DEPARTMENT OF COMMERCE
BUREAU OF FISHERIES

REPORT

OF THE

UNITED STATES COMMISSIONER OF FISHERIES

FOR THE FISCAL YEAR 1923

WITH

APPENDIXES

HENRY O'MALLEY
Commissioner

WASHINGTON
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Report of the United States Commissioner of Fisheries

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Bureau of Fisheries Document No. 946.

REPORT OF THE COMMISSIONER OF FISHERIES, 1923.

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DEPARTMENT OF COMMERCE,
BUREAU OF FISHERIES,
Washington, September 15, 1923.

SIR: I have the honor to submit herewith a report of the operations of the Bureau of Fisheries during the fiscal year ended June 30, 1923.

FISHERY INDUSTRIES SERVICES.

REVIEW.

The depression that existed in the fishery industries in 1921 was to a considerable extent relieved in 1922, as noted in my last report, and decidedly better conditions prevailed in the fiscal year 1923. In the New England vessel fisheries, in the calendar year 1922, 11.9 per cent fewer trips were made than in 1921, but the catch increased 6 per cent. Because of lower prices during part of the year there was a net decrease of 4.5 per cent from 1921 in the value of the product. In the spring of 1923, from January to May, inclusive, the landings were steadily greater than for 1922, except that in March, 1922, abnormally large landings were recorded, which were greater than the March, 1923, landings. In the first five months of 1923 the average price of fish landed from fishing vessels in New England was 4.64 cents per pound, as compared with 3.42 cents for the same period in 1922. At Seattle, in 1922, there was little change from the preceding year in either landings or value. In California, in 1923, there was an increase of 32.3 per cent in quantity over 1921, the production being 168,969,733 pounds.

In the Pacific Coast States the pack of canned salmon in 1922 showed a net decrease of 26.9 per cent in the number of cases and 6.5 per cent in value as compared with the pack of 1921; but this decrease was more than made up in Alaska, where there was an increase of 72 per cent in the number of cases and 51.7 per cent in value as compared with the previous year. The total pack of canned fishery products in the United States and Alaska in 1922 was valued at $60,464,947, an increase of 29.6 per cent over 1921. The by-products of the fisheries in 1922 were valued at $11,390,693, an increase of 36.4 per cent over their value in 1921.

Gratifying increases over the 1921 pack of sardines are recorded for both Maine and California in 1922. In Maine the increase amounted to 31.5 per cent in number of cases and 45.2 per cent in value; in California the increase amounted to 75.4 per cent in number of cases and 51.7 per cent in value. In the total sardine pack of both Maine and California there was an increase of 41.8 per cent in number of cases and 44.4 per cent in value.

The activities of the bureau included a market survey of Boston, Mass., similar to those previously made in other cities. In the field of statistics canvasses have been completed of the fisheries of New York, New Jersey, Pennsylvania, and Delaware for 1921, the shad and alewife fisheries of the Potomac River for 1922 and 1923; and the canned fishery products and by-products of the United States for 1922. The regular collections of statistics of the landings of the vessel fisheries at the ports of Boston and Gloucester, Mass., Portland, Me., and Seattle, Wash., have been carried out and the data published as statistical bulletins. The statistical bulletins of cold-storage holdings of frozen fish have also been issued monthly.

Technological investigations have included a continuation of experiments in the preservation of fish nets, including the preparation of a report of results up to January 1, 1923; freezing fish in brine; canning sardines; an examination into the possibilities of producing insulin, the newly discovered palliative for diabetes, from the pancreas of sharks; and certain work on the reddening of salt codfish.

The bureau also prepared and managed the exhibit of fisheries and fishery industries at the Brazilian International Centennial Exposition, which opened September 7, 1922, at Rio de Janeiro.

Broadcasting fisheries market reports was also begun and continued once a week for the benefit of the wholesale and retail fish trade.

FISH MERCHANDISING.

That part of the fish industry which has to do with distribution and sales remains the most important problem presented to those engaged in this business. The limit upon the volume of fish business that can be done at present is set by distribution rather than by production. The bureau has continued, in so far as its resources permitted, its efforts to be of service in this field.

In the autumn of 1922 a survey was made of the fish trade of Boston, Mass., our largest fishing port.

Boston, with a population of 748,060, is the principal landing port for the fisheries of the North Atlantic. It is also the greatest fishing port in the United States and among the greatest of the world's fishing ports. In the calendar year 1922 there were landed at Boston by vessels of 5 tons or over 106,190,403 pounds of fish, valued at $4,020,105. More than 80 per cent of its fishing business, on the basis of quantity, is in cod, haddock, halibut, mackerel, swordfish, and lobsters, a very different group of fish from those prominent in Seattle. A moderate or limited business is also done in alewives, butterfish, carp, flounders, salmon, smelts, suckers, clams, crabs, and oysters, and some 54 other species. In Boston there were 108 wholesale fish dealers and 171 retailers—one retailer for each 6,926 persons.

The production or landings of fish in the year ended September 30, 1922, was 101,949,725 pounds, valued at $4,051,350. In the month of September, 1922, the following products were landed at Boston: Fish, 13,244,074 pounds; lobsters, 616,355 pounds; clams, 338,964 pounds; oysters, 10,068 gallons, or 80,544 pounds; scallops, 478 gallons, or 3,824 pounds. The amount of fish frozen during 1922 was

8,946,183 pounds, and the amount shipped from Boston during September, 1922, was 14,383,761 pounds.

In the month of September, 1922, 56 per cent of all Boston's fish was consumed in Massachusetts, and 89 per cent in Massachusetts, Rhode Island, Connecticut, New York, and Pennsylvania. It is thus evident that while Boston has done much in developing her near-by market the more distant markets are still awaiting development. There is evidence also that this is the case with other centers of fish production. The per capita consumption of Boston fish in Massachusetts during the month of September, 1922, was over 1½ pounds, which must be increased by the fish taken at other Massachusetts ports, perhaps, to more than 2 pounds, or 24 pounds per capita annually. The per capita consumption of fish in the United States, as a whole, is probably not more than 12 or 14 pounds. This development of local fish consumption resulted in the shipment to Boston from the Pacific coast of 169 carloads of halibut and salmon during the year ended September 30, 1922, although Boston itself is the largest fish-producing port in the United States.

TECHNOLOGICAL INVESTIGATIONS.

It was pointed out, in connection with the discussion of the market survey of Boston, that the limit to the fish business was set by problems of distribution. The limit to extensive and successful distribution is fixed not only by incomplete organization of the industry but also by the lack of adequate methods of preserving and handling fish, so that they can be transported to distant markets in first-class edible condition. Other technical difficulties, such as the rapid decomposition of the nets he uses, further reduce the fisherman's reward for his arduous labors. Technological inquiry only can solve these problems, and it is in a continuation of such inquiries that the bureau's technological staff has been engaged.

BRINE-FREEZING OF FISH.

In Economic Circular No. 53, issued in 1921, the status of brine-freezing was outlined as it was at that time. It was pointed out that in principle brine-freezing seemed to have received sufficient test and approval by various scientific investigators, and that the chief problem ahead was the engineering problem of constructing a plant that would freeze fish on a large scale with a minimum of labor and expense. There has been constructed in the fishery products laboratory a brine-freezing apparatus of new design intended to meet these requirements. It consists of a tunnel 40 feet long provided with a short compartment at each end. The fish are suspended from horizontal bars that are mechanically conveyed through this tunnel. The fish first pass through a fresh-water spray in the entrance compartment for the purpose of washing; then through a violent spray of brine at —5 or —6° F. for 32 feet, wherein they are frozen; emerging from the brine spray, they again pass under a fresh-water spray, which removes the brine and applies a glaze. The conveyor is arranged for variable speed so that fish of different sizes may be treated for the time required to freeze. The conveyor is located so that it is not exposed to the corrosive action of the brine. Mechanical refrigeration is used to refrigerate coils or heat-absorbing units located in the bottom of the apparatus. The salt brine is circulated continuously, only a small volume being required. Trials so far made with this apparatus indicate that it freezes quite satisfactorily, though more extensive trials will yet be necessary. The fish are individually frozen, trim and straight.

PRESERVATION OF NETS.

The bureau's work on the preservation of fish nets has been carried to the point of yielding results of value. The several series of samples of twine that had been exposed at several localities in 1922 and tested monthly were completed, and the results were prepared for publication. In addition to numerous well-known preservative materials, there was tried for the first time copper oleate, in which the bureau hoped to discover a better preservative than any of those hitherto used. In so far as experiments of this kind go, the results fully justified expectations. Copper oleate, dissolved in gasoline or other suitable solvent and applied to cotton or linen lines, effected a superior preservation of tensile strength or resisted fouling to a remarkable degree without materially adding weight to the lines or diminishing their flexibility, as so many other preservatives do. The results were very much more satisfactory in salt water than in fresh water. In the latter the copper oleate seems to be somewhat more soluble than in salt water. In a new and larger series of experimental exposures of lines begun in the spring of 1923 several other commercial or proprietary preservatives were tested, and an effort also was made to reduce the solubility of copper oleate in water by the addition of linseed oil and paraffin and by other combinations. Success in this direction, if attained, will not only provide a suitable preservative for fresh water but will overcome one of the principal objections to the use of copper oleate in salt water; that is, its tendency to wash out of the lines.

CANNING SARDINES.

In the canning of sardines it is always necessary to remove some of the water from the fish before the cans are finally sealed, else the fish break down to a wet mass and present a poor appearance. In California the usual method of removing the excess water is to pass the fish through a bath of hot oil, wherein much of the water is cooked out. At the bureau's experimental laboratory at San Pedro, Calif., the conclusion has been reached, and heretofore reported, that the oil in which the frying is done becomes oxidized, rancid, and objectionable from a dietetic point of view, since part of it is carried on the fish into the can. During the fiscal year 1923 work has been confined chiefly to the solution of the problem of removing the water by methods other than frying in oil, and considerable progress can be reported. Three methods were tried, all of which showed some merit. They were (*a*) cooking in strong brine instead of oil, (*b*) steaming, and (*c*) canning raw after removal of excess water by brining and partial drying. A pack that appeared to be equal, if not superior, to any fried-in-oil product was made by a modified steaming process. Quite satisfactory products were prepared by the raw-pack method; that is, preliminary brining and drying, followed by sealing and processing. Good packs also were prepared by the method of cooking in brine, but this may perhaps be adjudged an unsatisfactory method because of the penetration of too much salt.

SALTING OF PACIFIC COAST MACKEREL.

Attention was given by the San Pedro laboratory to the salting of the Pacific Coast mackerel (*Scomber japonicus*). This fish is, in general, less fat than the Atlantic mackerel and its flesh is more likely to be dark in color. It was found, however, that the method that previously in the bureau's salting experiments had been found to be applicable to other fish in warm climates was here successful. This process consists in using high-purity salt applied dry to perfectly fresh fish that have been thoroughly cleaned of all blood and viscera. These points all seem to be essential. Packers, who have themselves hit upon most of these points, have found by experience that salt of inferior quality produces inferior fish and that any blood left in the fish darkens it. Freshness is also important, so much so that salting aboard the boats seems advisable.

PEARL ESSENCE.

Pearl essence, an incidental product of the fisheries, has continued to attract considerable attention, perhaps more because of its spectacular beauty and novel application than because of its industrial importance. Nevertheless, the business of manufacturing imitation pearls, which was at one time an exclusively European and Japanese industry, has migrated to America to a very large extent. New York City and its vicinity are now the center of a considerable imitation-pearl industry, based largely on the supply of pearl essence produced in the United States principally from herring and alewife scales.

A process of making a pearl essence has been elaborated in the fishery products laboratory which, in technique, is a radical departure from any methods known to have been used hitherto. By this method the lustrous material from the scales is removed in water, together with any dirt, blood, slime, etc., that may accompany the scales. The crude suspension is then treated chemically in such a way that the lustrous or nacreous particles are removed bodily from the crude liquor and transferred to ether and then to ethyl or amyl acetate, which are solvents of nitrocellulose, which, when dissolved in the suspension, makes a pearl lacquer. This applied to glass beads makes the "indestructible" pearl of commerce. "Essence" has been prepared by this process from the scales of numerous species of fish. The details of the process will be published in a separate document.

PARTICIPATION IN THE BRAZILIAN INTERNATIONAL CENTENNIAL EXPOSITION.

In accordance with that part of the act of Congress authorizing participation of the United States in the Brazilian exposition that provided for a fisheries exhibit, the bureau assembled collections of fishery products, apparatus, vessel models, transparencies, photographs, motion pictures, etc. Among the more important exhibits were those of the salmon industry, the New England banks fisheries, the oyster industry, the menhaden industry, canning and by-products of the fisheries, fishing gear, preservation of nets, and organization and functions of the Bureau of Fisheries. A brief description of the fishery industries of the United States was prepared and printed in English, Spanish, and Portuguese for distribution at the exposition.

CANNED FISHERY PRODUCTS AND BY-PRODUCTS.

The bureau made a canvass of the canned fishery products and fishery by-products industries of the United States and Alaska for the year 1922. The total value of the canned fishery products for the year was $60,464,947, and the value of the fishery by-products prepared, such as fish oil, fertilizer, fish meal, liquid glue, poultry grit, and lime from shells, was $11,390,693. The results of the canvass were published and distributed to the trade as Statistical Bulletin No. 570.

The pack of canned salmon, reduced to the equivalent of 48 pounds of fish to the case, amounted to 5,234,898 cases, valued at $38,420,717, of which 4,501,652 cases, valued at $29,787,193, were packed in Alaska, and 733,246 cases, valued at $8,633,524, in the Pacific Coast States. Other canned-salmon products, valued at $71,248, were also prepared.

The pack of sardines in Maine in 1922 amounted to 1,775,878 cases, valued at $5,750,109, compared with 1,350,631 cases, valued at $3,960,916, in 1921. The pack of sardines in California in 1922 was 728,979 cases, valued at $3,361,480, compared with 415,587 cases, valued at $2,346,446, in 1921.

The canning of shad is confined to Washington, Oregon, and California. The pack of shad in 1922 amounted to 2,257 cases, valued at $9,961, and of shad roe to 433 cases, valued at $8,517. The shad are packed in half-pound flat, half-pound oval, and 1-pound tall cans; the shad roe in half-pound flat and 1-pound oval cans; all with 48 cans to a case.

The pack of canned alewives and alewife roe in 1922 was prepared in Maryland, Virginia, and North Carolina. The pack of alewives amounted to 1,043 cases, valued at $1,994, and of alewife roe to 38,298 cases, valued at $137,514.

The pack of canned albacore in California in 1922 amounted to 272,563 cases, valued at $2,304,935; canned tuna to 345,363 cases, valued at $1,989,977; canned bonito to 10,591 cases, valued at $58,900; canned yellowtail to 4,403 cases, valued at $18,994; and other canned products to 31,548 cases, valued at $182,033. These products were packed in cans of various sizes and mostly with 48 cans to a case.

Shrimp were canned in North Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana. The pack in 1922 amounted to 586,691 cases, valued at $3,064,087. Louisiana ranked first with a pack of 179,164 cases, valued at $951,302, and Mississippi ranked second with a pack of 174,466 cases, valued at $882,389. The greater part of the pack, or 545,402 cases, valued at $2,843,516, was put up in No. 1 cans, four dozen to the case. The remainder was packed in No. 1½ and No. 2½ cans, two dozen to the case, and No. 10 cans, one-half dozen to the case.

Crabs were canned at two plants in Virginia, five in Alaska, and one each in Maine and Washington, the pack amounting to 9,111 cases, valued at $104,171.

The pack of razor clams in 1922 was confined to Washington, Oregon, and Alaska and amounted to 139,656 cases, valued at $879,956. It included whole and minced clams and clam juice. The pack of hard clams, confined to Florida and Washington, amounted to 53,349 cases, valued at $298,042, and included whole and minced clams, clam bouillon, chowder, and juice. Soft clams were canned in Maine, Massachusetts, and Rhode Island, and the pack amounted to 116,635 cases, valued at $538,367, including whole clams, clam bouillon, chowder, and broth.

In 1922 oysters were canned in Maryland, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana. The pack amounted to 522,549 cases, valued at $2,423,616, compared with 455,550 cases, valued at $2,179,271, the previous year.

In addition to the canned products already referred to, there were packed in Maine, Massachusetts, New York, New Jersey, Maryland, Virginia, North Carolina, and Washington, 224,304 cases of miscellaneous fishery products, valued at $840,329.

In 1922 there were 45 factories engaged in the manufacture of products from menhaden, as compared with 39 factories in 1921. The number of menhaden utilized was 1,212,450,669, or 747,470,402 pounds, valued at $2,457,690. The products included 93,576 tons of scrap and fish meal, valued at $3,221,758, and 7,102,677 gallons of oil, valued at $2,904,833, the total value of the products amounting to $6,126,591.

The total production of fish oils in 1922, including menhaden oil, in the United States and Alaska amounted to 10,535,473 gallons, valued at $4,230,760. The various oils produced were as follows: Menhaden oil, 7,102,677 gallons, valued at $2,904,833; whale oil, 1,863,015 gallons, valued at $731,000; sperm oil, 384,130 gallons, valued at $153,714; herring oil, 450,362 gallons, valued at $150,144; sardine oil, 428,859 gallons, valued at $145,668; tuna oil, 86,099 gallons, valued at $62,702; salmon oil, 25,989 gallons, valued at $9,435; cod and cod-liver oil, 71,539 gallons, valued at $33,666; and miscellaneous fish oils, 122,803 gallons, valued at $39,598.

The production of fish scrap and meal, including menhaden, and shrimp bran in 1922 amounted to 116,166 tons, valued at $4,336,677. The production of dried scrap and meal was 89,459 tons, valued at $3,755,787; of acidulated scrap 25,712 tons, valued at $555,973; of crude or green scrap 433 tons, valued at $9,519; and of shrimp bran, 562 tons, valued at $15,398. Of the quantity of dried scrap produced in the menhaden industry 7,172 tons, valued at $390,677, were reported sold as fish meal.

In 1922 there were 56 plants engaged in converting oyster shells into poultry grit and lime. The poultry grit produced from this source amounted to 236,021 tons, valued at $2,005,838, and the lime to 93,168 tons, valued at $431,213.

Other by-products of the fisheries included fish glue, shark hides, agar-agar, pearl or fish-scale essence, shark fins, whalebones (skeletons), whale tails, ambergris, herring skins, and alewife scales, to the value of $386,205.

FROZEN-FISH TRADE.

Statistics of the cold-storage holdings of frozen fish have been collected and published by the Bureau of Markets, Department of Agriculture, beginning with October, 1916. These reports give the holdings on the fifteenth day of each month. Through the courtesy of that bureau arrangements were made in December, 1921, for the Bureau of Fisheries to publish and disseminate this information, beginning with the returns for January 15, 1922, in the form of a monthly statistical bulletin. This bulletin gives the holdings by species and sections, total holdings for the current month and for the same month of the previous year, the five-year average, holdings for the previous month, and the quantity of each species frozen during the month.

In 1922 there were in operation 274 freezers that were devoted wholly or partly to the cold storage of fish. The holdings were very much smaller in 1922 than they had been on the corresponding dates in several previous years. The smallest holdings were in May and the largest in November.

The greater part of the freezing of fish, or 80 per cent, was in the New England, Middle Atlantic (including the Great Lakes in New York and Pennsylvania), and the Northwestern States, which include Montana, Wyoming, Idaho, Washington, and Oregon. The total quantity of fish frozen during the year was 75,453,674 pounds. Of this quantity, 24.67 per cent was frozen in New England, 27.12 per cent in the Middle Atlantic, and 27.94 per cent in the Northwestern section. Compared with the previous year, there was a decrease of 3,720,218 pounds in the total quantity frozen. The principal species and quantities frozen during the year 1922 were salmon, 12,143,194 pounds; ciscoes, 10,245,252 pounds; herring, 7,964,778 pounds; mackerel, 6,165,248 pounds; whiting, 6,058,126 pounds; and halibut, 5,122,396 pounds. Several other species were frozen in large quantities, and miscellaneous fishes not shown separately by species amounted to 10,956,348 pounds.

NEW ENGLAND VESSEL FISHERIES.

The bureau through its local agents has collected statistics of the vessel fisheries at Boston and Gloucester, Mass., and Portland, Me., which have been published in monthly and annual statistical bulletins. Two annual bulletins have been issued, one showing the catch by months and the other by fishing grounds. There was a decrease in the number of trips with an increase in the quantity and a decrease in the value of the products landed at these ports as compared with the previous year. At Portland, while there was a decrease in the number of trips, there was an increase in both the quantity and value of the products landed.

The fishing fleet at these ports during the calendar year 1922 numbered 338 sail, steam, and gasoline-screw vessels, including 28 steam trawlers. These vessels landed at Boston 2,893 trips, aggregating 106,190,403 pounds of fish, valued at $4,020,105; at Gloucester, 1,653 trips, aggregating 37,751,223 pounds, valued at $813,353; and at Portland, 1,803 trips, aggregating 15,933,765 pounds, valued at $632,474. The total for the three ports amounted to 6,349 trips, aggregating 159,875,391 pounds of fresh and salted fish, having a value to the fishermen of $5,465,932.

Compared with the previous year, there was a decrease of 857 trips, or 11.89 per cent, in the total number landed by the fishing fleet at Boston, Gloucester, and Portland, and an increase of 9,010,285 pounds, or 5.97 per cent, in the quantity, with a decrease of $256,697, or 4.48 per cent, in the value of the products landed. There was an increase in the quantity of all of the important species except pollock and halibut, and a decrease in the value of all except hake, herring, and swordfish. The catch of cod increased 1,665,151 pounds, or 3.11 per cent, in quantity and decreased $95,488, or 5.51 per cent, in value; haddock increased 2,783,289 pounds, or 4.12 per cent, in quantity and decreased $236,770, or 11.57 per cent, in value; cusk increased 149,035 pounds, or 7.10 per cent, in quantity and decreased $3,277, or 8.66 per cent, in value; and mackerel increased 1,342,567 pounds, or 39.67 per cent, in quantity and decreased $59,127, or 17.61 per cent, in value. Hake increased 838,139 pounds, or 18.47 per cent, in quantity and $1,728, or 15.76 per cent, in value; herring, 30,814 pounds, or 1 per cent, in quantity and $40,747, or 100.84 per cent, in value; and swordfish, 1,684,103 pounds, or 105.41 per cent, in quantity and $128,610, or 40.39 per cent, in value. Pollock decreased 1,847,926 pounds, or 26.60 per cent, in quantity and $46,636, or 28.32 per cent, in value; and halibut, 41,879 pounds, or 0.73 per cent, in quantity and $19,017, or 2.36 per cent, in value. The catch of Newfoundland herring increased from 551,400 pounds, valued at $19,584, in 1921, to 2,302,420 pounds, valued at $76,855, in 1922. In the various other species combined there was an increase of 2,406,992 pounds, or 77.73 per cent, in quantity and $32,533, or 23.90 per cent, in value.

The catch of scrod cod landed at these ports decreased from 1,150,577 pounds, valued at $10,844, in 1921, to 815,371 pounds, valued at $9,200, in 1922; and the catch of scrod haddock increased from 30,562 pounds, valued at $535, in 1921, to 253,283 pounds, valued at $4,261, in 1922. The small quantity of these grades landed, as compared with other grades of these species, is said to be due to the fact that the price is so low that the fishermen do not save all that are caught.

The fishery products landed at Boston, Gloucester, and Portland by fishing vessels each year are taken principally from fishing grounds off the coast of the United States. In the calendar year 1922, 78.96 per cent of the quantity and 75.27 per cent of the value of the catch landed by fishing vessels were from these grounds; 4.16 per cent of the quantity and 8.17 per cent of the value, consisting chiefly of cod, halibut, and herring, were from fishing banks off the coast of Newfoundland, and 16.88 per cent of the quantity and 16.56

per cent of the value from fishing grounds off the Canadian Provinces. There was some falling off in the percentage of products from grounds off the United States, with a small increase in that from grounds off Newfoundland and the Canadian Provinces compared with the previous year. Newfoundland herring constituted 1.44 per cent of the quantity and 1.40 per cent of the value of the fishery products landed at these ports during the year. The herring were taken from the treaty coast of Newfoundland and the cod, haddock, hake, halibut, and other species of that region were obtained from fishing banks on the high seas. All fish caught by American fishing vessels off the coast of the Canadian Provinces were from offshore fishing grounds.

Haddock ranked first in both quantity and value in the vessel fisheries at these ports in 1922, the catch amounting to 70,195,998 pounds, valued at $1,809,400, all landed fresh except 131,385 pounds salted, valued at $2,736. The catch of cod was 55,180,165 pounds, valued at $1,635,279, including 5,006,170 pounds salted, valued at $188,552. The catch of hake was 5,374,247 pounds, valued at $111,331, all landed fresh except 32,910 pounds salted, valued at $555. The greater part of the catch was landed at Boston. The catch of pollock was 5,097,085 pounds, valued at $118,006, all landed fresh except 49,300 pounds salted, valued at $938. The catch of cusk was 2,247,450 pounds, valued at $34,552, all landed fresh except 53,435 pounds salted, valued at $1,204. The catch of halibut was 5,624,149 pounds, valued at $784,057, all landed fresh except 15,706 pounds salted, valued at $915. There was a small decrease in the catch of halibut in both quantity and value as compared with the previous year. The quantity landed at Boston was 3,948,456 pounds, valued at $550,735; at Gloucester, 58,058 pounds, valued at $7,696; and at Portland, 1,617,635 pounds, valued at $225,626. The catch of swordfish was 3,281,748 pounds, valued at $447,016; and of flounders, 3,281,327 pounds, valued at $134,749. The catch of herring amounted to 2,644,354 pounds, valued at $81,154. Of this quantity, 341,934 pounds, valued at $4,299, were taken off the coast of the United States and landed fresh, and the remainder, including 410,000 pounds fresh, frozen, valued at $20,500, and 1,892,420 pounds salted, valued at $56,355, were Newfoundland herring.

The total catch of fresh mackerel taken by the American fishing fleet in 1922 was 53,703 barrels, compared with 40,323 barrels in 1921, an increase of 13,380 barrels. The total catch of salted mackerel was 2,749 barrels, compared with 3,242 barrels in 1921, a decrease of 493 barrels. The quantity of mackerel landed at Boston, Gloucester, and Portland by the fishing fleet in 1922 was 4,726,747 pounds, valued at $276,499, of which 4,266,367 pounds, valued at $239,111, were fresh and 460,380 pounds, valued at $37,388, were salted.

In 1923 the total catch of mackerel up to July 1 was 22,866 barrels fresh and 217 barrels salted, compared with 25,090 barrels fresh and 2,344 barrels salted for the same period in 1922. The southern mackerel fleet numbered about 25 purse-seine vessels and 136 gill-net vessels. Both seiners and netters had poor success on account of windy weather and scarcity of fish during the spring months. The first catch was landed at Norfolk April 9, consisting of 300 pounds of large mackerel, which sold at 75 cents per pound in New York. This was three days earlier than the landing of the first catch the previous year. A considerable quantity of tinker mackerel scattered in small schools was reported in the south. The first catch of mackerel from Cape Shore was landed at Yarmouth, Nova Scotia, May 29, consisting of 4,000 pounds of large mackerel, which were shipped to Boston. The first arrival at Boston, direct from the fleet, was on June 7, consisting of 20,000 pounds of large mackerel, which sold at 6½ cents per pound. Fresh mackerel sold during the season from 6½ to 40 cents per pound, according to market conditions, and salted mackerel from Cape Shore sold at $11 per barrel.

VESSEL FISHERIES AT SEATTLE, WASH.

Statistics of the vessel fisheries at Seattle, Wash., have been collected by the local agent and published as monthly and annual statistical bulletins, giving the quantity and value of fishery products landed by American fishing and collecting vessels during the year at that port.

