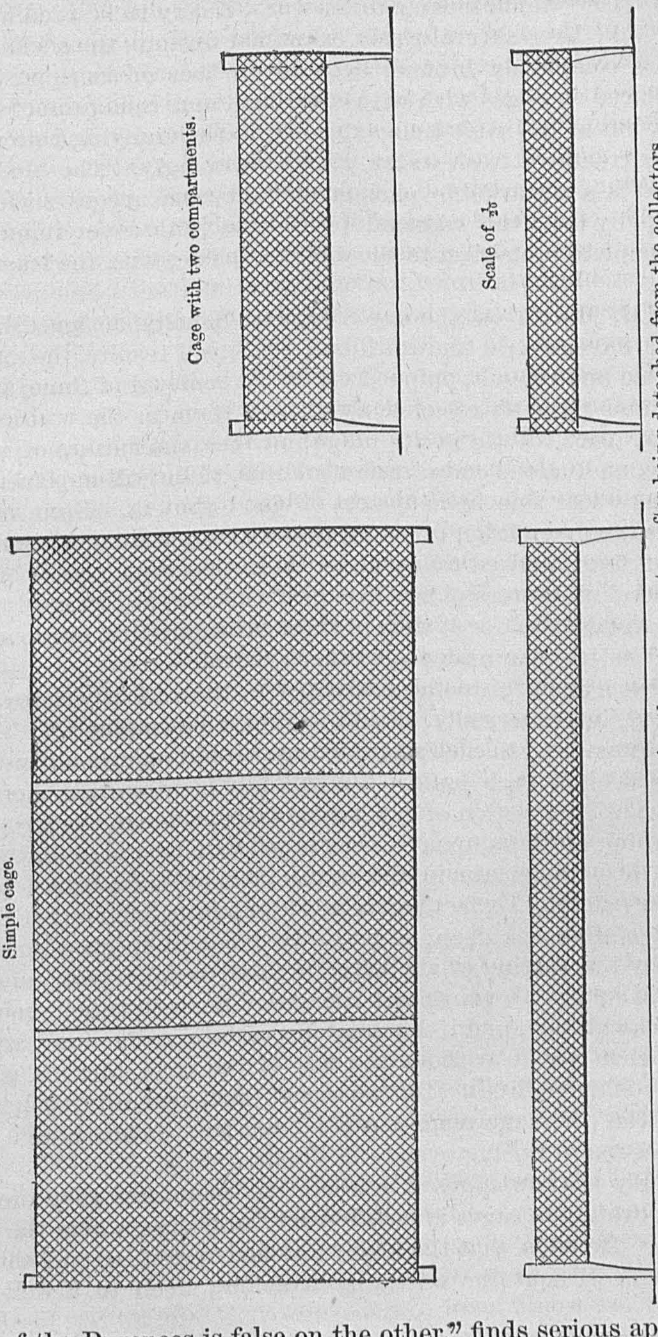


FIG. 7.—Cages of metal wire gauze to receive the young oysters after being detached from the collectors.

one side of the Pyrenees is false on the other," finds serious application here, and progress is hindered with this very diversity of methods.

But, in a general way, it must be acknowledged that the cage is indispensable to the culturist, whether he possesses greater or less numbers of them. They are necessary to his work, if only to be used as "ambulances." We have several times examined oysters, the shells of which had been completely broken, even to the loss of some portions, and which placed in cages with wire coverings, and thus protected against enemies, but at the same time subjected to the vivifying action of light and of currents of fresh water, grew surprisingly. The shell healed, and, what is a remarkable phenomenon, new calcareous scales formed most rapidly over the wounded portion, as if to cover it quickly and afford complete protection to the mollusk inside, with the least possible delay.

The MM. Martin on the one side, and Solminihac and Mauduy on the other, have several times utilized, with good results, the numberless bits of lime and cement, chipped off by the removal of the oysters from the tile, and formerly rejected, by placing them in the wire cages. It suffices to place all these chippings in cages, the meshes of which are quite fine, and, at the end of a few months, there will appear upon this calcareous waste fine little oysters of good growth. From a stock of from three to five million of young oysters, they were quite surprised to find about four hundred thousand saved in this way.

In general, all oysters placed in cages, whether they be newly hatched, the young, small seed, or oysters of three years' growth, improve remarkably, and better than under any other system.

Experience upon this point is conclusive; theoretically the oyster cage is excellent, but practically, should it always be employed? This question, to be answered in each separate case, would require a consideration of the location of each park. We will only mention that there is, first and above all, a question of expense to be considered.

Everything depends upon the increased value given to the oysters, by allowing them to remain in the cage. A cage costs from four to five dollars; is generally six feet and a half long, thirty-nine inches wide, and six and a half inches deep; it needs to be kept in good repair, is destroyed by the rusting of the wire, in three or four years, and, consequently, is subject to continued renewal. Each culturist should make his own calculation, and if he has any certain method of proceeding, with sufficient profit, without the use of the cage, there is no reason why he should employ it. But we repeat that, generally, such is not the case, and the wire cage renders a great service. It furnishes a solution to the question of raising oysters in the first stage.

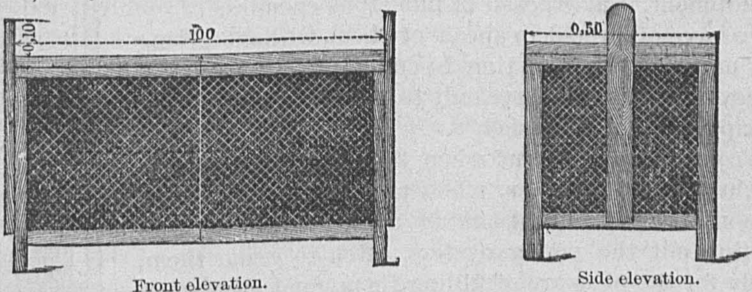
M. Gressy acknowledges it himself, but maintains that the raising of young oysters in cages is possible only in basins, where the surf has no action. He adds, that the newly hatched oyster, left to itself, will do well enough without the cages, by attaching itself to a well-selected place.

"The location best adapted to the young oyster, not attached to the tile, is the highest zone of the park, a short distance below low-water mark; higher up they would die from the effects of the sun's rays in summer, and from the cold in winter. Fish and crabs, especially the former, venture less to this height; they frequent, by preference, the deeper region of the park, which is seldom uncovered. It is evident to me that, by placing the young unattached oyster at the height which I have indicated, they are preserved, whereas when placed lower down they may be considered as lost."

The conclusion seems rational to us, in a general way, that at the time of the removal of the young oyster, if it is detached from the tile, it should be placed in a cage. They may be scattered through the upper parts of the park, after they have acquired some size and strength, and may be placed near the lower current, in the lower part of the park, when they are able to offer greater resistance to attacks upon them.

This principle being acknowledged, what is the proper time of removal from the collectors? The oyster culturists of Morbihan admit, as a general rule, that it should be done early, and in this they are right. To leave the collectors in place for one or two years would be to provoke a dangerous deposit of mud, which would have the disadvantage of stifling a part of the crop. The usual practice is to begin the work of removal in March and April; a flexible knife is passed under the coating of the tile, and thus is obtained rapidly, and without harming the oyster, that particular product termed oyster seed by Dr. Kemmerer. In March and April, the growing season begins; oysters grow in the summer and fatten in the winter.

Also, if oysters should be injured during removal, in the beginning of



Front elevation. Side elevation.

Fig. 8.—Cage for holding the day's work.

spring, they are then in the best condition for healing. Still, there is one very intelligent culturist, M. Alphonse Martin, who begins detaching his oysters in the month of November.

"I have three hundred and fifty cages," says he, "and, therefore, possess the means of placing all my young in them for the winter, thus to protect these unfortunate mollusks, within a restricted area, and save them from crabs and fishes, the accumulation of mud, and the force of the current, which would carry them

Fig. 9.—Scoop.

away. By this method there is also obtained a finely shaped oyster, which does not carry with it a disagreeable impression of mortar, and which is not flat like those left for fifteen months upon the tiles.

The conditions of sale and the facility of raising are the only things which can determine whether the oysters, hatched in July, should be removed from the collectors in October, or not until the following April.

Claires and submerged basins.—Whatever may be the time of detachment of the oyster, it is recognized, at Morbihan, as indispensable to have at one's disposition claires or basins, in which the collectors may be placed during the winter season. At that period of the year, great cold is often caused by northerly and easterly winds. During these winds, the sea falls more than when the wind is southwest, often to such an extent that it might leave all the collectors of a park uncovered for several hours. This would suffice to ruin everything. The winter of 1870 was severe in this respect. M. Eugène Leroux declares that he then lost fifteen thousand dollars worth of oysters in one day, and others suffered in like manner.

M. Gressy has wisely distributed claires and basins around his parks, at Cuhan, and warmly recommends all culturists to put their stock under shelter during the winter.

The fine basins of M. de Wolbock are well known, and M. Eugène Leroux has just been having some made. Our oyster culturists cannot be too much encouraged on this point.

Enemies of the oyster.—From the time of the removal of the oyster from the collector to the period of its normal development, it is exposed to numerous enemies.

We have often had to speak of them, without giving their names. It is now time to enter into some details, an easy task, since we have only to reproduce the spirited description of M. Chaumel.

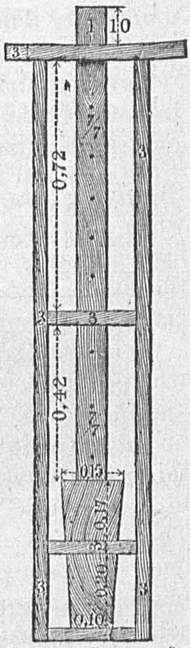


Fig. 10.—Gateway for reservoirs.

"From the spring time, when they put in an appearance, until cold weather, when they leave us, we see these miserable crabs roaming about, searching and ferreting out the young oysters, often to crush them, merely for the pleasure of killing them, for I have often seen them going from one to another, crushing them in their claws, and never stopping until I had seized them and crushed them in turn. With oysters which they cannot break they resort to strategy; stopping near them they watch, without noise or motion, until the valves of the oyster are opened, then they thrust in the elbow of one of their claws, and with the fine extremity of another tear out the oyster, which, in this case, they devour.

If the crab misses its stroke, and gets in only the extremity of its claw, upon which the oyster shuts down firmly, the latter is still a captive, for the crab drags it about as a galley-slave does his ball, and it is a damaged oyster for the culturist. But, fortunately for itself and for us, the oyster is not quite so foolish as it seems to be, and is not often, taken. I have almost always seen the crab pay the penalty. When they cannot do injury in this manner, they have recourse to another method, which is as follows:

"Whole groups of crabs unite together and dig holes, as large sometimes as a hand-basin, first using their claws, and then, when the holes become too deep to work in in this way, loading the mud or muddy sand upon their bodies and discharging it beyond the hole, thus burying all the oysters in the vicinity. By the action of the waves, oysters are often thrown into these holes and buried in them; this we tried to prevent by means of long-handled rakes. I neglected to state that the basins or holes dug by these sea-moles, the crabs, serve as a shelter for their progeny.

"Since I have spoken of the crabs, I will pass in review the other enemies of the oyster, which are the more to be feared; this is a matter of great interest to all.

"*Murex tarentinus* is furnished with a small apparatus, in the form of a rasp, armed with very sharp points, harder than diamond, with which it pierces and kills the oyster. This is a parasite of the most dangerous sort. I placed some of them upon collectors covered with young oysters, and saw the adults pierce the oysters, one after another. They did not leave the collector until they had killed the last one. Ordinarily it is the young *Murex* that attacks the young oysters, which they can pierce when they are scarcely the size of a pin. The older ones attack the larger oysters, and thus each has his field of destruction. To get rid of these dangerous parasites, they must be driven off at all times, but especially at the spring-tides of April and May.

"A most active search should then be made of the lower levels of the park, where all the stones, tiles, and wood-work should be moved, overturned, and inspected. Even the oysters themselves and the dead shells should be subjected to this examination. In the inspection made at this season, they are always to be found in groups of fifteen or twenty, and searching more closely about these groups, their eggs are often to be found. The eggs alone may even be discovered after the spawning season is over. These eggs look something like large grains of wheat; they are placed in an upright position, very firmly fastened at the base to the solid body upon which they have been deposited. The number of eggs in each cluster often amounts to several hundreds, and each egg contains at least thirty-three embryos. There is no need of my demonstrating further the importance of destroying both the *Murex* and their eggs. After hatching, the cluster of eggs continues to present the same appearance for a long time, and it is only by a close examination that an almost imperceptible opening on the top of the egg can be discovered; then it is too late to destroy them.

"Many persons mention the *Nassa reticulata* as a dangerous variety of periwinkle, quite as harmful as the preceding. My own observations and researches do not lead me to share this opinion.

"I must also speak of the *Thère*, a fish belonging to the family of Rays, and another formidable enemy of the oyster, which it devours after having crushed it in its powerful jaws. When this fish enters a park a veritable devastation follows. The havoc they produce must be seen to be appreciated. During my first year here, I had to suffer from their depredations; but I immediately put in practice the means which I had so fortunately employed at Arcachon, and which consists in increasing the number of pickets in such a manner as to hinder their advance. They always move in an oblique direction, when they sink to the bottom. Can my getting rid of them be ascribed to this contrivance? It is possible that, injuring themselves against the pickets a first time, they are not willing to run the risk again; or do these obstacles inspire them with fear? We are tempted to believe so, when we consider the pusillanimity of the *Thère*.

"Finally, more as a matter of curiosity than otherwise, I am going to mention a singular enemy of the young oyster, and this is the shrimp. But, as this animal requires a certain amount of space for its movements, it is difficult for it to commit great depredations about the collectors; it does some damage, however, in the following manner:

"In order to break off the young oyster, the shrimp proceeds after the manner of a battering-ram. It poises itself some distance off from the point to be struck, and then pounces down upon it with all the speed it can acquire, directing its spur, which is powerful compared with the rest of its body, upon the shell, which it thus penetrates. This attack is renewed, until it only remains for the shrimp to settle down upon its victim and devour it."

The star-fish, which the English oystermen dread so much upon their oyster banks, is little to be feared along the coast of the department of Morbihan. However, at the county fair of Vannes, Dr. Gressy exhibited a star-fish holding, entangled in its arms an oyster, the edges of which seemed to have been worn away by the file-like surface upon the under side of the rays of the star-fish. It is probable that, whether upon the banks or in the parks, the star-fishes feed upon oysters by seizing and holding them tightly, and filing away the edges, until the mollusk is sufficiently uncovered to be devoured by suction.

Besides these enemies, which may be said to act directly, there are others which cause ravages none the less sensible, because produced indirectly. Thus the sea worm excavates cavities into which the oysters sink, become swallowed up in the mud, and die. The only preventive against them is to macadamize the muddy or clayey soil with gravel or broken shells.

In speaking of the different zones of the parks, we have had occasion to mention the polyps, which attach themselves to the collectors, like so many little blisters; without being exactly enemies, they act like the mussels, which also sometimes assume the place of the oyster and develop upon the shell of the young or of the adult. MM. Solminihac and Mauduy had occasion to observe at Bélon regular invasions of mussels, which, in a certain measure, prevented the growth of the oysters.

The means of preventing this has not yet been discovered, but the disastrous action of the mussels may be, in a great measure, hindered, by keeping the oysters in a state of great cleanliness. In this respect the young in cages may be easily subjected to washings, either by means of the Dutch shovel or with a suction pump. Cleanliness, in general, is the best guarantee against enemies of this kind.

Upon the whole, the enemy most dreaded by our culturists is the crab. In order to get rid of them, many devices have been suggested. M. Liazard's invention has been especially noticed. It is a prism, covered with wire cloth, closed at the bottom, and with an opening at the top. The interior is partly filled with stones, as ballast, and bits of fish, as bait. When the crab once enters at the top he becomes imprisoned. A considerable number are sometimes caught in this way.

CHAPTER IV.

PARKS FOR RAISING AND FATTENING OYSTERS.

Possibility of raising and fattening oysters along the shores of Morbihan.—Following the details already given, it will be seen that, in Morbihan, if not *all* the breeding parks, at least the best among them, consist, first, of the shore, along which the collectors are placed; second, of claires, or places where the stock can be protected during the winter; and, third, of cages or other appliances for protecting the oyster recently detached from the collector against their enemies, in cases where a portion of the tile has not been allowed to remain attached to the shell. These parks should be completed by the addition of special places, called raising parks, in which the oysters collected might be allowed to grow.

Unfortunately, raising and fattening parks are not of general occurrence in Morbihan, or, at least, are insufficient for the convenience of the entire stock collected. The efforts of those who understand the importance of the work we are now discussing should, in the future, be directed to this branch of oyster culture. The question of breeding is already understood, but that of raising and fattening is yet to be perfected. As regards the breeding of oysters, we have encountered certain well established practices and principles; but as to raising and fattening there exists an uncertainty, which will be remedied in the future.

Here we again find that the nature of the bottom upon which the oyster grows is all-important in its influences. This mollusk has more the external qualities of a vegetable than an animal. Almost incapable of moving from place to place, it feels to the fullest extent the influence of the soil which serves as its bed. We have seen what difficulties had to be overcome, in order to carry on breeding successfully in the midst of our mud; what will it then be as to raising and fattening? Some persons, influenced by a feeling of timidity, mingled with incredulity, ask themselves whether raising and fattening is possible along our coast. When such questions have been proposed to us we have always answered affirmatively, and it will be useful to make known the reasons upon which our hopes are based.

There exists in the world a privileged country, where the oyster industry occupies a prominent stand; that country is the United States. There, immense fortunes have been made in this industry, the capital of one American oyster dealer having been computed as high as ten millions. Now, if it be true that the character of the coast and the nature of the bottom exercise a preponderating influence, what are the particular features of this coast and what constitutes so favorable a bottom?