The fishing fleet at Seattle in 1922 landed 836 trips, amounting to 11,332,050 pounds of fish, having a value to the fishermen of $1,249,822, from fishing grounds along the coast from Oregon to Portlock Bank, Alaska. The largest quantities were taken from Flattery Banks, west coast of Vancouver Island, and Hecate Strait. The products included halibut, 9,938,150 pounds, valued at $1,196,390; sablefish, 1,014,100 pounds, valued at $46,652; "lingcod," 258,200 pounds, valued at $4,509; and rockfishes, 121,600 pounds, valued at $2,271. Compared with the previous year there was a decrease of 30 trips by fishing vessels and 2,334,650 pounds, or 17.08 per cent, in the quantity and $173,481, or 12.18 per cent, in the value of the products. There was a decrease in the catch of halibut of 1,542,850 pounds, or 13.43 per cent, in quantity and $139,268, or 10.42 per cent in value. The catch of sablefish decreased 505,300 pounds, or 33.25 per cent, in quantity and $17,033, or 26.74 per cent, in value. The catch of "lingcod" decreased 205,100 pounds, or 44.27 per cent, in quantity and $11,882, or 72.49 per cent, in value; and the catch of rockfishes decreased 81,400 pounds, or 40.09 per cent, in quantity and $5,298, or 69.99 per cent, in value.

The fishery products taken in Puget Sound and landed at Seattle by collecting vessels during the year amounted to 15,083,390 pounds, valued at $964,832. This quantity included 13,615,780 pounds of salmon, valued at $882,481, and the remainder consisted of herring, sturgeon, steelhead trout, smelt, perch, rockfishes, "lingcod," flounders, sole, and crabs. Compared with the previous year there was an increase in the products landed by collecting vessels of 2,654,865 pounds, or 21.36 per cent, in quantity and $185,954, or 23.87 per cent, in value.

FISHERIES OF CALIFORNIA.

Through the courtesy of the California Fish and Game Commission the bureau has received statistics of the catch of fish, by species and by counties, for California, and also the quantity of fish imported into California from Mexico during the calendar year 1922. The catch of fish taken in the waters of California in 1922 amounted to

168,969,733 pounds, compared with 127,728,623 pounds the previous year, an increase of 41,241,110 pounds, or 32.28 per cent. The species taken in largest quantities were pilchards, 93,399,900 pounds; albacore and tuna, 17,920,019 pounds; flounders, 11,341,262 pounds; bonito, or skipjack, 10,998,855 pounds; salmon, 7,235,124 pounds; barracuda, 4,710,753 pounds; rockfishes, 4,238,480 pounds; yellowtail, 3,111,198 pounds; mackerel, 2,466,762 pounds; white sea bass, or squeteague, 2,195,932 pounds; abalones, 1,523,394 pounds; and shad, 1,109,445 pounds.

The imports of fish from Mexico in 1922 amounted to 12,146,066 pounds, as compared with 6,699,817 pounds the previous year. The principal species imported were albacore and tuna, 6,179,754 pounds; barracuda, 1,528,770 pounds; bonito, or skipjack, 1,792,592 pounds; flounders, 817,304 pounds; white sea bass or squeteague, 736,220 pounds; sea crawfish or spiny lobster, 640,466 pounds; and yellowtail, 303,292 pounds.

FISHERIES OF NEW YORK, NEW JERSEY, PENNSYLVANIA, AND DELAWARE.

A canvass of the fisheries of New York, New Jersey, Pennsylvania, and Delaware was made for the calendar year 1921, and the results were published in condensed form as Statistical Bulletin No. 569.

The number of persons engaged in the fisheries of New York was 7,145, the investment was $13,836,455, and the products amounted to 210,377,152 pounds, valued at $4,986,918. The principal species taken, in the order of their value, were oysters, 9,500,295 pounds, or 1,357,185 bushels, valued at $1,785,913; menhaden, 179,447,799 pounds, valued at $1,117,235; flounders, 4,471,161 pounds, valued at $283,412; clams, 1,006,538 pounds, or 121,113 bushels, valued at $260,773; squeteagues, "sea trout," or weakfish, 1,921,036 pounds, valued at $228,524; scallops, 1,235,760, or 205,960 bushels, valued at $217,108; lobster, 1,037,395 pounds, valued at $196,762; and bluefish, 1,082,917 pounds, valued at $176,726. Compared with 1904, there was a decrease of 4,348, or 37.83 per cent, in the number of persons employed; an increase of $3,214,839, or 30.26 per cent, in the investment; and a decrease of 67,272,595 pounds, or 24.23 per cent, in the quantity and $1,243,640, or 19.96 per cent, in the value of the products.

The number of persons engaged in the fisheries of New Jersey was 5,771, the investment was $4,701,704, and the products amounted to 96,936,784 pounds, valued at $5,983,406. The principal species taken, in the order of their value, were oysters, 22,997,555 pounds, or 3,285,365 bushels, valued at $2,759,930; squeteagues, "sea trout," or weakfish, 11,651,735 pounds, valued at $902,439; bluefish, 2,243,425 pounds, valued at $390,947; clams, 925,588 pounds, or 112,111 bushels, valued at $385,198; scup or porgy, 4,115,552 pounds, valued at $200,046; butterfish, 2,862,491 pounds, valued at $159,286; flounders, 1,985,340 pounds, valued at $140,586; croaker, 3,815,554 pounds, valued at $126,700; menhaden, 30,405,093 pounds, valued at $121,451; and mackerel, 584,386 pounds, valued at $100,556. Compared with 1904, there was a decrease of 3,323, or 36.54 per cent, in the number of persons employed, but an increase of $2,015,908 in the investment, and of 6,828,716 pounds, or 7.57 per cent, in the quantity and $2,597,991, or 76.74 per cent, in the value of the products.

The number of persons engaged in the fisheries of Pennsylvania was 591, the investment was $1,375,778, and the products amounted to 594,613 pounds, valued at $44,621. The principal species taken, in the order of their value, were squeteagues, "sea trout," or weakfish, 240,000 pounds, valued at $14,400; sea bass, 135,000 pounds, valued at $12,500; scup or porgy, 142,000 pounds, valued at $7,100; shad, 18,872 pounds, valued at $5,834; suckers, 21,199 pounds, valued at $2,469; carp, 9,712 pounds, valued at $1,511; and alewives, 20,085 pounds, valued at $405. Compared with 1904, there was a decrease of 821, or 58.14 per cent, in the number of persons employed, of $721,937, or 34.41 per cent, in the investment, and of 1,451,681 pounds, or 70.94 per cent, in the quantity and $122,878, or 73.36 per cent, in the value of the products.

The number of persons engaged in the fisheries of Delaware was 976, the investment was $585,616, and the products amounted to 25,023,193 pounds, valued at $652,448. The principal species taken, in the order of their value, were oysters, 4,315,731 pounds, or 616,533 bushels, valued at $450,873; menhaden, 18,082,000 pounds, valued at $67,970; squeteagues, "sea trout," or weakfish, 886,550 pounds, valued at $53,317; croaker, 418,873 pounds, valued at $18,682; shad, 86,836 pounds, valued at $16,312; carp, 87,820 pounds, valued at $13,166; sturgeon, including roe, 13,962 pounds, valued at $6,952; and alewives, 351,590 pounds, valued at $6,431. Compared with 1904, there was a decrease of 923, or 48.60 per cent, in the number of persons employed, and of $84,379, or 12.59 per cent, in the investment, but an increase of 19,414,904 pounds, or 346.18 per cent, in the quantity and $392,858, or 151.53 per cent, in the value of the products.

SHAD FISHERY OF THE HUDSON RIVER.

The shad fishery of the Hudson River in 1921 had engaged 307 persons, the investment was $44,607, and the catch was 35,448 shad in number, or 130,803 pounds, valued at $30,623. Of this quantity 28,948 shad, or 104,883 pounds, valued at $24,329, were taken in New York, and 6,500, or 25,920 pounds, valued at $6,294, in New Jersey. Compared with 1920, there was a decrease of 61 persons, and of 13,867 shad, or 69,041 pounds, and $25,706 in the value, but an increase of $4,256 in the investment.

In 1922 there were engaged 272 persons, the investment was $40,342, and the catch was 48,336 shad, or 175,186 pounds, valued at $39,706. The catch in New York was 36,111 shad, or 128,324 pounds, valued at $27,451, and in New Jersey, 12,225 shad, or 46,862 pounds, valued at $12,255. Compared with 1920, there was a decrease of 96 persons, and of 979 shad, or 24,658 pounds, and $16,603 in the value, with practically no change in the investment.

FLORIDA SPONGE FISHERY.

The quantity of sponges sold at the Sponge Exchange, Tarpon Springs, Fla., in 1922, was 526,885 pounds, valued at $699,092. This total included large wool sponges, 248,475 pounds, valued at $596,199; small wool, 70,478 pounds, valued at $42,286; yellow, 115,455 pounds, valued at $37,637; grass, 84,892 pounds, valued at $20,379; and wire, 7,585 pounds, valued at $2,588. It is estimated that sponges to the value of $50,000 were sold at Tarpon Springs outside of the exchange. Information as to the quantity sold at Key West is not available but is known to be comparatively small.

INQUIRY RESPECTING FOOD FISHES AND FISHING GROUNDS.

INTRODUCTION.

The effect of the gradual development of the fisheries of the United States has borne unequally upon the several resources exploited, partly as a result of the intensity with which the fisheries have been prosecuted in relation to the abundance of the original supply, partly owing to peculiarities in the distribution and life histories of the several species, partly as the consequence of ruinous methods of fishing or wanton and short-sighted destruction, and partly as an inevitable sequence of the social, industrial, and commercial development of the country and the consequent modification of the character of the waters. Certain species like the sturgeon have become almost extinct commercially, the natural oyster beds in some originally richly endowed areas have been depleted or destroyed, the Atlantic salmon has become hardly more than a memory in the United States, the shad runs in almost all streams are sadly reduced, the salmons of the Pacific Coast States and Alaska are no longer able to support the fisheries of former years, and in some places are on the verge of economic extinction, and the halibut banks of the western Atlantic have been reduced far below their pristine productivity, and those of the north Pacific Ocean are following the same course.

The resources that have been more particularly affected are those that are fixed to the bottom or have limited powers of locomotion, those that are confined to circumscribed bodies of water, or that run into such waters for spawning or other purposes at certain seasons of the year, or those that mature slowly and are represented by comparatively few individuals of large size.

On the other hand, there are many fishes, particularly marine species, some of them of paramount economic importance, that show no indications of depletion. These are mainly species of wide distribution, abundance, and high reproductive capacity and that at no time congregate in narrow waters where they come under the control of the activities of man as exhibited by fishing operations or obstruction, pollution, or other alteration of their accustomed environment. It does not follow, however, that because no evidences of depletion have been detected it can be assumed certainly in all cases that it has not begun, or that it may not occur as the cumulative result of existing operations and conditions or future developments.

The correction of existing and the prevention of prospective depletion has been sought principally through the agency of fish culture and legislation more or less restrictive of fishing operations and practices. It is obvious that a foundation for these measures must be established on an accurate and reasonably complete knowledge of the life histories of the organisms with which they deal, as otherwise they may prove wasteful and ineffective while at the same time imposing futile obstacles to the development of a legitimate and essential industry. The work of the division of scientific inquiry of the bureau is directed to the acquisition of this knowledge and its adaptation to the needs of the fisheries, its principal activities during the fiscal year being epitomized in the following pages.

STUDIES OF FISHES.

The salmon fisheries of Alaska present the most critical problem of fishery conservation confronting the bureau at the present time, the intensity of the fishery developed during recent years having very seriously depleted the runs in some streams, while almost everywhere the diminution has made itself manifest to a degree threatening eventual disaster. As is explained in more detail elsewhere in this report, the laws under which the bureau has been endeavoring to conserve this fishery are inadequate, and it has been necessary to invoke the powers of the President to create fishery reservations to give the immediate control of the situation necessary to save the fish.

While studies made during the past decade have added much to knowledge of the habits and life histories of the Pacific coast salmons, their wide distribution from California to the Arctic, the differences in environment through their range, and the fact that practically each stream has its own exclusive school of fish, makes their study laborious, time-consuming, and difficult. With the purpose of preparing a sound basis for regulatory measures that will conserve the fish while permitting the maximum safe exploitation of the fisheries, the bureau for a number of years past has engaged specialists to conduct the necessary investigations.

The enumeration of the salmon passing into Karluk River, on Kodiak Island, which has been referred to in previous reports, was continued during the year and a similar work was undertaken at Chignik. These studies are intended to furnish data of the ratio of fish on the spawning grounds to the total run necessary to maintain an unimpaired supply.

In an effort to determine the composition of sea schools of salmon in respect to the location of their spawning streams, about 4,000 adult fish were marked with aluminum tags at various places on or near the Alaska Peninsula. A considerable percentage of these was retaken, and valuable data were obtained regarding the oceanic migrations of the fish. This work will be supplemented and extended by tagging about 10,000 fish during the fiscal year 1924. A report on the progress of these studies was published during the year. Since 1916 nearly 750,000 young salmon have been marked by cutting off various of the fins and liberating them in the Columbia, Sacramento, and Quinault Rivers. On their return to the streams after several years spent in the sea these fish are easily recognized. During the spring of 1920, 100,000 young sockeye salmon, reared from eggs brought from Alaska in 1918, were so marked and liberated in the Columbia River with the invaluable cooperation of the Oregon Fish Commission. In 1922 large numbers of these, grown to maturity, returned to the river, and scales and data from approximately 1,200 were obtained. This, of course, does not represent the number entering the river. The fish, both in external appearance and qualities of flesh, retained the characters of their Alaskan ancestry, being distinctly different from native Columbia River fish of the same species.

Many of the important former spawning grounds of the blueback salmon of the Columbia River have been made inaccessible by the construction of power and irrigation works, and in 1922 an investigation was made to locate the spawning places now resorted to. It was found that a spawning run progresses at least to Sunbeam Dam on Salmon River, Idaho, and that the improvement of the fishway at that place to make it more readily passable to fish bound for Redfish Lakes should be undertaken.

The investigations on the Coregoninæ, or whitefishes, which are among the most important commercially of the Great Lakes, have been continued; the field work was completed early in the fiscal year, and the attention of the investigators has been directed for some months to the examination and comparison of collections and the compilation of data to be included in the final report on the systematic relations and natural history of the various species. Many data bearing on the differences between various races of whitefish and other coregonine fishes are now available, and especial attention is being given to the life history of the whitefish. The University of Michigan and the State Biological Survey are evincing a fine spirit of cooperation, which will materially aid and advance the work.

For a number of years the bureau made investigations, as opportunity occurred, of the salmons, trouts, and smelts of the Atlantic coast, but the work was suspended in 1921 on the resignation of the assistant who had been conducting it. It was resumed during 1923 on the return of the investigator to the service, and considerable progress has been made in assembling the accumulated data for publication. Some light has been thrown on the complicated relationships of the trouts, and material is on hand for clearing up certain puzzling matters of particular interest to fish culturists and anglers, but during the year attention has been devoted chiefly to smelts, which are important economically both as local food supplies, as entering into commerce, and as food for other fishes. As a consequence of the assiduity with which the smelt fisheries have been prosecuted, the supply of fish is being depleted gradually, and the report in preparation will be comprehensive of all facts relating to them that may be significant in efforts toward their conservation where still abundant and their increase in waters that have been depleted.

In cooperation with members of the faculty of the University of Wisconsin, studies of the natural foods of fresh-water fishes, particularly the basses, sunfishes, and perch, in wild waters, have been conducted with very small assistance from the bureau.

The available fisheries of interior waters and of the streams falling directly into the sea, as a whole, are now exploited to their permissible limits, and in some cases already mentioned are showing more or less marked indications of exhaustion. For increased production of fish food to meet the demands of growing population recourse must be had to that great reservoir of food, the sea. Of the strictly marine fishes none of the more important species, with the exception of the halibut, are exhibiting the criteria of depletion excepting, perhaps, locally; but with a conceivably possible but by no means imminent large increase in consumption, such symptoms may manifest themselves on some of the banks and fishery grounds more adjacent to our coasts, and it is not impossible that they are already present obscurely. It will be highly important to recognize them promptly, that corrective measures may be taken before conditions become so critical as to require drastic action economically objectionable. For these reasons comprehensive investigations of important fishery areas north and east of Cape Cod were undertaken a number of years ago and continued to the present time, with an interruption of several years during the war.

The fundamental facts of the distribution of water temperatures and salinities, the horizontal and vertical circulation of the water, the resulting production and distribution of the primary foods of fishes, and the dissemination of their eggs and young have been determined more accurately than on any other part of our Atlantic coast. During the year the most important work in this connection has been the release of 1,500 drift bottles for current determinations in cooperation with studies of like character conducted by the Canadian Government in the home waters. Plans have been laid for supplementary work during the fiscal year 1924. Also, following a project of cooperation with Canada, 2,396 cod, haddock, and pollock were marked with metal tags and released, and the practice will be continued until a total of 10,000 fish has been so treated. This experiment is to elucidate the facts of the migration, growth, etc., of these important food fishes, and will be supplemented by other studies during the coming year that will develop the other information necessary for the formulation of conservation measures, which at any time may become necessary.

A correlated investigation during the year was the study of the seasonal changes of the plankton of the vicinity of Woods Hole, based largely on the collections made by the bureau's laboratory at that place over a long series of years. Plankton is composed of the floating plants and animals, mostly minute, which constitute practically the sole food of most marine fish fry and directly or indirectly the food of most of the adults. On it primarily depends the fish production of the sea.

During the year there was completed and submitted for publication a comprehensive report briefly describing all of the fishes known to occur in the Gulf of Maine and epitomizing what is known of their life histories. This work, and a large part of the other work of the bureau in that region during the past 10 years, has been made possible by the cooperation of the director of the Museum of Comparative Zoology at Cambridge, Mass., and Dr. H. B. Bigelow, of the same institution.

The field work of the investigation of the fisheries of Chesapeake Bay was completed in June, 1922; the collections and data have been consigned to specialists, and considerable progress has been made toward a comprehensive report on the region. This investigation repeats, in a more circumscribed area, the general features of that conducted in the Gulf of Maine. The U. S. Coast and Geodetic Survey, the U. S. Geological Survey, and the U. S. Weather Bureau have all cooperated by furnishing valuable data respecting the hydrography and meteorology of the Chesapeake basin.

OYSTER INVESTIGATIONS.

Oyster investigations in Long Island Sound and Great South Bay were continued during the year, the field work lasting from early in June until September 20.

The special purpose of the work in Great South Bay is to discover the cause of the great mortality which frequently occurs after an abundant "set" has apparently established the basis for a good crop. The presumption has been established that this is due to conditions peculiar to the bottom or the stratum of water near the bottom. Well-grown oysters of the set of 1921 were found in compact groups in various situations a few feet above the bottom, while all those that had set so abundantly on or near the bottom had died shortly after becoming attached. The work planned for the summer was the testing of various types of cultch that would permit a set above the danger zone, but this purpose was defeated by the exceedingly poor set of 1922, possibly due to unstable water conditions.

The investigations in Connecticut revealed that a much better than ordinary set followed a reasonably early spawning in harbor and inshore waters, lending some confirmation to the previous indications that failures of recent years have been due to the depletion of the inshore beds from overfishing and the results of pollutions. Oyster larvæ were found in Housatonic River, recently devoid of oysters, where some had been planted in the spring.

In cooperation with the Bureau of Chemistry a study was made of conditions in Housatonic River and New Haven Harbor in respect to trade pollutions from heavy metals, oxygen content, and alkalinity. One of the difficulties encountered in all of these investigations has been the lack of precise information regarding the pristine and present hydrographic and planktonic conditions. To furnish such data of the existing state of the waters, the *Fish Hawk*, under the direction of the naturalist of the *Albatross*, was detailed to make a survey of conditions that might bear on the mortality obtaining among the oyster fry and the spat after a brief period of survival. The field work was practically complete at the close of the fiscal year, with the exception of a few weeks' special study of inshore polluted areas.

INVESTIGATIONS RELATING TO FISH CULTURE.

The biological station at Fairport, Iowa, has continued its experiments in the culture of various of the important commercial fishes of the Mississippi Valley. The hatching and rearing of buffalo fish in ponds as an adjunct to the farm-food supply appears feasible, but it is doubtful if the species can be so produced on a commercial scale, owing to the large pond area required for attainment of maximum growth in large numbers.

The results of experiments with the channel cat have been sufficiently promising to warrant setting aside several ponds for the work, and at the close of the year the indications were that there would be justification for undertaking the work on a basis of practical magnitude next season.

The spawning habits of the paddlefish, a disappearing species particularly valuable for the production of caviar, are entirely unknown, notwithstanding the work of a number of investigators. A number of young fish are now being reared at the laboratory, but they have not yet reached the spawning age.

The hackleback sturgeon is another highly prized fish likewise imperiled by the fishery as now conducted, and drastic control will be necessary if it is not to be economically exterminated. Unlike most fishes, the hackleback does not spawn annually. The rock sturgeon is in the same category with the hackleback in respect to its individual value and waning numbers, and both species have been the subject of study and experiment for the development of practical regulatory and fish-cultural measures for their conservation.

The bureau's fish pathologist has been engaged principally in the investigation of certain diseases that have produced serious losses of fish at various hatcheries and during distribution of the young. One of the most widespread and destructive of these maladies affecting trout was found to be due to an intestinal parasite (*Octomitus salmonis*) which causes fatal enteritis. No means for directly combating this disease have been developed, but palliative measures, such as the avoidance of overcrowding and the maintenance of a lower water temperature during transportation, have decreased the mortality.

The brood stock of bass and, to a minor degree, other pondfishes at Neosho (Mo.) station has developed from time to time numerous cases of sterility, which have seriously curtailed the output of the station. An investigation during the past year has shown this to be due to an ovarian infection by the larvæ of a tapeworm.

During the latter part of the year a series of experiments for developing a more satisfactory diet for trout was inaugurated at the hatchery at Manchester, Iowa, and the laboratory at Fairport, Iowa, under the direction of the fish pathologist. In the light of present knowledge of mammalian nutrition, to which much attention has been directed in recent years, it appears that the foods now used in hatcheries may be deficient in certain essential constituents, particularly vitamines and salts. It is not improbable that these deficiencies may contribute to the troubles encountered by fish-culturists, and it is hoped that a more fully adequate ration can be devised as a result of the current investigation.

The pathologist and several members of the staff of Fairport laboratory have made a number of investigations of epidemics occurring both in wild waters and in State and private hatcheries.

FRESH-WATER MUSSELS.

Investigations and experiments relating to the pearl-button mussels of the Mississippi River drainage system have been continued in the interests of improvement in the methods of mussel culture and other essentials for the conservation of these economically important mollusks.

Studies of the factors affecting the survival and growth of juvenile mussels after they have passed the parasitic larval stage have been attended with results warranting the establishment of a small rearing system, consisting of 150 metal troughs with a capacity of about 750,000 mussels, an important feature of which is the exclusion of light. The indications are that more tangible and better-controlled results will accrue from this method than are now attained by the infection of fish liberated in the open waters with all the attendant uncertainties as to the fate of the little mussels dropped fortuitously.

Statistical and biological surveys have been conducted during the year in Lake Pepin and Lake Pokegama, in both of which mussel culture has been carried on for several years. In Lake Pepin there has been also an alternate sectional closure to commercial mussel fishing. The survey of Lake Pepin indicates that there has been an increase in the commercially important mucket (*Lampsilus luteola*), propagated by the bureau, while the other species not propagated have decreased. The facts developed in this survey are the most conclusive evidence of the value of mussel culture so far obtained.

The personnel of the Fairport laboratory has been active in assisting the State authorities in developing rational legal measures for the conservation of the mussel beds, as a consequence of which the States of Minnesota, Iowa, Wisconsin, and Illinois have entered into cooperative closure of alternate sections of the Mississippi River between Brownsville, Minn., and Keokuk, Iowa, and Arkansas has announced the intention to pursue the same system of regulation on the Black and White Rivers.

MOSQUITO CONTROL.

Investigations relative to mosquito control by means of fish, particularly the top minnow Gambusia, were continued at Augusta, Ga., from July 1 to November 10, in cooperation with the U. S. Public Health Service.

The problems under immediate consideration were the effects of various types of vegetation on mosquito production; the effects of increased competition for food among Gambusia upon the rate of mosquito production; sex frequency and the relative vitality of the sexes of Gambusia; and the proper treatment of the fish in captivity and under shipment.

Tests made with various types of vegetation, including some that have been considered inimical to mosquito production, show that few, if any, of them prevent mosquitoes breeding, but that many species of plants do not form barriers between top minnows and mosquito larvæ and are therefore neutral in their effects on mosquito production in waters containing the minnows. It was shown also that it is not always the dense vegetation, as is commonly believed, that forms the best protection for mosquito larvæ against fish.

Competition for food among Gambusia is advantageous, and even in the presence of a serious barrier complete mosquito control may be approached if sufficient minnows are present. The observations on the vitality of the sexes indicated that the males succumb more easily than the females.

Under shipping conditions Gambusia lived equally well in vessels of the same diameter when only one-third full of water as they did when the vessels were filled two-thirds full, and tests indicate that shipments can be made most successfully when the temperature of the water ranges from 83° F. downward. During December, 1922, 200 Gambusias were shipped to Palestine with a loss of but 30 en route.

During the year two rather extensive trips were made by the assistant in charge of the investigation to various sections of the Southeastern States for the purpose of inspecting malaria-control projects and to offer suggestions to local health officers concerning the proper use of mosquito-destroying fish. The annual conferences of the National Malaria Committee and the field men conducting malaria-control work were attended.

FOULING OF VESSEL BOTTOMS.

In September, 1922, at the request of the Navy Department, the bureau undertook direction of an investigation of the marine growths on the bottoms of ships to determine, if possible, the conditions governing the amount and character of such growths and the possible seasonal and regional factors affecting them, with a view of securing data on the problem of preventing their attachment to ships' bottoms, as well as to determine the docking intervals for ships in various kinds of service.

The investigation has also indicated, rather conclusively, that most of the fouling occurs while the ships are in harbors and that vessels in commission that never stay more than six or seven days in any port and that travel between ports a considerable distance apart do not foul seriously, at least during August to March, in the North Atlantic Ocean. On the other hand, it is found that vessels that lie continuously at anchor in any one port for the five or six winter months become heavily coated with hydroids but not with barnacles.

Cooperation has been extended to the Navy Department in testing the relative efficiency of various antifouling paints.

MISCELLANEOUS INVESTIGATIONS IN INTERIOR WATERS.

Cooperation has been continued with the Wisconsin Geological and Natural History Survey in important investigations of the fundamental conditions of fish life in lakes. The aquatic plants, the plankton, bottom fauna, and mussels of Green Lake were studied during the past year with reference to quantity and distribution. Arrangements have been made for the continuance of these investigations during the fiscal year 1924.

In cooperation with the Illinois Natural History Survey, the Chicago Drainage District, and the U. S. Public Health Service, a statistical survey of the Illinois River for 1921 was made by members of the staff of the Fairport Biological Station in connection with a study of the effects of pollution and the reclamation of land along the stream upon public health, recreation, agriculture, and the fisheries.

During the summer of 1922, in cooperation with the National Park Service, the bureau made an investigation of the pelicans in the Yellowstone National Park to determine their destructiveness in relation to the trout, the supply of which the bureau helps to maintain by artificial propagation. The results of this investigation indicate that the pelican is a highly specialized predatory bird, and that its breeding period in the park is so precisely synchronized with that of the trout that its depredations effect maximum losses. It was originally suggested that attention be directed rather definitely to the problem presented by the parasites of the pelicans and of the trout in Yellowstone Lake. Some data were secured on this point, but the general problem of the destructiveness of the birds with respect to the trout, after conferences on the ground, was considered to be of such immediate importance that the question of parasites was temporarily relegated to the background and has not been the subject of special attention.

OPERATION OF BIOLOGICAL LABORATORIES.

The biological laboratory at Fairport, Iowa, has been operated as usual, conducting investigations and experiments in the interests of the economic aquatic resources of the Mississippi Valley and practical fish culture and mussel culture as an aid to their conservation. The more important activities have been mentioned briefly in their appropriate places in preceding pages of this report.

The laboratory at Woods Hole was operated during the summer with a small staff of the bureau's employees, and its facilities were extended, at no additional expense, to a number of independent investigators making studies of various problems of marine biology. During the remainder of the year it was used as a base for the staff of the *Albatross*, who were engaged in investigations of the basic food organisms of the region and in the oceanographic and biologic studies mentioned in connection with the investigation of the causes of the disastrous conditions obtaining in the oyster industry in Long Island Sound and contiguous waters.

There is still an almost complete lack of personnel at the Beaufort (N. C.) laboratory, due to the impossibility of filling the vacant positions with competent men at the salaries available. The work on diamond-back terrapin culture made some progress, and the facilities of the laboratory were profitably employed during a large part of the year by investigators of the Navy Department employed in the study of fouling of ships' bottoms. During the summer of 1922 several independent investigators made use of the laboratory. Repairs have been made to buildings, sea wall, and grounds, and the station is in satisfactory physical condition.

The situation at Key West (Fla.) laboratory is also unsatisfactory in respect to personnel for the same reasons as at Beaufort. Some improvement in the buildings and grounds were made during the year, but the incomplete condition of the station and the lack of personnel render it nearly unproductive at present.

POLLUTION OF WATERS.

The bureau's recommendation of a small appropriation for the systematic study of water pollutions in their relation to the fisheries failed to receive the favorable consideration of Congress, and this important subject has received practically no attention during the year excepting as a part of the investigation into the conditions causing the failure of the oyster set in Long Island Sound. I feel that I can not do better than reiterate the statement carried by my report of last year:

> Pollution of interior streams and waterways by industrial wastes and municipal sewage has been the subject of complaint and protest for many years. Industry itself frequently has been a victim of its own acts through inability to use the polluted water with safety in boilers or for the many other industrial purposes that require pure water. The public health has been menaced, public works have been damaged, agriculture has suffered, and in some parts of the country the streams have been swept bare of living things, including

fishes and other animals of economic importance. Recently the vast development of petroleum production and transportation, the use of its derivatives for manifold purposes ashore, and particularly as fuel on ships, has introduced a new element of serious pollution in the great harbors and in places on the open coast.

The pollutions are almost as varied as industry and in many cases are not only complex in themselves but are further complicated by their reactions on one another and on the natural constituents of the waters themselves. The waters can not be restored to their pristine purity, nor to any state approaching it, by mere legislative fiat, and the sooner that fact is appreciated and constructive measures are taken the better for the public welfare.

The pecuniary losses now suffered as the result of water pollutions are enormous, and the preventable damage to the life and beauty of our streams, lakes, and seacoast is beyond estimate in terms of mere money. If existing abuses are to be corrected and new ones prevented without inflicting widespread economic injury, something more constructive than drastic laws must come into being. There must be corrective legislation, but it should be based on something more substantial than a perfectly justifiable desire for improvement. Complete utilization of raw materials is an ideal not attainable. Industry must be accompanied by "waste," and the wastes must be disposed of in some manner. The problem is to devise ways of disposing of them so as to minimize their harmfulness while still permitting industrial development. This is the problem of the biologist, the chemist, and the engineer working in cooperation.

The effects of these pollutions on the fisheries are the only phases of the subject that officially concern the bureau, and it has continued to endeavor, so far as its means would permit, to contribute to the solution of the problems involved; but it is futile to expect that much can be done unless money and, particularly, trained and capable men are provided for the purpose of determining facts and their practical and scientific implications.

PROPAGATION AND DISTRIBUTION OF FOOD FISHES.

REVIEW.

During the fiscal year 1923 the fish-cultural operations of the bureau were conducted along the same lines as in 1922. Work at some of the more remote substations had to be discontinued owing to insufficient funds, particularly on the Pacific coast, where it is the practice to operate widely scattered field stations on or near the spawning grounds in order to supply the salmon hatcheries with their full quota of eggs. No attempt was made to collect eggs of the pike perch and yellow perch at the Bay City (Mich.) or the Swanton (Vt.) substations. In the marine fish-cultural field the usual offshore work of collecting and fertilizing eggs of the cod, haddock, and other commercial species, and immediately returning them to the natural spawning grounds, had to be omitted.

The Green Lake (Me.) station was closed at the beginning of the fiscal year by authority of Congress, on the recommendation of the bureau. Fish-cultural work at this station has been handicapped by the nature of the water supply, taken from a large open pond, which frequently during the early spring months attained a temperature too high for trout rearing, thus necessitating the premature planting of all stock on hand. In view of the limitations imposed on the work by these conditions, and the very appreciable increase in the cost of maintaining and operating the station within recent years, it was deemed advisable to close it.

Generally speaking, conditions were not favorable to fish culture during the year. Low-water stages on the west coast interfered with the run of fish in many of the streams early in the season, only to be followed later by heavy floods, which in some instances carried away the racks and permitted the escape of the brood stock held below. A large number of lake-trout eggs were taken, but adverse weather during the spawning season curtailed the collections of whitefish and cisco eggs.

In the Lake Erie field pike-perch propagation was seriously curtailed by the late spring and the large accumulations of ice remaining on the spawning grounds beyond the usual time. On the other hand, a remarkably good showing was made in the propagation of carp at Port Clinton, Ohio. The carp fishery of this region is an important industry, yielding an annual product valued at approximately a million dollars, and the local fishermen are very appreciative of the bureau's efforts to maintain the supply. As a result of their hearty cooperation, the collection of eggs last season was the largest ever made by the bureau. The fishermen take carp in large numbers in the course of their ascent of the Portage River during the spring to spawn and transfer them to ponds from 5 to 15 acres in area, where they are held and fed on shelled corn until September and are then shipped alive to the New York markets. The buffalo-fish, a species which the commercial fishermen regards as more valuable than the carp, was introduced into the Portage River by the bureau several years ago and appears to have become established there.

A successful season was experienced in the collection of buffalo-fish eggs in Louisiana, but owing to pollution of the water supply from floods in the Ouachita River, very heavy losses were sustained during the incubation period, thus reducing the output. The bureau received considerable assistance in the collection of the eggs and the distribution of the fry through the cooperation extended by the Louisiana Conservation Commission.

The collection of cod eggs on the Atlantic coast was the largest ever made by the bureau, but there was a considerable reduction in the output of other species from the marine hatcheries owing partly to adverse natural conditions during the spawning season and partly to lessened activities of the commercial fishermen on account of the low market prices prevailing for the species in question during the spawning period.

Shortage of funds necessitated the omission of the usual purchase of adult Atlantic salmon as a source of egg supply for the Craig Brook (Me.) station. Thus far the Penobscot River fishermen have refused to cooperate with the bureau on a reasonable basis in its efforts to maintain the supply of salmon in that river, and unless they can be prevailed upon to adopt a more favorable attitude a large measure of success can not be expected. It is essential that the fishermen turn over brood fish to the bureau at the prevailing market price without requiring a bonus for handling, as at present. The maintenance of the salmon supply in this region is of far greater importance to the local fishermen than to anyone else, and they should lend the bureau a reasonable amount of assistance in connection with its efforts in their behalf.

The shad-spawning season on the Potomac River was unusually late, no eggs being available until near the end of April, fully three weeks beyond the usual time. Scarcity of snow, slight rainfall, and unseasonably low temperatures undoubtedly had their effect in delaying and shortening the spawning period. Shad are extremely sensitive to the temperature and quality of water, and they will enter those streams only where the conditions are favorable.

As will be noted from the summary of distribution, the output of fingerling fish of all species was 35 per cent smaller than that of the previous year. This is largely accounted for by the smaller number of rescued fish handled as compared with that year. Shortage in the general propagation fund also had its effect upon this branch of the work, as large numbers of young fish can not be reared without involving considerable expense for food and labor.

During the fiscal year 1923 fish-cultural work was conducted by the bureau in 33 States and in the Territory of Alaska, involving the operation of 37 main stations and 32 auxiliaries, and the propagation of over 40 species of food fishes. Consignments of eyed eggs of certain species were furnished on request to several foreign Governments, and in numerous instances allotments of eggs were transferred to State hatcheries and other stations of the bureau as an economical and efficient means of rehabilitating depleted waters.

The bureau does not transfer eggs or fry of the important commercial fishes to points remote from the source of collection, as the entire available supply is needed for the maintenance of the fisheries in home waters. This applies especially to the Pacific salmons, to the whitefish, lake trout, and pike perch of the Great Lakes region, and to the shad and the marine species of the Atlantic coast.

Summary, by species, of the output of fish and fish eggs during the fiscal year ended June 30, 1923.

Species.	Eggs.	Fry.	Fingerlings.	Total.
Catfish			37,092,979	37,092,979
Buffalofish	163,169,500	5,925,000	9,429,838	178,524,338
Carp	29,000,000	115,000,000	14,226,110	158,226,110
Shad		16,971,000		16,971,000
Glut herring		150,000,000		150,000,000
Whitefish	148,041,000	208,675,000	3,000	356,719,000
Cisco	10,000,000	39,000,000		49,000,000
Chinook salmon	4,205,000	720,000	28,965,045	33,890,045
Chum salmon		8,274,830	14,997,900	23,272,730
Humpback salmon		396,950	1,915,435	2,312,385
Silver salmon	100,000	8,371,025	5,910,630	14,381,655
Sockeye salmon	10,678,400	31,582,000	50,949,400	93,209,800
Steelhead salmon	1,744,000	275,000	5,339,005	7,358,005
Atlantic salmon		451,000	40,038	491,038
Landlocked salmon	76,872	727,670	92,800	897,342
Rainbow trout	2,689,960	754,000	3,408,159	6,852,119
Black-spotted trout	10,127,100	2,160,100	1,492,700	13,779,900
Loch Leven trout			43,800	43,800
Lake trout	7,253,300	34,748,415	232,080	42,233,795
Brook trout	725,300	2,841,400	8,477,250	12,043,950
Smelt	16,280,000	28,000,000		44,280,000
Pike and pickerel			905,395	905,395
Crappie			35,602,522	35,602,522
Largemouth black bass		806,500	1,342,349	2,148,849
Smallmouth black bass		449,400	79,007	528,407
Rock bass			64,035	64,035
Warmouth bass			8,350	8,350
Sunfish			26,854,257	26,854,257
Pike perch	37,275,000	63,365,000		100,640,000
Yellow perch	3,680,000	136,325,000	936,295	140,941,295
White perch			675	675
Striped bass		16,341,000		16,341,000
White bass			40,085	40,085
Fresh-water drum			49,026	49,026
Cod	650,980,000	376,813,000		1,027,793,000
Haddock	104,400,000	2,960,000		107,360,000
Pollock	33,960,000	276,098,000		310,058,000
Flounder	229,345,000	1,058,781,000		1,288,126,000
Miscellaneous fishes			15,818,142	15,818,142
Total	1,463,730,432	2,586,812,290	264,316,307	4,314,859,029

DISTRIBUTION OF OUTPUT OF HATCHERIES.

As heretofore, the fish and fish eggs produced at the bureau's stations were widely distributed, the output of commercial fishes being liberated as fry in suitable public waters, while the various species adapted for interior ponds, lakes, and streams were assigned on applications submitted by individuals, organizations, and State fisheries authorities. Shipments were made to practically every part of the United States, the coastal regions of Alaska, and to several foreign countries.

The five specially equipped cars of the bureau are used principally for the distribution of fishes to interior waters, including both public and private ponds, lakes, and streams, for which individual applications have been submitted, and waters within the United States forest reservations and national parks. In addition, the cars are employed to some extent in shipping fry from the Great Lakes hatcheries to distant spawning grounds that can not be reached conveniently by boat. In all other cases the distribution of the commercial species is accomplished without the use of the cars, most of the fish being liberated on spawning grounds in the immediate vicinity of the hatcheries.

During the fiscal year 1923 the bureau's cars and messengers covered 415,505 miles of travel on regular passenger trains, in the course of which 11,500 applications for fish were filled. Of this total, 70,118 miles were traveled by the cars and 345,387 miles by detached messengers.

In a number of instances the bureau refused to entertain applications for such spiny-rayed fishes as bass and pike for introduction into waters connected with the salmon streams of the west coast, on the ground that such fishes would be certain to prove destructive to the existing valuable fisheries of that region. If placed in such waters, the young of these predatory fishes would almost certainly eventually ascend the salmon and trout streams to the natural spawning grounds, prey upon the eggs and young of the indigenous species, and destroy their nests.

The bureau has also found it necessary to refuse trout and smallmouth black bass for stocking waters in the South, where the temperature becomes too high for these fishes. It also refuses to furnish bass and other warm-water fishes for introduction in rivers and lakes where these species are indigenous and already abound. Many persons submit applications for fish without considering the necessity. If the fishing happens to be poor they apparently think that the mere planting of fresh supplies of fish will afford a bountiful stock. In any event, it is easier to ask for "something for nothing" than to exercise care and vigilance in the conservation of that which already exists. In such cases the essential requirement is not additional plants of fish but adequate protection for the existing stock during the spawning season and the application of proper restrictive regulations during the remainder of the year. If well protected, most of the warm-water fishes will maintain themselves and multiply without other assistance where the conditions are congenial. The demands for fish for depleted waters throughout the country are so great as to tax the resources of the bureau, and it can not undertake to furnish stock for waters that need nothing but reasonable protection to restore them to full productivity.

RELATIONS WITH STATES IN FISH CULTURE.

To meet the heavy demands by tourists and automobile parties upon the fishing in the waters of many States, the State authorities have had either to increase the production at their own hatcheries or to work in closer harmony than heretofore with the bureau. The cooperative relations thus established have been beneficial to both parties and in many instances have resulted in more economical and efficient work than would otherwise have been possible.

In several parts of the country eggs are collected conjointly by the bureau and the State fish commissions. In some instances the bureau's personnel is lent to the State authorities for the development of egg-collecting fields with the understanding that an equitable division of the eggs or the resulting fry will be made. In the southern districts of the Mississippi Valley young fish are removed from more or less inaccessible waters, where they are crowded together in large numbers and serve only as prey for larger fish, and are placed in a more suitable environment, that they may eventually be of benefit to the public. In the upper Mississippi Valley assistance is rendered by the neighboring States in transferring fish from landlocked pools to tributary waters of the Mississippi River where favorable conditions exist. In several cases surplus eggs have been exchanged by State organizations and the bureau with advantage to both parties.

With the increasing demand for fish other cooperative relations between the bureau and the States have assumed larger proportions. The bureau is constantly calling the attention of various State officials to the necessity for more adequate laws for the protection of the food and game fishes within their boundaries. At the present time legislation of this character is lacking to a greater extent in the Southern States than in any other part of the country. The fisheries of the South have not as yet become so depleted as in many parts of the North, and, owing to the natural productivity of southern waters, the need for protective legislation has not become so imperative. However, the large influx of tourists to the Southern States during the winter months is rapidly changing the situation, and unless these States adopt measures for the protection of fish, particularly during the spawning season, their waters will soon be in a state of depletion. Not only are the laws inadequate but very few States in this region make any additions to the existing stock by the introduction of fish produced at their own hatcheries.

The cooperative relations that have heretofore existed between the bureau and the Canadian fisheries authorities have been continued. Every year the bureau's station at Cape Vincent, N. Y., collects large numbers of whitefish and cisco eggs on the Canadian side in the Bay of Quinte, and not only turns over a portion of such collections to the Canadian hatcheries but also liberates in Canadian waters a certain percentage of the fry produced. The bureau has also received from the Canadian authorities consignments of Atlantic-salmon eggs and has returned in exchange eggs of the rainbow, brook, and blackspotted trout. This cooperation between the two countries has resulted in each case in a greater output of fish than would otherwise have been possible and has led to the introduction of species that were especially desirable or necessary for the maintenance of existing fisheries.

During the fiscal year 1923 the fisheries authorities of 26 States were supplied with fish or fish eggs, as is shown in the following table:

Assignments of fish and fish eggs to State and Territorial fish commissions, fiscal year 1923.

[Asterisk (*) denotes eggs; dagger (†) fry; all others are fingerlings.]

State and species.	Number.
Alaska:	
Brook trout	*50,000
Sockeye salmon	*5,098,936
California:	
Black-spotted trout	*100,000
Lake trout	*100,000
Colorado: Lake trout	*50,000
Connecticut: Lake trout	*30,000
Hawaii:	
Blackspotted trout	*50,000
Rainbow trout	*25,000
Idaho:	
Blackspotted trout	*125,000
Brook trout	900
Catfish	1,500
Rainbow trout	4,500
Whitefish	*1,000,000
Iowa:	
Lake trout	*75,000
Rainbow trout	*153,600
Louisiana:	
Black bass	24
Buffalofish	†1,200,000
Crappie	250
Sunfish	1,700
Maine: Lake trout	*50,000
Maryland:	
Brook trout	750
Chinook salmon	*15,000
Do	†4,000
Crappie	100
Humpback salmon	†3,350
Rainbow trout	400
Do	*114,000
Whitefish	*192,000
Michigan:	
Cisco	*10,000,000
Lake trout	†636,000
Minnesota:	
Black bass	600
Catfish	12,700
Crappie	17,900
Lake trout	*200,000
Sunfish	7,520
Yellow perch	100
Missouri:	
Rainbow trout	*50,000
Yellow perch	*3,680,000
Montana:	
Blackspotted trout	*1,599,000
Lake trout	*50,000
Steelhead salmon	*100,000
Whitefish	*1,000,000
New Hampshire:	
Chinook salmon	*120,000
Lake trout	*50,000
Landlocked salmon	*20,349
New Jersey:	
Rainbow trout	*100,000
Sunfish	88
New Mexico:	
Blackspotted trout	*50,000
Do	62,000
Brook trout	*300,000
Rainbow trout	*69,500
New York:	
Lake trout	*1,250,000
Whitefish	*31,885,000
North Dakota:	
Black bass	400
Buffalofish	1,110
Catfish	9,600
Crappie	5,550
Sunfish	1,330
Yellow perch	1,100
Ohio: Pike perch	*37,275,000
Oklahoma: Rainbow trout	119,151
Oregon:	
Blackspotted trout	*50,000
Chinook salmon	*4,000,000
Sockeye salmon	*5,045,000
Steelhead salmon	*370,000
Pennsylvania:	
Rainbow trout	*681,000
Whitefish	*28,000,000
Utah:	
Catfish	28,400
Lake trout	*150,000
Vermont:	
Lake trout	*130,000
Landlocked salmon	*20,349
Steelhead salmon	8,000
Washington:	
Sockeye salmon	*534,464
Steelhead salmon	*95,000
Do	50,000
West Virginia:	
Brook trout	352,000
Rainbow trout	500,000
Wisconsin:	
Black bass	8,350
Catfish	16,150
Crappie	7,800
Lake trout	*3,000,000
Do	†1,760,000
Wyoming:	
Blackspotted trout	*550,000
Do	†300,000
Lake trout	*150,000
Rainbow trout	*309,000
Total	*138,112,198 †3,903,350 1,219,973

Shipments of fish eggs to foreign countries, fiscal year 1923.

Country and species.	Number of eggs shipped.	Country and species.	Number of eggs shipped.
Argentina: Steelhead salmon	25,000	Germany: Rainbow trout	68,000
Canada:		Netherlands:	
Blackspotted trout	317,000	Chinook salmon	200,000
Steelhead salmon	400,000	Rainbow trout	50,000
Whitefish	44,000,000		
Czechoslovakia: Rainbow trout	100,000	Total	45,160,000

COOPERATION WITH FISH-PROTECTIVE ASSOCIATIONS.

Throughout the year the bureau has worked in close harmony with fishing clubs and other organizations interested in stocking certain waters or in securing legislation for their protection. Such organizations have assisted in the distribution of fish by promptly meeting shipments sent out by cars or detached messengers and carefully liberating them in the most suitable waters available. The bureau has furnished these agencies information as to the best methods of planting fish, and in some instances public talks have been given by the bureau's representatives explaining its work at some length. In other instances the bureau's employees have been detailed to give advice to State organizations, their expenses while thus engaged being borne by the State in question.

PROPAGATION OF MIGRATORY FISHES OF ATLANTIC RIVERS.

Owing to various unfavorable conditions, the season's results in shad propagation on the Potomac River and in the Albermarle Sound district were smaller than for several years past. At the Bryans Point station the unusually cold and stormy weather prevailing practically throughout the spawning season interfered with fishing operations, and the river water remained too cold to ripen the eggs and cause the fish to seek shallow waters to spawn until about two weeks beyond the usual time. Shortly after the middle of April egg collections were undertaken and continuously prosecuted until May 15, and 17,677,000 eggs were secured. Shad work at the Edenton station was practically negligible as a result of a recently adopted decision to issue no permits for the operation of gill nets on the usual spawning grounds. In past years gill nets have constituted the main source of supply for shad eggs for this station, but experience having shown that many of the fishermen were not complying with the terms of the license, its discontinuance was deemed advisable. The results of the season's work in the propagation of glut herring at the Edenton station were most encouraging, the egg collections being increased over last year's collections by approximately 200 per cent, notwithstanding the difficulty encountered in obtaining efficient spawn takers to handle the large numbers of fish available.

Eggs to the number of 313,000,000 were obtained and incubated at an average cost of $2.14 per 1,000,000. The propagation of this species represents conservation of the highest type, since the eggs would be sent to the market in the fish and lost were it not for the bureau's intervention. In past years the fishermen of the region have appeared reluctant to cooperate with the bureau in furnishing eggs, but they now seem to realize the importance of the work and it is believed there will be no difficulty hereafter in obtaining an egg supply.

The Weldon substation, on the Roanoke River, was fitted up for striped-bass propagation as usual, but egg collections were discontinued at the height of the spawning season, as it was found that the large amount of trade waste discharged into the river from a local manufacturing plant was polluting the water and killing the fry liberated from the hatchery. The total egg collection amounted to 22,084,000. At the beginning of the spawning season the fishermen at this point were loath to cooperate in the collection of eggs on a fair basis, but this opposition was overcome after the situation had been fully explained to them.

The usual collection of adult Atlantic salmon at the Craig Brook (Me.) station could not be made, due to the washing away of the barrier at the Dead Brook inclosure, where it has been customary to hold the fish for several months awaiting the development of their spawn. Five hundred thousand Atlantic salmon eggs, received at the Craig Brook station from the Canadian Government in exchange for an equal number of trout eggs, produced 466,000 fry, all of which, with the exception of a small number reserved for rearing to the fingerling stage, were liberated in the Penobscot River and its tributaries.

It is believed that greater results than heretofore may be attained by rearing a comparatively small number of fish to the No. 2 or No. 3 fingerling stage before liberating, and this policy will be pursued in connection with any future operations with this species. It is probable, however, that Atlantic salmon propagation on the Penobscot will be entirely discontinued unless the fishermen of the region show a greater willingness than they have thus far shown to cooperate in the work.

PROPAGATION OF COMMERCIAL SPECIES OF THE GREAT LAKES.

The bureau's work in this region was concerned as usual with the propagation of such important commercial fishes as the lake trout, whitefish, pike perch, yellow perch, and carp. Most of the eggs obtained from these species are taken from fish caught for the market by the commercial fishermen and incubated in the bureau's hatcheries, the resulting fry being liberated on the natural spawning grounds. Owing to heavy storms, which prevailed practically throughout the incubation period, there was a considerable shortage in whitefish egg collections as compared with the previous year, and the quality of those secured was impaired by the quantities of slime and sediment carried in the water supply. On the other hand, the weather in the spawning fields where lake trout eggs are obtained was favorable, and the collections of that species exceeded those made in 1922.

In the eastern end of Lake Ontario the ciscoes, for some unknown reason, did not resort to the spawning grounds in the usual numbers. Especially was this true in the ordinarily prolific Bay of Quinte, the catch of the commercial fishermen in that field being very much below the average. As a consequence the egg collections for the Cape Vincent hatchery were reduced far below the total of last year. The smaller than average collection of pike perch eggs in the Put in Bay field resulted from an unduly late fishing season, the setting of the fishermen's nets being greatly interfered with by the large bodies of ice that remained in the lake to a late period. The collection of carp eggs in the Portage River district was the largest ever made by the bureau. All the carp fishermen of this region are greatly interested in the success of the work and are cooperating heartily in the bureau's efforts to increase its egg collections.

PROPAGATION OF PACIFIC SALMONS.

In the Pacific coast and Alaska fields the collection of salmon eggs amounted, in round numbers, to 179,000,000, or approximately 50,000,000 less than were secured last year, this considerable shortage being due to unusual water conditions. In some of the streams where operations were conducted the water stages were so low as to prevent fish from entering, while in other fields the racks installed to intercept the run were carried away by floods, permitting the escape of brood stock upon which the stations were depending for their egg supply.

A successful season was experienced in the collection of sockeye salmon eggs for the Afognak (Alaska) station, 61,790,000 being secured. The steady increase in the yearly egg collections in this region since 1912, when the run of salmon was destroyed by the eruption of Mount Katmai, would seem to indicate beyond doubt the effectiveness of artificial propagation. With the view of obtaining some definite information along this line as a preliminary to extending the work if the conditions warrant, steps have been taken to make an annual count of the salmon passing up the Karluk River, the first count to be made during the current season.

At the beginning of the sockeye spawning season at the Yes Bay (Alaska) station the water stages were too low to permit of egg collections, the conditions in this respect remaining unfavorable up to the end of the first week in September. Eggs to the number of 25,000,000 were taken between that time and September 22, when the work was abruptly terminated by heavy rains, which flooded and carried away the racks, permitting the escape of brood fish estimated to contain at least 10,000,000 eggs. This station has been making a point of rearing large numbers of young salmon to the fingerling stage before liberating them, and in order to conduct the work as advantageously as possible has inclosed the outlet of a natural slough, which appears to make an excellent feeding ground. The Forest Service has cooperated with the bureau in this region by constructing a trail to connect the station with tidewater.

In the Washington field the floods were especially severe in the Quilcene River, on which the Duckabush and Quilcene hatcheries are located, the water remaining at a very high stage for several weeks during a critical period. The 1922 annual census of sockeye salmon descending through the weir at Quinault Lake, Wash., was concluded on September 13 of that year, the total count amounting to

248,935 fish. The annual count for 1923 began March 20, and between that time and June 30 the number passing above the weir aggregated 123,022, as compared with 199,489 for the corresponding period of the previous year.

In the Oregon field the racks and other collecting equipment were damaged considerably by floods, which were heavy enough to wash away the station site on the upper Clackamas River and to carry out 200 feet of the flume and crib of the intake at the Little White Salmon hatchery. The total egg collections in this field were approximately 27,000,000, as compared with 63,000,000 last year. Part of this falling off may be attributed to depletion resulting from the heavy fishing operations four years ago, though success in the collection of eggs of any of the Pacific salmons is largely dependent on local water conditions in the streams, regardless of other influences. It is probable that the large industrial dams constructed in recent years will greatly interfere with stream flow, as the water is impounded during the wet season for use during periods of slight rainfall. Deforestation also has a deleterious effect on fish-cultural operations, causing the rainfall to drain rapidly from the land and overflow the streams where work is being conducted.

The marine stations in New England experienced a considerable falling off in egg collections, the total of all species secured amounting to but 3,200,876,000, as compared with 3,955,314,000 taken last year. The shortage occurred principally in the propagation of the winter flounder and haddock, and was the direct result of the low-market prices prevailing for fish of these species, which curtailed the commercial catch from which eggs are obtained. On the other hand, cod eggs were plentiful, both at the Woods Hole and the Gloucester stations, the collections for the two hatcheries exceeding 1,279,000,000, or more than twice the number secured in 1922.

In the Gloucester field the conditions connected with the propagation of pollock were even more unfavorable than last year. There seemed to be an abundance of fish on the spawning grounds, but they were constantly shifting about and large numbers remained close to the bottom where the nets could not reach them. The catch of the commercial fishermen was, therefore, small, and the egg collections for the station were correspondingly reduced. Owing to the large amount of surface water entering the harbor, part of the cod eggs secured for the Gloucester station could not be successfully incubated in the hatchery and 277,500,000 were planted on the fishing grounds immediately after being fertilized.

The fish-cultural output of the Boothbay Harbor (Me.) station was confined to the winter flounder, efforts to secure eggs of the pollock, haddock, and cod being unsuccessful. Late in February the station employees undertook the collection of a brood stock of winter flounders but were hampered by the heavy ice fields and abundance of snow on the fishing grounds, very few fish and no eggs being obtained until late in March. Notwithstanding this serious delay, about 5,000 brood fish were captured, the first on March 20, and between that time and May 10, the end of the spawning season, 943,316,000 eggs were secured. Comparatively small results were yielded in the usually prolific Linekins Bay field, as most of the fish in that territory remained in water from 30 to 40 fathoms deep throughout the season.