From the St. Lawrence to Florida, the American coast is deeply indented. Magnificent bays, like those of Boston and New York, are succeeded by the steep banks of the Delaware, which waters Philadelphia, and of the Chesapeake, whose tributaries pass by Washington and Baltimore, Richmond and Fredericksburg. Farther to the south, along the coast of South Carolina, we find the interior seas, called Albemarle and Pamlico Sounds, which seem like great basins, protected from the high waves by immense breakwaters.

All along the coast, from North to South, the soundings indicate sand, sandy mud, and rich, shelly bottoms. In the coves, mud is found; and the bays, whether large or small, receive an abundance of fresh water, from many streams and small rivers. Sometimes this mixture is effected by small tributaries, as in Delaware Bay, and again by large rivers, which, near their mouths, are quite majestic in character; such are the Potomac and the Rappahannock. When these numerous indentures, these rapid currents, and these seas, which penetrate even into the interior, are studied and examined, one is struck with their similarity to those of the coast of Brittany.

We also have a great gulf, deeply indented and dotted about with islands; we also have large rivers, with brackish water and rapid currents, and shores tranquilly washed by the waters of the sea. If the Americans, thanks to their favorable coast, have a profusion of oysters and cultivate them with care, we may also, since the problem of breeding has been solved, endeavor to raise fair crops, as Providence has furnished suitable localities for so doing within reach of our culturists. To such as have said to us "Breeding is our field, let others attend to the raising," I have always replied, we must not neglect the raising of oysters, but make a division of labor so as not to neglect fine resources and lose great riches.

The oyster must be raised and fattened upon its own ground, and then it will be unrivalled. This must be insisted upon, and this is the reply to be made to all who bring forward as obstacles to success the mud, the changeable bottom, the sacrifices to be made, and the struggle to be maintained.

Choice of bottom; character of the water.—After what has been said, it will be understood that it is not possible to state principles as positively, with regard to the raising and fattening of oysters, as has been done in the case of breeding.

However, it would appear that the foundation of this special branch of oyster culture is to be sought in the natural action of the bottom and of the currents. M. Charles, one of the oldest oyster culturists in the country, declares that, for the purpose of raising and fattening, nothing is as valuable as the natural bottom, well prepared. The only suitable preparation consists in giving it a little solidity, by incorporating calcareous ingredients with it, when possible. In this manner, a bottom is obtained, analogous to that which exists along the coast of America.

M. de Broca has informed us that the American oyster thrives on a bottom of muddy sand, rich in animal life and sufficiently sheltered against heavy seas; and, he adds, "that the brackish water, occurring at the mouths of certain rivers, constitutes one of the best elements for the success of this industry."

Moreover, so true is this, that only in the last extremity should recourse be had to artificial means. Americans, in order to raise and fatten their oysters, content themselves with planting them in creeks, where the action of the currents is felt, but where they are, at the same time, completely sheltered and where the depth of water varies from three to nine feet, above low-water mark.

M. de Broca, who furnishes this information, adds the following judicious observation:

"In America, parks, as we understand them in France, are unknown. American oyster culture, more simple in its details, consists in planting, the mollusks along the shores of the sea-coast. Where there is only sand, they grow but little and do not fatten; where mud alone exists, they contract a bad flavor and are in danger of being stifled; but where the sand is mixed with a moderate quantity of mud, they develop wonderfully, especially if the water be moderately salt."

The choice of bottom is always a delicate subject, because it has so important an influence upon the raising and fattening.

Dr. Henri Leroux states that "the low price of oysters now depends entirely upon the greater or less area given over by the State to oyster-culture."

The great difficulty is that the bottom must be selected and appropriated. At first sight, it would appear that the gulf of Morbihan and certain portions of our river banks, between low and high tide marks, might be utilized with success. This is an experiment which many of the culturists of Morbihan are disposed to hazard.

Upon this subject we have heard manifested a desire to see in the waters of a raising or fattening park the animal matter, upon which the oysters might feed. This idea should be set aside from the beginning, nothing being required but a firm bottom and tidal action.

As we have said before, the oyster is a remarkable laboratory, where transformations are effected naturally; very little is necessary for the development of this mollusk, and the best is that which is most easily assimilated and which readily escapes our notice.

It is remarkable that the same idea should have prevailed in all countries, where the raising and fattening of oysters has been undertaken.

M. de Broca says: "A belief, which has gained some credit in England and America, is to the effect that oysters may be fattened by scattering a little flour (corn-meal being commonly employed) in the water which covers them. Some oyster-planters in New Jersey," he says, "have tried this, but it is probable that the use of meal has little or no effect upon the oyster, whose stomach is so delicate as to appear incapable of digesting such nourishment."

Preparation of the bottom.—Setting aside the possibility of raising oysters artificially, the first thing to be sought for is a firm bottom, and if this cannot be found it must be made. M. Chaumel has accomplished this result in the gulf of Morbihan, and his example may be easily followed. It has been necessary to do the same thing in the river Bélon, which answers for fattening, as the river Trinité does for breeding. MM. Solminihac & Mauduy, who have built a remarkable establishment at Bélon, have had great difficulties to overcome. "The bottom of the river," they say, "is not everywhere favorable to the existence of the oyster. In most places the borders of the channel, which are the only suitable localities, presented slopes of mud in which the oysters disappeared almost as soon as placed there. We had, therefore, to adapt the bottom to our purposes; we removed from eight inches to two feet of mud, macadamized the surface, and thus constructed a bed suitable for the oyster. Our efforts were crowned with success, for the oysters placed upon this artificial bottom in the early spring (as far as possible during the month of March), became completely transformed as to the nature of the shell, and increased very considerably in size, at the same time that the edible portion fattened greatly."

But this formation of bottom is not always possible in the streams and along the shores of Morbihan. In a little river which flows into the bay of Lorient, a culturist has been led into an ingenious system, to which future success would appear to be secured. M. Turlure, to whom a park had been conceded in the river Ter, had for some time contented himself with simply planting oysters along the channel, where they improved greatly and soon became edible. Anxious to extend his field of operations, he found himself unable to utilize the muddy portions, as the work of consolidating the bottom there would have been very great and expensive. He decided, therefore, to make use of the cups of M. Michel, superintendent of the hydraulic works, in the port of Lorient. These cups, constructed of a kind of cement, are about nine inches square, and are capable of containing about four and a half inches of water.

At first two kinds of these cups were utilized, the one being pierced through the bottom, and the other solid on all sides. The first combined with the second might serve as "ambulances." It would appear that the non-perforated cup is really of practical importance, and destined to become of great service in certain cases.

M. Turlure has now 52,000 of them placed in his park, in elevated places, where raising would have been impossible under any other system. They contain fourteen millions of oysters. The net cost price of this work of solidifying the bottom amounts to about $1.62 a square yard.

It is impossible, at the present time, to pronounce upon the value of this system, but it deserves to be studied with scrupulous care. From a theoretical point of view, however, it presents the advantage of affording oysters, both large and small, an exclusively calcareous bottom, over which may be spread a fine mud of a good brown color, and which, not containing animal or decomposed vegetable matter, exercises no harmful influence upon the oyster.

The fact must not be lost sight of that, so long as the mud does not become black from the liberation of sulphurous matters, it is, if not favorable, at least inoffensive. After turning black it acts as a poison upon the oyster.

Coste made known the mortality which overtook the oysters in Lake Fusaro, about the year 1820, on account of the appearance of sulphurous fumes, due to volcanic eruptions, and the fatal influence of mud containing sulphur is to-day well known to all the culturists of Morbihan.

In case a deposit of the black mud should form upon the basins in the Michel system, the action of the atmosphere and light would rapidly transform it. It would become brown by the absorption of oxygen, which changes sulphurets into sulphates.

What is most remarkable in connection with the breeding and raising parks of Morbihan is the great diversity in the methods of work, and the attachment of each culturist to his own system. This, on the whole, is praiseworthy, because, with such a multiplicity of trials, the true road to success is more likely to be discovered.

At the mouth of the river Ter, we find the parks of M. Charles, where the method of proceeding is totally different from that of M. Turlure, whose parks are about three hundred yards further up on the same river; and yet the success of M. Charles is assured, and the reputation of his oysters already made.

He has selling parks upon the emergent portions of the banks, a large shipping basin, and in the cove of Kérolé, an excellent basin with a bottom of clayey sand, where the growth is remarkable, even though there is no current. The oyster develops rapidly, and in six months increases in size from a quarter of an inch to an inch and a quarter.

But in the case of M. Charles, as in that of M. Turlure, in Bélon, as well as in Morbihan, it is always necessary to commence by removing the mud, and forming artificially a hard bottom, in order to secure a good increase and insure the fattening of the oyster. All these conditions seem admirably united in the parks of M. Pozzy, at Ludré-en-Sarzeau.

The fine flour-mill of Ludré, situated upon a point projecting into the sea, and which appears like an establishment where human industry has endeavored to seize from nature an important motor power, has an immense reservoir of nearly one hundred acres in extent; on one side, there are walled parks, intended to receive the cars, and on the other, raising basins with a surface of over seven acres. By the action of the waves, a certain current is produced in the parks, and the large reservoir, acting like a storehouse, makes it possible at almost any moment to concentrate upon any of the parks a continuous and steady flow. A careful examination of the functions of the different parts of that most judiciously arranged establishment of M. Pozzy, shows that he possesses, in the parks of Ludré, the means of varying, at will, the action of those natural forces, which are so favorable to the growth of the young oyster. The clayey bottom of the carefully cemented basins can be readily adapted to raising, and the possibility of placing the cars, containing the young oysters, under the vivifying action of the currents, admits of early growth, difficult to obtain in ordinary parks.

Upon the whole, and despite the almost embryonic state of this branch of raising and fattening, we can predict, in a short time, very successful results in parks so favorably situated and so judiciously arranged as those of M. Pozzy, at Ludré.

Basins.—It is indispensable that several fattening parks and shipping basins should be added to all raising parks; this is a necessity to which our culturists of Lorient, in the gulf of Morbihan, and at Bélon, have been obliged to conform. Where they are wanting, much is left unprovided for, to the great loss of the industry.

Care to be taken in raising and fattening oysters.—Having described the arrangement of the parks, it is interesting to point out the care which should be taken to insure growth and fattening. First of all, the oysters should not be piled upon one another. Coste said the proportion to be followed in distributing them should be a million of oysters to two acres. This is the proportion used at Marennes. In America they are disposed under the same conditions, and all culturists have stated the proportion to be one hundred oysters to the square yard. This point seems to have been settled beyond dispute.

As to the special attentions to be observed, MM. Mauduy and Solminihac have briefly summed them up, in the following terms:

"We take great care of our parked oysters, because experience has shown that the more attention given them, the more satisfactory are the results. These cares consist mainly in removing all foreign matters, which the tides may deposit in the parks, in turning the oysters, in re-arranging those that are badly placed, and in repairing defects in the bottom, after which the oysters may be replaced upon it. These operations require the employment of a considerable number of workmen, all the year round."

The duration of the term of parking for an oyster of salable size, varies from six months to one year. There is nothing which more requires the eye of the master, and constant and active watchfulness.

Results obtained; turning green.—The results obtained are in proportion to the efforts displayed. The well-parked oyster upon our shores will assume a closed shell; while before parking it consisted of a chamber containing fœtid water, which spreads throughout the interior when the knife is employed. This defect it loses and assumes a solid and resisting surface. The oyster grows, its flesh loses its brown color and becomes quite white. Everything indicates a change for the better, as pleasing to the palate as to the eye.

One quality, long considered as peculiar to the oysters of Marennes, a greenish coloration, is easily produced in the parks of Morbihan. This singular phenomenon consists in the appearance of a very decided greenish color, affecting especially the breathing organs, that is to say, the four branchial leaves.

Coste had observed this fact at Marennes, and had also noticed that the green oysters always became white at spawning time. "Those," said he, "which previously presented this appearance, became paler, little by little, as fecundation took place and finished by losing the color entirely, at the time of spawning. On the other hand, those which were white when placed in the parks remained so. It is only after the month of August, that they recover from this temporary loss of color, which does not affect the trade, since the color reappears immediately after spawning."

It is now proved that the process of turning green in the parks of Morbihan, is connected with the entrance of fresh water into the parks, and the development of vegetation upon the bottom. It is effected in a few days and has no relation to fattening. What causes the transformation? Some of our culturists attribute it to a disease of the liver, others exclusively to the influence of the bottom.

Berthelot, who carefully analyzed the green oysters, thinks he can ascribe the green color to a metallic oxide, doubtless the oxide of iron.

The blue marl of the Seudre contains analogous elements. This alone indicates that the bed, on which the oysters are placed, exercises so decisive an influence upon them, that to improve the bed may be said to improve the oysters.

The presence of oxide of iron in Morbihan is scarcely admissible, hence it must be the green vegetation that produces the color of the oyster. M. Charles has observed that vegetation tends to disappear around the oysters which become green; but he rightly admits that the process of turning is only possible because of particular dispositions of the animal, either illness or otherwise, which disappear at the period of spawning.

However this may be, the fact remains that in the parks of Morbihan the green tinge, so much demanded by lovers of oysters in the south, may be obtained with great facility, and also that the color has nothing to do with fattening, nor with the special qualities of the oyster.

CHAPTER V.

MEASURES REQUIRED TO INSURE THE PROSPERITY OF OYSTER CULTURE.

On the preceding pages, we have endeavored to point out the state of oyster culture in Morbihan. It is important to draw from these details some conclusions, to show what future is in reserve for this industry, and by what measures such a future may be assured.

Principal cause of the failure of Coste.—It is evident to all that, in spite of the scientific knowledge, the zeal, and the labors of Coste, his attempts, so far as regards commercial results, were radically fruitless. Nevertheless, he had at his disposition apparatus, boats, auxiliaries as intelligent as devoted, and also, to a certain extent, the resources of the public treasury. Still the reason is very simple. That impersonal being, called the state, is incapable of creating any industry. It sufficed to relinquish oyster culture to the culturists, who, although intelligent and well informed, are, in the majority of cases, neither savants nor academicians, to insure success, where only failure had been predicted.

This is because the state lacks that powerful lever called individual interest. An occupation is not possible unless an assured profit may be realized from it. The merchant alone can be certain of this, from a study of the markets and the demands of consumers. The poorest merchant in France is the state. The state has quite another part to play. Charged with the protection of all, it cannot descend from this elevated sphere of general usefulness into the arena, where opposing interests are contending—an arena which it always leaves defeated and often injured. To abandon its reserve and endeavor, by taxation, to create a national industry is an act of socialism, generous, perhaps, but from which others will derive the benefits.

Napoleon III, in his youth, had a passion for studying these questions, and sometimes lent an attentive ear to these grand socialistic theories; this was why Coste obtained so much support from the Emperor. Led away by his own ardor, he did not notice that he was gliding down a fatal slope, and that he would fall at last, in spite of all his efforts. If, instead of going to the Tuileries, he had addressed himself to an association of capitalists, or to the trade, who could have participated in his confidences, then oyster culture, disengaged from the shackles of the state, would, from the beginning, have taken a higher stand and progressed with surer steps.

We do not wish to underrate the importance of the part played by the state, for we are going to appeal to its aid in another matter; but we think it should be well understood that the two domains, of industry and of government, are totally distinct. By confounding them, powerlessness replaces fertile effort, and the most important work is crowned only with failure.

We do not wish, in any way, to diminish the gratitude due to those, whether functionaries of state or others, who have labored for the creation and development of this industry; but we feel the necessity of proclaiming, in a certain measure, the omnipotence and vigilance of individual interest. We believe that, imbued with this thought, the public administration would desire, even more in the future than in the past, to free from fetters and obstacles the pathway along which this industry must move, in order to attain a high degree of prosperity.

Necessity of establishing parks for raising and fattening oysters.—The prosperity of oyster culture will be secured when, in addition to breeding, a matter already of certainty, there is established a methodical system of raising and fattening.

"The oyster," says Dr. Kemmerer, "which is now rather a luxury, would become an article of general consumption. In Paris, in the month of January, 1875, more than 185,635,000 French oysters were consumed, a flattering result for oyster culture. The oyster culturists of Marennes acknowledge that, out of seven millions of oysters, they lose six in their fattening parks, which is a shameful acknowledgment for the industry."

We have no influence over these figures, but we are going to endeavor to roughly sketch out the oyster statistics of the present and of the future, in this interesting department of Morbihan.

According to the statements furnished us by the commissioners of maritime inscription, there are, within the approximate limits of Morbihan, 535 oyster parks, occupying an area of about 1,065 acres. It is difficult to make a division between the breeding parks and the parks for raising and fattening. A careful examination, however, leads to the following classification: 100 acres are used for breeding, and 965 for raising and fattening. It will be prudent to reduce the last figure to 750, because several parks are but little used, and many are almost abandoned.

Since it takes three years to raise an oyster, and since, during the growing and fattening period, about one square yard is required for a hundred individuals, it follows that it would require about 7½ acres of bottom to raise and fatten one million young oysters. This is the number theoretically, but practically some portions of the concessions are found to be much more favorable than others, and some portions are even unsuitable for raising and fattening. Taking this into account, and adding the space lost in entrance ways, &c., we must double the area, and call it fifteen acres. In the 100 acres set aside for breeding purposes, what does the number of young produced a year amount to? It is difficult to answer this question, and the methods of enumeration vary. Some persons count the tiles, and thus obtain a mean of the number; others try to count the oysters actually produced; the latter approach nearest to the truth.