At the Woods Hole (Mass.) station considerable difficulty was experienced in securing a vessel equipped with a well for the transportation of brood cod as a source of egg supply, the vessels formerly employed for this work having either been sold or lost. A small one suitable for the purpose was finally hired at Newport, R. I., and, arrangements having been made with the various trap owners to supply cod, approximately 2,800 were transferred from the fishing grounds to the station. These fish yielded 555,584,000 eggs, and 114,000,000 additional were obtained for the station by spawn takers operating in Cape Cod Bay. Due to unfavorable weather conditions in the Waquoit Bay collecting field, the collection of winter flounder eggs for the Woods Hole station was the smallest in several years, only 369,865,000 being secured. The work with this species was undertaken on January 16 and completed April 4.

CULTIVATION OF FISHES OF INTERIOR WATERS.

Collections of eggs of the brook, rainbow, blackspotted, and Loch Leven trouts at the various stations devoted to work with these species amounted, in round numbers, to 47,349,000, or 8,823,000 in excess of those collected in 1922. The increase in output over that of last year was even greater, due to smaller losses sustained during the incubation and rearing periods.

A very successful collection of brook-trout eggs was made for the Leadville (Colo.) station, but there was a falling off, compared with the previous year, in the percentage of hatch. In accordance with the usual custom, 500,000 of the eyed eggs were forwarded to the Bozeman (Mont.) station, with the view of utilizing the resulting fry in stocking suitable waters in the Glacier National Park.

During the month of November the force attached to the Springville (Utah) station, in cooperation with employees of the Utah State fisheries department, collected 8,250,000 brook trout eggs in Fish Lake, of which the station received 3,200,000 as its share. The egg collections at this lake have shown a steady increase ever since the work was inaugurated by the bureau in 1917, the number taken that year being 2,785,000. Collections of rainbow-trout eggs were also made at Fish Lake during the spring of 1923, the station receiving 882,000.

During April and May eggs from wild rainbow trout to the number of 1,500,000 were taken at the Meadow Creek field station, in Madison Valley, Mont. Some trouble was experienced in fertilizing them and the losses to the eyed stage were abnormally large, only 810,000 good eggs resulting from the work. These were of excellent quality, however. At the Bozeman (Mont.) station the entire pond system is being remodeled, and when the work is completed the capacity of the station for rearing fry and fingerling fish will be materially increased.

A very successful season was experienced in the propagation of blackspotted trout in the Yellowstone Park during the summer of 1922 under the direction of the superintendent of the Leadville (Colo.) station. The egg collections, as compared with the previous year, were nearly doubled and the output of fry was proportionately large. It is planned hereafter to utilize a larger percentage of the young fish resulting from egg collections in this field in building up fishing in the Yellowstone Park, and with this end in view extensive rearing and planting arrangements are under way. Operations in this field during 1923 were undertaken late in May, under the supervision of the district supervisor of the Mississippi Valley rescue station, and 4,794,000 eggs had been secured up to and including June 30.

Egg collections in the Saratoga (Wyo.) field practically were confined to brook trout and rainbow trout, though a few Loch Leven trout eggs were taken from brood stock carried in the station ponds. The operation of the recently constructed rainbow-trout field station on Sage Creek during the spring months was made exceedingly difficult by the almost impassable mountain roads, which were still heavily blocked with snow on May 1. The substation was finally reached, as a result of great effort, and a fairly successful season's work was accomplished. Low-water stages in the Pathfinder Reservoir caused an unusually light run of fish. Eggs were taken throughout the month of May and up to June 7, the total collection amounting to 1,237,150.

The season's output of trout from Manchester (Iowa) station was very seriously curtailed by the flooding of the station reservation during a heavy storm in July, 1922, at which time a large number of brood brook and rainbow trout were washed from the ponds and perished on the station grounds. This loss was partially overcome through the donation of a considerable number of adult brook trout by the Sportsmen's Club, of Calmer, Iowa, and small consignments of rainbow-trout eggs received in the following spring from the Madison Valley (Mont.) and Springville (Utah) fields. Part of the fry resulting from these western eggs will be reared for the purpose of replenishing the depleted brood stock.

During March and April a heavy mortality occurred among the young brook trout at the Hartsville (Mass.) station. It was found impossible to check it by any of the methods of treatment usually applied, and before the distribution could be made the stock had been reduced fully 40 per cent by losses. An investigation showed the presence of the parasite Octomitus, elsewhere referred to in this report, and the mortality was probably due to it, possibly aggravated by unfavorable water conditions which may have reduced the resistance of the young fish.

At the newly established Roaring River auxiliary of the Neosho (Mo.) station the results of the first season in rainbow-trout propagation were disappointing, only 958,720 eggs being obtained from the 3,000 adult and 7,000 yearling fish on hand. The low egg production is attributed to underfeeding of the brood stock by the owner of the ponds. A more satisfactory season's work was experienced at Bourbon, Mo., where another field auxiliary of the Neosho station was operated for the first time. An arrangement was entered into with the owner of the property whereby the bureau is to receive two-thirds of all the fingerling fish produced. As the site is in the eastern part of the State, its use as a fish-rearing plant will not only effect a material saving in distribution expenses but a greater number of fish than formerly will be available for stocking waters in that section of the country. During the year the bureau leased a private pond system at Langdon, Kans, to be operated as an auxiliary of the Neosho station for the production of bass and crappie. The work was started in the spring of 1923, but owing to flooded conditions the output of fish was small.

Owing to the adverse weather conditions encountered, the production of pond fishes was below normal at several of the stations engaged in that branch of fish culture. The most serious reduction was at the stations located at White Sulphur Springs, W. Va., Northville, Mich., Mammoth Springs, Ark., and Erwin, Tenn., at all of which points violently fluctuating air and water temperatures during the spawning season caused the destruction of many nests of eggs. More favorable natural conditions obtained at the Tupelo (Miss.), Orangeburg (S. C.), and Louisville (Ky.) stations, and the output of bass and allied species from those stations was the largest in their history.

The spawning of buffalofish at the Atchafalaya (La.) station extended from February 15 to March 28, and during this period approximately 179,000,000 eggs were secured. As at many other points, the work was retarded and curtailed by unseasonable weather and water conditions. On March 5 all lowlands in the vicinity of the hatchery were inundated by flood waters coming down from the Ouachita River. The salts and oil with which the flood waters were charged put a stop to the run of spawning fish and also polluted the hatchery water, killing the entire stock of eggs on hand at the time. From then on to the close of the spawning season all eggs secured were fertilized and immediately returned to the waters from which the parent fish were taken.

The work of rescuing stranded food fishes from overflowed lands bordering the Mississippi River was taken up July 1 and prosecuted daily until the 1st of November, when freezing weather necessitated its discontinuance. The field of operations extended from Prescott, Minn., to Andalusia, Ill., and the rescued fishes included nearly every food species native to the region. Of the 139,799,031 fish handled in the course of the season, 1,164,952 were distributed to applicants, and the remainder was released in the Mississippi River and its tributaries. The smaller results obtained, as compared with the previous year, were due to the abnormal water stages in the river during the usual salvage period.

In view of the difficulty experienced in transporting or holding for later distribution the crappie and sunfish rescued during extremely warm weather, some experiments were made at the Homer station with the copper-sulphate treatment for the prevention and cure of fungoid growths. As a result of the tests, it was found that the very small crappie and sunfish were too weak to withstand the treatment, but that it might be advantageously applied to the larger fishes and to the more vigorous individuals among the smaller ones. Its general use therefore will be resorted to hereafter in handling and holding fish of these species at the several collecting points in the rescue field.

ALASKA FISHERIES SERVICE.

EXTENT OF THE ALASKA FISHERIES.

The Alaskan salmon industry returned to practically normal proportions in the season of 1922 after its decline in 1921. Many salmon canneries were reopened and 15 new ones established, making a total of 123 plants operated as against 83 in the previous year. A number of plants remained closed, in some instances operations being carried on jointly by two or more companies at one plant. Market conditions also improved, thus promising a successful season. The larger production in 1922 resulted chiefly from the unusually heavy run of humpback salmon in southeastern Alaska.

The catch of salmon in the Alaska fisheries in 1922 was 72,370,400 fish, of which 33,898,772 were red or sockeye salmon, 30,589,342 humpback or pink salmon, 5,273,883 chum or keta salmon, 1,838,094 coho or silver salmon, and 770,309 king or spring salmon. Apportioned by geographical districts, the catch in southeast Alaska was 31,055,302 fish; central Alaska, 15,612,843 fish; and western Alaska, 25,702,255 fish. Comparing these figures with the returns for 1921, there was a total increase of about 91 per cent. All species, with the exception of kings, were taken in greater numbers. The number of humpbacks taken in 1922 was an increase of about 327 per cent over the take in 1921.

The 123 canneries utilized the greater part of the catch of salmon in the canned pack, which comprised 4,501,652 cases with a market value of $29,787,193, an increase of 1,904,826 cases, or approximately 72 per cent, and $10,154,449 in value over the previous year. The pack of all species, except kings, was larger.

Other salmon products were 4,266,050 pounds of mild-cured fish, valued at $821,169; 3,585,100 pounds of pickled fish, valued at $248,015; 3,849,153 pounds of frozen fish, valued at $261,094; 3,802,729 pounds of fresh fish, valued at $271,869; 906,550 pounds of dried or smoked fish, valued at $148,464; 774,000 pounds of fertilizer, valued at $23,438; and 12,989 gallons of oil, valued at $5,015; the total value of the products of the salmon industry of Alaska in 1922 being $31,566,257.

The herring fishery ranked next to the salmon fishery in 1922, totaling 35,995,450 pounds of Scotch-cured fish, valued at $2,030,975; 237,850 pounds of Norwegian-cured fish, valued at $14,009; 240,000 pounds of dry salted for food, valued at $9,600; 425,241 gallons of oil, valued at $144,418; 1,646 tons of fertilizer, valued at $98,528; and 3,488,615 pounds of bait, valued at $31,586.

The halibut fishery produced 7,886,764 pounds of fresh fish, valued at $772,610, and 3,188,473 pounds of frozen fish, valued at $262,357.

The cod fishery yielded a catch valued at $464,169 and the whale fishery $409,518. Clam products were valued at $185,007 and shrimp products at $126,690. Other minor items were: Crabs, $47,379; trout, $5,914; sablefish, $1,538; flatfish, $367; and ling cod, $26.

The entire Alaska fishery industry gave employment to 21,974 persons, represented an investment of $54,590,302, and yielded products valued at $36,170,948.

A detailed account of the extent and condition of the Alaska fisheries in 1922 and of the activities of the bureau under the laws and regulations for the protection of the fisheries is embodied in the annual report of the Alaska service for that year.[1]

ENFORCEMENT OF FISHERY LAWS AND REGULATIONS.

Primarily for the purpose of enforcing the fishery laws and regulations, the bureau in 1922 operated 8 of its own vessels in Alaskan waters, and in addition 22 small boats were chartered for varying periods and 6 launches, maintained on Bristol Bay chiefly for the destruction of predatory fish, were used for patrol service during the fishing season. On account of shortage of funds the force of temporary stream guards, of which there were 60 in 1922, will necessarily be employed for a shorter period in the season of 1923. The total force aggregates 19 statutory employees, 25 men on vessels, and 69 stream guards and temporary assistants.

A number of prosecutions were made for violations of the fishery laws and regulations in 1922, the majority being for fishing in streams or within the prohibited distances of the mouths of streams. In the cases disposed of fines and costs amounted to about $2,500, with two jail sentences of 30 days and one of 20 days. A few cases had not been brought to trial at the end of the year. The stationing of stream guards at the mouths of many salmon streams operated, without doubt, as a deterrent to unlawful fishing in protected waters and thus aided materially in conserving the runs of salmon.

Markers were erected at the mouths of a number of streams that heretofore had been unmarked, and those destroyed or defaced were replaced. Some work was also done to clear streams of obstructions and render them more easily accessible to spawning salmon. Investigations were made and results reported to the Federal Power Commission in regard to the effect proposed power projects on certain streams would have on the runs of salmon.

PRIVATE SALMON HATCHERIES.

In 1923 two private salmon hatcheries were operated in Alaska as authorized by law. The hatchery of the Alaska Packers Association on Naha Stream liberated 16,985,000 red salmon fry in the fiscal year 1923, and that of the Northwestern Fisheries Co., located on Hugh Smith Lake, liberated 6,007,000 red salmon fry in the same period. The total rebate of taxes on canned salmon, at the rate of 40 cents per 1,000 fry released by these hatcheries, amounted to $9,196.80.

Representatives of the Washington State Fish Commission made collections of humpback-salmon eggs in Prince William Sound in the season of 1922. Very heavy losses occurred during the early stages of the work, and on request of the bureau the collecting of eggs was discontinued. The eggs on hand were eyed, and shipments made in October totaled 14,571,708 eyed humpback-salmon eggs.

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[1] Alaska Fishery and Fur-Seal Industries, in 1922. By Ward T. Bower. (Bureau of Fisheries Document No. 951.)

NEW SALMON-FISHERY REGULATIONS.

Under date of November 3, 1922, an Executive order was issued creating a reserve designated as the Southwestern Alaska Fisheries Reservation, including Bristol Bay, Kodiak and Afognak waters, and Cook Inlet. Hearings were held at Seattle and San Francisco the latter part of November to consider necessary restrictions on fishing in the reserved districts. Revised regulations for the Alaska Peninsula Fisheries Reservation and regulations for the administration of the newly created Southwestern Alaska Fisheries Reservation were issued December 14 and 16, 1922, respectively. The full text of these regulations and of the Executive order of November 3 will be found in the report of Alaska Fishery and Fur-Seal Industries in 1922.

For the season of 1923 a total of 90 formal permits for fishery operations within these reserves were issued by the Secretary of Commerce, of which 9 were canceled before the beginning of the fishing season, leaving 81 under which operations were carried on. Eight supplementary permits were granted in connection with permits previously issued. Permits effective in the season of 1923 are as follows:

Alaska Peninsula Fisheries Reservation.

No. 1.	Alaska Packers Association	Chignik.
No. 2.	Columbia River Packers' Association	Do.
No. 3.	Northwestern Fisheries Co	Do.
No. 4.	Shumagin Packing Co	Squaw Harbor.
No. 5.	P. E. Harris & Co	False Pass.
No. 6.	Pacific American Fisheries	Ikatan.
No. 7.	Pacific American Fisheries	King Cove.
No. 8.	Everett Packing Co	Herendeen Bay.
No. 9.	Fidalgo Island Packing Co	Do.
No. 10.	Pacific American Fisheries	Nelson Lagoon.
No. 11.	Pacific American Fisheries	Port Moller.
No. 12.	Phoenix Packing Co	Herendeen Bay.
No. 13.	George Albert	Port Heiden.
No. 70.	Union Fish Co	10 stations.
No. 86.	Brown Fish Co	2 stations.

Southwestern Alaska Fisheries Reservation.

BRISTOL BAY DISTRICT.

No. 14.	Alaska Packers Association	Kvichak.
No. 15.	Alaska Packers Association	Do.
No. 16.	Alaska Packers Association	Naknek.
No. 17.	Alaska Packers Association	Do.
No. 18.	Alaska Packers Association	Do.
No. 19.	Alaska Packers Association	Egegik.
No. 20.	Alaska Packers Association	Ugashik.
No. 21.	Alaska Packers Association	Nushagak.
No. 22.	Alaska Packers Association	Do.
No. 24.	Alaska-Portland Packers' Association	Naknek.
No. 25.	Alaska Salmon Co	Kvichak.
No. 26.	Alaska Salmon Co	Wood River.
No. 27.	Bristol Bay Packing Co	Koggiung.
No. 28.	Carlisle Packing Co	Koggiung River.
No. 29.	Columbia River Packers' Association	Nushagak.
No. 30.	International Packing Co	Ugashik.
No. 31.	Libby, McNeill & Libby	Egegik.
No. 32.	Libby, McNeill & Libby	Ekuk.
No. 33.	Libby, McNeill & Libby	Nushagak.

No. 34. Libby, McNeill & Libby	Lockanok.
No. 35. Libby, McNeill & Libby	Libbyville.
No. 36. Libby, McNeill & Libby	Koggiung.
No. 37. Libby, McNeill & Libby	Igushik.
No. 38. Naknek Packing Co	Naknek.
No. 39. Peter M. Nelson	Kvichak.
No. 40. Northwestern Fisheries Co	Naknek.
No. 41. Northwestern Fisheries Co	Nushagak.
No. 42. Red Salmon Canning Co	Ugashik.
No. 43. Red Salmon Canning Co	Naknek.
No. 72. Peter M. Nelson	Copenhagen Creek.
No. 74. Peter M. Nelson	Igushik.
No. 77. Bering Sea Salmon Packing Co	King Salmon Creek.
No. 85. Alaska-Portland Packers' Association	Nushagak.
No. 88. Alaska Calmon Co	Kvichak.

COOK INLET DISTRICT.

No. 44. Alaska Packers Association	Kasilof.
No. 46. Anchorage Packing Co	Anchorage.
No. 48. Fidalgo Island Packing Co	Port Graham.
No. 50. Kamishak Canning Co	Kamishak Bay.
No. 51. Libby, McNeill & Libby	Kenai.
No. 52. North Coast Packing Co	Ninilchik.
No. 53. Northwestern Fisheries Co	Kenai.
No. 66. Delorne and Wilson	Chisik Island.
No. 75. H. J. Emard	Moose Point.
No. 81. Pioneer Canneries (Inc.)	Snug Harbor.
No. 82. Arctic Packing Co	English Bay.
No. 84. Charles B. Myers	Paulie Creek.
No. 90. Alaska Year-Round Canneries Co	Seldovia.

KODIAK-AFOGNAK DISTRICT.

No. 56. Alaska Packers Association	Larsen Bay.
No. 57. Northwestern Fisheries Co	Uyak.
No. 58. Robinson Packing Corporation	Zachar Bay.
No. 61. Michael P. Galvin	Our Island.
No. 62. Kodiak Fisheries Co	Kodiak.
No. 63. Katmai Packing Co	Uzinki.
No. 64. Kodiak Island Fishing & Packing Co	Uganik Bay.
No. 65. Pajoman & Trout	Raspberry Island.
No. 67. W. J. Erskine Co	Kodiak.
No. 68. Alaska Sea Food Products Co	Three Saints Bay.
No. 69. San Juan Fishing & Packing Co	Uganik Bay.
No. 71. The W. J. Imlach Packing Co	Uzinki.
No. 76. Uganik Packing Co	Uganik Bay.
No. 78. Opheim & Sargent	Shuyak Island.
No. 79. Hemrich Packing Co	Kukak Bay.
No. 80. R. M. Dahl	Uyak Bay.
No. 83. Breyer & Freund	Raspberry Island.
No. 87. Alitak Packing Co	Lazy Bay.
No. 89. Hopp & Danielsen	Uganik Bay.

Permits for operations on a small scale have also been granted to a number of local residents by the bureau's representatives in the districts, 27 such permits having been issued in the Alaska Peninsula Fisheries Reservation, 90 in Bristol Bay district, 120 in Cook Inlet, and 60 in the Kodiak-Afognak district.

SPECIAL STUDIES AND INVESTIGATIONS.

Mention of these is made in a preceding section of this report, but it appears desirable to refer to them here to complete in one section a record of the bureau's activities in Alaska.

Counts of red salmon ascending to their spawning grounds were made on Karluk and Chignik Rivers in the season of 1922 and are being renewed in the season of 1923. Inasmuch as these streams afford an excellent opportunity for determining the commercial catch of salmon and at the same time enable satisfactory results in counting salmon passing upstream, it is felt that reliable information as to the percentage of escapement necessary to perpetuate the runs without diminution can be developed eventually. This will necessitate counts over a series of years. Similar counting operations were inaugurated in the season of 1923 on Nelson River, flowing into Herendeen Bay, but were abandoned on account of physical difficulties, and on two streams tributary to Alitak Bay on Kodiak Island.

Under the direction of Dr. C. H. Gilbert, important investigations were made in western Alaska in 1922 and will be continued upon a larger scale through the season of 1923, with a view to determining migration routes of salmon. Interesting information has already resulted in this connection from the tagging of 4,000 red salmon at Ikatan Bay and other waters of that general region in 1922. While most of the fish subsequently recaptured were taken in the vicinity where tagged, a number were secured in Bristol Bay and a few on Cook Inlet, and one even on the Kuskokwim River.

A party remained over the winter in the Nushagak region to investigate the salmon-spawning grounds and endeavor to ascertain the size of the escapement in 1922. A specialist was sent to the Cook Inlet district in the season of 1923 to investigate the extent of the clam beds and thus secure data as a basis for the proper regulation of the fishery. A study of the salmon fishery of the Kuskokwim River was made in 1922, and the destruction of predatory fishes in streams tributary to Bristol Bay was again conducted along lines followed in recent years.

PROTECTION OF WALRUS AND SEA LIONS.

No changes were made in the walrus and sea lion regulations issued April 21, 1921, nor were any violations reported during the year.

NEW LEGISLATION NEEDED.

The fisheries of Alaska are being administered under the provisions of the act of June 26, 1906. This law is wholly inadequate and there is urgent need of new legislation to meet present-day conditions. The expansion of the fishery and modifications in methods make effective conservation impossible in many sections. This situation has been brought to attention repeatedly but so far without avail, and it is earnestly hoped that at its next session Congress will afford the desired relief. While the situation has been helped through the creation of reservations by Executive order, that expedient is regarded merely as a temporary measure pending the enactment of the legislation necessary for adequate control of a grave situation. To those who have opposed fishery reservations upon grounds of principle, the answer is that the fishery must be saved now and the reservation policy is the only possible means until Congress acts. The best means available have been used to alleviate a critical situation until the final cure, through added legislation, can be effected.

ALASKA LEGISLATURE.

At its regular session early in the year 1923, the Territorial Legislature of Alaska passed several laws bearing upon the fisheries. One of these added materially to the license-tax rates on products and on certain fishing apparatus, another provided for the licensing of fishermen, and the third imposed certain closed seasons on fishing in the waters of southeast Alaska.

ALASKA FUR-SEAL SERVICE.

GENERAL ACTIVITIES AT THE PRIBILOF ISLANDS.

The administrative work on the Pribilof Islands was carried on in the usual manner by the bureau's staff of 15 white employees. The population of the two islands consists of about 325 native men, women, and children, who carry on the physical work of sealing and foxing and other activities, supervised by the bureau's representatives. Compensation for these services is in the form of nominal cash payments for the work of taking seal and fox skins, together with subsistence, including food, fuel and clothing, and living quarters, school facilities, and medical attention. In addition to the island natives, from 50 to 60 native laborers are secured each year from the Aleutian Islands for the period of active sealing.

The work of the bureau on the islands covers a wide range, for, in addition to sealing and foxing operations, it involves the erection of buildings, construction of roads, maintenance of machinery and equipment necessarily various in so remote and isolated a region, construction and repair of small boats used for landing cargo, installation of water-supply and electric-lighting systems for the villages on each island, operation of a by-products plant for the production of oil for use in dressing sealskins, preparation of seal meat for feeding foxes during the winter season, and the keeping of extensive records of all activities.

Supplies for the Pribilof Islands were transported from Seattle by chartered commercial vessels during the summer of 1922, but in 1923 it was again possible to secure cargo space on the naval radio tender *Gold Star*, which also transported a number of passengers for the bureau. Passengers and small lots of supplies were also carried by vessels of the Coast Guard and by the commercial steamer *Buford* in the spring of 1923.

The process of removing pelts by stripping from the body of fur seals, developed within the last two or three seasons, was continued along more extensive lines. This process requires certain marginal cuts to permit the literal pulling off of the pelt, but does away with the use of knives, as formerly, for separating the skin from the underlying tissues. This reduces or practically eliminates cuts, to the consequent enhancement of the value of the pelts. The improved process of stripping necessitates washing and blubbering the pelts on the islands before they are salted. In the season of 1922 approximately 50 per cent of the skins were taken in this manner. Expansion in facilities will make possible its application to about 75 per cent in 1923. It is planned to remove practically all skins in this way during the next season.

A party headed by Assistant Secretary Huston was at the Pribilof Islands from July 11 to 19, 1922, for the purpose of observing methods and giving consideration to administrative policies. Included in the party were Dr. Leonhard Steineger, of the U. S. National Museum, a noted authority in regard to the fur seals of the north Pacific, and Ward T. Bower, of the Bureau of Fisheries. After leaving the Pribilofs, visits were made to the Commander Islands to note conditions regarding the Russian fur-seal herd, and to Robben Island, to which the Japanese herd resorts. Consideration was also given to fishery and fur-seal matters in Japan and elsewhere.

A representative of the bureau authenticated 625 fur-seal skins taken by Indians in the vicinity of Sitka, Alaska, during the spring migration of 1923, and 1 additional skin that had been taken in the spring of 1922 but not authenticated at that time. Indians also took 871 fur-seal skins off the coast of Washington, which were authenticated by the superintendent of the Neah Bay Reservation under authorization by the Department of Commerce. A patrol for the protection of the seal herd during its migration to the Pribilof Islands was conducted by vessels of the U. S. Coast Guard. Four vessels of the bureau also maintained a patrol of the sealing grounds in the vicinity of Sitka.

The bureau's vessel *Eider* performed excellent service for the islands during the first six months of the current fiscal year in which she made seven trips from Unalaska to the Pribilof Islands. One trip was made to King Cove in an effort to secure native workmen for sealing on the Pribilofs and one trip to Belkofsky to return native laborers to their homes. Early in January the vessel was ordered to Cordova for repairs and later was sent to Seattle for the installation of a Diesel engine. The vessel was still at Seattle at the end of the fiscal year but was expected to return to Alaska about the middle of July.

SEAL HERD.

The 1922 estimate of the seal herd, as of August 10, gives the total number of animals as 604,962, an increase of 23,519 over 1921. In 1922 some experiments were made in photographing sections of the rookeries, with a view to determining the practicability of the use of photography in the counting of seals. No conclusive results were obtained.

TAKE OF SEALSKINS.

The number of seals killed under Government supervision on the Pribilof Islands in 1922 was 31,156, of which 30,260 were taken during the regular season ended August 5 and the remainder in the fall and winter.

An important innovation this season has been the branding on the back with a hot iron of 5,000 3-year-old male seals for breeding purposes. This work was done before the beginning of extensive commercial killing. In addition to the 5,000 thus branded, 5,000 were temporarily marked by shearing the hair on top of the head, so that these animals were exempted from killing in the current season, and thus from abundance of caution the actual reserve of 5,000 required by law has been doubled. Since only 3-year-old seals are killed for their skins, none of these animals will be killed intentionally in later years and will thus be allowed to develop to maturity, subject only to natural mortality.

SALES OF SEALSKINS.

In the fiscal year 1923 two public auction sales of fur-seal skins were held at St. Louis. At the sale on October 9, 1922, 17,194 dressed, dyed, and machined skins brought $535,967.50, and in addition 164 raw, washed, and dried skins and 37 raw salted skins were sold for $87.55; at the sale on May 28, 1923, 18,118 dressed, dyed, and machined skins brought $564,224.75, a total of 35,513 skins and $1,100,279.80. These prices averaged approximately the same as in the previous year.

At the May sale there were also sold 55 sealskins from the Japanese herd on Robben Island, representing the share of the United States in the skins taken in 1921. They brought a total of $1,940.

As a result of the sales of fur-seal skins from the Pribilof Islands in the fiscal year 1923 the sum of $69,105.86 has been paid to Great Britain and a like amount to Japan covering value of their respective shares of skins under the terms of the North Pacific Sealing Convention of 1911.

FOXES AND REINDEER.

Herds of blue foxes of considerable commercial importance are maintained on the Pribilof Islands. To a large extent these herds support themselves, feeding on the carcasses remaining from seal killings and on the immense flocks of sea birds that nest on the islands, but winter feeding is also provided for by the preserving of seal carcasses. During the winter of 1922–23 a total of 888 blue and 29 white fox skins was taken. The prevalence of warm, wet weather on St. George Island, which has the larger herd, seriously interfered with foxing operations during the season, as the animals were able to secure food in plenty and were not forced to come to the traps for food. A breeding reserve was also marked and released on St. George Island.

The 712 blue and 21 white fox skins taken in the winter of 1921–22 were sold at public auction at St. Louis, October 9, 1922. The total amount bid was $67,310, an average of $93.18 for blue and $46 for white skins. In addition, 12 live blue foxes were sold for stocking fox farms in Alaska, delivery being made at Unalaska in September. The price received for the live animals was $175 each.

The herds of reindeer, which were introduced on the Pribilof Islands in 1911, now furnish a valuable supply of fresh meat. It was estimated that there were approximately 400 animals on the islands at the end of the calendar year 1922, while 60 animals had been used for food during the preceding 12 months—38 on St. Paul Island and 22 on St. George.

COOPERATION WITH OTHER GOVERNMENT AGENCIES.

The International Committee on Marine Fishery Investigations met in Washington on November 10, 1922, and in Toronto on May 4, 1923. The first meeting was attended by three representatives each of the United States and Canada, and the second by two representatives of the United States and three of Canada. At the Toronto meeting the committee had the satisfaction of welcoming a representative of France, that country, by reason of its fisheries in the western Atlantic, having officially expressed a desire to participate in these conferences. The representative of Newfoundland was unable to attend either meeting. Plans were laid for coordinating certain of the marine-fisheries investigations of the countries represented.

Helpful relations have been maintained with the Bureau of Standards, Coast and Geodetic Survey, Bureau of the Census, and Bureau of Foreign and Domestic Commerce.

The National Park Service and the Forest Service have cooperated in stocking streams with fish and in facilitating fish-cultural work in other respects, and assistance to various branches of the bureau's activities has been rendered by the Bureau of Indian Affairs, the Reclamation Service, and the Geological Survey.

An assistant was again detailed to the Public Health Service for investigations of mosquito control through the agency of fishes.

The Navy Department furnished transportation for supplies and personnel to the Pribilof Islands, and the Coast Guard Service as usual extended valuable assistance on many occasions.

The Consular Service has supplied important information concerning the fisheries of foreign countries.

VESSEL SERVICE NOTES, 1923.

The steamer *Fish Hawk* has continued the hydrographic and biological survey of Long Island Sound, which was inaugurated at the end of the last fiscal year. Eight round trips, aggregating 2,213 miles of steaming, have been made, from 30 to 56 stations being covered on each trip. The *Fish Hawk* has not been extensively overhauled since 1916 and is in urgent need of repairs and new propellers, for which a special appropriation has been asked.

The steamer *Halcyon* has been engaged in carrying on a fishery investigation in the north Atlantic and in fish-cultural operations in connection with the Gloucester and Woods Hole stations. In July current observations were made on lines 150 miles each from Sandy Hook and Chatham and 25 miles from Cape Elizabeth, and April, May, and June were spent in tagging codfish in the vicinity of Nantucket. During August and September the crew was occupied in overhauling the gas boat *Kittiwake* preparatory to her transfer to Seattle, and in February valuable service was performed by the

Halcyon in keeping channels open through the ice in the harbors of Gloucester, Salem, and Manchester. In all the vessel steamed 3,575 miles.

The *Phalarope* and *Gannet* were utilized for fish-cultural and collecting work at the Woods Hole and Gloucester (Mass.) stations, respectively, and the former was brought to the Potomac River for use at the hatchery at Bryans Point, Md., during the shad season. In October her crew took the *Kittiwake* from Woods Hole to Norfolk, whence she was carried on a Navy transport to Seattle.

In addition to the steamer *Shearwater*, the bureau now operates two large gas boats, the *Curlew* and *Fulmar*, on the Great Lakes. These are attached to the fish-cultural stations at Put in Bay, Ohio, Cape Vincent, N. Y., and Charlevoix, Mich.

The supply vessel *Eider* made seven round trips between Unalaska, Alaska, and the Pribilof Islands, carrying Government employees, freight, and supplies, and two trips to Belkofsky with native laborers who had been employed on the islands. During the winter exceedingly stormy weather prevailed, which delayed operations and at times prevented the vessel from going to sea. In December an attempt was made to save the gas vessel *Lister*, which was ashore at Cape Makushin, about 40 miles from Unalaska. The wife and family of the captain were transported to Unalaska. In February the *Eider* was taken to Cordova for repairs to her engines and upper works, but as it was finally decided to equip her with new engines she proceeded to Seattle, where she arrived March 24. The old 110-horsepower engine has been removed and a 140-horsepower Diesel engine installed. It is believed the change will effect a great saving in the cost of fuel and also give the vessel needed additional power. Other changes and improvements will add to her efficiency and seaworthiness. During the year she cruised 7,420 miles.

The usual patrol and fisheries investigations were carried on in southeast Alaskan waters by the gas boats *Auklet*, *Murre*, *Petrel*, and *Widgeon*; the *Scoter* operated in Bristol Bay, the *Tern* on the Yukon River, and the *Merganser* was sent to Chignik. While these Alaska boats are on active duty only during spring, summer, and early fall months, the service they are called on to perform is onerous, exacting, and often dangerous. They cruised during the year from 4,000 to 7,300 miles each. During inactive periods their crews are kept busy with repairs and upkeep, and in addition are called on for other work not directly pertaining to vessels and boats.

The *Kittiwake*, originally obtained from the Navy, reached Seattle in the spring of 1923, and is being refitted and furnished with a more powerful engine to fit her for the needs of the Alaska service. In May the small gas boat *Ibis* was purchased for use at Chignik.

The activities of vessels in Alaska are briefly stated in the section of this report dealing with the bureau's work in the Territory.

APPROPRIATIONS.

The regular appropriations for the bureau for the fiscal year 1923 aggregated $1,262,090, as follows:

Salaries	$456, 960
Pay, officers and crews of vessels for Alaska service	31, 630
Miscellaneous expenses:	
Administration	11, 000
Propagation of food fishes	375, 000
Maintenance of vessels	100, 000
Inquiry respecting food fishes	40, 000
Statistical inquiry	20, 000
Protecting sponge fisheries	3, 000
Protecting seal and salmon fisheries	165, 000
Repairs to fish-cultural stations:	
Yes Bay, Alaska	7, 000
Duluth, Minn	6, 000
Gloucester, Mass	6, 500
Establishment of station on Mississippi River	40, 000
Total	1, 262, 090

Respectfully submitted.

HENRY O'MALLEY,
Commissioner of Fisheries.

To Hon. HERBERT HOOVER,
Secretary of Commerce.

PROPERTIES AND VALUES OF CERTAIN FISH-NET PRESERVATIVES.[1]

By HARDEN F. TAYLOR, *Chief technologist*, and ARTHUR W. WELLS, *Assistant technologist, U. S. Bureau of Fisheries.*

Contribution from the Fishery Products Laboratory, Washington, D. C.[2]

CONTENTS.

[1] Appendix I to the Report of the U. S. Commissioner of Fisheries for 1923. B. F. Doc. 947.

[2] The Bureau of Standards, Department of Commerce, through its division of textiles, cooperated freely with the Bureau of Fisheries in furnishing and testing the apparatus used for tensile strength, in providing facilities in a room of constant temperature and humidity for making the tests and the measurements of tensile strength, in preparing graphs, and in making valuable suggestions and criticisms.

INTRODUCTION.

Most of the fish taken commercially in the waters of the United States are captured by means of textile gear that is perishable—chiefly cotton and linen. The value of the webbing and lines used by our fishermen, as shown in Table 1, is approximately $14,000,000. When this sum is compared with the value of the annual catch of fish, which for the entire nation is about 2,500,000,000 pounds, valued at $80,000,000, it appears that the invested capital for gear is very large; boats, houses, machinery, and the like further increase the cost. Not only is this item for textile gear large, but the gear itself is very perishable. Many nets wear out in one season; perhaps most nets last less than two full seasons. Such rapid loss of invested capital becomes, therefore, of the nature of overhead expense, which helps to diminish the fisherman's reward for his labor, but which must in the end be paid for, at least in part, by the consumer. When considered from the viewpoint of the individual fisherman, a fishing vessel, or company, the importance of reducing the cost of this item is obvious, but no less obvious is its importance when considered as a part of our national economy.

TABLE 1.—*Number and value of fishing nets in the United States.*

	Number.	Value.[1]		Number.	Value.[1]
Seines	5,440	$1,877,278	Otter trawls	1,287	$74,017
Gill nets	223,890	4,196,592	Paranzella nets	44	9,000
Trammel nets	3,312	116,611	Lampara nets	65	29,500
Pound nets, trap nets, and weirs	17,968	6,355,281	Lines	....	514,918
Fyke nets	62,570	449,247	Eel pots and traps	23,792	28,695
Stop nets	207	13,367	Lobster pots	247,324	623,475
Hoop nets, pots, and traps	23,047	44,819	Total	608,983	14,337,630
Beam trawls	87	4,835			

[1] These figures, obtained in the regular canvasses of the fisheries, represent not new value but values of the gear owned by the fishermen at the time of the canvass.

One would think, in view of these facts, that the art of preserving nets effectively would already have reached a high degree of perfection, but it has not done so. The literature of the subject is very small; the number of scientific papers reporting serious research into the subject can almost be counted on one's fingers. The conclusions found in the few papers reviewed are mostly inadequate, dealing as they do mainly with the factor of tensile strength and being based on too short periods of exposure. Furthermore, the principal materials used for net preservatives seem to have come into use for insufficient reasons. Tar, the commonest material, appears to be used principally because it is available, cheap, and does some good, though never developed especially to meet any particular requirement, and indeed answering rather poorly most of the requirements of a good all-round preservative. Tanning extracts seem to have come into use through reasoning by a false analogy that if tanning preserves skins it will preserve cotton and linen lines also. As a matter of fact, there is no chemical similarity between cotton or linen and animal skins, and, as will be seen later, very little good results from the use of tanning materials alone on cotton or linen.

The plain need is therefore obvious. The various preservatives now available should be subjected to thoroughgoing scientific investigation to determine their suitability and effectiveness in every way as general or special preservatives, and a serious effort should be made to produce a material that really meets the many requirements of a suitable, efficacious, and all-round preservative of fish nets. The present paper will report results of experiments and tests made during the past two years with these objects in view.

GENERAL SUMMARY.

The principal results and conclusions arrived at and reported in detail in the main part of this paper following are here summarized.

1. The following preservatives and preservative methods were tested: Coal tar, pine tar, coal and pine tar mixed, two proprietary petroleum products, quercitron and potassium bichromate, the Dutch tanning method, copper oleate in nine variations, two proprietary copper paints, a proprietary waterproofing compound, gilsonite (sold

under a trade name), and two combinations of copper oleate and coal tar.

2. The textiles tested were No. 24 cable-laid, hard-finish twine cotton and10-ply linen thread.

3. The factors determined were tensile strength, flexibility, wearing quality, increase in weight, shrinkage, resistance to fouling by marine growths, color imparted, and in some cases liability to spontaneous heating.

4. For determining flexibility and wearing quality machines were devised and made. The construction and operation of these machines are described.

5. Series of lines treated with various preservatives were exposed to weather conditions in the air, in Atlantic Ocean water at three places, and in fresh water at one place.

6. In the series exposed to weather conditions, the deterioration was comparatively slight. Those preservatives with a heavy body, such as the tars and gilsonite, preserved better than did those without heavy body.

7. In the salt water, if preservation of tensile strength only is considered, those samples that contained copper in some form were best preserved.

8. Tar was a fairly good preservative in salt water for about two months, after which time lines treated by it began to lose strength. Coal tar and pine tar were similar in effect, but coal tar was slightly better.

9. Tar, either coal or pine, caused a great increase in stiffness and weight, both of which increases were quantitatively measured. Tar failed to protect nets against fouling by growths of hydroids and barnacles.

10. Tanning by quercitron followed by a treatment with potassium bichromate, without copper, was a poor preservative. Lines treated by this method showed little superiority to untreated lines.

11. Tanning by the Dutch method (quercitron followed by ammoniacal copper sulphate, or bluestone, solution) was much better than quercitron and potassium bichromate. It deposited some copper in the line, preserved fairly well, and increased weight and stiffness only slightly. It was troublesome to apply, caused considerable shrinkage of the line, and was not so good generally as preservatives that deposit more copper in the line. On cotton lines in fresh water it was a good preservative.

12. The proprietary petroleum products and a proprietary gilsonite that were studied showed little value as net preservatives. They increased the weight and stiffness of the line without causing any noticeable preservation. They showed no favorable effect on tensile strength, wearing quality, or resistance to fouling

13. Copper paint, of which two commercial brands were studied, gave excellent preservation of tensile strength and resisted to a high degree fouling by marine growths; but it excessively increased stiffness and weight of lines to which it was applied, and because of its harshness greatly diminished the resistance of the lines to abrasion or wear.

14. Copper oleate, here tested for the first time and now proposed as a net preservative, showed many valuable characteristics. Dissolved in gasoline and applied it penetrated instantly and dried on

the lines quickly. It preserved tensile strength well in salt water, resisted fouling by marine growths, resisted abrasion or wear as well as any other preservative, increased weight and stiffness only slightly, and imparted an acceptable green color to the line. In fresh water results were less promising. Directions are given for making and using it.

15. Marked differences in the behavior of lines were manifested at different places and in different waters. At Beaufort, N. C., in salt water, sample lines fouled more heavily and disintegrated more rapidly than they did at either Key West, Fla., or at Woods Hole, Mass. In fresh water of Lake Erie, at Put in Bay, Ohio, the sample lines suffered more rapid deterioration than they did at any place in salt water.

16. On linen lines quercitron and potassium bichromate, the Dutch method, a petroleum product, and copper oleate were tested. Copper oleate preserved best in both salt and fresh water. The Dutch method was good; the others were worthless. Linen line, with or without preservatives, and in salt or fresh water, deteriorated more rapidly than cotton lines.

17. In no preservative studied was there detected any tendency toward spontaneous heating or combustion. Such cases of heating of nets as occur must be ascribed to something other than simply the preservative.

18. Even with highly oxidizable oils, such as linseed oil, the temperature necessary to kindle spontaneous heating is in excess of 122° F. (50° C.).

19. Cotton lines exposed to temperature as high as 302° F. (150° C.) dry heat, or 257° F. (125° C.) under steam pressure for two hours showed no significant loss of tensile strength. Higher temperatures than these are necessary to produce any weakening of lines.

20. A mathematical procedure was devised for grading the several materials for all-round usefulness as fish-net preservatives with new white cotton line as a standard of reference. By this method copper oleate easily led all the materials tested as an all-round preservative in salt water.

PRELIMINARY EXPERIMENTS.

In a paper by J. T. Cunningham (1902) mention was made of the successive use of soap and copper sulphate, by which lines were colored a blue green, a method used by French sardine fishermen. This method, which deposits a comparatively insoluble form of copper in the lines, appeared to deserve more attention than it had yet received. Copper is well known to be an exceedingly toxic substance to lower plant life, bacteria, algæ, etc., and highly antagonistic to certain ferments, although comparatively harmless to the higher animals, and therefore seemed a good prospect for trial in different forms. The ferrocyanide of copper is highly insoluble, impermeable to water when dried, and can be applied without difficulty by wetting the lines successively with solutions of copper sulphate and potassium ferrocyanide. Accordingly, in 1920 a small preliminary series of exposures and tests was carried out that included these two treatments—copper soap and copper ferrocyanide. For comparison and control untreated lines were used, and also the method found in the literature to be best. This latter method, described by Bull (1902) and reviewed by Taylor (1921, p. 22), consists of treating the lines first with a hot solution of quercitron in water, then with a cold solution of potassium bichromate and copper sulphate.

The lines prepared for exposure were treated as follows: (1) Lines treated by Bull's method (quercitron, potassium bichromate, and copper sulphate); (2) a tenth normal solution of copper sulphate followed by a tenth normal solution of potassium ferrocyanide; (3) a tenth normal solution of potassium ferrocyanide followed by a tenth normal solution of copper sulphate; (4) same as (2), but half normal solutions instead of tenth normal solutions were used; (5) a hot solution of soap followed by a hot solution of copper sulphate.

Samples of No. 24 white cable-laid, hard-finish cotton lines were prepared, two by each method, and sent to Beaufort, N. C., for immersion in sea water in June. One sample of each was removed and tested after 4 weeks, the other after 10 weeks. Table 2 shows the tensile strength in kilograms.

TABLE 2.—*Tensile strength of cotton lines exposed in sea water at Beaufort, N. C., 1920.*

Number and method of treatment.	Tensile strength after—	
	4 weeks.	10 weeks.
	Kilograms.	*Kilograms.*
1. Bull's method (quercitron, etc.)	13.40	7.78
2. Tenth normal copper sulphate and tenth normal potassium ferrocyanide	10.86	3.66
3. Tenth normal potassium ferrocyanide and tenth normal copper sulphate	10.62	3.22
4. Half normal copper sulphate and potassium ferrocyanide	13.06	4.98
5. Soap and copper sulphate	11.96	7.32
6. Untreated, control (tensile strength before exposure, 18 kg.)	10.48	1.18

Bull's method was best. Copper ferrocyanide was a failure, for the reason, obvious on examination, that all the copper ferrocyanide was deposited near the surface of the line; the inner parts were not reached. The copper soap preserved nearly as well as Bull's method, though examination revealed the soap to be confined largely to the exterior of the line, and the copper soap itself was a precipitate not uniformly spread over the fibers.

CONCLUSIONS FROM PRELIMINARY EXPERIMENTS.

None of the methods included can be regarded as satisfactory, as a marked decomposition occurs in all of them on 10 weeks' exposure.

Copper ferrocyanide is of little value.

Copper soap promises well and calls for more study to effect good penetration and uniform distribution.

COPPER SOAP.

The green precipitate deposited on the lines by successive applications of soap and bluestone is, of course, copper soap, a mixture of several fatty acid salts of copper oleate, stearate, palmitate, etc. The two principal defects in this mode of application are (1) the precipitate first formed near the surface of the line prevents further penetration of the reagents, and (2) the precipitate is in the form of irregular particles adhering to the fibers, not enveloping them in a continuous film. It was found that a uniform deposit could be produced and thorough penetration effected if the copper soap were dissolved in a suitable solvent and so applied. Benzol, gasoline, carbon tetrachloride, turpentine, oils, etc., dissolve copper oleate, but not stearate. Accordingly, attention was from this time confined to copper oleate dissolved in benzol, gasoline, kerosene, etc., and in the many experiments with samples of lines preserved copper oleate was included in a variety of concentrations and combinations to determine its value absolutely and in comparison with other preservatives.

Before further experiments were begun, however, it was necessary to solve certain problems connected with the application of copper oleate solutions. It was found that when benzol is used as a solvent the solution in the line creeps to the surface during the evaporation of benzol, so that on the dried line almost all of the copper oleate is on the outside. It was found that a small quantity of mineral oil added to the benzol solution remains and prevents the oleate from creeping. With gasoline the difficulty was scarcely so great, yet it seems wise to add the oil, by which means a perfectly uniform deposit is secured throughout the line.

EXPERIMENTAL EXPOSURE AND TESTING OF LINES.

Four series of experiments were undertaken with a view of determining the effects of the preservatives. Different geographical regions were chosen to determine differences that might arise from that cause; and from time to time new tests were carried out as the need for them appeared and as soon as the technique of applying them could be worked out. These tests will be described as they arise in connection with the experiments. No. 24 cable-laid, hard-finish cotton line was used uniformly throughout for cotton line; for linen line 10-ply salmon gill netting was used. The results are therefore comparable.

NOTATION OF SAMPLES.

In the following key all samples designated by the same letter of the alphabet are always treated with the same preservatives in the same way. In all the results recorded herein the symbols and identifying numbers refer to this key.

Key to symbols for preservatives studied.

COTTON LINES.

A......White line—untreated—No. 24 medium laid cotton line used as a control.

B......Copper oleate—7 per cent concentration in gasoline. Lines were dipped into this solution and allowed to become thoroughly saturated. This requires two or three minutes. The lines were then removed and spread out to dry (not piled in a heap).

C......Copper oleate—7 per cent concentration in gasoline and containing 5 cc. of mineral oil to every 95 cc. of solution and 1–1000 parts of cresol. Applied same as B.

D......Copper oleate—11 per cent concentration in gasoline. Applied same as B.

E......Copper oleate—11 per cent concentration in gasoline and containing 2 cc. of mineral oil for every 95 cc. of solution. Applied same as B.

F.......Equal weights of heavy coal tar (sp. gr. about 1.25) and benzol were mixed. The benzol thinned the tar sufficiently, so that no heating was necessary. The lines were then dipped into this tar-benzol solution, soaked for 5 or 10 minutes, and then wound out on a reel to dry. As the lines were drawn out of the tar they were drawn between the fingers in order to remove the excess tar adhering to the lines. This may also be accomplished by using a wringer.

G.......Equal weights of pine tar (sp. gr. 1.18) and benzol were mixed, the benzol serving as a thinner, and thus eliminating the use of heat. Applied same as F.

H.......Coal tar 25 per cent, pine tar 25 per cent, and benzol 50 per cent were mixed and applied same as F.

I.......Quercitron and potassium bichromate. The lines were steeped in a hot solution of quercitron, 1 pound to 2 gallons of water, until the solution was cold, dried, again steeped in the same way and again dried. They were then immersed for a few minutes in a solution of potassium bichromate 3½ pounds to 150 gallons of water. This method was tried for the purpose of comparison with the Dutch method in which tanning extract and copper are used together.

J.......Petroleum product No. 1. This is a product made and sold by a western oil-refining company as a preservative for fish nets. It is a heavy, black liquid, closely resembling tar and is applied in the same way as tar; that is, by dipping once in the cold liquid and then winding on a reel to dry. The product is ready for use as purchased from the manufacturer.

K.......Proprietary waterproofing material. All lines used in experiments with this material were treated at the factory of the concern making the material. The material is a thin, black liquid of specific gravity about 0.850 and is applied by dipping the line into the solution. No heating is necessary.

L.......Dutch method. The lines were steeped in a hot solution of quercitron, 1 pound to 2 gallons of water, until the solution was cold, dried, again steeped in the same way, and again dried. They were then immersed for a few minutes in an ammoniacal solution of copper sulphate, containing 1 pound of copper sulphate and 3 pounds of 25 per cent liquid ammonia for every 12½ gallons of water. For a full description of this method see Olie (1918).

M.......Copper oleate—7½ per cent concentration in gasoline. Applied same as B.

N.......Copper oleate—12½ per cent concentration in gasoline with 5 cc. of mineral oil for every 95 cc. of the copper oleate solution, and 1–1000 parts of cresol. Applied same as B.

O.......Copper oleate—12½ per cent concentration in gasoline. There was no mineral oil added to this. It was run for the purpose of comparison with those combinations of copper oleate solution with oil. Applied same as B.

P.......Copper oleate—12½ per cent concentration in gasoline with 5 cc. of mineral oil to every 95 cc. of copper oleate solution. Applied same as B.

Q.......Copper paint No. 1. This is a red copper paint similar to that used on ships' bottoms. The principal ingredient is copper oxide suspended in some vehicle, such as thin coal tar. The paint was mixed with an equal volume of creosote oil and the line dipped into this solution. The twine was then wound out on a reel. It is preferably used immediately after such treatment, but may be allowed to dry before putting in water.

R.......Copper paint No. 2. This is another red copper paint, similar to Q, but containing more copper. This is applied without any additional thinning, but otherwise the same as Q. The preservative may be allowed to dry or used immediately. The twine was left much stiffer than when treated with copper paint No. 1, and the increase in weight was much greater. More copper was deposited in the line than in the case of Q.

S.......Gilsonite. This is an asphalt product sold by a western company under a proprietary name as a fish-net preservative. It is a thin, black liquid having a specific gravity of about 0.870. The product is sold ready for use and is applied by allowing the line to soak in the liquid for about 20 minutes and then winding out on a reel and allowing to dry.

X.......Petroleum product No. 2. This product is sold by the same concern as was petroleum product No. 1(J). The No. 2 is a black liquid, thinner than No. 1, and intended for use on gill nets and other light gear that must be left flexible. Applied same as J.

Y.......This preservative is a mixture of 50 per cent heavy coal tar (road tar), 35 per cent benzol, and 15 per cent copper oleate (each by weight). Applied same as F.

Z......The lines are first treated with a 15 per cent solution of copper oleate in gasoline, allowed to dry and then dipped into a solution of coal tar and benzol, 50 per cent each. The lines are then dried as in the case of coal tar (F).

AA.....Copper oleate—15 per cent concentration in gasoline. Applied same as B.

LINEN LINES.

T......Untreated, 10-ply 40, Irish flax salmon thread, used as a control.

U......Copper oleate—12½ per cent concentration in gasoline. This is the same preservative as was described under P for cotton line and is applied the same as P.

V......Quercitron and potassium bichromate. This is the same method as was described under I for cotton thread.

W......Dutch method. This is the same method as was described under L for cotton line.

BB....Petroleum product No. 2. This is the same product as was described under X for cotton line and is applied same as X.

CC......Copper oleate—15 per cent concentration in gasoline. This is the same solution as was described under AA for cotton line and is applied the same as the other copper oleate solutions; that is, by dipping the twine into the solution and then spreading out to dry.

METHOD OF TAKING SAMPLES.

In order that the same amount of line might be used for each sample, and that shrinkage might be measured, it was necessary to measure the samples under constant tension. To measure a line, one end of the line was made fast at one end of a long hall. The line was then paid out for about 100 feet, passed over a small pulley, and made fast to a 2-kg. weight. The line thus stretched out horizontally under a 2-kg. tension was measured with a steel tape. Trials showed that these measurements could be repeated to within 4 inches for 100-foot lengths. After the samples were treated with the several preservatives they were again measured in the same way as before, and the shrinkage was noted. The figures for shrinkage from all series of experiments will be considered together later (p. 50).

The accurately measured samples were weighed on the analytical balance before and after treatment by the preservatives and the gain in weight recorded. These gains will also be considered together after the several series of experiments have been considered (p. 46). Where the weight per unit length of any particular sample disagreed markedly from the others it was discarded as of over or under size. No doubt the figures contained in this paper show some discrepancies or variations that are due to differences in the line itself, but errors of this kind are reduced to a minimum by obtaining the average of results from numerous tests.

Because of the length of samples needed it was impossible to measure them in a room of constant air conditions. After trials with oven-dried samples for weighing it was found best to weigh in the air-dry condition.

SERIES EXPOSED TO WEATHER CONDITIONS AT WASHINGTON, D. C.

MATERIALS TESTED.

Cotton lines were prepared by each of 11 different preservatives and preservative methods, namely, copper oleate in four different concentrations or combinations, B, C, D, and E; coal tar, F; pine tar, G; the two tars in equal parts, H; quercitron and potassium bichromate, I; petroleum product No. 1, J; a proprietary waterproofing material, K; and the Dutch method, L; untreated white line, A, was used as a control. Seven samples were prepared by each preservative, one to hold as an unexposed check; the other six to be exposed.

These samples were lightly stretched on the roof of the Fishery Products Laboratory, Washington, D. C., on November 25, 1921. At the end of each succeeding month for six months one sample treated by each preservative and one control sample were removed and tested for tensile strength. The experiments made by others in England, Norway, and Holland have usually lasted only about two months. In the present instance it was desired to have a full test of endurance, so the exposures were continued for six months.

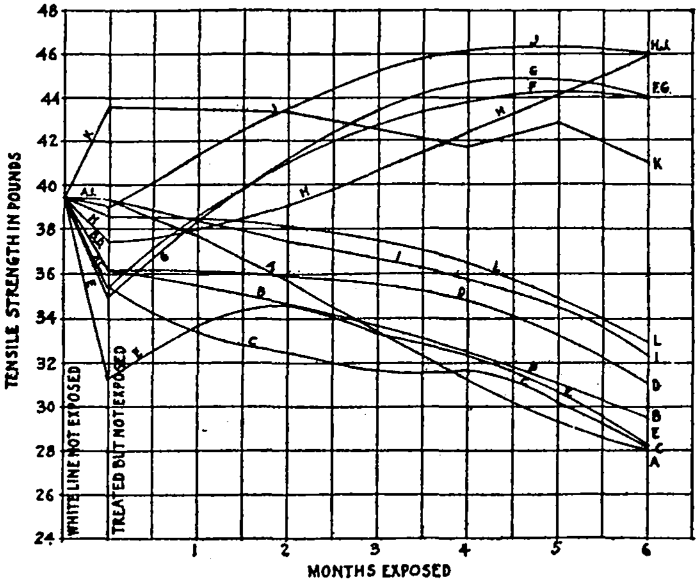

FIG. 1.—Tensile strength of cotton lines exposed to weather conditions at Washington, D. C.

TENSILE STRENGTH.