Deducting for losses, the production really varies from two hundred to a thousand oysters, to a square yard of the area of a breeding park. In some parks there is a square yard of collecting surface to a square yard of the park; others have only a foot or a foot and a half.

Breeding, therefore, along our coast, varies every year in the production of from eighty millions to four hundred millions of oysters, but we believe it is not prudent to accept any figure higher than eighty millions. Dredged oysters are not included in this sum.

If we accept the figure of fifteen acres of raising and fattening parks, for the annual production of a million oysters, it results that a surface of 1,200 acres is required to raise what is produced; the figures given above show that there are only about 750.

Consequently, if the production continues to increase, and if the practice of raising remains at a stand-still, the supply exceeding the demand, prices will be lowered, speculation will interfere, and we shall arrive at a crisis.

Do not accuse us of pessimism. The industry of canning sardines is now passing through an unfortunate phase, on account of an excess of production. It is asked, What will be the effect upon the maritime inscription, if this fishery is given up, if our coasts become deserted? What is there to offset this result? The future does not look bright.

It is to be hoped that no such crisis is in store for the industry with which we are concerned, for oyster culture could not oppose it; once fallen, it would be difficult to raise it; then it would be useless to court inquiry, to make scrupulous examinations, and to ask oyster culturists what ought to have been done. Now is the time to attend to the needs of oyster culture in Morbihan; the way must be prepared immediately, and sufficient space accorded this industry to extend its labors. What is necessary to attain this result? Attend to the raising and fattening, which means, that a great deal more space is required.

For the actual production of 80 millions of oysters, 1,200 acres in parks are required; for the future production of two hundred millions, we must have 3,000 acres. Where will they be found upon the coast of Morbihan? The shores are muddy; the attempt to utilize them would be to change the order of things; to modify the equilibrium in the beds of rivers, and induce a deposit of mud. On the other hand, if a high rent, which would be justified by a well-established occupation, be imposed upon our culturists, a budding industry will be stifled. The influence of the state should come in between the culturists, who desire to develop their establishments, and the obstacles, opposed to such development. It is incontestable that, to prevent the deposition of mud and the modification of the bed of our rivers, the creation of parks might be combined with a judicious system of damming. But this operation necessitates a connected study of the courses of our rivers, which could not be undertaken by our culturists, who have not the means necessary to bring it to a successful issue.

The state alone, by means of the help employed by the minister of public works, might set on foot the requisite studies to determine at once: first, the surfaces which can be transformed; second, the technical conditions under which this transformation is possible, without injury to the general welfare. This labor accomplished, the result should be brought to the knowledge of culturists, who could then take into consideration the chances of gain or loss, success or failure, which the labor of raising and fattening might offer them.

Would it not be desirable to know to what extent this industry might be developed upon the coast of Morbihan, if this programme could be realized, and these numerous parks established?

At present 80 millions of young oysters a year represent a value of from $60,000 to $80,000. If the process of fattening were made practicable, the increased production would place 40 millions of edible oysters at the disposition of consumers, and then the results of the industry might be reckoned at about $1,200,000, calculating the price to be about $16 a thousand. The 80 millions of young oysters require 160,000 days' labor, of both men and women; if raising were undertaken, 600,000 days' labor would be necessary. Let it not be asserted in opposition to this that, after all, the fattening of oysters is attended to in other places, and though Morbihan may suffer by not undertaking it, still the general interest would not be the loser. This is an error, because the bottom can be adapted to fattening, and therefore not to utilize it is to neglect a source of wealth.

It is the duty of the authorities of the department of Morbihan to examine the situation well. The preserving of sardines along our coast already realizes about $2,000,000 annually. Oysters, to the value of $1,200,000, might easily be put into market, and so the annual amount of the industries of our coast would amount to $3,200,000. This is a considerable sum, and large enough to warrant the attention of those who believe, that the public wealth is closely allied with individual and local wealth.

Rent.—In case our desires were to be carried out, and the study of transformable bottoms made, at what rate should the rental be fixed? Every service must be paid for; this is a principle of economy which enters largely into all our habits. A rent must, therefore, be decided upon. The rate is the only point to be discussed.

The rent, especially in the beginning, should be very small, and of a nature merely to secure the rights of the public domain. It would be a pity to see a fiscal measure trammel upon this industry, which still feels its way along so timidly. It is true that in the present state of our public treasury, and with the debts which weigh upon our country, every source of revenue is eagerly sought for, but yet we must be careful not to kill the goose that lays golden eggs. As Bastia has said, there are two sides to this question, one seen, and one not seen; what is seen is the rent, which may enrich the public treasury; what is not seen, is the fact that by putting an obstacle, even a slight one, in the way of the early efforts of culturists, the progress of an industry might be stopped, the result of which would be a certain reaction upon the public welfare. From this point of view, there is a great service to be rendered to oyster culture. The state, by accepting the proposition, would be playing precisely the part it should, and its intervention could never have more beneficial results.

Concessions for a long term.—This question leads naturally to a consideration of the method of granting concessions, now in vogue in already existing parks, and that to be followed in the future.

At present, as is well known, every culturist is entirely dependent upon the administration; the concessions are nominative and revokable; what a minister has given with a stroke of his pen he can likewise take away. We have heard it said that administrative favor might cause trouble to this industry, by arbitrariness or favoritism, but we do not fear this, for we believe that the principles of equity, integrity, and justice, which are the patrimony of the administration, will ever be held in honor. But from another point of view this question deserves to be attentively studied.

A culturist is authorized to found an establishment by a permit which is entirely revokable. He expends a considerable sum of money upon his establishment, but he entirely ignores what the future may have in reserve for him. In case of death, what will become of his industry? Into whose hands will his concession pass? Will his descendents, direct or indirect, have the right of pre-emption? The administration, with a high standard of impartiality, may know how to conciliate all parties; but for most parties this is a simple hope. A hope does not afford that certainty which belongs to an arrangement, known to every one and determined upon beforehand. Besides, how can one calculate the redemption of capital? There can be no stated period of possession; all is absolute uncertainty. An urgent reform is demanded upon two points:

1st. The concession should be made for a fixed period, with the privilege of renewal by the retainer, unless the public interests demand otherwise.

2d. An acknowledgment of the right of pre-emption for the descendents, or of a valuation to be placed upon the park in case of change, and, also, a right of pre-emption, for those who reside along a river, to that which faces their property.

A concession given for a stated period will have the immense advantage of enabling the culturist to calculate a total or partial redemption of his capital, which will afford him some certainty for the future. This certainty will engender confidence, which is inseparable from progress.

On this point, our French oyster culturists have once more given an example of that peculiarity of our national character, exhibiting at times an exaggerated fear and again an incomparable audacity.

It is generally stated that we are lacking in commercial spirit, that the English and Americans, more daring than we, know better how to venture in untrodden paths, and, thanks to these qualities, attain wonderful results in all industrial pursuits.

It will not be rash to assert that neither English nor Americans would have hazarded the establishment of an industry, the existence of which depended upon an authorization, which was revokable from one day to the next. The most venturesome would have held back before such instability; and what proves this is, that American legislation has been categorical in this respect.

Thus, in Massachusetts, where the celebrated Northern oyster is found, the concessions are made for twenty years, the oyster culturist and his heirs having the exclusive privilege of the conceded ground. In Rhode Island, where oysters are extensively cultivated along the banks of Providence River, the shortest concessions are for five years and the longest for ten years. In Connecticut, each authorization indicates the duration of the concession made. Farther still, not only is a stated duration of concession considered indispensable in America, but, in many cases, those who reside upon the banks of a river are acknowledged to have the right of cultivating oysters along the frontage of their own property. This is the case in New York, New Jersey, Delaware, Maryland, &c.

In this manner, legislation has shown that human activity can and should develop itself, not only on the land, but also in the domain of the sea; it has comprehended that the initiative should always be left to those who would engage in any undertaking, both as regards the cultivation of the land and the sea bottom. Without entering into the realm of industry, it has removed obstacles and taken all measures not to hinder the advancement of oyster culture. Here we find both an example and a lesson; an example, for, notwithstanding the wealth derived from the oyster trade in the United States, legislation protects oyster culture, a thing which is wanting with us here in France, where the need of it seemed to us, a short time ago, as real as irremediable; a lesson, because it is only in making of the sea-coast, not a special domain, but one subject to the ordinary rights of ownership, that we can accustom the people to sea-coast affairs, and thus build up and perpetuate a race of seamen, like that of which America is justly proud.

In England, where there has also been a falling off in the cultivation of oysters, an inquiry has been instituted. The principal conclusion of this inquiry is remarkable, and the duty of the government is marked out in the following terms: "Let it be provided that associations or persons may easily obtain a title of possession, sufficiently secure, to such portions of the bed of the sea as they desire to work, in order that they may be induced to employ the capital necessary to furnish and keep up their fisheries."

No doubt is possible upon this point. French oyster culture will never become an industry destined to thrive, until its future shall be assured. It depends upon the government alone to remedy the evil, by conceding, with guarantees as to duration of lease and facilities of transmission, parks sufficiently extensive for the double purpose of breeding and raising.

What is it they oppose to us? Is it that public interest might necessitate labors which would lead to a dispossession, in the case of concessions for a certified time with acquired rights? That navigation or some other maritime interest might require freedom of the coast, understanding by freedom its remaining entirely in the hands of the state? The answers are readily made, and upon this basis of discussion oyster culture is impregnable. Where there is a will there is a way. It is acknowledged that, so far as concerns the public welfare, the recruiting of our sailors, our marine power and our marine industries should be sustained, at any cost. This is the main point, the end to be attained, and all that is secondary to it should be disregarded. By hesitating, on account of objections in the matter of details, which may, perhaps, have some value, we are led astray, and soon lose sight of the greatness of the object. The state must be constantly reminded of this object; it must be convinced that here is a work which the government alone can undertake, and which we confidently hope it will perform.

Reforms of detail.—Besides these reforms and innovations, which we so earnestly desire, there is still a good deal of progress to be realized in detail.

We have shown the importance of the current for reproduction and raising; now, these currents being found in the deeper portions, it must systematically be permitted oyster culture to approach the channels. We have shown how powerful the current is in sweeping away the mud, accidentally deposited in the deeper places, and consequently all facilities for the cleansing of the parks should be fearlessly afforded.

We have shown how great was the solicitude of our culturists for the restocking of our oyster beds; let them be permitted to approach the banks, which will become, for those interested in them, objects of active watchfulness and attentive care. In fine, we will add that marauding should be severely repressed.

In America, where centralization is little known, and where almost every one protects himself, we have a remarkable example.

In Rhode Island, oyster thefts are punished by fines, varying from \$24 to \$120, accompanied by imprisonment, sometimes for a year.

In Connecticut the fine amounts to \$72, with imprisonment for six months, and in the other States the laws are also severe.

CONCLUSION.

In a word, to study and reclaim transformable surfaces; to give concessions for a long term, with acquired rights for the retainers; to extend the liberty of culturists, and to enact severe police measures; such is the conclusion of our studies upon the part to be undertaken by the state in the matter of oyster culture.

The culturists will do the rest; in this respect, the past guarantees the future; their courage and energy will place oyster culture foremost among French industries.

In conclusion, may we be allowed to state how happy we have been to find all our culturists rendering to Coste the honor which is due him; all confer on him the glory of being the founder of oyster culture.

"Let us proclaim it aloud," says Dr. Kemmerer, "because it is true: the academician, Coste, was the founder of this new science."

"I know that certain minds, filled with jealousy, dispute with his scarcely cold ashes these first scientific attempts; but his writings, as well as those of all the oyster culturists of the time, exist to cast ridicule upon these posthumous inventors."

To this cry of indignation, we add the touching words of M. Chaumel:

"In concluding, may I be allowed a souvenir of affection and gratitude to M. Coste, the learned professor of embryology, to whom oyster culture owes everything; for, without him, of that which occupies us here there would be absolutely nothing.

"After having trodden for many years a path bestrewn with thorns, leaning upon my arm, his failing eyes often caught a glimpse of the laurels of the promised land, though he died in sorrow. If, more fortunate than my dear master, it pleases God that I have the honor to gather them, it will be both sweet and pleasing for me to lay them upon his tomb."

We have been pleased to hear this touching unanimity, which should be noted, for our age has given birth to critics, whose sight is easily dazed by glory. It would seem as if they tried to measure everything by their own proportions. But our culturists of Brittany have escaped this contagion. As, for what is solid and true, they have ever had an unvarying devotion, and a fidelity, which is the eternal honor of their race, they have proclaimed their admiration for Coste, gloried in humbly acknowledging themselves to be the disciples of the master, feeling that, if gratitude be a duty, it is also a noble quality.

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XXXIV.—RESULTS OF THE INVESTIGATIONS RELATIVE TO THE OYSTER AND ITS CULTIVATION AT THE END OF THE FIRST YEAR OF THESE INVESTIGATIONS.*

[Appendix to the Sixth Annual Report of the Zoological Station of the Netherlands Zoological Association.] †

LEIDEN, 1881.

The review (*catalogue raisonné*) of the *literature of the oyster*, referred to in our report, was completed during the month of June. It is intended to form the first part of the final report on the investigations relative to the oyster, but on account of its size (104 pp. 8vo, close print) it has been thought best not to embody it in this appendix. The table of contents of this review, which has not been given to the book-trade, is as follows:

* "*Overzicht van den stand van het onderzoek de oester en haar cultuur betreffende aan het einde van het eerste onderzoekingsjaar.*"—Translated from Dutch by HERMAN JACOBSON.

† *Zesde Jaarverslag | omtrent het | zoölogisch station | der | Nederlandsche | Dierkundige Vereeniging, | uitgebracht door de Commissie voor het zoölogisch station, | op de Vergadering van* 10 *December,* 1881. |

VII. Works relating to the oyster-fisheries and the cultivation of the oyster on the coasts of *Denmark, Sweden, and Norway.*

VIII. Works relating to the attempts to establish oyster-beds on the coasts of *the Baltic.*

IX. Works relating to the oyster-fisheries and the cultivation of the oyster on the coasts of *the Mediterranean and Adriatic.*

X. Works relating to the oyster-fisheries and the cultivation of the oyster on *the east coast of North America.*

XI. Works relating to the oyster-fisheries and the cultivation of the oyster on the coast of *China.*

Alphabetical index.

The investigations relative to the ANATOMY OF THE OYSTER were in charge of Messrs. *Hoek, Vosmaer* and *Waalewijn.*

Dr. *Hoek* writes that, as far as the generative organs are concerned, the more important questions are those relating to physiology, at least in viewing the matter from the point of view of an oyster cultivator. These questions—to mention some of them—are as follows: *At what age does the oyster begin to propagate? What percentage of the oysters on a bed take part in the propagating process? Does the propagating oyster exercise the functions of one sex or of both sexes? Does one and the same oyster propagate once or more than once a year?* &c. All former investigators, who have occupied themselves with this subject, have attempted to answer these and other similar questions. The reason why they did not succeed—for even the investigations made by the most prominent among them (*Davaine, Lacaze-Duthiers, Möbius,* &c.), have not led to any *certain* results, but only to more or less doubtful *suppositions*—must be found in the circumstance, that an attempt was made to answer these questions, without any satisfactory knowledge of the anatomical (both macroscopic and microscopic) construction of the oyster.

What is the construction of the generative organs? Where are they located? How are the generative products emitted? These three questions seem so simple that it is difficult to imagine that they could not be satisfactorily answered by the aid of the experience of former investigators. The oyster is not such a rare shell-fish, nor can it be classed among those animals which, on account of their small size, are difficult to examine. The fact that its anatomy is particularly little known is doubtless owing to the circumstance that the oyster—more than other mollusks—presents great difficulties to the use of the dissecting needle, scalpel, and magnifying glass, to such a degree as to make such experiments appear futile and bring them to an abrupt close. Our more modern methods of investigation cannot yet be said to be entirely suited to the nature of the oyster; it will nevertheless be to these methods that we will have to look for a speedy and deeper insight into the construction of the generative organs.

These methods consist principally in hardening the oyster and in obtaining their sections for microscopic observations. Oysters can be hardened by means of different liquids; as far as our experience goes, we are inclined to give preference to pure alcohol or combinations of chromium.

The results which have so far been reached, and which, from their nature, must be considered as preliminary, are given below. Although it would perhaps be preferable not to publish some of these supposed results, as yet, we shall give them, so that they may serve as guides in future investigations:

(1.) The generative organ of the oyster is not, as in other lamellibranchiates, a strictly localized organ, but extends equally on both sides of the body. The organ on the right side is connected with that on the left, both on the abdomen and on the back, and besides this by a portion which bounds the pericardial cavity in front. It is therefore a continuous organ which does not extend into the mantle.

(2.) The generative organ is located near the surface of the body, but is separated from the skin by a thin layer of tissue.

(3.) The generative organ consists of a system of vessels which, throughout, have an anastomotic character, and which run parallel with the surface of the oyster, and from their internal sides or faces there arise blind tubular prolongations which extend inwards into the tissue of the body. In these tubes the generative products are developed.

(4.) The generative products are developed from the epithelial cells, which cover the inner sides of these blind tubes or follicles. During this process both male and female generative products are developed close to each other in one and the same follicle, and can gradually be distinguished from each other by their structure and the manner in which they color.

(5.) It must be considered as a rule, that one of the two generative products in one and the same oyster will, in its development, by far exceed the other. Those generative organs which furnish principally *male* products, contain but few eggs, and these in a very backward state; whilst in those organs which furnish principally *female* products, the male products appear to be still less developed than the female products in the first mentioned case.

(6.) The generative organs of an oyster, having young spat in its gills, appear in sections as large vacant spaces. Whilst in such oysters nearly all the eggs had disappeared from the follicles, the male products were much more developed than had been observed in some principally female oysters, during the period that the eggs were still in the follicles. This observation seems to favor the opinion that the same follicles develop first eggs and then spermatozoa. This, however, does not prove that the reverse cannot also be the case.

(7.) The opinion advanced by *Lacaze-Duthiers*, that all the blind tubular acini or follicles of the generative organ, on both sides of the body, pour their contents into a main channel, having an opening on each side near the surface of the body, located under the mantle on the ventral side of the large muscle, rests on a mistake.

(8.) *Rolleston's* and *Robertson's* opinion, that lymphatic vessels occur in Lamellibranchiates, deserves to be carefully examined. There are, in the oyster, vessels, the inside of which is coated with a layer of cells with small cilia. These may be observed especially in both sides of the pericardial cavity. Occasionally specimens are obtained in which they can only be distinguished from the anastomosing vessels, on the internal aspect of which the generative follicles are found, by the greater length of the hairs. In some specimens such a supposed lymphatic vessel, according to the view of *Rolleston* and *Robertson*, may be observed, one side of which is coated with young eggs.

(9.) It is improbable that the organ of Bojanus has anything to do with the emission of the generative products. Nothing is known concerning such an organ in the oyster; but everything which relates to the determination of the anatomy of the generative organs of the oyster, should be carefully observed. It is found on the ventral side of the pericardial cavity and communicates with it through a narrow slit, almost a distinct papilla. In sections of this organ cæcal tubes may be observed, the yellow and peculiarly formed cells of which are highly characteristic.

(10.) It may be considered as *absolutely* certain that the eggs are impregnated by spermatozoids from another oyster; but it cannot as yet be said with certainty whether these spermatozoids reach the eggs at the very moment they are emitted, or whether this takes place in the generative follicles or in some of the vessels. Whenever an oyster has eggs between her gills, all that can be said with absolute certainty is this, that *these* eggs have been produced by *that* oyster.

Dr. *Vasmaer* offered the following report of his observations relative to the natural history of the oyster:

Owing to the nature of the case the following observations can only be regarded as implied by their title, as *a report of my activity*. It would be unjust to look at present for important results.

After having microscopically examined a number of large oysters, in order to get a general idea, I soon became convinced that success could only be looked for from microscopic observations. The method now so much in vogue of making a series of sections or slices, in order to obtain a clearer insight into the structure of the animal, will doubtless throw light on many dark points. Although I am sorry to say that I am not yet able to state where the generative vessels empty, I feel convinced that a series of sections will lead to some certainty in this matter. It is certain, however, that the opinions of *Lacaze-Duthiers* and those who have followed him are not correct.

Firmly convinced that the method referred to is preferable to all others, I have not only made numerous sections of small oysters, which, therefore, in their entirety, could be subjected to microscopic observations, but also of large oysters, cutting thick slices in different directions; and by sketches which I have made of all these cuts, I have been enabled to compare these observations with those made in other specimens and in the usual way. In the first place, as regards the shape and location of the gut, or rather of the entire digestive canal, I found that it is not nearly as uniform as is generally supposed. I, for my part at least, have not seen mention made, in any work, of a different location of this duct. It also seems to me an important circumstance that, as a general rule, the anus is located on the side and not at the end of the duct. A small bag is, therefore, formed at the end of the duct which, in one case observed by me, showed a sort of worm-like appendage.

A series of sections is extremely well suited to give some idea of the relation between the generative organ and the liver. Whilst the generative organ appears to thin out round the liver dorsally, it gradually increases in thickness towards the bottom ventral side; the liver, however, runs, though much narrower, through to the place where the great cavity begins, which contains the heart and the so-called organ of Bojanus. [The liver does not extend to the pericardiac space; this is the case in *Ostrea Virginiana* as well as in *O. edulis*, as may be shown in longitudinal sections.—J. A. Ryder.]

More than once I have had to make injections of the heart and the vessels originating in it, but I cannot say that these attempts have been particularly successful. Of larger blood vessels I could, on the large cuts, only distinguish one (probably the aorta). In view of the fact that there are still strange and conflicting opinions as to the course of the blood vessels, further experiments with injections cannot be too highly recommended. Important conclusions may possibly be drawn from the contraction of the heart, which continues for a long time after the oyster has been opened; at least various questions are thereby suggested, such as whether the motion of the so-called Bojanus organ is voluntary or involuntary? I think I have noticed that the diastole and systole did not take place simultaneously in both portions of the heart, but alternately. I must repeat, however, what I said above, that all these observations bear more or less the character of *suppositions*, which stand in need of further proof.

As regards the method of making preparations, several of those commonly in use have been tried. The hardening by means of Müller's liquid, which in the beginning seemed to promise well, cannot be recommended for fine microscopic cuts.

It will be best to use alcohol of 70 per cent. or of 90 per cent., or pure alcohol, and then to embed the hardened oyster in paraffine in the well-known way; or also picric acid, which takes the lime out of the shell. In this manner small, one-year old (and younger) oysters can be preserved whole.

I need hardly say that it is very important to examine oysters of *various* ages. Special attention should, however, be paid to *young* oysters, and to the development of the generative organs in these. As far as my observations go, exclusively male or exclusively female oysters do not occur. In full-grown, healthy oysters an oval lump of spermatozoa may be observed, surrounded by free eggs placed radially and with great regularity. In comparing perpendicular and other cuts, these eggs appear in close elliptically-shaped groups or lumps, each in a tissue pouch, or several together in one and the same pouch. The eggs are generally attached by a wide base; are granular, and provided with a large, round nucleus and nucleoli. In specimens stained with fine picrocarmine the difference between the nucleus, with its appurtenances—*sit venia verbo*—and the egg-cell itself can be very distinctly observed. The egg-cell has a brownish-yellow color, and is granular, whilst the nucleus is reddish, and appears to be a homogeneous body. In oysters which have already lost some of their young spat, the empty pouches or hulls may be seen in considerable number. As far as my observations go, I am inclined to think that eggs and spermatozoa do not mature simultaneously. It seems that new generative products may at a later period be developed in the empty pouches. It would be worth the trouble to examine into this matter carefully.

My preliminary observations have convinced me that it is absolutely indispensable to the success of these investigations to make *a series* of sections of oysters of *different* ages and examine these carefully. If during the coming year I am privileged to continue my investigations, I shall principally follow this method.

The investigations relative to *the history of the development of the oyster* are perhaps farther advanced than any other portion of our investigations. They were in charge of Dr. *Horst* and Professor *Hoffmann*. Mr. *Horst* made use of the booth of the zoological station at *Wemeldinge*, described in the first part of our report; and his observations were so successful that he was enabled to prepare a brief review of the embryology of the oyster, accompanied by the necessary illustrations. This review is too extensive, however, to be embodied in this report, as a whole, and we shall therefore give its principal features in brief outline.

It is particularly difficult to obtain the necessary facts relative to the first stages of the development of the oyster; and it is hoped that next year's observations will supplement those of the present year. The principal difficulty lies in the circumstance that, as a general rule, more female (mother) oysters are found with old than with quite young brood. There is no doubt that, in their general features, the first stages of the development of the oyster-egg resemble those of other bivalves. The result of the first stage in the process of development is, that the lower (*vegetative*) pole of the egg is formed of a large granular cell from which the *entoderm** (and *mesoderm?*) develop, whilst on the upper (*animal*) pole numerous smaller cells may be observed which furnish the material for

*I have retained two terms, which are not found either in Webster's Dictionary or in Dunglison's Medical Dictionary, and which—not being Dutch, but Greek—will be the *ectoderm*. The last-mentioned cells gradually grow all round the vegetative cell or sphere without however inclosing it entirely. Afterwards these cells also begin to segment, and a layer of cylindrical cells is formed, which is slightly invaginated or pushed inward at one point and which forms the *entoderm*.

About the same time a crescent-shaped groove is formed at the other pole of the egg by an invagination or pushing inwards of the entodermal cells (erroneously called the gastrula mouth by former investigators), from which the shell-gland is developed. Soon after this we see the formation of the primary intestinal channel by a further invagination of the entodermal surface. Back of the opening of the mouth a few large cells make their appearance, which must probably be considered as the first mesodermal cells. The shell-gland has now assumed the shape of a deep little bag, the wall of which is composed of large cylindrical cells. The portion of the ventral side located below the mouth projects considerably during the succeeding stage, so as to form a sort of foot, as in the embryo of the snail.

During the further growth of the embryo the entoderm develops into a spacious stomach cavity, with a sac-like appendage, which later forms the end of the intestine, but which is still closed; the gastrula mouth becomes the permanent mouth. The ectoderm is now lifted up from close contact with the entoderm and in this way the body cavity is developed. The invagination of the shell-gland has meanwhile disappeared almost entirely by an inflection of its margin. Its place is now occupied by a thickening of the ectoderm, consisting of long conical cells. These cells develop a thin membrane, which is the first trace of the shell, from which it appears that the bivalvular shell does not originally appear as such, but that the shell begins to form as one piece. Above the mouth a circlet of vibratory filaments begins to make its appearance, which later forms the *velum*, the organ of motion of the larva.

During the succeeding stage the shell rapidly increases in size, and almost entirely envelops the larva; the *velum* becomes more clearly defined, and in the center of the velar area, encircled by its ciliary ring or crown, a thickening of the ectoderm (velar plate) begins to make its appearance. A funnel-shaped gullet forms the entrance to the pear-shaped stomach, whilst the hinder portion of the intestine develops an opening communicating with the outside.

By the appearance of pigment at different points of the body of the larva (velar plale, gullet, stomach) the *white spat* assumes a dark gray color and becomes *black spat*. On both sides of the intestine muscles begin to develop, running downward from the hinge, by means of which the head part, which protrudes from the shell, can be drawn in; and like the abductor muscle, which connects the left and the right valves of the shell and closes them, the former are also developed from mesodermal

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easier understood, if given in the original, than if a translation had been attempted: "*entoderm*," "*mesoderm*." The similar term "*ectoderm*" is found in Webster, but not in Dunglison.—TRANSLATOR.

cells. The *velum* now appears as a double row of long threads, which surround a vaulted surface, and in the center of which lies the velar plate or thickening, which projects outwardly, and consists of several layers of cells; from this the pharynx* (mouth) arises at a later period. The intestinal channel has meanwhile increased considerably both in length and width; the stomach has been divided by a constriction into a lower and upper portion, and the intestine arises from the line of junction of the two. The anterior portion of the stomach develops on the upper side a large round sac, the rudiment of the liver; the whole intestinal channel is coated internally with fine ciliary filaments, with the exception probably of the hepatic protuberance. On the ventral side of the larva, in nearly the same place where formerly the so-called "foot" was located, a knob-shaped enlargement of the ectoderm begins to make its appearance, which is probably the rudiment of the pedal (parieto-splanchnic) *ganglion*.

Older stages than those on which the above observations were made have not been examined. In order to recognize very young oysters which have just adhered to an object, a glazed tile covered with pure lime has been successfully substituted for the usual collector (stone tiles covered with a mixture of lime and sand); on such a collector an oyster measuring only 0.57 millimeter could be distinctly recognized with the naked eye.

In conclusion Dr. *Horst* gives some information relative to a presumed enemy of the oyster spat. He says that in his aquarium, which contained a female (mother) oyster, which every now and then emitted large quantities of spat, there were also a number of actinia (sea-anemones). The quantity of oyster spat decreased visibly without his being able to discover the cause, until one day he saw bluish-gray pellets, measuring but a few millimeters, come out of the mouth of an actinia. These pellets appeared to consist exclusively of empty oyster shells of the most diminutive size, and therefore showed that the actinia had been feeding on oyster spat.

Professor *Hoffmann* makes the following report on his investigations: During the second half of July he occupied himself with some investigations relative to the development of the oyster. The great heat during July, by which the temperature in the wooden shed rose to 94°, made it impossible to steadily continue the observations.

The first stages of segmentation were not observed, whilst full observations, both on optic and actual sections, were taken during the gastrula stage. The *gastrula*† does not belong to the hollow, but rather to the

* The Dutch word "*bovenslokdarmknoop*" is not found in any Dutch dictionary. Mr. Ryder has rendered it as the rudiment of the mouth or pharynx.—TRANSLATOR.

† This word is not found in Webster's English nor Dunglison's Medical Dictionary. The words *coelogastrula* and *sterrogastrula* are translated hollow and solid type by Mr. Ryder. These are words of little consequence, except as descriptive of different conditions of development of the body cavity. All mollusca nova appear to pass at first through a sterrogastrula stage, followed by a coelogastrula condition.—TRANSLATOR.

solid type. The cells of the mesoderm, whose origin I cannot state with absolute certainty, but which appeared to me to be a product of the entoderm, do not form a continuous sheet or leaf, but begin to be differentiated at a very early period into embryonic muscle and connective tissue. The præconchial invagination begins to make its appearance at a very early stage, the cells of the ectoderm being distinguished by their high cylinder-shaped appearance; the shell therefore belongs to a very early embryonic formation; in young oysters the post-larval shell of which has already formed, the embryonic shell can still be very distinctly observed. Full information as to the results of my observations of oyster embryos, made principally on cross-section, are at the disposal of the Commission, in case they should desire it for their final report.

As regards the investigations relative to *the young oyster, after it has settled*, Dr. *Hubrecht* writes: "The time which I spent at the station in June was almost wholly devoted to the regulation of the physico-meteorological observations, the prelimary results of which will be published in full at some future time. On my return, in August, we made a distribution of the work assigned to us, and I was commissioned to occupy myself with the oyster larvæ and their settling on the tiles, but was much delayed in my work by the long-continued unfavorable and cold weather. Regular observations were out of the question during this month, the season of the settling of the oyster spat having been brought on prematurely by the hot weather in July. I was therefore obliged to abandon the task which I had set myself for this year, and devoted all the time I could spare from the physico-meteorological observations, to the study of the anatomy of the oyster, more especially of those points on which the opinions of scientists differ very much, and where there are still important gaps in our knowledge, viz, the heart with the pericardium, the organ of Bojanus, and the channels through which the generative products are emitted. I made numerous microscopic sections of one to three year old oysters; but these results of these observations I shall reserve for our final report, because it will require the uninterrupted observations of another summer, to bring this investigation to a satisfactory close."

Dr. *Van Rees* writes regarding his observations on the radius of distribution of the oyster spat and the conditions under which they settle, as follows: "Whilst at the zoological station during the second half of June I noticed the forerunners of the oyster spat. To my great regret I was not able to be in *Bergen op Zoom* during July and continue my observations at that place. When I returned during the last days of July, I noticed that a great deal of spat had settled. By fishing in different places I found, however, numerous oyster larvæ swimming about in the water, which could be kept alive for several days in sea-water contained in wide, open glass jars. In fishing I used the tow net in the manner in which I had seen Professor *Weismann* use it in the Lake of Constance. The tinned iron hoop of the net is furnished with a long, free bag of very fine gauze, weighted with a stone or a piece of lead, the net is let down to a limited depth, and left under water a shorter or longer time—say 5 to 10 minutes—according to the force of the current and the swiftness of the boat. Even at a moderate rate of speed the net tightens, and everything which floats into it is retained by the fine meshes. A piece of wire-grating closes the opening of the net to larger objects. Drawing it carefully out of the water it is turned inside out into a wide glass jar with fresh sea-water. After having, by microscopic observations, obtained a general idea of the various animal forms contained in the water, it is not difficult to distinguish them from each other, with the naked eye or with a magnifying glass, particularly by their different motions.

"During my first experiments with the above described net I found it to be extremely well suited to my purpose. This was, in the first place, to find the proportion of oyster larvæ floating near the surface, in deeper water, and immediately above the bottom, at different times, and in as many places as possible. It seemed important to me to get an idea of this proportion, especially in connection with the following considerations.

"The swiftness with which the oyster larva moves about by means of the thread-like apparatus, is very insignificant as compared with the swiftness of the current of the tide when coming in or going out. As regards the radius of distribution of the oyster spat, it is entirely dependent on the varying swiftness of the current. In the river *Scheldt*, where natural and artificial oyster beds are scattered all over the river, oyster spat is probably floating about everywhere as soon as the time has arrived for the spat to become detached from the mother oyster. Whether oyster spat will settle more freely in one place than in another will, therefore, depend not so much on the radius of distribution of the oyster larvæ of this or that oyster bed as on the peculiar conditions of the current. It is, therefore, in the first place, necessary to learn to know the swiftness and direction of the currents in the principal portions of the river *Scheldt*, and it is consequently a matter for which we are very thankful that the minister of public works has given his support so freely to this part of our observations. A thorough knowledge of the currents, combined with practical experience, will give us a better insight into the reason why certain localities are better adapted to the settling of the oyster spat than others. In studying this subject, special attention should be paid to the manner in which the oyster larvæ are distributed over the different depths of water, as unfortunately but little is known at present concerning this important matter. Although their organs of motion do not enable them to go any great distance—which, moreover, is not essential to their distribution—these organs, nevertheless, furnish them with an entirely satisfactory power of rising and sinking, and of keeping themselves afloat in the water when it is not violently agitated. In connection with the conditions of current and temperature, the distribution of the larvæ in the water is a question of primary importance.

"It was a grievous disappointment to me that I had to let the greater portion of the month of July go by without making any observations in this direction; and as the weather during August was exceptionally unfavorable, I could not make up for time lost in July. Spat fell during all of this month, but regular observations at favorable points had become absolutely impossible. During the coming summer I hope to be able to devote my undivided attention to the distribution of the oyster larvæ."