This factor was measured on a tensile-strength machine at the U. S. Bureau of Standards.[3] The machine was automatic, motor-driven, and recorded the tensile strength by means of a moving pen. Because of variations in the line it is necessary to take the average of a number of tests. The figure given for the control is the average of 60 tests, all others of 15. Table 3 gives the results of the measurements of tensile strength for the lines exposed to weather conditions at Washington, D. C. The same results are expressed graphically in Figure 1, wherein the curves are smoothed by the method of moving averages.

[3] See footnote 2, p. 1.

TABLE 3.—*Tensile strength of cotton lines exposed on roof of Fishery Products Laboratory, Washington, D. C., 1922.*

Symbol and treatment.	Unexposed.	Number of months exposed.					
		1	2	3	4	5	6
	Tensile strength in pounds.						
A—White line, untreated control	[1] 39.3	37.3	36.3	33.8	31.4	27.5	28.0
B—Copper oleate 7 per cent in gasoline	36.1	35.3	35.0	34.0	31.9	31.9	29.6
C—Copper oleate 7 per cent in gasoline, 5 per cent oil, 1-1000 cresol	35.5	34.0	33.4	33.2	31.6	31.1	28.2
D—Copper oleate 11 per cent in gasoline	36.1	36.5	36.1	35.3	35.8	34.4	31.1
E—Copper oleate 11 per cent in gasoline, 2 per cent oil	31.4	33.8	33.8	33.2	33.8	31.2	28.4
F—Coal tar 50 per cent, benzol 50 per cent	35.4	43.5	36.9	44.0	46.1	43.1	44.0
G—Pine tar 50 per cent, benzol 50 per cent	35.2	39.6	39.8	44.7	47.0	44.1	44.0
H—Coal tar 25 per cent, pine tar 25 per cent, benzol 50 per cent	37.4	38.2	37.0	41.6	43.3	43.0	46.0
I—Quercitron and potassium bichromate	39.3	40.0	36.6	35.7	36.2	36.6	32.4
J—Petroleum product No. 1	39.0	41.4	44.0	45.7	40.4	47.0	46.0
K—Proprietary waterproofing material	43.7	([2])	43.5	([2])	41.8	42.8	41.0
L—Dutch method	38.6	37.6	39.0	37.6	36.2	36.0	33.0

[1] Average of 60 breaks; every other figure in this table is the average of 15 breaks.
[2] No sample run.

Here, it will be observed, the lines preserved by any of the materials suffer an immediate diminution of strength even before they are exposed. (K, the commercial waterproofing was not tested immediately after treatment.) The reason for this diminution of strength appears to be the lubrication of the fibers. The cotton line used consists of comparatively short fibers that are made to serve the purpose of a long line by being twisted together. The friction between the fibers holds them together. When a pull breaks the line, some of the fibers are actually broken, others disengaged. The introduction of a foreign substance between these fibers or strands may greatly alter the behavior of the line. A lubricant, by diminishing the friction between the fibers, causes more of them to slip out or become disengaged and fewer to break; consequently, the line is weakened. We see that most of our preservatives immediately after application cause such a weakening. These remarks may not, and probably do not, apply to lines made of very long fiber cotton, like sea-island cotton. The tensile strength of such lines is probably the sum of the tensile strengths of the fibers, and binders would have little effect on the tensile strength.

On the other hand, anything between the fibers that increases the friction or glues the fibers together will cause an increase in strength. This effect becomes evident after the material begins to become sticky or dry. In the present instance the lines treated with copper oleate, B, C, D, and E, and by the tanning methods, I and L, on exposure to the weather suffer a gradual though small diminution of strength. At the end of six months' exposure to weather the lines are still strong and useful. These preservatives have no body or binder. The other preservatives that have a body or binder—namely, coal tar, F; pine tar, G; a mixture of the two, H; and the petroleum product No. 1, J—show an increase in strength as the preservative dries. This increase is sufficient to neutralize any deterioration of the fibers. Those preservatives that behave in a similar way are grouped together in Figure 2, where F, G, H, and J represent all preservatives that have a heavy body, B, C, D, E, I, and L those that have no heavy body, and A untreated line.

SUMMARY OF RESULTS OF WASHINGTON EXPERIMENTS.

1. The effects of exposure of cotton lines to outdoor weather conditions in Washington, D. C., in winter were small; lines so exposed suffered very little deterioration.
2. All preservatives here used caused an immediate small diminution in tensile strength.
3. Preservatives that have a heavy body, such as tar, by binding together the fibers caused an increase in tensile strength after the material became hard and dry.

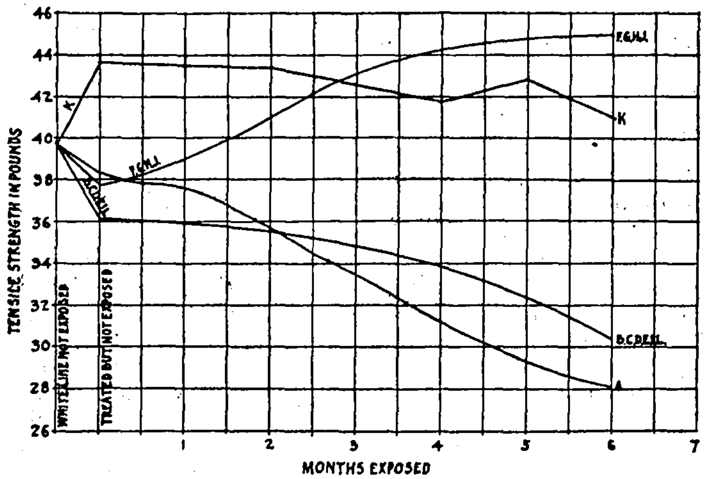

FIG. 2.—Tensile strength of cotton lines exposed to weather conditions at Washington, D. C., grouped.

4. Tar and the petroleum product were adequate and effective preservatives where only weather conditions were encountered.
5. The modifications of copper oleate showed only trifling differences between themselves.

SERIES EXPOSED IN SEA WATER AT KEY WEST, FLA.

WATER CONDITIONS AT KEY WEST.

The sea at Key West is part of the Gulf Stream. The temperature and density of the water during the period the lines were exposed are shown in Table 4. The water is characterized by an abundance of lime.. The bottom in this region is covered with a crust of limestone, and a fine white sediment in the water deposits on the articles placed in it. It may be for this reason that the lines did not deteriorate as rapidly as was expected. There were no barnacles or other marine growths on the samples returned.

TABLE 4.—*Water conditions at Key West, Fla.*

Year and month.	Temperature.						Specific gravity.		
	Maximum.		Minimum.		Average.		Maximum.	Minimum.	Average.
	°F.	°C.	°F.	°C.	°F.	°C.			
1921.									
November	82	28	75	24	79	26.0	1.027	1.020	1.024
December	81	27	68	20	74	23.5	1.029	1.026	1.027
1922.									
January	82	28	63	17	72	22.4	1.030	1.020	1.028
February	82	28	68	20	75	24.0	1.028	1.015	1.022
March	86	30	73	23	80	26.5	1.027	1.025	1.026

MATERIALS TESTED.

In this series 11 preservatives and preservative methods and a control were tested. The preservatives and preservative methods were copper oleate in four variations, B, C, D, and E; coal tar, F; pine tar, G; the two tars in equal parts, H; quercitron and potassium bichromate, I; petroleum product No. 1, J; proprietary waterproofing material, K; and the Dutch method, L.

The samples of No. 24 cotton line, six treated by each method, were fastened to a frame made of galvanized iron pipe and immersed in a cement tide pond at the U. S. Fisheries Station, Key West, Fla., on November 7, 1921. A set of samples was removed every 3 weeks for 18 weeks.

TENSILE STRENGTH.

The samples were tested for tensile strength as already described (p. 10). Table 5 gives the results. These results are shown graphically in Figures 3 and 4, but in Figure 4 those preservatives that give similar results are grouped for easy comparison. In both figures the curves are smoothed by the method of moving averages.

TABLE 5.—*Tensile strength of cotton lines exposed in sea water at Key West, Fla.*

Symbol and treatment.	Unexposed.	Number of weeks exposed.					
		3	6	9	12	15	18
	Tensile strength in pounds.						
A—White line, untreated control	[1] 39.3	37.3	34.3	35.0	29.3	26.2	13.7
B—Copper oleate 7 per cent in gasoline	36.1	34.7	35.1	36.6	35.0	33.4	29.6
C—Copper oleate 7 per cent in gasoline, 5 per cent oil (by volume), 1-1000 cresol	35.5	32.4	41.5	34.5	34.1	35.8	34.5
D—Copper oleate 11 per cent in gasoline	36.1	37.6	37.4	36.6	37.9	37.9	37.9
E—Copper oleate 11 per cent in gasoline, 2 per cent oil	31.4	35.0	33.9	33.5	84.4	34.3	35.4
F—Coal tar 50 per cent, benzol 50 per cent	35.4	43.2	51.0	50.2	47.8	49.6	44.4
G—Pine tar 50 per cent, benzol 50 per cent	35.2	43.9	38.9	44.8	44.2	47.0	41.0
H—Pine and coal tar, 25 per cent each, benzol 50 per cent	87.4	52.2	53.0	44.0	50.1	46.0	51.0
I—Quercitron and potassium bichromate	39.3	36.1	40.6	31.7	25.1	17.6	14.4
J—Petroleum product No. 1	39.0	40.6	34.0	81.0	27.9	19.7	17.0
K—Proprietary waterproofing material	43.7	48.9	42.0	36.6	27.1	20.5	16.2
L—Dutch method	38.6	41.4	41.1	40.7	39.0	36.3	24.4

[1] Average of 60 breaks; every other figure in this table is the average of 15 breaks.

It is apparent, in the first place, that the effect of the sea water at Key West is much more severe than that of the weather at Washington. The untreated line and also those lines treated by quercitron and potassium bichromate, I, petroleum product, J, as well as the proprietary waterproofing material, K, were all but completely rotten in 18 weeks, though a two or three months' test (as was done in the European experiments) would have shown them to

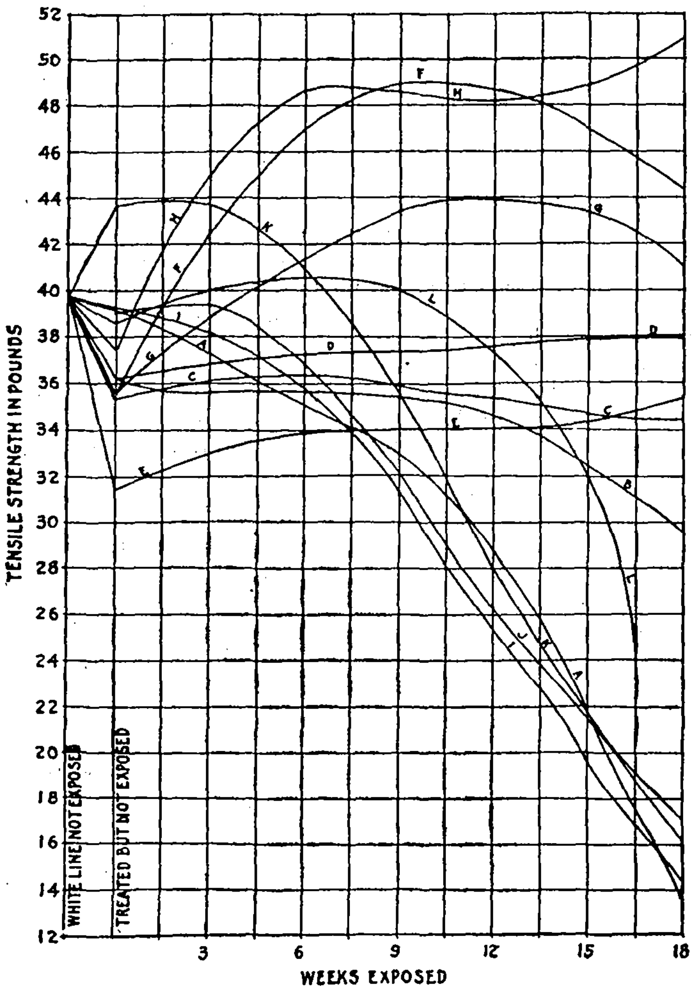

FIG. 3.—Tensile strength of cotton lines exposed in sea water at Key West, Fla.

be good. The Dutch method, L, which deposits a little copper in the lines, was somewhat better, though lines treated by it, too, showed marked deterioration, especially after the fourth month. The only preservative that brought the samples through four and one-half months' exposure unimpaired in tensile strength were the three tars, F, G, H, and the copper oleate, B, C, D, E. The difference between the tar and the copper oleate is that the tar stuck the fibers together, and thus increased the tensile strength, while the copper oleate did not stick the fibers, but by its preservative action prevented decay and held the lines throughout the test up to their original strength. The lines preserved with copper oleate did not show great differences between themselves, nor do the different kinds of tar show important differences.

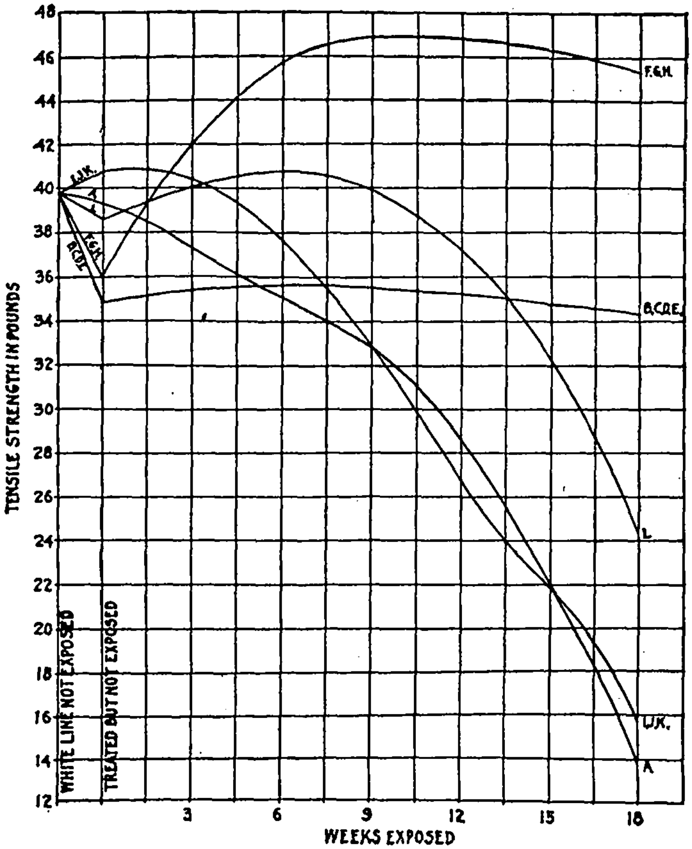

FIG. 4.—Tensile strength of cotton lines exposed in sea water at Key West, Fla., grouped.

SUMMARY OF RESULTS OF KEY WEST EXPERIMENTS.

1. Exposure to sea water at Key West had a severer action on cotton lines than the weather at Washington, D. C.

2. Quercitron and potassium bichromate, petroleum product, and the proprietary waterproofing material showed no noteworthy preserving effect.

3. The Dutch method was somewhat better, though the lines treated by it showed marked deterioration in four and one-half months.

4. The lines preserved with copper oleate showed no substantial deterioration in six months' exposure at Key West; an immediate

diminution in strength after treatment was apparently due to the lubricating effect. The variations of copper oleate showed no considerable differences between themselves.

5. Coal tar, pine tar, and the mixture of the two preserved the tensile strength unimpaired for four and one-half months.

6. The tars also increased the tensile strength by sticking the fibers of the twine together.

7. No growth of marine plants or animals was attached to any of the lines at Key West.

SERIES EXPOSED IN SEA WATER AT BEAUFORT, N. C.

The exposures were made in the water of Beaufort harbor, at the wharf of the U. S. Fisheries Biological Laboratory, from February 15 to August 15, 1922.

WATER CONDITIONS AT BEAUFORT.

The water temperature and salinity for the six months are given in Table 6. Here both salinity and temperature vary more than they do at Key West, the water being at times considerably diluted with fresh water. There is abundant growth of barnacles, hydroids, ascidians, sea anemones, and other attached marine growths.

TABLE 6.—*Water conditions at Beaufort, N. C.*

Year and month.	Temperature.						Specific gravity.		
	Maximum.		Minimum.		Average.		Maximum.	Minimum.	Average.
1922.	°*F*.	°*C*.	°*F*.	°*C*.	°*F*.	°*C*.			
February	60	16	44	7	54	12	1.019	1.015	1.016
March	71	22	52	11	60	16	1.018	1.009	1.015
April	73	23	57	14	68	20	1.023	1.016	1.021
May	80	27	62	17	73	23	1.023	1.018	1.020
June	84	29	73	23	79	26	1.021	1.014	1.018
July	86	30	77	25	82	28	1.022	1.016	1.019
August	82	28	77	25	79	26	1.021	1.014	1.018

TESTS WITH COTTON LINES.

The lines to be exposed were measured and weighed by the methods already described (p. 9). After treatment they were again measured and weighed and differences noted, as shrinkage and increase of weight, respectively. These factors will be considered later. In this series of experiments two new tests were introduced, namely, tests of flexibility and of wearing quality, as influenced by the preservatives. These factors will be discussed in connection with the data obtained concerning them.

MATERIALS TESTED.

The cotton twine used here was, as before, No. 24 cable-laid, hard-finish cotton, in individual samples, each 100 feet long.

The preservatives and preservative methods were as follows: Coal, pine, and mixed tar; F, G, and H, as in the previous experiments; quercitron and potassium bichromate, I; petroleum product

No. 1, J; and also a similar material by new formula by the same company, which we designate petroleum product No. 2, symbolized by X; the Dutch method, L; four variations of copper oleate, M, N, O, and P; two commercial brands of copper paint sold for fish-net preservatives, No. 1, Q and No. 2, R.

TENSILE STRENGTH.

Of the preservatives here considered for the first time the two samples of copper paint cause an immediate increase in the strength of the line. These materials, containing cuprous oxide, suspended in a binding material, cause great internal friction, which manifests itself in its effect on tensile strength and also, as will be seen later, on flexibility and the mechanical wearing quality of the lines. All of the other materials caused the usual diminution of tensile strength by internal lubrication.

The results of tensile strength measurements are given in Table 7. The same results are shown graphically in Figure 5, where the individual preservatives are shown, and in Figure 6, where the preservatives that behave similarly are presented in groups, such groups being the copper paints, copper oleates, and tars.

TABLE 7.—*Tensile strength of cotton lines exposed in sea water at Beaufort, N. C.*

Symbol and treatment.	Unexposed.	Number of months exposed. 1	2	3	4	5	6
		Tensile strength in pounds.					
A—White line, untreated control	[1] 39.3	33.0	5.3	2.9	[2]	[2]	[2]
F—Coal tar 50 per cent, benzol 50 per cent	35.4	46.0	44.9	36.2	23.2	18.0	[2]
G—Pine tar 50 per cent, benzol 50 per cent	35.2	45.0	46.9	33.8	11.9	3.1	[2]
H—Coal and pine tar, 25 per cent each, benzol 50 per cent	37.4	45.0	46.8	33.9	27.9	16.2	[2]
I—Quercitron and potassium bichromate	39.3	42.4	19.6	3.2	[2]	[2]	[2]
J—Petroleum product No. 1	39.0	40.0	23.4	8.7	[2]	[2]	[2]
L—Dutch method	38.6	40.3	37.0	35.3	20.3	8.3	4.9
M—Copper oleate 7.5 per cent in gasoline	34.2	36.2	36.6	28.6	16.6	11.0	9.7
N—Copper oleate 7.5 per cent in gasoline, 5 per cent oil, 1-1000 cresol	33.2	35.2	33.8	33.9	25.4	20.8	12.0
O—Copper oleate 12.5 per cent in gasoline	33.6	36.6	40.3	30.0	21.3	25.1	8.8
P—Copper oleate 12½ per cent in gasoline, 2 per cent oil	36.3	37.2	39.0	37.0	29.7	19.5	16.9
Q—Copper paint No. 1, 50 per cent creosote oil	41.5	42.0	42.4	40.8	41.0	33.0	18.9
R—Copper paint No. 2	42.7	48.0	50.0	49.5	47.0	40.0	38.3
S—Gilsonite	35.5	28.2	14.5	8.5	3.9	[2]	[2]
X—Petroleum product No. 2	32.9	34.0	5.7	[2]	[2]	[2]	[2]

[1] Average of 60 breaks; every other figure in this table is the average of 15 breaks.
[2] Sample was disintegrated and gone.

Upon exposure the lines Q and R, preserved with copper paint, are easily in the lead, as far as preservation of tensile strength is concerned. At the end of six months' exposure lines preserved by them are nearly as strong as the original untreated line, though a weakening begins to appear in three or four months. Next to those preserved with copper paint, in the diminishing order of tensile strength at the end of six months' exposure, come those treated with the copper oleates, the Dutch method, and the tars. Of these the tarred lines, F, G, and H, made an excellent showing for two months (that is, as long as creosote was present), after which a very rapid deterioration occurred. The establishment on them of a heavy growth of ascidians or sea squirts broke the lines and carried them away. The Dutch method followed the tars closely, being not quite so good at first, but better at the finish. The lines treated with copper oleate, M, N, O, and P, showed at the beginning the

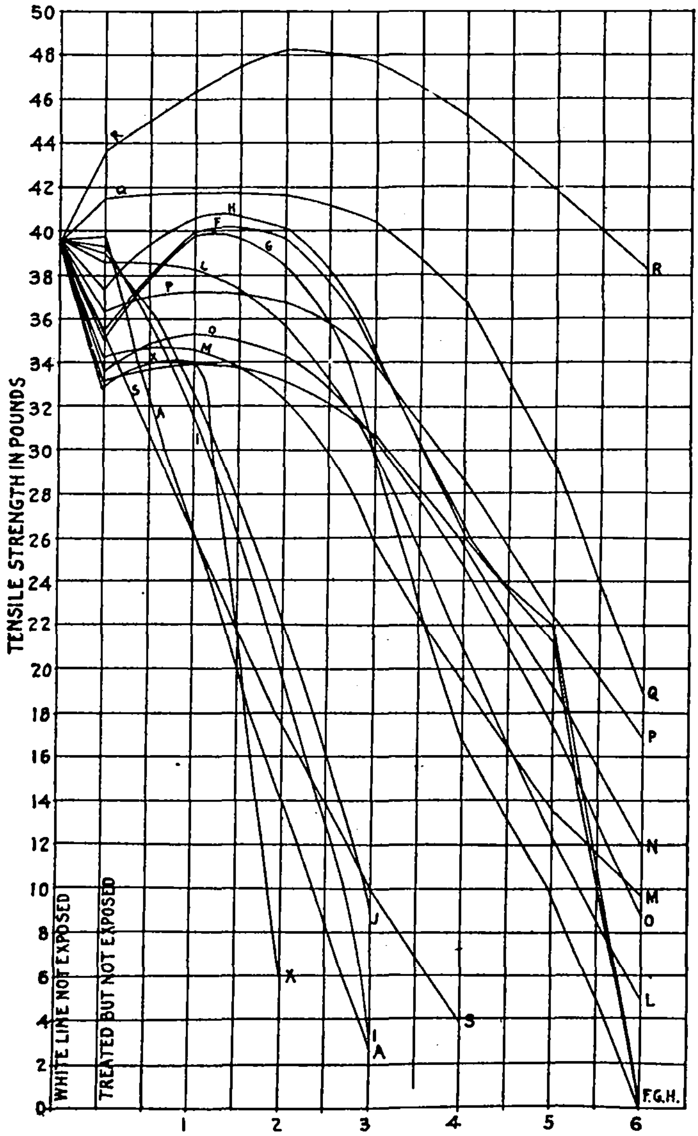

FIG. 5.—Tensile strength of cotton lines exposed in sea water at Beaufort, N. C.

usual weakening due to lubrication, but upon exposure lost strength less rapidly than those preserved by either the Dutch method or tar; in fact, were second only to those treated with the copper paint at the end of six months.

The other preservatives exposed at Beaufort showed no preserving effect worth considering. These were quercitron and potassium bichromate, I; petroleum products, Nos. 1 and 2, J and X; and gilsonite, S. These materials and methods may be definitely eliminated by this experiment, since they do not preserve.

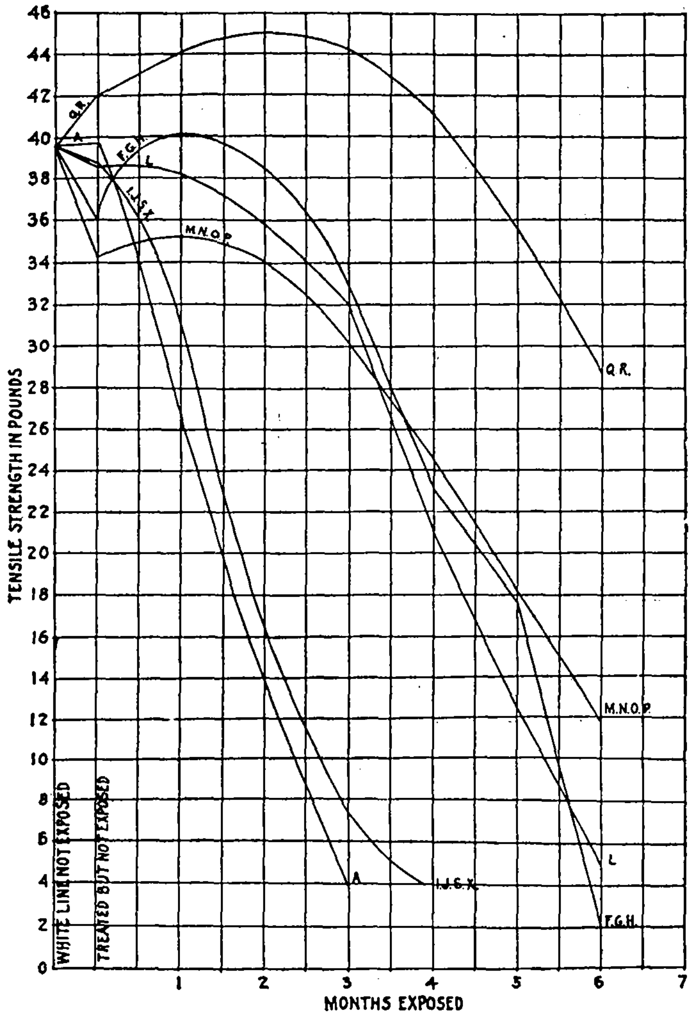

FIG. 6.—Tensile strength of cotton lines exposed in sea water at Beaufort, N. C., grouped.

The results of these experiments show also that lines suffer deterioration much more rapidly at Beaufort than at Key West. This applies equally to untreated lines and to those treated with preservatives.

FLEXIBILITY.

If preservation of tensile strength on exposure were a sure and sufficient criterion, it would now be proper to pronounce copper paint the best preservative, copper oleate next, then the Dutch method, and finally the tars. Tensile strength, however important it is, is not the only consideration—indeed, in many cases is not the most important consideration.

Flexibility is a factor of great importance in many kinds of fishing textiles. In gill nets a stiff or wiry line will cause the approaching fish to react on coming in contact with the net and to turn and leave, whereas a soft line yields and the fish becomes gilled in his effort to get through. It is also said that a school of fish when surrounded by a purse seine will, upon striking a soft net, continue to exert themselves against it, forcing it outward while the net is being pursed from below. In this manner the entire school is captured; but if the net is stiff and wiry, experienced fishermen say, the fish will react and "sound," or dive, before the seine can be pursed, and thus escape. The factor of flexibility of netting has long been recognized in a qualitative way; but, so far as the writers are aware,

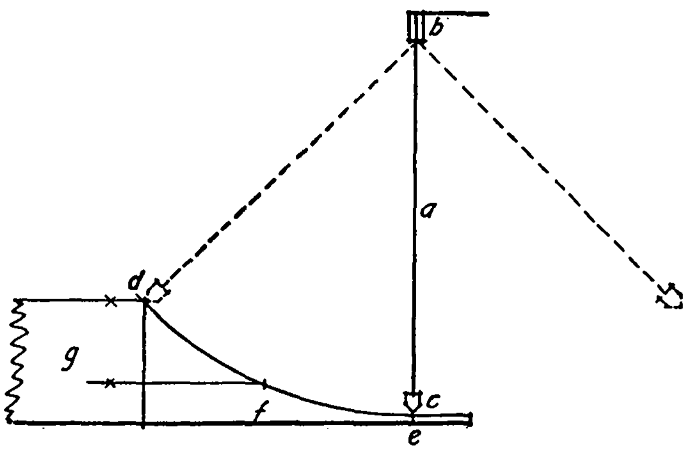

FIG. 7.—Equipment used for testing the flexibility of lines.

no effort has ever been made to measure it quantitatively. The writers have devised a simple method of measuring quantitatively the flexibility of lines treated with various preservatives, and by that means have obtained some highly interesting figures for the several materials studied.