On the PHYSICO-METEOROLOGICAL OBSERVATIONS in the Eastern *Scheldt* during 1881, the following report was offered by Mr. *Hubrecht*, who had been assisted in his work by Mr. *van Kervel:*

As soon as possible after the Commission of the Zoological Station had, at their meeting of March 10, resolved that the observations of the oyster cultivation (and subjects connected therewith) in the Eastern *Scheldt*, should also be extended to the condition of the water, its temperature and density, as well as the nature of the currents in the *Scheldt*, which might exercise an influence on oyster cultivation, the commission opened negotiations with Prof. *C. H. D. Buys Ballot*, of *Utrecht*, Director of the Meteorological Institute. To his kind aid and the friendly assistance of Dr. *Maurits Snellen* we owe the knowledge of various imporant facts as to the best manner and time of taking observations, and of a peculiarly arranged areometer, which was manufactured under the supervision of Dr. *Maurits Snellen*, and which deserves the preference over other areometers which we tried. To these gentlemen we herewith express our best thanks.

From the very beginning we felt convinced that, on entering a field in which none of our number felt at home, we ran great risk of making mistakes and of drawing erroneous conclusions, if we did not call in the aid of competent persons at the right time. It soon became evident that the observations on the current would not only require theoretical knowledge and technical experience which we did not possess, but would also involve considerable expense, which our treasury was not able to bear. These difficulties, however, would only deter us from making the desired observations if it should appear that we could not have the help of competent persons. Our hope that the minister of public works would allow the expenses of these observations to be borne by his department was not put to shame, and by a letter from him, under date of August 26, 1881, we were authorized to enter into an arrangement with the chief engineer of Zealand. Thanks to the kind assistance of this officer and of the district engineers stationed at *Goes* and *Zierikzee*, we had a preliminary conference on the subject, where we had an opportunity to state the ideas which led us to the supposition that there must be some connection between the settling of the oyster spat in certain localities and the local currents in such places, and to submit them to the greater experience of these gentlemen who were better acquainted with the Eastern *Scheldt*. After we had consulted with these gentlemen as to the best way of making the desired observations, and had visited various points on the Eastern *Scheldt*, on the 16th of August, with them, we felt that we must no longer trespass on their time, when (as mentioned above) we were gladdened by the letter from the minister, during the latter part of August. We intend to embody the results of these investigations in our final report as soon as they have been communicated to us. It is hardly necessary to say that, as long as we are not in possession of these results (we hope to receive them during the first months of the year 1882), no connection can be traced between them and the facts mentioned in this report, and that we cannot attempt to draw up a plan for the observations to be taken on the oyster beds during the following years, but that nevertheless we may entertain the hope that we may come to know *some* of those general laws which govern the distribution of the oyster in this and other localities.

We have still to report our observations on the temperature and density of the sea water. Prof. *Buys Ballot*, Director of the Meteorological Institute, told us that, if such observations taken at different points of the *Scheldt* were to be really valuable, they must be taken three times a day, at high water, low water, and at 2 p. m., by the sun-dial, when the heat of the sun is supposed to have exercised its most powerful influence. In reporting such observations it should also be mentioned what the state of the weather was at the time, as rain and wind may have a considerable influence on the temperature and density of the sea-water.

As regards the areometer above referred to, and manufactured at *Utrecht* by Mr. *Olland*, Prof. *Buys Ballot* advised us to get in addition one of the large areometers which are used by the German "Commission for the investigation of the German waters" in the German Ocean, and which are fully described and highly praised in their official report. The relative value of these different instruments could, however, only be ascertained by practically testing them in the observations which we had before us. Mr. *Steger*, of *Kiel* (Germany), furnished us this instrument as well as a set of areometers, which had also been recommended by the German commission. In using these instruments it has been found desirable to make some slight modifications, which were made by the engineer of the torpedo service No. I.

Prof. *Buys Ballot* also advised us to use the maximum and minimum thermometers according to the *Negretti* and *Zambra* system. As the water in the Eastern *Scheldt* is, comparatively speaking, not very deep, he thought it would be sufficient to observe the temperature of the water in the areometer, provided it is sufficiently thick and is drawn up quick enough not to allow any considerable quantity of sea water from higher layers to flow into it.

In conclusion, we must mention that through Mr. *W. Leemans*, engineer, we obtained from the ministry of public works the loan of an iron areometer, which was subjected to a comparison with the above-mentioned instrume ts, and which was used in the observations made at *Tholeu*, of which we shall speak later.

We also employed a number of thermometers and areometers from the firm of *Kipp*, at *Delft*, likewise with the view of obtaining a knowledge of the instruments most suitable for our purpose.

This will suffice to give an idea of the *instruments* with which we operated, and we will only briefly refer to the *method* pursued in our operations during the past summer.

Thanks to the friendly assistance of the minister of marine, we got the promise of co-operating with us from Mr. *J. F. van Kervel*, retired lieutenant, 1st class, Netherlands Navy, and during the course of the summer we had ample opportunity to experience the great value of his services. From his former occupation, more familiar than any of our number with the use of physical and meteorological instruments, he was ever ready not only to give his advice regarding the most profitable way of making observations and the conclusions which might be drawn from such observations, but also to give his personal aid whenever he thought that his presence at any of our stations of observation might be of use in furthering our object. Also in August, when, through the kindness of the minister of war, we obtained the use of one of the steamers of the torpedo service at *Brielle* for two weeks for the purpose of making observations on the Eastern *Scheldt* (see the private report on the subject), it was Mr. *van Kervel* who, in spite of the extremely unfavorable weather, gave his personal aid and attention to these observations. We herewith express to him our warmest thanks, and the hope that in the future we may count on his co-operation, without which our progress on this (to us) strange field would be considerably delayed, if not entirely stopped.

The method and object of the last-mentioned observations were as follows:

(1.) To ascertain to what modifications the temperature and saltness of the sea water in the Eastern *Scheldt* is subject:

a. At different times.

b. At different depths.

(2.) To ascertain if these modifications are everywhere apparent to the same degree, and also if there is a noticeable difference in this respect between banks which are deep under the water and those which are occasionally dry.

(3.) To ascertain whether there is any connection between these modifications and the phenomena of the current, as far as they have been observed by the engineers of the Department of Public Works.

(4.) To find whether there is any connection between the settling of a greater and smaller quantity of oyster spat and the following:

a. The nature of the bottom.

b. Phenomena of the current.

c. Changes in the temperature of the water; and,

d. Changes in the density of the water.

These four points, which are here given in the order in which the difficulty of their explanation increases, give an outline of the problem, the solution of which we are seeking. The fourth point at the same time indicates what results long-continued and carefully made comparative observations may possibly lead to. These results, however, will, in our opinion, not be reached in the near future, although we feel convinced that any positive results in this direction will not only be of importance to oyster culture in its present state, but will also serve as a guide in exploring other localities, where in former years profitable oyster fisheries were carried on, which at present have entirely disappeared.

From the causes already referred to we are still less able to return an answer to the question mentioned under No. 3. Our observations of the temperature and density of the water are as yet not numerous enough, and in some respects not reliable enough, to justify us in basing upon them comparisons such as are there indicated. The observations with which we have been occupied during the past summer are principally those mentioned under Nos. 1 and 2. As has been said before, we were obliged not only to determine the respective value of our different instruments, but also to endeavor to arrive at some definite result as to the manner in which *long-continued* observations of this kind should be regulated—who should take such observations, and how they should be taken. Knowing that we could only spend a few short summer months in the localities where the observations must be taken, and fully aware of the great importance of obtaining full data also from other seasons of the year (especially autumn and spring), we made inquiries of a number of oyster cultivators, whether among their employés suitable persons could be found who would permanently take charge of these observations, and thus furnish us with the desired data. From different parties we obtained highly valuable aid in this respect. In the first place we must here mention Mr. *Wagtho*, of *Tholen*, who took observations during the whole summer, and still continues to do so; furthermore Messrs. *F. Leo de Leeuw*, of *Wemeldinge*, *C. L. de Meulemeester*, of *Bergen op Zoom*, and the watchmen of the firms of *Hagan & Brand* and *Bolier & de Groot*. All of their observations, taken during the past year, have been tabulated, and will be appended to our first report in that shape. We shall, as a matter of course, in continuing these observations, have to rely on the active co-operation of the oyster cultivators. The importance of their aid cannot be overestimated, and the results of such observations will undoubtedly gain in value, if based on a broad basis of facts, carefully and patiently gathered during a long period of time. We hardly need say, that the establishment of such stations of observation goes beyond the financial means of the Zoological Station. Private enterprise should therefore share this burden with us.

The daily observations, which, as has been mentioned, are taken three times a day, are transmitted to us, and entered on specially-prepared forms. From these forms it will appear that the observations were not only taken at certain regular hours, but also at a uniform depth, which, at low water, was still 3 meters under the surface of the water. We thought that thereby we should increase the value of these observations for drawing comparisons.

Besides this series of observations, which were in part at least entrusted to subordinates, Mr. *van Kervel*, during August, took a number of observations, with a view to obtaining the greatest possible degree of accuracy, by thus controling the observations taken at *Tholen*, *Wemeldinge*, &c. These observations were unfortunately somewhat limited by the exceedingly unfavorable condition of the weather. We deem it important to give the results of these observations in their entirety, as, in our opinion, furnishing important hints as to the method to be followed in future observations on the Eastern *Scheldt*.*

Mr. *van Kervel* adds the following remarks to this table:

"It is somewhat surprising that out of more than 30 careful observations from which the table has been prepared, the difference of temperature between the bottom and surface water is so small, compared with the difference, observable in this respect, in the observations taken at *Tholen* and *Wemeldinge*."

We shall have to ascertain, by further observations, whether these differences are caused partly by the presence of a larger quantity of marsh water, and partly by the main current of the Eastern *Scheldt* which at *Wemeldinge* flows close to the bank.

The figures given in said table furnish ample food for thought; they prove that, at the time when these observations were taken by means of excellent instruments and with the greatest care, the differences of temperature at various points of the Eastern *Scheldt*, between the bottom and the surface, were very small and in some cases hardly noticeable.

The water in the deep places and that in the shallow places does not show any considerable difference of temperature, whilst there was a great difference in the depth at which the observations were taken, this difference ranging from 2 to 21 meters.

This important result will, during the coming year, be made the subject of new and careful observations, taken as frequently and in as many places as possible. If this preliminary result seems to be confirmed, this will prove that there is no need of so many stations of observation on the *Scheldt* as we had imagined in the beginning, and that, if only a good point of observation has once been selected, additional observa-

*See table at the end of this paper.

tions of the bottom temperature may not be needed for drawing up an exact table of the changes of temperature to which the water on the oyster beds is subject.

The observations relative to the saltness of the water will, during the coming year, be brought into a more definite relation to the results of the observations on the current taken by the engineers.

The two series of observations, both those on the temperature and those on the saltness of the water, should go on simultaneously with investigations as to the quantity of oyster spat, not which settles on this or that oyster bed, but which is found in given portions of the water of the *Scheldt*. We do not conceal from ourselves the great difficulty of investigating this latter point, but we feel convinced that this will be the most certain way of obtaining really reliable results. During the course of the winter we propose to study out a method by which such investigations could be made. The experiments in that direction made in 1881 have not yet led to results definite enough in their character to enable us to make a final decision as to the best method of carrying on these observations. Simultaneously with these investigations careful observations should be taken of the quantity of oyster spat found on the different beds during the year, not only on the so-called "tile beds" (where tiles are employed as collectors), but also in different parts of the eastern *Scheldt*.

We have been informed by many persons of experience in these matters that circumstances of a local character (still water near the main current, the emptying of two currents, as at the *Eendracht*, deep holes in the bottom, &c.) are considered to have great influence on the settling of the spat; and this also formed the starting point of some of our consultations with the engineers in regard to observations on the current. We shall refer to this matter more fully in our final report; here we will only mention what has been communicated to Mr. *van Kervel* relative to the settling of spat on those portions of oyster beds where his observations were taken. (See the *table*.)

(1.) The portion of lot 324, near the pit or hole, is considered to be very favorable to the settling of oyster spat, especially near the edge (more particularly the northern edge), and also along the upper portion of the steep walls of the hole.

In the deep portion of the hole very few oysters are found. (See *table*, column of observations, relative to the nature of the bottom). On the portion of lot 324, referred to, no oysters are planted.

(2.) Oyster spat settles very freely south of the "*Laagte*."

(3.) Oyster spat settles in considerable quantities in the northeastern portion of lot 267, and seems to flourish better there than in the northwestern portion of lot 266.

(4.) Also in lot 231 and in its vicinity oyster spat is said to settle very freely.

(5.) It is well known that large quantities of oyster spat settle in the

"*Eendracht*," from some distance north of the *Vosmeer Ferry* to the so-called "*Nachtegaal*"; this applies especially to the whole of lot 38 in the "*Nachtegaal*."

In the above we have endeavored to give a brief sketch of our past and our future activity; and the reader will thereby get an idea of the slow progress of our investigations, chiefly owing to the circumstance that so far no definite way whatever has been marked out for us. An investigation like the present requires time and patience, especially in the beginning; it is certain, however, that as we begin more and more to reach the firm basis of reliable observations we shall be able to report more rapid progress. Once more, briefly put, the questions which we must have steadily in view are these: What influence do the temperature and saltness of the water have during the period when the larvæ are passed from the mother oyster? Which way does the spat travel when passed from the mother oyster, and in what manner is this way determined by circumstances directly connected with current, temperature, and saltness, and how can it be controlled by means of these data? What influence do these same circumstances exercise on the full-grown oyster.

As regards the study of those animals which live on the same beds as the oysters, as their enemies, parasites, friends, or messmates, we have to present the following reports:

I. INFUSORIA.—(Report by Dr. J. van Rees.)

With regard to those infusoria ciliata, which I observed near the oysters, I shall for the present confine myself to the following short notice. The fauna of the brackish water of the *Scheldt*, in general, differs but little from the fauna of the North Sea, as far as I have learned to know it at the *Helder*, *Flushing*, and *Nieuwediep*.

Besides some few forms described by *Claparède*, *Lachmann* and *Stein*, a few of those varieties were found which *Cohn* has observed in the water of the Baltic, and a description of which he has published;* but his description is far from systematic, and leaves much to be desired, especially as regards the illustrations.

Among the forms of infusoria which I observed, there were the following:

Of the group of the HALOTRICHÆ: a few small varieties of *Lacrymaria*, *Amphileptus* and *Leionotus*; (*Amphileptus meleagris Cl. Lachm.*, which I had found in the *Helder* as a parasite on *Carchesium polipinum*, did not occur here) also *Glaucoma scintillans*, *Cyclidium glaucoma*, and *Cyclidium elongatum Cl. Lachm.*, erroneously called by *Cohn* with a new name, *Limbus velifer*. Concerning this last-mentioned kind I must say that they do not have *one* but *two* pseudo-membranes consisting of very fine cilia, which extend from the front part of the animal to the outer side of the little oval mouth.

* "*Zeitschrift für Wissenschaftliche Zoologie*," Vol. XVI, 1866.

Of HYPOTRICHÆ I found *Chilodon cucullulus* a few varieties of *Ervilia* and *Dysteria* (not quite the same forms which I observed on the coast). Related to these there is another form, also new in our fauna, and which is principally distinguished by dark grains of pigment scattered irregularly all through the body, and found in unusually large masses in a certain place close under the surface, and only covered with a strongly convex somewhat broad elevation of the *ectosarc** entirely free from grains, which doubtless answers the purpose of a lens. This variety is moreover distinguished by an unusually wide and perfectly straight esophagus.

Among the few ASPIDISCÆ I noticed *Aspidisca limbifera* which I had also observed in the *Helder*, and which is distinguished by a fine wavy hem running along the right side and round the edge of the back part.

Of the EUPLOTES I found here, as well as near the coast, a variety closely related to Stein's *Euplotes harpa* (from the Baltic), and distinguished from this one principally by a more regular inner edge of the peristome ("*Stirnrand*" of Stein). Just as in the coast-waters I again found two sizes of this variety closely resembling each other, and but few intermediary stages. Of *Euplotes longipes* Cl. Lachm., recently described by me in an article, "*Zur Kenntniss der Bewimperung der Hypotrichen Infusoriën*," I found large numbers. I likewise found Stein's *Uronychia transfuga* resembling the *Campylopus paradoxus* of *Claparède* and *Lachmann.* On account of its restlessness this variety presents unusual difficulties to the observer. It is my opinion, however, that all three varieties belong to the same genus (*Uronychia*).

Of the genus STYLOPLOTES, which is related to the EUPLOTES and URONYCHIÆ, I found, besides *Styloplotes grandis mihi* (also described in the above-mentioned article), and a small variety which I had noticed in *Nieuwediep*, a third kind, but only in small numbers.

Besides some small OXYTRICHINÆ I also found the beautiful *Oxytricha saltans* (*Actinotricha saltans, Cohn*), which immediately strikes the eye by its four strong adoral ciliary plates. I also noticed some varieties of the group STICHOTRICHA and UROLEPTUS, amongst the rest the *Oxytricha auricularis* Cl. Lachm., but, as on the coast, in very small number. *Cohn's Oxytricha flava*, which does not belong to that group, but rather to that of UROSTYLA, of a beautiful orange, red, or brown color, was also found here, but not in as large numbers as in the sea. *Cohn*, in his illustrations, does not show the proper distribution of color on this animal; the color is exclusively found in small but very distinct little balls or bags, which refract the light, and are arranged in rows. The very rapid changes of form to which this animal is subject, make it very difficult to make accurate observations of it.

Of the group of PERITRICHA I found only a few forms, a few varieties of the genus *Vorticella* and *Zoöthamnium*, the same as on the coast.

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* *Cf.* foot-note on p. 6. The same remark applies here as to *entoderm* and *mesoderm.*—TRANSLATOR.