Method of measuring flexibility.—The method consists, essentially, of measuring the energy dissipated (or converted into heat) in bending a sample of the line through a definite angle. For this purpose advantage was taken of the well-known laws of the pendulum. The apparatus consists of a pair of simple wooden jaws, *b*, Figure 7, supported from a horizontal support rod not shown in the figure. A block, *g*, serves as a base, and is cut out as an arc of a circle with the jaws, *b*, as a center, so arranged that a sample of twine gripped in the jaws will just fail to reach when the plummet, *c*, is attached and swings freely. The plummet, *c*, is made of brass and is so constructed that the twine can be gripped straight and true at the center.

The sample of line, *a*, is gripped in the jaws and the plummet attached at the lower end. The plummet is displaced from the

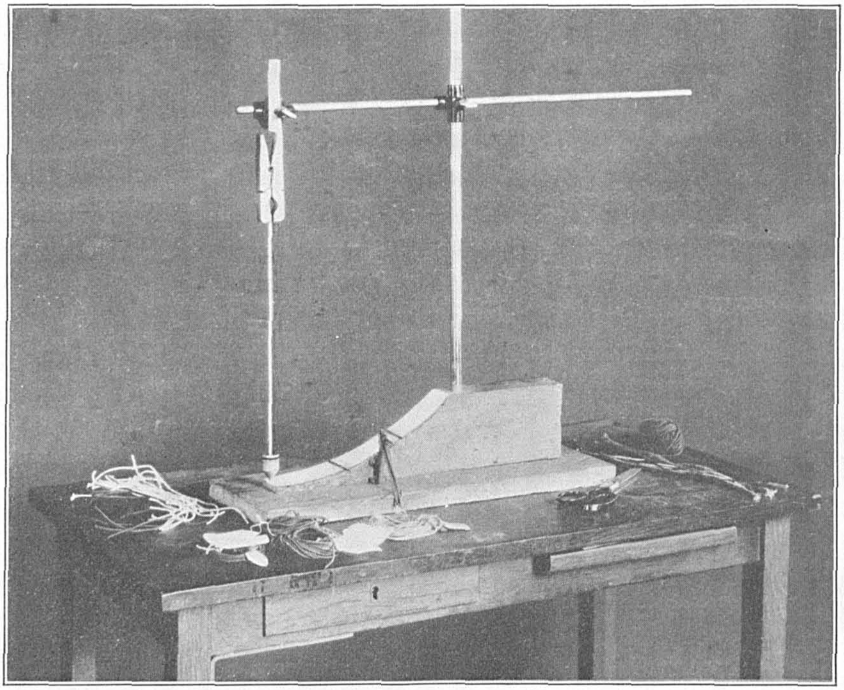

FIG. 8.—Apparatus used for testing the flexibility of lines.

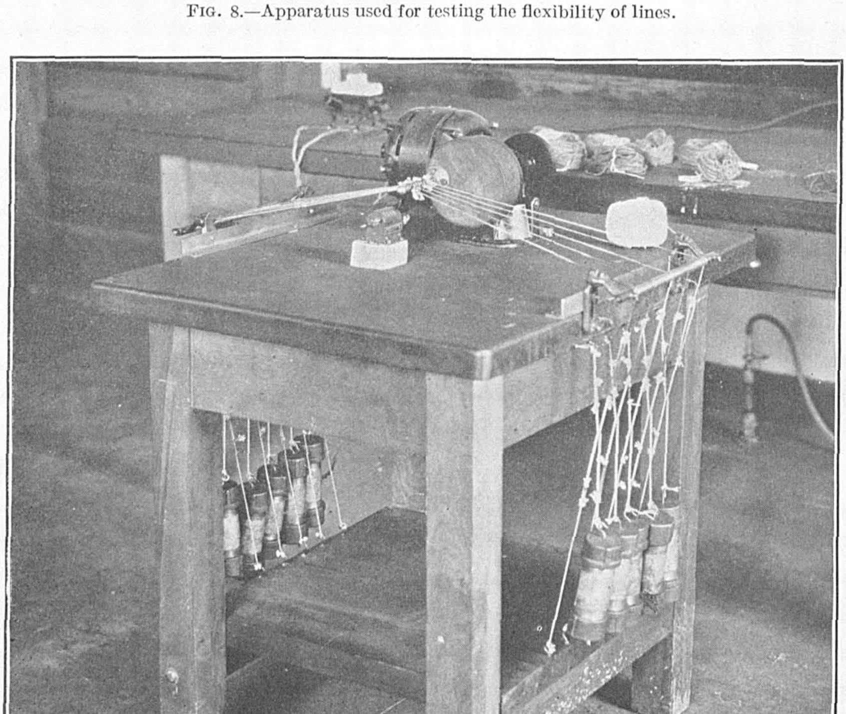

FIG. 9.—Machine used for making wearing tests.

vertical position over *e*, to a convenient point, *d;* that is, so that the pendulum when released will swing through an angle. As the pendulum swings it bends the twine back and forth. The bending of the twine is work and causes the energy originally imparted to the plummet to diminish; that is, the oscillations of the pendulum are of diminishing amplitude. Presently the pendulum will be swinging only to some selected point, *f*, as its highest point. If the oscillations from the start are counted until the pendulum swings only to point *f*, the number will be a measure of the energy that has been transformed in bending the line—the more flexible the sample the greater the number of oscillations necessary to reduce the amplitude to the predetermined angle.

For the present work the following arbitrary standards were adopted as convenient and easily measured: Distance from jaws to arc base, 30 cm.; weight of plummet 50 g.; angle of first oscillation, one radian (57.2958°, or 57°17′45″) or 15 cm. of arc from the vertical position to the starting point, *d;* angle of last oscillation one-half radian (28.6479° or 28°38′52.5″). All the data on flexibility in this paper are obtained on these standards. They are convenient and satisfactory, though there are some grounds for considering a smaller angle of oscillation as a possible improvement. The instrument used in our tests is shown in Figure 8. In the present work the results have been expressed by the number of oscillations necessary to reduce the amplitude by the amount chosen, one-half radian. The actual amount of energy may be calculated in the following way:

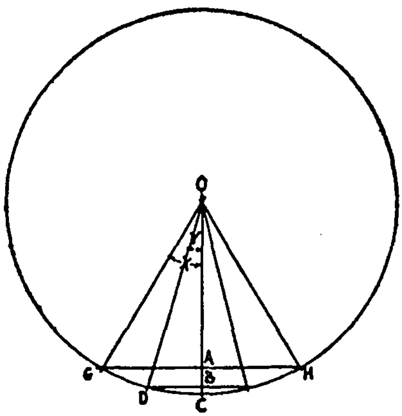

FIG. 10.

When the 50-gram plummet is elevated from C to G, Figure 10, it receives energy in ergs, equal to its elevation, AC, times its mass, in grams, times the force of gravitation. When its amplitude has been reduced so that it rises only to D on its upward swing, it possesses energy expressed in the same way, only with the lesser elevation, BC; that is, the number of ergs of energy that have disappeared in bending the twine is equal to the difference in elevation times mass, times gravitation, or,

$$\text{Energy consumed} = (OB - OA) \times 50 \times 980$$

to determine $OB - OA$ we determine OB as $r \cos y$ where r is the radius of the circle and y is one-fourth radian, or $14.3239° = 29.07$ and OA as $r \cos x$, where x is one-half radian, or $28.6479° = 26.33$. The difference here is therefore $29.07 - 26.33 = 2.74$ cm. and the energy that has disappeared is $2.74 \times 50 \times 980 = 134{,}260$ ergs. This quantity, being always the same for the different samples as long as we maintain the same standards, we have but to divide it by the number of oscillations to find the average amount of energy transformed in bending any particular sample one time through the average amplitude, three-fourths radian, or 42.97°. Of course, since each oscillation is of different amplitude, the amount of energy that is transformed with each oscillation is accordingly smaller than that for the preceding, but for practical purposes only the average would be necessary.

It may be objected that the friction of the air is considerable and variable. Efforts were made to determine this source of error, but it was found impracticable to do this precisely, because the angle chosen was too large for the swinging of a frictionless (agate knife-edges) bearing. For this reason a smaller working angle might be better as permitting an accurate determination of the air-friction error. In any case this error is small and practically constant, so that it is not corrected in this paper.

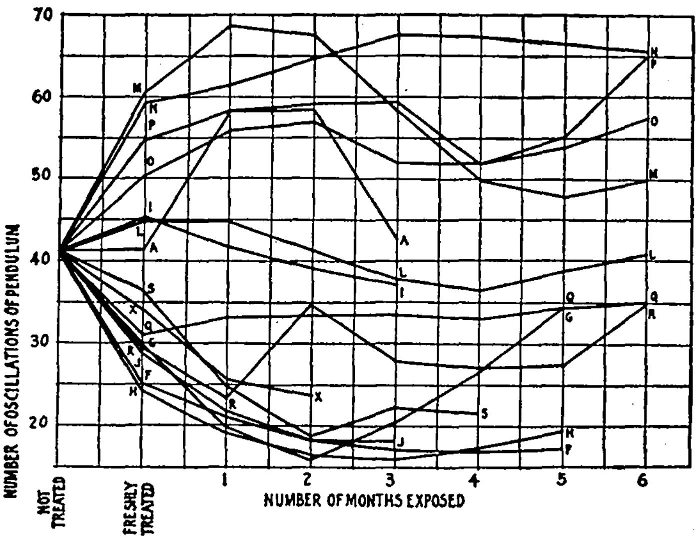

FIG. 11.—Flexibility of cotton lines exposed in sea water at Beaufort, N. C.

Two other sources of error in this test require attention. One is a variation in the flexibility at various places on the sample, the other is a change in flexibility caused by the action of heat, generated by bending, on the viscosity of the preservative. The method of making the test takes these two factors into account. Ten pieces, each about 32 cm. long, were cut from the sample to be tested. One was placed in the jaws of the tester and the number of oscillations counted in the manner described. This test was repeated 10 times at the one place on each test piece, 100 tests being made on each sample. If heating is considerable the successive tests at the same place will show increasing flexibility with preservatives that are subject to variation in flexibility with temperature. Progressive increase in flexibility on repeated bending was found in lines treated with tar, petroleum product No. 1, gilsonite, copper oleate, slight increase in quercitron and potassium bichromate, the Dutch method, petroleum product No. 2, and copper paint No. 2, and no increase at all in copper paint No. 1 and untreated white line.

Results of flexibility tests.—The samples included in the Beaufort series were all tested for flexibility (1) immediately after treatment, and (2) after each month of exposure in the water. In Table 8 and in Figure 11 the results of these tests are given; in Figure 12 the same results are shown by groups of preservatives that had a similar effect on flexibility.

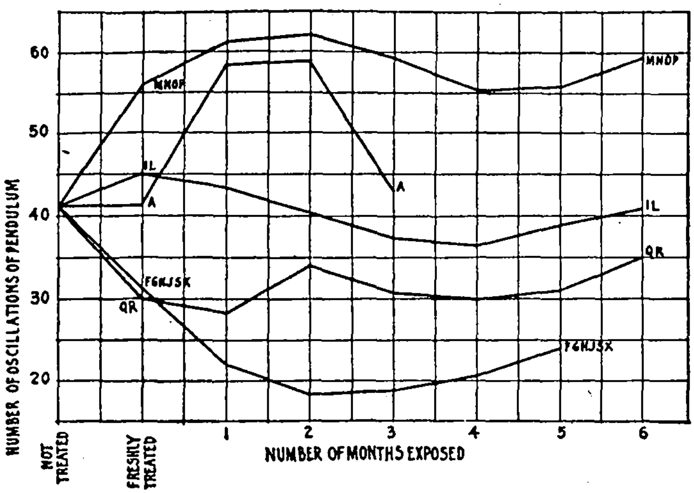

FIG. 12.—Flexibility of cotton lines exposed in sea water at Beaufort, N. C., grouped.

TABLE 8.—*Flexibility of lines exposed to ocean water at Beaufort, N. C.*[1]

Symbol and treatment.	Unexposed.	Number of months exposed.					
		1	2	3	4	5	6
	Number of oscillations.						
A—White line, untreated control	41.3	70.6	62.7	43.8	(2)	(2)	(2)
F—Coal tar 50 per cent, benzol 50 per cent	25.0	19.3	18.9	16.6	16.1	18.0	(2)
G—Pine tar 50 per cent, benzol 50 per cent	29.9	15.0	14.8	18.1	27.4	34.2	(2)
H—Pine tar 25 per cent, coal tar 25 per cent, benzol 50 per cent	24.2	18.0	14.8	16.6	16.5	19.2	(2)
I—Quercitron and potassium bichromate	45.1	44.8	35.9	37.0	(2)	(2)	(2)
J—Petroleum product No. 1	29.0	18.2	18.1	18.2	(2)	(2)	(2)
L—Dutch method	44.9	44.3	45.5	33.8	33.6	41.7	40.5
M—Copper oleate 7½ per cent in gasoline	60.5	74.3	71.8	56.6	46.4	46.7	49.7
N—Copper oleate 12½ per cent in gasoline, 5 per cent oil, 1-1000 cresol	59.1	61.4	63.9	68.4	70.1	62.8	65.4
O—Copper oleate 12½ per cent in gasoline	50.2	60.9	56.8	53.0	45.9	58.4	57.8
P—Copper oleate 12½ per cent in gasoline, 2 per cent oil	49.6	64.3	57.5	55.5	64.7	35.3	64.4
Q—Copper paint No. 1	31.1	39.3	29.3	31.0	39.6	28.2	34.6
R—Copper paint No. 2	29.4	14.6	26.4	33.9	23.6	23.3	34.6
S—Gilsonite	36.5	21.1	17.2	18.0	21.3	(2)	(2)
X—Petroleum product No. 1	34.3	18.9	23.5	(2)	(2)	(2)	(2)

[1] Every figure in this table is the average of 100 tests.
[2] Sample was disintegrated and gone.

The most flexible lines after treatment are those treated with copper oleate, M, N, O, and P, which make around 60 oscillations; those treated by the tanning methods—that is, quercitron and potassium bichromate, I, and the Dutch method, L—are next in flexibility, with about 40 oscillations; copper paint, which made such a good showing in the tensile-strength tests, is here at a great disadvantage, the lines being stiff or wiry and making only about 30 oscillations under the conditions described; finally, the tars, petroleum products, and gilsonite cause the greatest stiffening, the lines treated with them making only about 20 oscillations.

According to these tests, if we express the flexibility of tarred lines as 1, then the other preservatives have approximately the following flexibility values:

Petroleum product	1
Gilsonite	1
Copper paints	1½
Tanning methods	2
Copper oleate	3

RESISTANCE TO MECHANICAL WEAR OR ABRASION (WEARING QUALITY).

In experiments so far presented and discussed, the undesirable changes in the lines were brought about during exposure principally

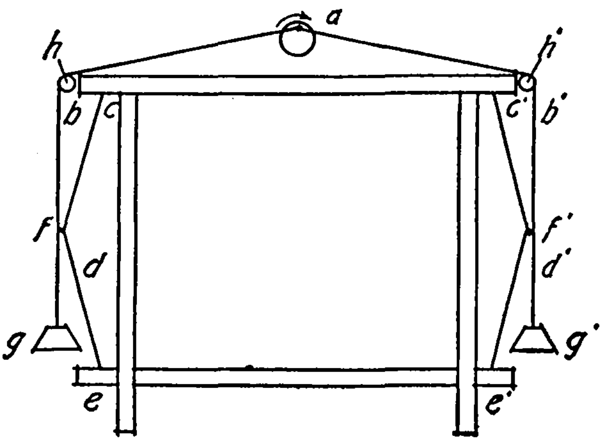

FIG. 13.—Apparatus used for testing the wearing quality of lines.

by decomposition or weakening of the lines, presumably by chemical or biological agencies. These agencies are, perhaps, not always the greatest enemy of lines. It has been shown that in air and exposed to the weather cotton lines do not undergo rapid deterioration. Many types of nets are actually in the water only a small part of the time. They are handled much, however, are dragged over the gunwales of boats and across decks and wharves, and the lines rub against themselves during such handling. No doubt this factor of mechanical wear or abrasion is highly important in such gear as purse seines, haul or drag seines, and trawls. It is to be expected, also, that the preservatives used will have an important bearing on this factor. Like flexibility, it has often been recognized qualitatively as a factor, but has never been given quantitative measurement or expression. In the present work the attempt was made to measure the wearing quality of the lines treated.

Method of measuring wearing quality.—The principle of the method is the obvious one, which consists of drawing or "sawing" the lines across some wearing or abrading edge under a constant pull and measuring the number of strokes required to wear it out. In practice, however, this proved to be difficult of application. Close-grained wood was tried first, but the results were not at all consistent or even similar for similar samples. It was found that the edge wore sleek at a very inconstant rate. With iron, steel, hard rubber, and even glass the same difficulties were encountered. The most satisfactory results were obtained by causing the sample to saw against itself at a rather acute angle and under pull of a definite weight.

The construction and operation of the machine for making this test is shown diagrammatically in Figure 13. To an eccentric, *a*, are fastened the lines to be tested, *b* and *b'*, which are passed over the rollers, *h* and *h'*, and fastened at *c* and *c'*. Other pieces of the same line, *d* and *d'*, are made fast at *e* and *e'*, and run through the slack part of *b* and *b'*, at *f* and *f'*. The samples so attached form angles *efh* and *efg*, etc., of about 13°. Weights of 1 kg. (*g* and *g'*) are attached to the free ends of the lower piece of line. The eccentric *a* is revolved by a motor, imparting a reciprocating motion to the samples *b* and *b'*, which causes them to saw across similar samples, *d* and *d'*. The samples thus wear out and the weights drop to the floor. The number of strokes necessary to wear each sample down to a breaking strength of 1 kg. is taken as a measure of the wearing quality. The machine was made so as to run 10 samples at a time, five on each side of the table, and a mechanical revolution counter was used to assist in keeping count. In Figure 9 (p. 21), the machine used is shown with all samples in, ready to start.

TABLE 9.—*Wearing quality of cotton lines exposed in sea water at Beaufort, N. C.*

Symbol and treatment.	Unexposed.	Number of months exposed.					
		1	2	3	4	5	6
	Number of strokes.						
A—White line, untreated control	[1]399.0	56.8	[2]	[2]	[2]	[2]	[2]
F—Coal tar 50 per cent, benzol 50 per cent	189.4	172.4	94.5	103.9	34.4	14.0	[2]
G—Pine tar 50 per cent, benzol 50 per cent	159.7	141.4	97.8	75.1	5.7	[2]	[2]
H—Pine tar and coal tar 25 per cent each, benzol 50 per cent	168.5	171.6	107.2	92.6	43.6	9.8	[2]
I—Quercitron and potassium bichromate	50.9	45.1	[2]	[2]	[2]	[2]	[2]
J—Petroleum product No. 1	281.3	124.2	17.0	[2]	[2]	[2]	[2]
L—Dutch method	46.6	84.6	79.6	91.0	8.8	0	0
M—Copper oleate 7½ per cent in gasoline	118.4	167.4	141.2	129.2	12.8	8.1	6.1
N—Copper oleate 12½ per cent in gasoline, oil 5 per cent, cresol 1-1000	127.5	157.3	117.0	150.9	79.4	42.8	22.8
O—Copper oleate 12½ per cent in gasoline	191.1	191.9	143.6	123.3	40.4	48.1	5.1
P—Copper oleate 12½ per cent in gasoline, 2 per cent oil	141.7	228.8	167.4	182.4	122.0	13.2	41.5
Q—Copper paint No. 1 plus 50 per cent creosote oil	23.0	57.4	43.6	58.7	56.7	34.2	11.6
R—Copper paint No. 2	89.0	30.8	17.0	17.9	12.5	14.1	14.0
S—Gilsonite	280.0	207.4	24.4	[2]	[2]	[2]	[2]
X—Petroleum product No. 2	132.0	31.8	1.8	[2]	[2]	[2]	[2]

[1] Average of 100 tests; every other figure in this table is the average of 50 tests.
[2] Line was disintegrated and gone.

Results of wearing tests.—This method of making the mechanical wearing tests on the various samples exposed and tested, though good enough for use and having already given some valuable data, is still not all that one could wish. It is an extremely severe test, and no line that is seriously impaired in strength by exposure endures more than a few strokes. Linen line will not endure more than half a dozen strokes. The results it gives are influenced considerably by tensile strength, though other factors also enter. Because of a rather wide variation 50 tests (five sets on the machine) were made on each sample, and the figures here given are the averages, respectively, of 50 tests. The lines were dry when tested. These results, which are somewhat surprising, are shown in Table 9 and graphically in Figures 14 and 15.

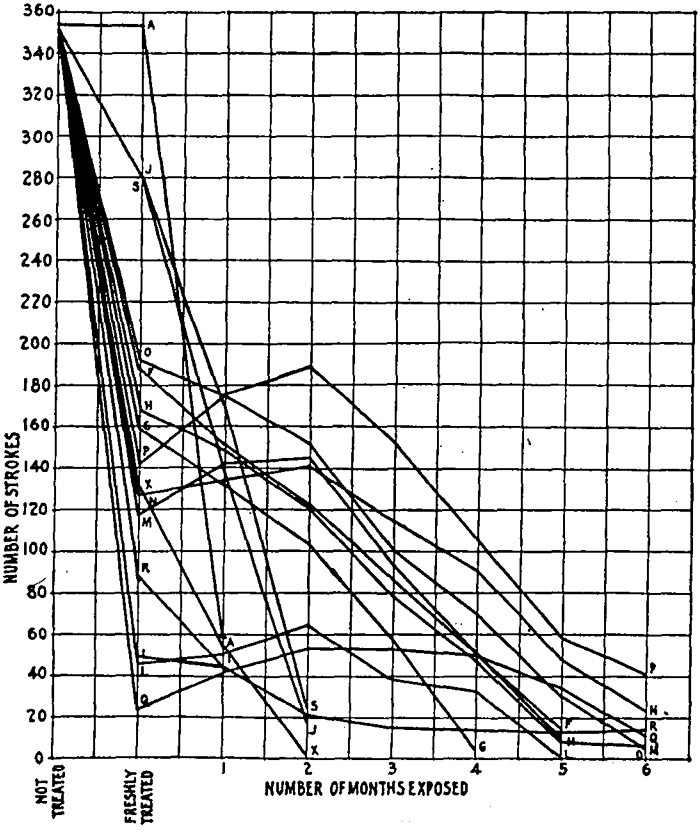

FIG. 14.—Wearing quality of cotton lines exposed in sea water at Beaufort, N. C.

Among the points worthy of note are the following: Of the fresh unexposed lines the untreated line, A, wore best of all. Any preservative tried immediately diminished the wearing ability in the following increasing order: The petroleum product No. 1, J, and gilsonite, S, reduced the wearing quality least; the three tars, F, G, and H, reduced it more; the copper oleates, M, N, O, and P (O showing an apparently anomalous wearing quality), reduced it yet more; and finally a group very low in wearing ability, consisting of all the others, namely, the copper paints, Q and R, quercitron and potassium bichromate, I, and the Dutch method, L, reduced it most of all. It should be noted that the tarry preservatives, or others having a protective body, do have the property attributed to them of protecting against chafing or wearing.

Upon exposure, however, the relative wearing abilities rapidly change. The untreated line, A, and lines treated by the petroleum products J and X, gilsonite, S, and quercitron and potassium bichromate, I, all rapidly lose wearing quality so that in two months it is practically zero. Lines treated with the copper paints, Q and R, never have much wearing ability, even when freshly treated. Yet,

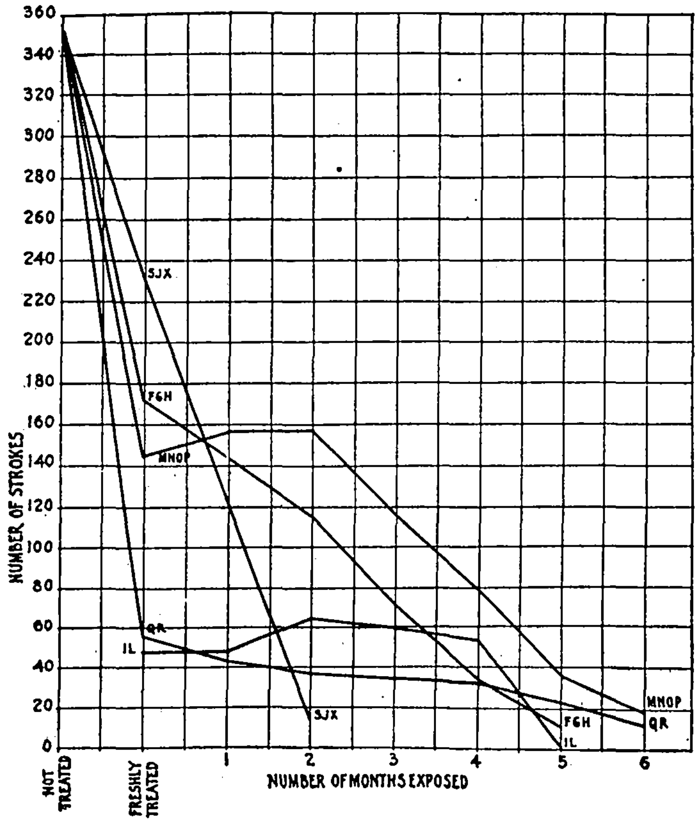

FIG. 15.—Wearing quality of cotton lines exposed in sea water at Beaufort, N. C., grouped.

because decomposition of the line is so well prevented and tensile strength so well preserved, such wearing quality as they have persists well through the full six months. The tarred lines do fairly well but suffer a steady decline in wearing quality. Lines preserved with copper oleate lead all others after the first month. This material is waxy or soapy and seems to possess physical properties that enable a line treated by it to rub without giving up its fibers. The harshness of copper paint and of the tanning extracts also is easily palpable and shows up clearly in the results. The conclusions from this test are plainly that (1) all preservatives studied cause an immediate diminution of wearing quality as compared with new white line in the dry condition, (2) copper paints, which give such good results with tensile strength tests, are very poor in their resistance to mechanical wear, and (3) copper oleate leads all the preservatives in mechanical wearing ability upon exposure.

It is obvious that this factor is highly important in the selection of a proper preservative. The test described may or may not simulate closely the wear that nets receive while in use. Nevertheless, it is mechanical wear and brings out marked and unexpected differences in the several preservatives. It is therefore believed to be of value as a test.

RESISTANCE TO FOULING BY MARINE GROWTHS.

When nets remain in water for a long time, as pound nets, traps, etc., must, they are subject to fouling by growths by barnacles, hydroids, ascidians, algæ, etc. These organisms are objectionable for several reasons. Barnacles injure the fisherman's hands and make handling the net difficult; fouling growths cause the nets to resist current and tides, which accordingly causes greater strains on the nets. The weight of the fouling may many times over exceed the weight of the net and therefore greatly increase the strain on it. It is a desirable characteristic of net preservatives that they prevent the accumulation of these growths.

At Key West, Fla., no noticeable fouling appeared on any of the lines. At Beaufort, N. C., however, fouling proved to be an important consideration. Figures 16, 17, 18, and 19 show the samples of cotton and linen lines that were returned from Beaufort at the end of four months before they were subjected to tests. The key to these is as follows: All of these samples were prepared at the same time, were placed in the water at the same time and place, and were taken up at the end of four months, with the exception of X, which was in the water only one month.

Symbol and treatment.	Condition after four months in water.
A—White line; no treatment	Disintegrated and gone.
F—Coal tar	Fouled with hydroids and barnacles.
G—Pine tar	Do.
H—Pine and coal tar	Do
I—Quercitron and potassium bichromate.	Covered with dense matting of hydroids.
J—Petroleum product No. 1	Do.
L—Dutch method	Few hydroids; nearly clean.
M, N, O, P—Copper oleate	Substantially clean; very few barnacles; no hydroids.
Q, R—Copper paints	Perfectly clean; no growths.
S—Gilsonite	Fouled with hydroids and barnacles.
X—Petroleum product No. 2	Fouled, less than petroleum product No. 1. This sample had been in water only one month.
U—Copper oleate	Slightly fouled; some hydroids; no barnacles.
W—Dutch method	Do.