Vaginicola crystallina Ehbr., and *Cothurnia nodosa* Cl. Lachm., besides a large number of intermediate forms, were also very common. Besides these I noticed a *Strombidium* and the elegant *Halteria pulex* Cl. Lachm. (without any good reason called *Acarella siro* by *Cohn*).

Of HETEROTRICHÆ no trace could be discovered.

As my knowledge of a number of important varieties is still very defective, I hope that another prolonged visit to the *Scheldt* will enable me to fill many gaps.

II. SPONGES.—(Report by Dr. *G. C. J. Vosmaer.*)

In the beginning of July, when I had not yet begun my work at the station, Dr. *R. Horst* wrote me, that at *Yerseke* he had found on the so-called collectors a large number of calcareous sponges. Thanks to his forethought I am now in possession of a large number of them. When later in the season I searched for sponges at *Bergen op Zoom*, I found in Mr. *de Meulemeester's* pits the same kind which I recognized as *Sycandra ciliata* (trans. var. *coronata*), according to *Haeckel's* terminology. In examining a large number of specimens, among them some very large ones (up to 80 millimeters) I became doubtful whether *Sycandra ciliata H.* and *coronata H.* can be considered as two different species, and whether they should not, as in former times, be looked upon as two varieties of one and the same species. The circumstance that I had to class all the specimens which I examined, under the "transitory variety," seems to speak strongly in favor of the last-mentioned opinion. I hope to continue my observations with the view of forming a definite opinion on this subject. To whatever kind these sponges may belong, the fact that calcareous sponges occur on our coast is entirely new. It is also peculiar that all such objects are found on the lower side of the collectors, and that they therefore *hang* with their osculæ downward.

Another important discovery was that of another sponge belonging to the family of the *Chalinea*, which is probably identical with *Chalinula fertilis, Kell.*, 1880. This sponge, which is likewise new in our fauna, appears as a light brownish-red crust on the oyster shells, especially on the large oysters called "*paardepooten*"="horse-feet." Most of them seemed to come from Lot 250, near *Yerseke*, and some were also found by me in the "*Eendracht*" (Lot 18) near *Tholen.* I hope that I shall be able at some future time to give a fuller account of these sponges.

A kind of sponge, found in many places on our coast, and called by Johnston *Halichondria panicea*—a name which is no longer employed—is also found amongst oysters.

In how far either of these kinds of sponges is healthful or hurtful to the oyster, cannot be determined at the present time.

III. WORMS.—(Report by Dr. *R. Horst.*)

The varieties of worms mentioned below were found on the oyster-beds during the past summer. This list does not, however, pretend to give *all* the species of *Annelida* living on the oyster-beds; for no one had specially occupied himself in gathering specimens of this group.

The most frequent kind was *Nereis pelagica* L., which is very common on our coasts; some specimens wore their remarkable wedding garment (*Epithoken*). But few specimens were found of *Nereis longissima* Johnst., and *Nereis Dumerilii* Aud. & Edw.; two of the latter kind were found in one oyster. The *Phyllodoce* family was represented by *Phyllodoce maculata* Johnst. and *Eulalia virides* Oersted, also found in other portions of our waters. Of the *Polynoë* family I found *Lepidonotus squamatus* L. almost as frequently as *Nereis pelagica*, also *Polynoë impar* Johnst. (*Evarne impar* Malmgr.) less frequent than the preceding, and *Polynoë cirrata* Aud. & Edw. (*Harmothoë imbricata* Malmgr.) I also found a number of very small specimens (only measuring 3 millimeters) of *Pholoë minuta* Oersted, also belonging to this group. *Capitella capitata*, van Ben. repeatedly observed on our coasts, was also found here.

IV. ARTICULATES.—(Report by Dr. *P. P. C. Hoek.*)

The number of articulates which have been observed is very small, and it is certain that it is only a small portion of those which occur here. We will mention the following:

(1.) *Cirripeds.*

Balanus crenatus Brug., very common on oyster shells.

Sacculina carcini Thomps. *Only* found on the lower portion of *Carcinus moenas* L.

(2.) *Arthrostracans.*

a. Lœmodipods:

Caprella linearis Lin. A few specimens of the small variety were found near *Kattendijke* and in the *Eendracht.*

b. Amphipods:

Microdeuteropus Spec.—Probably a new variety; chiefly remarkable on account of its being generally found in the slits of the folds of the oyster shell, between the beard of the oyster, &c.

Gammarus marinus, Leach. Very common near *Bergen op Zoom* found on different kinds of fucus, &c.*

Allorchestes imbricatus sp., Bate. Found near *Wieren*, together with *Gammarus marinus.*

Talitrus locusta Latr. Everywhere between and under the stones in the oyster pits.

. Isopods:

Ligia oceanica Lin. Very common with *Talitrus* along the stones.

*Prof. *W. F. R. Suringar*, of *Leiden*, was kind enough to determine for me three kinds of fucus which are very common near *Bergen op Zoom*, viz, *Fucus vesiculosus*, L., *Fucus platycarpus*, *Thuret*, and *Ozothallia vulgaris*, Dcne (=*Fucus nodosus*, L.).

3. *Thoracostracans.*

a. Macrourans:

Homarus vulgaris Bel. One specimen was found on the *Yersche* oyster bed.

Crangon vulgaris Fabr. Below *Wemeldinge*, in the Eastern *Scheldt*.

b. Anomurans:

Pagurus bernhardus Lin. Found here and there in the Eastern *Scheldt*.

c. Brachyurans:

Carcinus mœnas L. Very common on the oyster grounds.

Hyas coarctatus Leach, var. A dark-red variety with a peculiarly felt-like body was found once.

APPENDIX: *Pycnogonida.*

Pyonogonum litorale, Ström. Some specimens were found near *Kattendijke*, below *Wemeldinge*, and in some other places.

V.—MOLLUSKS.

As has already been said at the end of our private report, only the most common kinds of mollusks are observed here. As relating to this part of our investigation, we give below a letter from the secretary of the commission, dated November 9, 1881, and addressed to the superintendent of the *Scheldt and Zeeuw-stream* fisheries:

LEIDEN, *November* 9, 1881.

To the Superintendent of Fisheries in the Scheldt and the Zeeuw-stream, at Tholen:

In reply to your letter No. 6402, of June 7, 1881, and the one further explaining it, of 12th July, 1881, No. 6482, the Commission of the Zoological Station has the honor to report as follows:

The inquiry addressed by you to the Commission relates to the occurrence of the "Drill"* on oysters imported from *Arcachon* and planted on *Herkingsche* Banks. As you are of opinion that the "Drill" has not been found in our waters till now, you have requested us to make an investigation of the subject, with the view to ascertain whether this animal has been introduced with the oysters referred to, and if so, has of course remained alive during the transportation.

On the 14th July, 1881, I personally visited the *Herkingsche* Banks, in company with one of your officers. Thanks to the kind aid of Messrs. *van den Berg*, who rent several lots on these banks, we were enabled to examine on some of these lots everything which, by means of a scraper, had been brought up from the bottom in our presence. I examined on

* The French word "*Perceur*" is given in the original, no Dutch translation of it having been attempted. Mr. Ryder translates it by this word "Drill."—TRANSLATOR.

this occasion a very large number of oysters, and on none of them did I find the peculiarly-shaped egg-shells of the "Drill"; neither did I find either young or old, living or dead specimens of the animal itself.

We did not continue this investigation, principally because we felt that it would be fruitless. Considering that, even in the most unfavorable case, the quantity of "Drills" is very small, we doubt whether a continuation of this investigation would be of any use. The chance was very slender that by dredging we would find either the animal itself or its young; and, on the other hand, as long as a single oyster and a single foot of ground remained unexamined the circumstance of our not finding any "Drills" would not justify us in drawing any conclusions as to their non-occurrence in these waters.

Such theoretical considerations would, however, not have prevented us from seeking greater certainty on this point by a second investigation, if it had not been for the fact that an accurate investigation of the entire mollusk fauna of our country might involve questions which should be approached with the utmost caution. Supposing we had obtained the absolute certainty that a "Drill" was living or had lived among the oysters planted on the *Herkingsche* Banks, this would by no means prove incontrovertibly that this "Drill" had been recently introduced from the coast of France among Arcachon oysters.

The "Drill" which is referred to in the above is the *Murex erinaceus*, L. The *Murex tarentinus*, Lamark, is, according to some writers, a variety of the same genus, found in more southern seas, the Mediterranean, &c., whilst according to others (among them *Gwyn Jeffreys*, an authority of the first rank), *Murex tarentinus* is nothing more nor less than a full-grown *Murex erinaceus*. This animal is quite common on the coast of France, from the south as far as *Boulogne;* on the coast of Great Britain it is found on rocky bottoms, from the tide line as far as the region of the Laminarians, both on the southern and western coasts of England and Scotland, and on the coasts of Ireland and Wales. This animal has also been repeatedly observed on the eastern coast of England and Scotland, in the mouth of the Thames, near Yarmouth, Scarborough, Northumberland, Durham, in the Bay of Berwick, near Aberdeen, and in the Moray Firth (*Gwyn Jeffreys*). It is also found near Ostend and Blankenberg, on the coast of Belgium, although not as frequently. (*F. de Malsine* observed a live specimen on a ray near Ostend.) As far as the coast of the Netherlands is concerned, *Herklots* says this animal belongs to its fauna, without telling us, unfortunately, where he has observed it. The museum of the Zeeuw Association, at *Middleburg*, possesses a specimen which came from the North Sea. I must also mention, in conclusion, that, according to *Lovén*, this animal is found in the Kattegat, but not farther north, either on the coast of Scandinavia or in the open North Sea. The fact of its having been found near Yarmouth is only given on the authority of the "*Commission zur Untersuchung der deutschen Meere*"—Commission for investigating the German Seas.

As this animal is found in all these different localities, it will not astonish us that it occasionally occurs on the coast of the Netherlands, and, in fact, it is rather surprising that this animal is so rare in our coast fauna. We shall find an explanation of this circumstance by examining the nature of the bottom; the *Murex erinaceus* does not live on a sandy or clay bottom, but shows a decided preference for rocky bottoms. That our oyster grounds have so far been free from this animal, which is so hurtful to the oyster, must in the first place be ascribed to the bottom, and in the second place to their shallowness. We are all the more inclined to embrace this opinion when we remember that the Zeeuw oyster grounds for more than a century (*Job Baster*) have been stocked not only with oysters imported from Arcachon (as the oyster cultivators at *Bruinisse* assured me they have worked with Arcachon oysters for several years), but also with young oysters from Great Britain, and that the "Drill" could easily have been introduced from the last-mentioned country. The scattered cases where the *Murex* referred to have been observed on the coast of the Netherlands may possibly have been caused by its having been introduced with other shell fish; if this could be ascertained beyond a doubt, we would possess a proof (although only a negative one) of the correctness of our supposition that the non-occurrence or rare occurrence of the "Drill" must principally be ascribed to conditions existing on our oyster-grounds which are not favorable to the development of this animal.

If we are to have a more thorough examination of the oysters imported from Arcachon (and other points on the coasts of France and Great Britain), and planted on the Zeeuw oyster grounds, with the view to ascertain whether or not the "Drill" is found there, we deem it necessary to answer the following question: "Must the *Murex erinaceus* L., even now be considered as a representative—though a very scarce one at that—of the fauna of the Eastern *Scheldt* and the neighboring waters?" Both for this investigation and for an accurate determination of the localities where natural oyster and muscle grounds are found, an exhaustive examination, from a zoological point of view, of the Eastern *Scheldt* seems absolutely necessary. The matter of undertaking such an investigation will form the subject of serious consideration by the commission.

Very respectfully,

DR. P. P. C. HOEK,

Secretary of the Commission of the Zoological Station."

The above appendix will, in the opinion of the commission, give an idea of the present condition of the investigation. In said appendix it has been mentioned repeatedly that in our final report, which will be published when the entire investigation has been brought to a close, *all* the results will be given in full, if necessary, accompanied by illustrations and maps.

Tabular statement of observations relative to the density and temperature of the water in the Eastern Scheldt and in the "Eendracht" in the neighborhood of the oyster grounds, August, 1881.

AUGUST 22, 1881.—Wind SW., cool; light showers; clearing weather; temperature of the atmosphere at 12 m. 19.8°C.; low water at Bergen op Zoom about 8 a. m.

Place of observation.	Hour of observation.	Depth of water in meters.	Ebb tide.				Flood tide.			
			Bottom.		Surface.		Bottom.		Surface.	
			Areometer.	Ther. C.	Areometer.	Ther. C.	Areometer.	Ther. C.	Areometer.	Ther. C.
				°		°		°		°
Bergsche Diep, near the black buoy outside the harbor	11.00 a. m. 12.00 m. 12.30 p. m.	2.3 3.1 2.4					1021.1 1021.6 1021.9	 15.8 16		16 15.8 16
Bergsche Diep (Lot No. 336)										
Northern portion of Lot No. 339										
In the pit or hole of Lot No. 324[1]	12.00 m.	12					1022.1	16.8	1022.1	16.6
Northern edge of the pit of Lot No. 324[2]	12.30 p. m.	5					1022.1	16.9	1022.1	16.9
Zilverput (Silver-pit) south of Lot No. 324										
Bergsche Diep (Lot 307)										
In the "Laagte," on muscle lots between Lots No. 306 and 307[3]	10.00 a. m.	1.6					1021.9	16.2	1021.9	16.2
Lot 310, *between* the "*Laagte*" and "*Diep van de Kraaijer*"[4]	11.00 a. m.	3					1022.1	16.5	1022.1	16.5
Lot 267, close to the dike[5]										
Lot 267, farther out in the stream										
Diep van de Kraaijer (Lot 285)										
Lot 231, near Pietermanskreek										
Pietermanskreek (Lot 248)										
Lodijksche gat (Lot 274)	1.45 p. m.	17					1022.3	17.1	1022.3	17.1
Yersche Bank (Lot 226)	2.00 p. m.	4.5	1022.3	17.1	1022.3	17				
Wemeldinge (Lot 470)										
Eendracht, near Tholen (Lot 22)										
Eendracht (Lot 38), the "*Nachtegaal.*"[6]										
Near the Vosmeer Ferry (Lot 445)[7]										

[1] The bottom of the hole clayey and sandy. [2] The edge of the pit covered with shell sand and shell gravel. [3] During the preceding days much rain fell. Whenever the sluices on the south coast of Tholen show marsh water, it flows at the beginning of the flood tide along and over the "*Laagte*." [4] Flood tide currents coming from the "*Lodijksche gat*," and others, coming from the stream north of "*Vogelaar*," meet each other probably near or a little to the south of the "*Laagte*." [5] At low water this place is dry. When the sun shines the flood tide, therefore flows over a considerably heated bottom. [6] At 4.30, when the water had fallen considerably, a three-fourth mile's northerly current flowed with the "*Nachtegaal.*" At 5 o'clock this northerly current was still more perceptible. [7] On the 23d and on the morning of the 24th much marsh water flowed into the "*Eendracht*," especially through the first sluice south of the *Vosmeer Ferry*. At 10 o'clock a weak northerly current could be noticed at *Vosmeer*. At 2.30 it was much stronger; and at 4, when the water was falling, there was a strong northerly current, flowing at the rate of 2 miles.

Tabular statement of observations relative to the density and temperature of the water in the Eastern Scheldt, &c.—Continued.

AUGUST 24, 1881.—Wind SW., quite cool; showery; every now and then rain; temperature of the atmosphere at 12 m., 18° C.; low-water at Tholen about 9.15 a. m.

Place of observation.	Hour of observation.	Depth of water in meters.	Ebb tide.				Flood tide.			
			Bottom.		Surface.		Bottom.		Surface.	
			Areometer.	Ther. C.	Areometer.	Ther. C.	Areometer.	Ther. C.	Areometer.	Ther. C.
				°		°		°		°
Bergsche Diep, near the black buoy outside the harbor										
Bergsche Diep (Lot No. 336)										
Northern portion of Lot No. 239										
In the pit or hole of Lot No. 324										
Northern edge of the pit of Lot No. 324										
Zilverput (Silver pit) south of Lot No. 324										
Bergsche Diep (Lot 307)										
In the "*Laagte*," on muscle lots between Lots No. 306 and 307										
Lot 310, *between* the "*Laagte*" and "*Diep van de Kraaijer*"										
Lot 267, close to the dike										
Lot 267, farther out in the stream										
Diep van de Kraaijer (Lot 285)										
Lot 231, near Pietermanskreek										
Pietermanskreek (Lot 248)										
Lodijksche gat (Lot 274)										
Yersche Bank (Lot 226)										
Wemeldinge (Lot 470)										
Eendracht, near Tholen (Lot 22)	10.45 a. m.	12					1121.8	17.4	1021.7	17.3
	5.30 p. m.	14	1021.9	16.8	1021.8	16.9				
Eendracht (Lot 38), the "*Nachtegaal*"	3.10 p. m.	5					1021.7	17.2	1021.6	17.2
	4.30 p. m.	4.5	1021.7	17	1021.7	17.1				
	5.00 p. m.	3.5	1021.7	16.9	1021.7	17				
Near the Vosmeer Ferry (Lot 445)	1.00 p. m.	5					1021.5	17.6	1021	17 5
	4.00 p. m.	6.5	1021.7	17.2	1021.6	17.2				

Tabular statement of observations relative to the density and temperature of the water in the Eastern Scheldt, &c.—Continued.

AUGUST 28, 1881.—Wind WNW., cool toward noon; clearing weather; temperature of the atmosphere at 12 m., 17.5° C.; high water at Bergen op Zoom about 5.30 a. m.

Place of observation.	Hour of observation.	Depth of water in meters.	Ebb tide.				Flood tide.			
			Bottom.		Surface.		Bottom.		Surface.	
			Areometer.	Ther. C.	Areometer.	Ther. C.	Areometer.	Ther. C.	Areometer.	Ther. C.
				°		°		°		°
Bergsche Diep, near the black buoy outside the harbor										
Bergsche Diep (Lot No. 336)	7.30 a. m.	7	1022.1	16.6	1022.1	16.6				
	12.40 p. m.	17					1022.2	16.7	1022.1	16.9
Northern portion of Lot No. 339										
In the pit or hole of Lot No. 324										
Northern edge of the pit of Lot No. 324	11.00 a. m.	4.5	1022.2	16.9	1022.2	16.9				
Zilverput (Silver pit), south of Lot No. 324	10.30 a. m.	8	1022.2	16.8	1022.2	16.9				
Bergsche Diep (Lot 307)	8.00 a. m.[1]	21	1022.3	16.6	1022.1	16.6				
	1.00 p. m.	9					1022.1	16.8	1022.1	17
In the "*Laagte*," on muscle lots between lots No. 306 and 307										
Lot 310, *between* the "*Laagte*" and "*Diep van de Kraaijer*"										
Lot 267, close to the dike	8.15 a. m.	2	1022.3	16.6	1022.3	16.6				
	12.15 p. m.	0.5					1022.1	17.8		
Lot 267, farther out in the stream	12.20 p. m.	16					1022.2	16.7	1022.1	16.9
Diep van de Kraaijer (Lot 285)										
Lot 231, near Pietermanskreek										
Pietermanskreek (Lot 248)										
Lodijksche gat (Lot 274)	9.15 a. m.	18	1022.3	16.6	1022.3	16.8				
Yersche Bank (Lot 226)										
Wemeldinge (Lot 470)										
Eendracht, near Tholen (Lot 22)										
Eendracht (Lot 38), the "*Nachtegaal*"										
Near the Vosmeer Ferry (Lot 445)										

[1] The observation taken in the ebb-tide current coming from the "*Eendracht*."

Tabular statement of observations relative to the density and temperature of the water in the Eastern Scheldt, &c.—Continued.

Place of observation.	AUGUST 29, 1881.—Wind SW., cool about noon; clear during the forenoon, later cloudy; temperature of the atmosphere at 12 m., 17° C.; high water at Bergen op Zoom about 6 a. m.									
	Hour of observation.	Depth of water in meters.	Ebb tide.				Flood tide.			
			Bottom.		Surface.		Bottom.		Surface.	
			Areometer.	Ther. C.	Areometer.	Ther. C.	Areometer.	Ther. C.	Areometer.	Ther. C.
				°		°		°		°
Bergsche Diep, near the black buoy outside the harbor										
Bergsche Diep (Lot No. 336)										
Northern portion of Lot No. 339	5.00 p. m.	6					1022.2	16.9	1022.1	16.8
In the pit or hole of Lot No. 324	4.30 p. m.	12					1022.2	16.8	1022.2	16.8
Northern edge of pit of Lot No. 324										
Zilverput (Silver pit), south of Lot 324										
Bergsche Diep (Lot 307)	9.45 a. m.[1]	18	1022.3	16.5	1022.2	16.5				
In the "Laagte," on muscle lots between Lots No. 306 and 307)										
Lot 310, *between* the "*Laagte*" and "*Diep van de Kraaijer*"										
Lot 267, close to the dike										
Lot 267, farther out in the stream										
Diep van de Kraaijer (Lot 285)	3.45 p. m.	11					1022.3	16.8	1022.3	16.8
Lot 231, near Pietermanskreek	11.00 a. m.	1	1022.3	17						
Pietermanskreek (Lot 248)	11.15 a. m.	3	1022.3	16.8	1022.3	16.9				
Lodijksche gat (Lot 274)	10.15 a. m.	21	1022.5	16.6	1022.4	16.8				
Yersche Bank (Lot 226)										
Wemeldinge (Lot 470)	2.15 p. m.	16					1022.5	16.9	1022.5	17
Eendracht, near Tholen (Lot 22)										
Eendracht (Lot 38), the "*Nachtegaal*"										
Near the Vosmeer Ferry (Lot 445)										

[1] The observation taken in the ebb-tide current coming from the "*Eendracht*."

XXXV.—OYSTER CULTIVATION IN THE NETHERLANDS.

By Dr. P. P. C. Hoek.*

[From Circular No. 2, 1879, of the *Deutsche Fischerei-Verein.*]

In his interesting work, *Die Austern und die Austernwirthschaft*, Berlin, 1877 (Oysters and Oyster Cultivation), Professor Möbius returns a negative answer to the question, whether the artificial cultivation of the oyster, according to the French system, can be carried on in German coast-waters; and assigns as the principal reasons for his conclusions the unfavorable conditions of tide and temperature.

Many a German reader will, therefore, be astonished to learn that oyster cultivation is very successfully carried on on the coast of the Netherlands. I have recently published a treatise, in the Dutch language on oyster caltivation in the Netherlands, as compared with such cultivation in France, and the unsuccessful attempts in that direction made in England and on the German coasts, and at the request of Professor Möbius, I shall here reproduce, in German translation, that portion of my treatise which relates to oyster cultivation in the Netherlands.

The rise in the price of oysters had produced on the coast of the Netherlands, as in other countries, a system of fishing, which might well be termed plundering or robbing, and the number of oysters decreased very perceptibly in consequence. The *Texel* oyster-beds have been almost exhausted, although a few years ago they enjoyed the reputation of possessing a great wealth of oysters. Thus a whole ship-load of young Texel oysters was sold in 1835 at mark 3.25 to mark 4 (77–95 cents). In 1836, Texel fishermen brought large oysters to Hamburg and Bremen and sold them at mark 1.90 to mark 2.60 (45 to 60 cents); besides these they sold 2,000,000 oysters to Amsterdam merchants at about 80 pfennig (20 cents) a hundred. These oysters were sold in the Amsterdam oyster-saloons at 2 mark (47 cents) a hundred. For a hundred oysters of the same kind 7 mark ($1.66) were paid in 1870, and ten mark ($2.38) in 1875.

When the Dutch Government, in 1870, began to give attention to the subject, the number of oysters had greatly decreased, not only on the Texel oyster-beds, but also on those of the coast of Groningen, Friesland,

*Dr. P. P. C. Hoek, in Leiden: Ueber Austernzucht in den Niederlanden.—Translated by Herman Jacobson.

and Zeeland. After some hesitation the government resolved in the year 1870 to prohibit general fishing on the large Yerseke oyster-bed in Zeeland and on the large oyster-beds in the Lauwer Sea, and to rent out these beds in small portions. This measure was both warmly defended and bitterly assailed. It is natural that a person owning oyster-beds—even if it should only be temporarily—will take much greater care to keep up the value of his oyster-beds, and if possible to increase their value, than fishermen who take oysters wherever they please. These latter will of course endeavor to obtain in the shortest possible time the greatest possible number of oysters, because they feel convinced that every oyster which they leave on the beds will increase the wealth, not of the oyster-bed, but that of the fisherman who comes after them. Many persons, however, viewed the subject from a philanthropic point of view, and maintained that it would be very hard for the "poor" fishermen, who live on the daily result of their fisheries, if general fishing on the oyster-beds were prohibited, because it would require some capital, if ever so small, to rent a portion of an oyster-bed. But regard to the interests of the *entire* population gained the victory, and at the present time, when hardly ten years have elapsed since the introduction of that measure, every one feels thankful for it. In the beginning the rents were not too high even for fishermen of moderate means, especially if they went shares with some neighbors or friends. Thus as early as 1870 some fishermen of Tholen rented portions of an oyster-bed, and did a good business.

But only the Zeeland oyster-beds have recovered from their condition of decadence, and have attained to a formerly unknown degree of prosperity. Oysters are occasionally fished on the *Texel* oyster-beds, but they are so few in number that it is hardly worth the trouble. The Groningen and Friesland beds in the Lauwer Sea have of late years been entirely abandoned, although they afforded good fishing in former times; principally because by the closing of the Reit Diep, a canal which communicated with the Lauwer sea, the Zoutkamp beds in the neighborhood of *Vostmahan* and in the *Dokkuwerdiep* have become entirely worthless.

Besides the oyster-beds which are rented out, there are still in Zeeland some public oyster-beds which do not seem to have undergone any material change during the last few years. The yield of these beds is not the same every year, but in 1875 it was very good.

During the summer months access to the oyster-beds is, at least officially, prohibited. But the police supervision leaves much to be desired, and in 1875 large numbers of young oysters were taken from these beds during the period of prohibition, and were sold to the lessees of portions of oyster-beds for the purpose of restocking their beds.

The rented oyster-beds, however, are the ones which deserve our special attention. This combination of oyster-beds forms the so-called Yerseke Bank in the eastern Schelde, between the coasts of South Beveland and Tholen, and has a surface area of 2,000 hectares (4,942 acres), but only a portion of this area is well adapted to the cultivation of oysters; the remaining portion, the so-called "flat bank" (*platte bank*) has *natural* oyster-beds, and fishing is there carried on with drag-nets. On this bank experiments in oyster cultivation were made as early as 1870. On the whole, the method introduced into France by *Coste* is followed; and consequently there is no exclusively artificial oyster cultivation.

The method referred to consists, as is well known, in catching young oysters and placing them in other portions of the bank where they are not exposed to so many dangers, and where consequently they have a better chance of growing and developing. Only in rare cases do these oysters reach the age of sexual maturity; for the following years recourse must therefore be had to the original oyster-beds. I will, in this connection, briefly describe how young oysters are taken and to what further treatment they are subjected.

In places where oysters are found and which are not too deep, different objects are thrown here and there into the water in the beginning of summer, with the view of offering to the young oysters a suitable surface to which they may cling. The places most favorable to this purpose are those in which, when the tide is out, enough water remains to allow the objects to which the oysters adhere to remain under water at all times. In the beginning a great variety of articles was used for this purpose: dishes covered with cement, milk-pans, sugar-bowls, and during the very first year 20,000 tiles covered with cement. It soon appeared that these tiles were best adapted to the purpose in view, but in the beginning the attempts to loosen the oysters proved unsuccessful in many cases, as many of the tender shells broke during the process. With the view of remedying this evil the tiles are at present covered with a crust of cement several millimeters in thickness, which can easily be removed, leaving a small piece of cement adhering to every oyster when loosened from the tile. As soon as the winter is past the collectors are removed from the bank and the young oysters are taken off.

The number of young oysters adhering to one collector (*e. g.*, a tile) differs of course very much. In 1875 the average number per tile was 25; this, however, was an exceptionally large number, for on an average there are not more than ten oysters to a tile. After the young oysters have been loosened from the tiles, they must be scattered in suitable places so that later they may easily be found again. In this way a portion at least of the young oysters are treated, viz, those which have attained a certain degree of hardiness; the remainder are placed in specially prepared boxes, some of which are placed on the banks, and others in the parks. These boxes rest on piles, and their top and bottom are covered with a wire grating; inside there is a partition likewise formed by wire grating. In these boxes the young oysters are protected from crabs and other enemies, whilst the water has free access and supplies all the food required.

The oyster parks or ponds are specially intended to protect the young oysters from the cold of winter, which is very hurtful to young oysters, especially when they are in shallow water. In his work (referred to above) Professor Möbius enters very fully into this question, and it is therefore not necessary for me to dwell on it any more.

Oysters which have been treated in the manner above described are ready for the market in the second year. It is but natural that only a portion of the young oysters which have been scattered should grow up and become fit for the market. The firm of Meulemuster & Co., in Bergen op Zoom, which owns one of the largest establishments for oyster cultivation on the Yerzeke Bank, forwarded between 2 to 3 millions of oysters to the market in 1875. This number was the result of 12½ millions young oysters placed on the bank during the season 1873–'74. About 70 per cent., therefore, had perished,* partly through the low temperature, but partly also by the numerous enemies of the oyster, prominent among which is the star-fish. In 1876 the same firm sold 2 millions oysters, which in the beginning of the season brought 80 marks ($19.04) a thousand, and somewhat later 100 marks ($23.80). These figures will convey an idea of the extent of the oyster business done by this firm. The total number of oysters which came into the market from these rented oyster-beds in 1875 was about 30 millions. From the official reports of the Netherlands Commission of Sea-fisheries (from which the above figures are taken), we are enabled to get the exact number of oysters which, in 1876, were furnished by the *natural* and *artificial* oyster-beds in the Zeeland waters (viz, 36 millions), but it is impossible to ascertain how many were furnished alone by the artificial beds. In 1877 the yield was not quite 10 millions, whilst in 1878 it was much larger. The market price in 1877 was, in the beginning of the season, 135 marks ($32.13), and somewhat later 160 marks ($38.08) a thousand. Good and bad years alternate, as in most other branches of industry. The peculiar feature of the oyster cultivation, as carried on in the Netherlands, is this, that two years ahead it can be ascertained with a tolerable degree of probability whether the oyster harvest will be a success or a failure. In 1877 a large number of young oysters were placed on the banks, and the winter 1877–'78 was a mild one, so that in all probability 1879 will be a good oyster year. The demand for Dutch oysters,

* It is said that in France about 80 per cent of the young oysters become fit for market. This seems to be owing to the circumstance that in the French oyster establishments the oysters, which have adhered to different objects in autumn, are not taken off in spring, but are allowed to cling to the collectors for a whole year. In employing this method twice the number of tiles is required, therefore a larger working capital. Last year (1878) attempts were made in the Zeeland oyster establishments to introduce the French method in the eastern *Scheldt*, and, as it seems, with good results.

especially in Germany and England, is so unlimited, that even in the most favorable years a good price can be obtained.

The above will, at any rate, furnish sufficient proof that oyster cultivation, according to the methods described, can be carried on very successfully in the Zeeland waters. It is very difficult, however, to answer satisfactorily the question, Why the same methods which on the Dutch coast have been productive of such good results have proved entire failures on the German and English coasts? As far as I can see, there are three causes which contribute to this result: (1) the happy idea of our government to rent out the Zeeland oyster-beds in small portions; (2) the fine business qualities of the men who engaged in this enterprise with genuine Dutch perseverance, simplicity, and zeal; and (3) the quality of the bottom, and the exceedingly favorable conditions of temperature and tide. The three last-mentioned causes are the ones to which these favorable results are mainly owing, and I therefore regret it all the more that I am not able to give further information on this subject.

In this short article it was only my purpose to direct the attention of other nations to oyster cultivation as carried on in the Netherlands. As regards statistical data and exhaustive descriptions of the methods employed, I refer the reader to the respective reports.

CIRCULAR OF THE NETHERLANDS ZOOLOGICAL ASSOCIATION.

HONORED SIR: The Commission of the Zoological Station intends during the coming summer months to inaugurate a series of investigations, on as extensive a scale as possible, relative to the anatomy, propagation, development, mode of life, &c., of the oyster. From the second half of April opportunity will be offered both at the principal station at Bergen op Zoom and at the branch station at *Wemeldinge* in South Beveland, to make such investigation.

A number of persons having already declared themselves willing to take part in these investigations, the commission is of opinion that a division of labor would greatly increase the chances of a favorable result, and I have therefore been directed to request that you will take an active part in these investigations. The commission will supply you with all the aids necessary for such an investigation, excepting optical instruments; and I would ask you, in case you should be inclined to comply with this request, to inform me as soon as possible.

The only condition imposed upon you by the commission in asking you to share in this undertaking is that you will consent to furnish us, after the investigations have been brought to a close, with as full a report as possible, accompanied by the necessary illustrations, &c., and in shape for publication. It is impossible for the commission to state at the present time in what shape the results of your investigation will be published. The commission, nevertheless, does not hesitate to make itself responsible (1) that the results of your investigations, if suitable, shall really be published, and (2) that whatever you furnish us shall be published under your name.

In order to give you an idea of the extent of the investigations which the commission have in view, I give below an outline of our programme, and at the same time inform you for what portions of it we have already received offers.

(1.) To prepare as complete a list as possible of all the works relating to the oyster, accompanied by short references, and to publish this list at an early date. The commission will take charge of this matter, and hopes to have the work ready in time so that it can be used during the coming summer.

(2.) To subject to an exhaustive investigation the anatomy of the oyster, and more especially that of its generative organs. Dr. Hoek and Dr. Vosmaer have this subject in charge.

(3.) To examine the contents of the stomach of the oyster, with the view of attaining absolute certainty as to its food.

(4.) To trace the development of the oyster:

(*a.*) The egg, from the time it has become impregnated till the young oyster leaves it. Dr. Horst and ———

(*b.*) The young oyster at the surface of the water until it goes toward the bottom, Prof. Hoffmann and ———

(*c.*) The young oyster after it has adhered to an object, Dr. Hubrecht and ———

(*d.*) To determine the limits of the migration of the young oyster, Dr. Van Rees and ———

(5.) To find the physical and meteorological conditions under which the young oyster leaves the egg and adheres to various objects, and to trace the normal course of life of an oyster, Dr. *Hubrecht* and ———

(6.) To study the life and habits of those animals which share the bank with the oysters, either as enemies, parasites, friends, or companions.

Protozoans	Dr. Van Rees.
Sponges, echinoderms, &c.	Dr. Vosmaer.
Worms	Dr. Horst.
Articulates	Dr. Hoek.
Mollusks	—— ———.
Fish	Dr. Hubrecht.

(7.) To answer practical questions relative to the industry of oyster cultivation not given under any of the six preceding heads.

The commission hopes that sooner or later at least two persons will be engaged in the investigation of each of the above subjects, and would state here that even as regards those subjects for which one or two persons have been mentioned, nothing definite has been settled, so that, if any of these subjects should offer special attractions to you, you will very probably be assigned to it.

As soon as all answers have been received, I shall address a more definite letter to you, so that we may arrive at some positive understanding with you.

Very respectfully, yours,

Dr. P. P. C. HOEK,

Secretary of the Commission of the Zoological Station.

LEIDEN, *March* 16, 1881.

XXXVI.—ON THE REASON FOR AN EXTRAORDINARILY RICH PRODUCTION OF OYSTERS IN A NATURAL BASIN.*

By Prof. H. H. RASCH.

After repeated requests from many persons living in the counties of Stavanger, North and South Bergenhus and Romsdal, who, because of the great diminution of the oyster fisheries, had in the space of the last year invested considerable sums to re-establish them by the method employed on the west coast of France, but always with unfortunate result, in the summer of 1878 I undertook a journey along the coasts of the above-mentioned districts. The object of my journey was made known through the newspapers. Shortly after my arrival at Stavanger, H. Gundersen, a custom-house officer in Egersund, told me that he knew a little lake (tarn), rich in oysters, which lies a few feet higher than the open sea close outside of it, which could convey salt water into the lake only during severe southwest storms combined with spring tides; the lake receives through a brook the surplus fresh water from two lakes situated higher. In the lake mentioned, which, because of its wealth of oysters, had from time immemorial received its name, Oyster Lake, is found, according to the informant's statement, the same abundance of oysters fastened on the perpendicular banks descending into the lake and on the bowlders which have fallen down from them. The truthfulness of the informant was established by the large number of living oysters which he brought with him. Most of them had grown together in clusters or clumps a foot long, but they were easily separated from one another. Specimens of such oysters were to be seen among the individuals exhibited by me in Berlin, which ought to call attention to the development of oysters in Oyster Lake.

That I should, as quickly as possible, devote myself to this much-favored lake is a matter of course, and, after I had a boat brought into it, I was able, with the help of a water telescope brought along, to satisfy myself that Gundersen's report was not exaggerated. Because of a continued drought which had prevailed for a long time previous to my arrival, the quantity of water in the two higher lakes had diminished, the brook flowing therefrom was entirely dried up, while at the same time the great evaporation from the surface of Oyster Lake itself had

* Translated from Nordisk Tidsskrift for Fiskeri, 1880, pp. 49–58, by Tarleton H. Bean.

caused it to fall about 6 inches lower than its outlet to the sea. The fresh-water layer was therefore evaporated so that the surface water had a salt taste. This condition was favorable in the respect that it had given the young oysters swarming about an opportunity to come up into the uppermost layer of water, where they had found points of contact on the branches of our common dog rose, *Rosa canina* L., which, being cut off, were accidentally thrown into the water. This was for me a hint as to how the gathering of young oysters in this basin ought to be managed.

The lake is surrounded on three sides by steep walls of rock 300 to 400 feet high, and only on the western side facing toward the open sea does the middle portion of the mountain slope on both sides down to the level of the lake. Through the southeastern depression, when the basin is full, fresh water flows out into the sea, while on the contrary during westerly storms sea-water presses in more easily through the northwestern depression, the bottom of which, however, lies nearly one-half foot higher than the southeastern.

A couple of fathoms from the shores the lake has nearly everywhere a depth of 6 meters, and slopes therefrom uniformly down towards the middle, where the depth is nearly 12 meters. In summer great masses of floating confervæ are found crowded together both on the surface and in the deeper strata of water. This conferva, the only aquatic plant in the lake, according to the determination of our algologist, N. Willes, is *Cladophora crispata* (Roth) Kuts.

In spring, when it begins to sprout, it is bright green, and develops, by the influence of the sun, a quantity of oxygen in the form of small bladders, which collect in masses in the closely entangled web which results from the extraordinary branching of this species. Through this quantity of air-bladders the cohering mass becomes so much lighter than the water that it frees itself from the bottom and rises toward the surface, where, little by little, it becomes darker—brownish—and at last quite black, whereupon it breaks up into minute fragments which fall to the bottom in the form of the finest dust, and communicate to it a jet black color. What part this black bottom-color plays in the singular thermal conditions of this lake I will attempt to show farther on.

Upon and in these masses of confervæ live two species of gastropods both belonging to the genus *Rissoa* and three or four *Acephalæ* of which especially a dwarfish form of *Cardium edule* is exceedingly numerous. The shells of these three species are black because of the fine confervæ dust mentioned, but by being transferred to sea-water, which is free from this black powder, they become gradually lighter and finally altogether white. At the same time, however, the black color has so penetrated into the shells that they cannot be made much lighter by rubbing. The young oysters of from one to two inches diameter always have black-striped shells, which can hardly be explained in any other way than that the black particles of confervæ have been taken up with their food and afterwards secreted in connection with the calcareous matter of which the shells are formed.

Besides the part which the conferva plays with regard to the temperature and oxygenation of the water, it probably furnishes the chief food of the oyster in the enormous masses of spores which it gives off. A similar but less important role as a means of nourishment is taken by the young of *Medusa aurita*, which occurs in the lake in enormous quantities and of all sizes. The young of the species of mollusks mentioned and of the crustacea living in the lake are less important in this respect. A little *Gammarid*, probably a variety of *G. pulex*, and the common shrimp, *Palæmon squilla* L., notably the last named, are exceedingly numerous.

The peculiarities above communicated with regard to the plant and animal life of this remarkable basin I did not of course discover during my first short visit, but the existence of a greater quantity of oysters than I had heretofore seen collected in one place, combined with the discovery of the branches of the dog rose covered with young oysters and the peculiar situation of the lake, were sufficient facts to warrant me, after my return to Stavanger, in advising my acquaintances living there to form a joint stock company, as soon as they could agree with the three owners of the lake as to the terms of the lease, to carry on oyster culture with combined forces, and I promised to support such an association in this matter by word and deed. A sufficient number of share-holders in such a company was quickly found, and they intrusted to the well-known customs-officer H. Gundersen the task of negotiating with the owners of the lake and agreeing with them about the terms of the lease. When this business was settled fourteen experimental collectors were set out by Gundersen on the 31st of July. These experimental collectors consisted partly of willow twigs fastened with nails to a wooden frame of laths, and partly of boards covered with cement. By means of stones fastened with ropes to the lower ends of the collectors these were held under the surface of the water in a vertical position. On the 17th of October, these were examined by some members of the company, among them the young pharmacist Buch, curator of the Stavanger Museum, and school principal A. Olsen, both of whom had been my companions in the examination of Oyster Lake. Mr. Buch communicated to me the result of this preliminary trial, which was certainly surprising because of the rapid growth of the oysters deposited—to particularize, some examples in the course of two months and seventeen days had reached a diameter of 35 millimeters—and because, also, of the unexpected fact that swarms of young had been emitted, since they found a great quantity of attached young so small that they could hardly be seen by the eye alone, and so could not have been more than a couple of days old.

On taking up the collectors Gundersen observed that the stones which were fastened to them to hold them under the water were quite warm to the touch, which was so much the more remarkable because cold weather had set in. Later in the autumn a thermometer was sent to the superintendent (one of the owners of the lake), who was requested to observe here and there in the course of the winter the temperature of the water at the bottom. The winter cold, which set in early in November, before he had received a thermometer, was unusually severe up to the end of March, so that a layer of ice a foot thick was formed over the lake. In the beginning of April he reported that the temperature at the bottom, in a depth of 28 feet, was 10° R. (54.5° F.), though the water was not yet free from ice. They believed in Stavanger that he had read incorrectly, but repeated examinations gave the same result. When Gundersen visited the lake in May, to place new collectors and examine the old, he found the temperature of the water 14° R. (63.5° F.), at a depth of 33 feet. This seemed incomprehensible to the members of the company, and gave occasion for many guesses as to the cause which could possibly produce the high temperature of the bottom water. The flowing out of warm springs in the bottom of the lake was regarded by some as the most probable, while others attributed it to the heat developed by the putrefaction (fermentation) of the masses of confervæ.

When they asked my opinion as to the explanation of this curious circumstance, I reserved it until, by a longer stay in the place, I had carefully examined the conditions which probably in connection with one another would give a better basis of explanation for the unquestionable fact than those propounded above, both of which seemed to me inadmissible. Last summer and fall I remained twice for a long time at the lake, and after my return to Christiania, I stated at one of the meetings of the scientific society my explanation of the causes of the exceptionally high temperature of this basin, both in summer and winter, a temperature which makes this lake, scarcely two hectares in area, with an average depth of 26 feet, a tropical water oasis in our cold north, and thereby a forcing-house for oysters. I hope that my explanation will be satisfactory to the scientific public since it has been sanctioned by our well-known hydrologist, Professor Mohn.

I suppose the causes to be the following:

1. *Its situation, protected from all cold winds;* because only the milder westerly winds coming from the sea can affect the surface of the lake, and that but slightly. Through the valley, which leads up to the lake from the north, from which originates the brook spoken of, a portion of Oyster Lake, it is true, can be affected by cold northerly wind, but the cooling effect of this wind, taken altogether, is comparatively slight, and when the lake becomes ice-bound and afterwards snow-covered, the cooling off will be reduced to a minimum.

2. *The black color of the bottom* is, according to my opinion, compared with the remaining reasons, the chief cause of the high temperature of the lake water; to this also the dark color of the mountain sides mentioned contributes in no small degree, in that, being illumined by the sun, they radiate a heat, which in the stratum of air saturated with

vapor, which rests over the lower portion of the mountain base, becomes very oppressive and sudorific, under a temperature which during my stay in Skyggen sometimes rose to 27° R. (92.75° F.). At a height of a little over 150 feet above the surface of the lake, this strong and oppressive heat diminished more rapidly than it had done during the ascent, notwithstanding the fact that one had not reached the edge of the depression which is found in the mountain wall which surrounds the lake upon the north and east, and through which the newly constructed road leads down to North Fjord.

3. The cooling off of the surface water produced by the radiation in clear nights counteracts in part the formation of the fog which originates by the shifting of the layer of vapor resting over the mountain base, when this is cooled after sunset. This is, however, the case only in perfectly calm weather; for when a brisk wind blew over the mountain surrounding the lake, I did not observe the formation of any fog. Thus, radiation deprived the water of far less heat than it had received during the day through the influence of the sun's rays.

There is no doubt that the black color of the bottom of the lake is the chief cause of the high temperature of the water; for when the sun's rays through the crystal clear water meet the black bottom, this absorbs the light rays, whereby the heat rays combined with these are set free in the same way as in the air, and every one has felt sensibly enough how strong this can be when he wears black clothing on a clear, sunshiny day. The heat given off from the sun-illumined bottom diffuses itself in accordance with physical law quickly upward to the overlying water stratum and communicates its temperature to the whole mass of water. When a body of water 26 feet deep and 2 hectares in area is heated up to 20° R. (77° F.) it certainly takes a long time before this will cool to 10° R. (54.5° F.), especially when half the water mass—the lowermost—is at perfect rest, which is the case here; for the current which is caused by the issue of the brook into the lake certainly does not reach very deep, all the more as this water is fresh and lighter than salt water, and consequently remains at the surface.

In the deepest part of the lake—12 meters, or 40 feet—the saltness of the water is greater than in the North Sea at a depth of 4 feet. On the 17th of October, 1878, Candidate Buch examined the saltness of the water in depths from 2 to 27 feet. In the latter the saltness was 3.90 per cent., and in the former 0.20.

In sinking the collectors at different depths they have been convinced that the depositing of the young does not take place below a depth of 18 or 19 feet, and that the size and number of the young diminish in from 14 to 18 or 19 feet. As to the cause of this I will not venture to express an opinion, but the fact is fully established.

The stratum of water in which oysters thrive best is between 3 and 14 or 15 feet, and I have called this stratum the oyster belt of Oyster Lake. In this belt the swarms of young appear to congregate in at least nine months of the year. The shoaling young retain their swimming power far longer than is stated by the authors who have attempted an explanation of this question. Gundersen and Prof. G. O. Sars have kept them living as long as eleven days, while the authors known to me state the duration of their swimming power to be four days at the most.

That all the conditions for a vigorous oyster growth are present in the above-described basin to an extent hitherto unknown is best shown by the rapid growth of the oysters living therein, their fatness, and the quick development of their reproductive function; to give details, individuals of eleven months old had already emitted broods of young. With reference to the question of the fertility of the oyster I will venture to remark that according to my opinion this is placed too low by many late writers when they estimate the number of young which an adult oyster will emit as only 1,000,000 or even fewer; for I am convinced that Leuwenhœck is correct in putting the number at many millions, yes, so far as I recollect, at 9,000,000.

From an oyster eleven months old taken from one of the collectors, which probably had scarcely begun to emit young, since many of the embryos had not yet broken through the egg-membrane, I preserved by estimate half of the number of young, and I am greatly at fault if this number does not considerably exceed 1,000,000.

The plan of suspending receptacles for the young, made of birch wood, on telegraph wires stretched in many directions across the lake and fastened to iron bolts which are fixed in holes made just at the margin of the water, was carried out this year. Last year only a couple of receptacles were placed; these were rather heavy collectors, consisting partly of old crab-traps and baskets filled with sticks, broken crockery, shells of blue mussels, *Mytilus edulis* L. and *modiolus*, were suspended on heavy, well-tarred ropes. Many of these ropes, however, became so rotten in the tepid fresh water that they parted and the collectors sometimes sunk in water so deep that they could not be found; but the collectors which were hung up and fell down in a less depth of water were found to be thickly covered with vigorous young oysters. The receptacles built by Groom, the merchant, of pieces of boards joined together in the form of book-cases showed themselves to be next best to those made of birch. They were, however, covered with young only on the under side of the pieces. On the same area the birch collectors yielded a much larger result, and the young on them could be easily gathered without injury. The young, which are intended for shipment or to be placed in the fattening grounds leased by the stock company, are taken from the lake down to North Fjord, where they are put into boxes with holes bored in them until they are sent away. In the latter part of July 65,000 young oysters averaging 2¼ inches in size, packed in 43 boxes, were transported 10 miles and deposited in a fattening-place 1½ miles from Stavanger. Of this number less than 100 were found dead when deposited, and those that were dead had been greatly injured in removing them from the collectors.

When they have placed many hundred receptacles for the young in Oyster Lake they will without doubt be able to harvest an extraordinary number of such young oysters.

From the description here given by me it is to be hoped that people will admit that the discovery of Oyster Lake may become a matter of great importance for oyster culture in Norway; regarding it both as a nursery for this highly esteemed mollusk wherefrom many of the oyster beds which were formerly rich may again be supplied with parent oysters, and as a school for the study of oyster culture.

APPENDIX J.

MISCELLANEOUS.

XXXVII.—LIST OF PATENTS ISSUED IN THE UNITED STATES, DURING THE YEARS 1879 AND 1880, RELATING TO FISH AND THE METHODS, PRODUCTS, AND APPLICATIONS OF THE FISHERIES.

By ROBERT G. DYRENFORTH,
Examiner-in-Chief, United States Patent Office.

FISH-HOOKS.

211906. L. S. Hill.................................February 4, 1879.
223194. W. F. Vaché..............................December 30, 1879.
218345. A. Wakaman..............................August 5, 1879.
228511. M. Bray.................................June 8, 1880.
231912. J. Irgens...............................September 7, 1880.
232706. G. G. Gregory...........................September 28, 1880.

FISH-TRAPS.

218737. W. J. Henderson.........................August 19, 1879.
228948. F. L. Sheldon...........................June 15, 1880.
230743. B. F. Chase.............................August 3, 1880.
232517. L. Lenglet..............................September 21, 1880.

FISHWAYS.

218299. M. McDonald.............................August 5, 1879.
228936. W. H. Rogers............................June 15, 1880.

HARPOONS AND SPEARS.

218540. C. M. Knowles...........................August 12, 1879.

NETS AND SEINES.

215031. H. Webb.................................May 6, 1879.

OYSTER CULTURE.

212389. F. Lang.................................February 18, 1879.
217558. L. J. Stewart...........................July 15, 1879.
221326. J. Langrall.............................November 4, 1879.
232740. T. McCosker.............................September 28, 1880.

OYSTER RAKES AND TONGS.

225155. W. L. Messick .... March 2, 1880.

REELS.

214495. L. T. Dickson .... April 22, 1879.
216242. C. N. A. Voss .... June 3, 1879.
219328. E. C. Vom Hofe .... September 2, 1879.
220776. S. W. Wardwell, jr .... October 21, 1879.
227000. G. Hancock .... April 27, 1880.
235017. H. Prichard .... November 30, 1880.
235157. F. A. Loomis .... December 7, 1880.
235511. T. H. Chubb .... December 14, 1880.
235512. T. H. Chubb .... December 14, 1880.
235513. T. H. Chubb .... December 14, 1880.

RODS.

222681. E. Earle .... December 16, 1879.
230650. J. S. Niswander .... August 3, 1880.
234812. F. Richardson .... November 23, 1880.

SINKERS.

235510. T. H. Chubb .... December 14, 1880.
231417. T. M. Foote .... August 24, 1880.

ICHTHYOCOLLA.

219667. T. O. Alsing .... September 16, 1879.
233973. W. V. Brigham .... November 2, 1880.
9226. J. S. Rogers (reissue) .... June 1, 1880.
9296. J. S. Rogers (reissue) .... July 13, 1880.

PRESERVING FISH.

215628. K. L. Jewell .... May 20, 1879.
223682. Sellman, Martin & Balkam .... January 20, 1880.
225938. C. Maré .... March 30, 1880.
226390. D. W. Davis .... April 13, 1880.
229368. P. H. Brink .... June 29, 1880.
235116. Charles Alden .... December 7, 1880.
235487. A. E. Arnold .... December 14, 1880.

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NOTE.—This index contains general references to the entire volume. More detailed indexes to eleven papers will be found at the pages indicated.

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