All the lines that resisted all fouling growths contained copper; that is, those treated with the copper paints, Q and R, and the four copper oleates, M, N, O, and P. The Dutch method, L, containing a very small quantity of copper, was fouled only slightly. All the others that contained no copper fouled to an objectionable degree, especially quercitron and potassium bichromate, I, and the petroleum

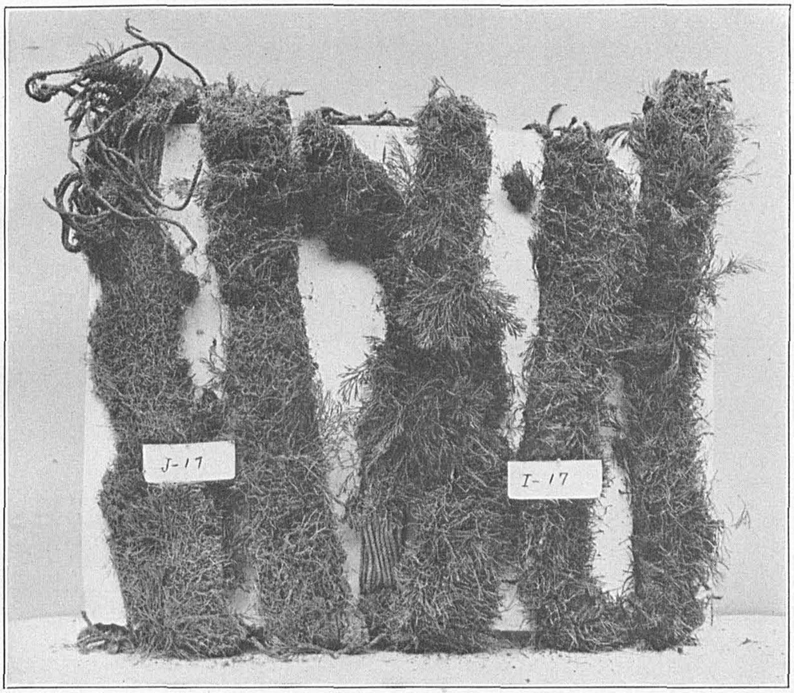

FIG. 16.—Cotton lines exposed in sea water at Beaufort, N. C., for four months. Heavily fouled. J, petroleum product No. 1; I, quercitron and potassium bichromate.

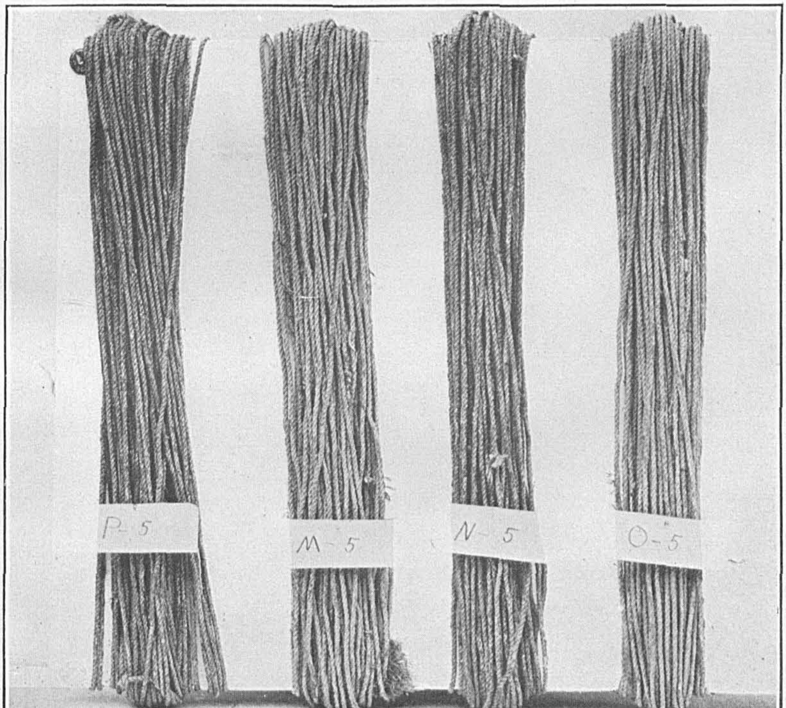

FIG. 17.—Cotton lines exposed in sea water at Beaufort, N. C., for four months. No fouling. All had been treated with copper oleate.

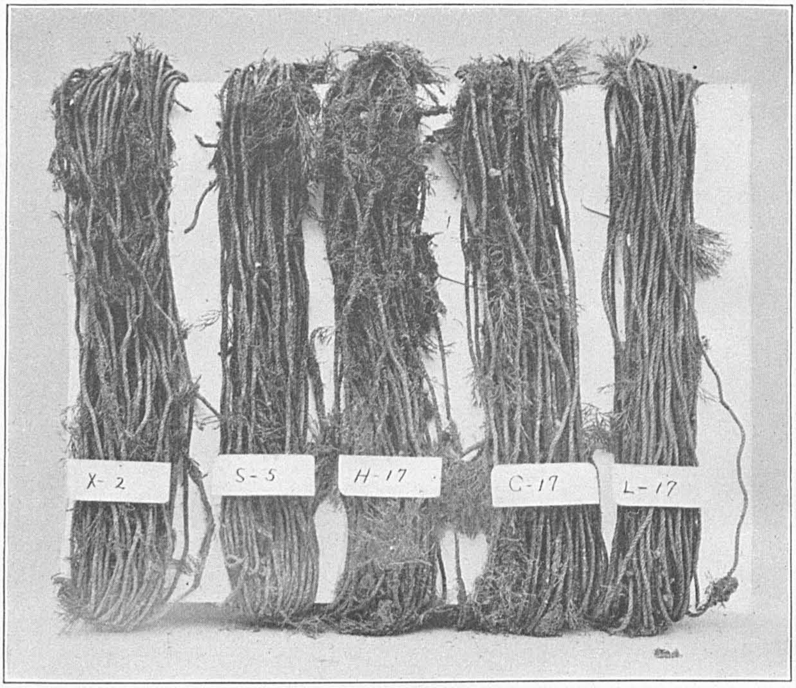

FIG. 18.—Cotton lines exposed in sea water at Beaufort, N. C. X, petroleum product No. 2, exposed one month; all the rest exposed four months. S, gilsonite; H, pine and coal tar; G, pine tar; L, Dutch method. All were somewhat fouled.

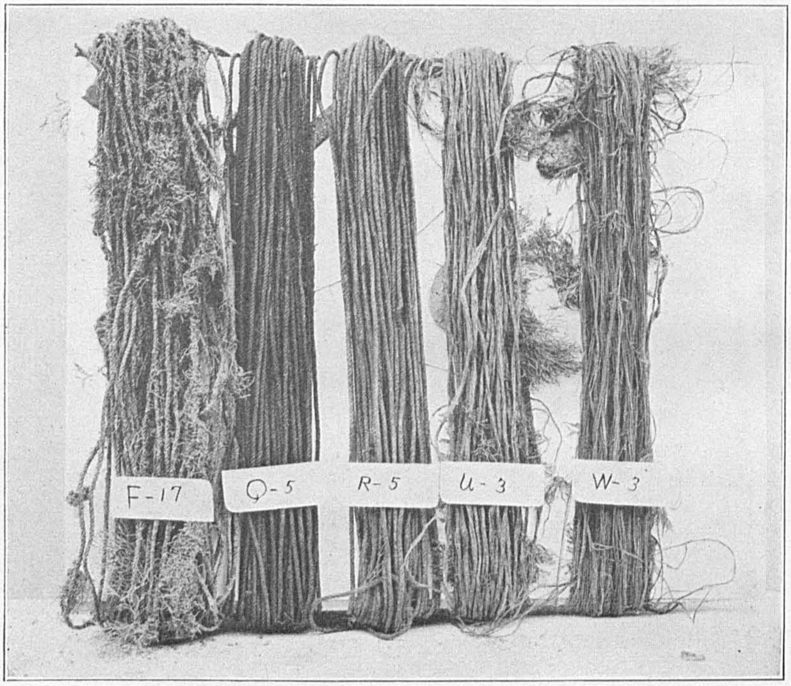

FIG. 19.—Three cotton and two linen lines exposed in sea water at Beaufort, N. C., for four months. F, coal tar on cotton, heavily fouled; Q, copper paint No. 1 on cotton and R, copper paint No. 2 on cotton, no fouling; U, copper oleate on linen and W, Dutch method on linen, both somewhat fouled.

product, J, lines treated with which are almost entirely covered with hydroids. The tarred lines are also heavily fouled. In the next two months after these samples were taken up the tarred samples were so heavily fouled with ascidians that they broke and were carried away. The lines treated by quercitron and potassium bichromate, I, petroleum products Nos. 1 and 2, J and X, and gilsonite, S, also failed to be returned.

Here, again, copper oleate shows to advantage, though no better with respect to prevention of fouling than copper paint. The petroleum products, gilsonite, quercitron and potassium bichromate, and the tars seem to produce an agreeable anchorage for these organisms, and this fact must be held seriously against them as net preservatives.

TESTS WITH LINEN LINES.

MATERIALS TESTED.

In this series of experiments samples of linen lines were included. The linen selected was 10-ply 40 "Irish flax salmon thread," loose-laid, such as is used in gill netting for salmon on the Pacific coast. The tensile strength of the untreated, unexposed line is 55.2 pounds, somewhat greater than that of No. 24 cotton twine. Although its tensile strength is greater than cotton, it is a characteristic of this linen line that it fails completely to resist mechanical wear on the testing machines, even the new untreated line falling in two in only a half dozen strokes. The exposed samples usually broke on the first stroke, so that it was useless to apply this test. This weakness is apparently due, at least in part, to the fact that the component strands of the line are not twisted together, but each acts separately. When the lines "saw" together, each individual strand is exposed; under such circumstances the life of the whole line is only equal to the life of one strand.

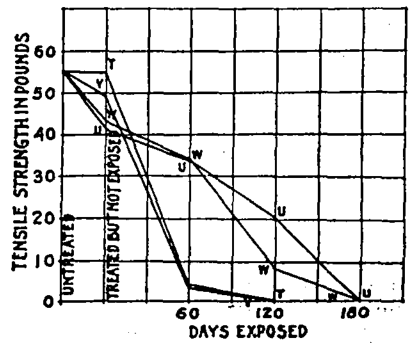

FIG. 20.—Tensile strength of linen lines exposed in sea water at Beaufort, N. C.

It would be useless to test for linen thread the preservatives that cause stiffness, such as tar, copper paint, and gilsonite. The preservatives and preservative methods physically suitable for gill nets and available at the beginning of these Beaufort experiments were three, quercitron and potassium bichromate, V (when applied to linen this symbol was given), Dutch method, W, copper oleate, U, the untreated linen, T, being the control. The samples were exposed at Beaufort 180 days, samples being returned each two months. The exposure began February 15 and continued to August 15, 1922.

TENSILE STRENGTH.

The results of the measurements of tensile strength of these samples are given in Table 10 and are shown graphically in Figure 20.

TABLE 10.—*Tensile strength of linen lines exposed to sea water at Beaufort, N. C.*

Symbol and treatment.	Unexposed.	Number of months exposed.		
		2	4	6
	Tensile strength in pounds.			
T—Untreated control	[1] 55.2	4.2	(2)	(2)
U—Copper oleate solution 12½ per cent in gasoline, 5 per cent oil	41.3	33.9	18.9	(2)
V—Quercitron and potassium bichromate	49.5	3.2	(2)	(2)
W—Dutch method	43.0	34.3	7.8	(2)

[1] Average of 50 breaks; every other figure in this table is the average of 15 breaks.
[2] Line was disintegrated and gone.

The conclusions from these tests are obvious: Linen lines, with or without preservatives, disintegrate more rapidly than cotton lines under the same conditions in salt water at Beaufort, all four samples having disappeared before the term of six months expired. Only the two samples that contained copper—that is, copper oleate, U, and the Dutch method, W—lasted four months, the one preserved by the Dutch method being then all but totally rotten. At the end of two months the lines treated by either the copper oleate or Dutch method are still serviceable, but the leading score in this experiment easily belongs to copper oleate.

The principal method of preserving these linen lines on the Pacific coast is barking—that is, treating with the hot extract of oak bark—which treatment is not followed by a mordant. Even when mordanted, as in quercitron and potassium bichromate, it is plain that no good results are obtained by the use of bark, unless possibly the periodical treatment with the infusion merely washes and sterilizes the net for the time being. When bark is mordanted with ammoniacal copper sulphate (Dutch method), considerable good is done; but this method is much more laborious and time-consuming than the application of copper oleate and not so effective. Washing the nets in bluestone (copper sulphate) solution, as done on the Pacific coast, may serve to keep the lines clean, but because of its solubility bluestone can not be a permanent preservative. The regular use of copper oleate in the salmon gill-net fishery should effect a marked saving in nets.

SUMMARY OF RESULTS OF BEAUFORT EXPERIMENTS.

1. The materials and preservative methods studied at Beaufort were: For cotton lines, copper oleate in four variations, coal tar, pine tar, coal tar and pine tar mixed, quercitron and potassium bichromate, petroleum products Nos. 1 and 2, Dutch method, copper paints, Nos. 1 and 2, and gilsonite; for linen lines, quercitron and potassium bichromate, Dutch method, and copper oleate, 12½ per cent solution.

2. In the preservation of tensile strength of cotton lines the copper paints, which contain heavy concentrations of copper, excelled. Copper oleate, in the concentrations tried, which were much less than those of copper paint, was next in order of superiority; the Dutch method, also containing copper, was third; the tars were fourth; all

the other preservatives failed to bring their respective lines through six months' exposure.

3. The effects of sea water at Beaufort were more severe than those at Key West, Fla., though temperatures at Beaufort were somewhat lower than those at Key West.

4. A method of and device for determining the flexibility of lines and changes therein brought about by the application of preservatives were devised, tested, and used. A description and discussion of this method and device are given (p. 20).

5. In diminishing the flexibility of the cotton lines the tars, petroleum residues, and gilsonite had the greatest effect, the copper paints had a large effect, the tanning methods caused some stiffening, and copper oleate had less effect than any other preservative studied.

6. A machine for determining the ability of lines to endure mechanical wear or abrasion was devised, tested, and used. A description and discussion of this device are given (p. 25).

7. In wearing ability the copper paints, which made such a good showing in preserving tensile strength, were at a great disadvantage. The lines treated with these and those treated with quercitron and potassium bichromate wore very poorly; those treated by the Dutch method wore rather better than those treated with copper paints or by quercitron and potassium bichromate; those treated with tar resisted mechanical abrasion well at first, but this quality was lost on exposure along with the disappearing tensile strength. The copper oleates, when applied as preservatives, enabled the lines to resist mechanical abrasion better than any of the preservatives.

8. All lines, except those treated with copper paint or copper oleate, were fouled by marine growths in four months at Beaufort. The lines treated by the Dutch method, which also contained copper, were slightly fouled. The lines treated by quercitron and potassium bichromate and those treated with a petroleum product were very heavily fouled. Copper oleate and copper paint effectually prevent fouling.

9. Of the linen lines only those treated with copper oleate or by the Dutch method endured four months' exposure at Beaufort. Of these two copper oleate was more efficacious and much easier to apply.

10. Linen lines deteriorated in sea water at Beaufort more rapidly than cotton lines, whether preserved or not.

SERIES EXPOSED IN SEA WATER AT WOODS HOLE, MASS.

Beginning June 9 and extending to December 9, 1922, a period of six months, a series of lines preserved with various materials was exposed in sea water at Woods Hole, Mass.

WATER CONDITIONS AT WOODS HOLE.

The water conditions at Woods Hole were different from those at either Key West or Beaufort, being cooler. The temperature and specific gravities that prevailed at Woods Hole during the period of test are shown in Table 11. The samples were suspended under the dock at the station of the U. S. Bureau of Fisheries Biological Laboratory. The water is full sea water, and the samples were subjected to the regular ebb and flow of the tide.

TABLE 11.—*Water conditions at Woods Hole, Mass.*

Year and month.	Temperature.						Specific gravity.		
	Maximum.		Minimum.		Average.		Maximum.	Minimum.	Average.
1922.	°*F.*	°*C.*	°*F.*	°*C.*	°*F.*	°*C.*			
June	66	18.3	61	16.1	63	17.2	1.024	1.023	1.023
July	69	20.5	65	18.3	67	19.4	1.024	1.023	1.023
August	71	21.6	66	18.8	68	20.0	1.024	1.023	1.023
September	68	20.0	62	16.6	66	18.8	1.023	1.022	1.022
October	64	17.7	50	10.0	59	15.0	1.025	1.023	1.023
November	51	10.5	40	4.4	47	8.3	1.025	1.024	1.024
December	42	6.0	31	−0.56	37	2.7	1.025	1.025	1.025

TESTS WITH COTTON LINES.

MATERIALS TESTED.

The lines tested in this series were the same as in the preceding experiments, No. 24 cable-laid hard-finish cotton twine.

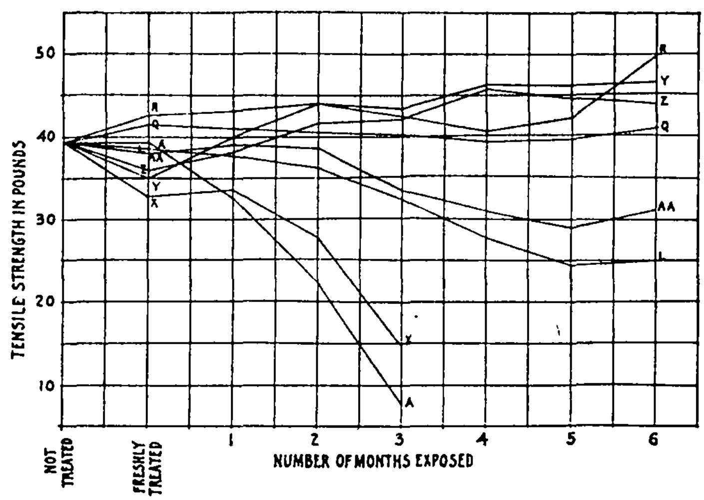

FIG. 21.—Tensile strength of cotton lines exposed in sea water at Woods Hole, Mass.

The preservatives and preservative methods tested were the Dutch method, L; copper paints Nos. 1 and 2, Q and R; petroleum product No. 2, X; copper oleate followed by coal tar diluted with benzol, Y; and copper oleate mixed with coal tar and the whole diluted with benzol, Z; copper oleate in 15 per cent solution in gasoline, AA; and the untreated line A, as control. The lines were measured and weighed, as before described (p. 9), treated, and again measured and weighed. The shrinkage and increase in weight will be considered later.

TENSILE STRENGTH.

Table 12 gives the results of tensile strength measurements on the unexposed and exposed cotton lines of the Woods Hole series. These results are shown graphically in Figure 21

TABLE 12.—*Tensile strength of cotton lines exposed in sea water at Woods Hole, Mass.*

Symbol and treatment.	Unexposed.	Number of months exposed.					
		1	2	3	4	5	6
	Tensile strength in pounds.						
A—Untreated white line	[1] 39.3	39.0	20.1	8.0	(2)	(2)	(2)
L—Dutch method	38.6	38.0	37.0	34.0	26.1	23.0	24.7
Q—Copper paint No. 1	41.5	42.0	40.0	40.0	40.6	37.0	40.8
R—Copper paint No. 2	42.7	42.0	45.0	45.0	37.5	39.0	49.6
X—Petroleum product No. 2	32.9	45.0	23.0	15.0	(2)	(2)	(2)
Y—Copper oleate 15 per cent, benzol 35 per cent, coal tar 50 per cent	35.0	43.0	42.0	47.0	42.6	50.0	46.5
Z—Copper oleate followed by coal tar	36.0	38.0	39.0	48.0	40.0	50.0	43.6
AA—Copper oleate, alone, 15 per cent gasoline	38.0	42.0	37.0	37.0	26.0	30.0	31.0

[1] Average of 60 breaks; every other figure in this table is the average of 15 breaks.
[2] Line was disintegrated and gone.

The lines treated with petroleum product No. 2, designated X, is scarcely better than the untreated line, A. This result is in keeping with the result obtained with the same preservative at Beaufort. The copper oleate, AA, employed in this case, is strikingly similar to the Dutch method, L, both of which show good preservation, though, as before, these preservatives do not add anything to the strength of the lines by a sticky effect on the fibers. When allowance is made for this effect in the lines treated with copper paint or the combinations of copper oleate and tar (Q, R, Y, and Z), strikingly similar preservation effect is noticed. As might be expected, the lines treated with copper oleate and tar behave very much like those treated with copper paint, since the mixture of copper oleate and tar is very similar to copper paint in composition. Each consists of a form of copper incorporated in a binder—the paints containing copper oxide, the tar mixture containing copper oleate. It should be noticed here, however, that the tar mixtures contain very much less copper than the copper paints and should accordingly be cheaper, though they preserve fully as well.

Between the two combinations of tar and copper oleate—that is, the separate application of the copper oleate and tar in the one case and the mixture of the two for application in the other—there is little difference. The combination can be easily and simply applied, since both the copper oleate and tar are soluble in benzol and may be applied cold. Perhaps the separate application of tar and copper oleate is slightly better, though the extra time and labor required to make the two applications would probably more than make up the difference. On the other hand, the separate application may be employed without the use of benzol by using a gasoline solution of copper oleate and following with tar in the usual way by the hot process.

These combinations of copper oleate and tar furnish a new possibility where nets are exposed to the most extreme conditions for long periods. Straight copper oleate is toxic and preserves to a high degree, but contains nothing in the way of a binder to hold it in the lines. When combined with tar it constitutes a permanent toxic ingredient that will stay in the lines over long periods, although creosote, the natural toxic principle of fresh tar, escapes during a short term of exposure.

It may further be noticed that the water at Woods Hole is not so severe in its effect on lines as that at Beaufort. The strength of the lines after the second month at Beaufort is similar to that of the Woods Hole lines after the fourth month.

FLEXIBILITY.

The samples used in this test were tested for flexibility by the pendulum method already described. The results of these tests are given in Table 13 and are shown graphically in Figure 22.

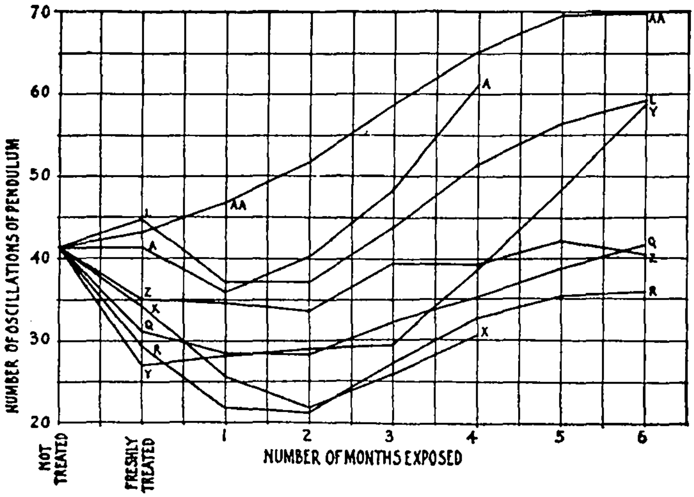

FIG. 22.—Flexibility of cotton lines exposed in sea water at Woods Hole, Mass.

TABLE 13.—*Flexibility of cotton lines exposed at Woods Hole, Mass.*[1]

Symbol and treatment.	Unexposed.	Number of months exposed. 1	2	3	4	5	6
	Number of oscillations.						
A—Untreated white line control	41.3	36.8	32.2	51.3	61.2	(2)	(2)
L—Dutch method	44.9	33.8	33.6	44.4	53.6	56.6	59.3
Q—Copper paint No. 1	31.1	26.5	28.1	30.8	37.4	37.2	41.5
R—Copper paint No. 2	29.4	16.5	19.5	27.5	34.4	35.6	35.6
X—Petroleum product No. 2	34.3	18.4	24.7	22.4	30.5	(2)	(2)
Y—Copper oleate 15 per cent, benzol 35 per cent, coal tar 50 per cent	27.0	30.5	27.7	28.8	31.7	55.3	58.6
Z—Copper oleate followed by coal tar	35.3	30.0	39.0	31.9	47.8	38.4	40.3
AA—Copper oleate 15 per cent in gasoline	43.1	46.4	51.0	56.9	68.9	70.5	70.0

[1] Each figure in this table is the average of 100 tests.
[2] Line was disintegrated and gone.

The general trend of the lines is at first toward a slight stiffening and later toward an increasing flexibility. The line AA, preserved with copper oleate, easily leads all the lines in flexibility, being more flexible than the untreated lines. The lines treated by the Dutch method were also sufficiently flexible. The copper paints, Q and R, tar and copper combinations, Y and Z, and petroleum product No. 2, designated by X, cause marked stiffening, all to about the same extent. Though the lines treated with petroleum product are, by a little, the stiffest, the copper paints also cause marked stiffening, and, upon comparison with the tar-copper-oleate combinations, show slight advantage in favor of the latter. Here, again, the copper

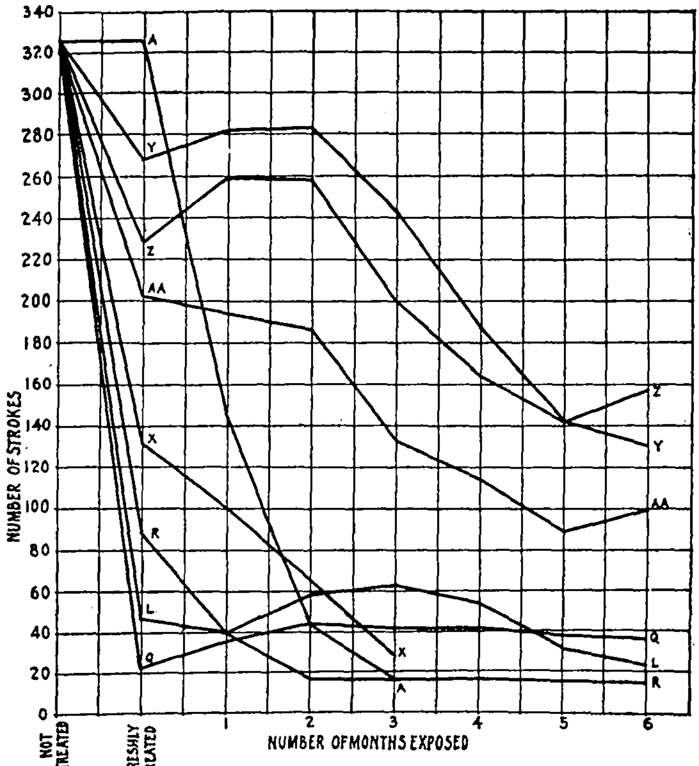

FIG. 23.—Wearing quality of cotton lines exposed in sea water at Woods Hole, Mass.

paints and tar-copper-oleate combinations, being somewhat similar in composition, give similar results. None of these materials would be suitable where flexibility is desired, but they are otherwise excellent preservatives.

WEARING QUALITY.

By the method already described, of sawing the lines against themselves (p. 25), the ability of the various lines exposed at Woods Hole to resist mechanical wear, was measured. The results are given in Table 14 and are shown graphically in Figure 23.

TABLE 14.—*Wearing quality of cotton lines exposed to sea water, Woods Hole, Mass.*

Symbol and treatment.	Unexposed.	Number of months exposed.					
		1	2	3	4	5	6
	Number of strokes.						
A—Not treated	[1] 399.0	80.9	37.0	17.5	(2)	(2)	(2)
L—Dutch method	46.6	29.8	53.7	95.4	40.4	30.5	23.9
Q—Copper paint No. 1	23.0	51.3	30.4	47.4	43.9	36.1	35.6
R—Copper paint No. 2	89.0	15.6	17.4	19.4	15.6	14.6	14.8
X—Petroleum product No. 2	132.0	104.0	67.1	29.6	(2)	(2)	(2)
Y—Copper oleate 15 per cent, benzol 35 per cent, coal tar 50 per cent	268.3	297.6	282.6	269.4	180.4	115.3	130.3
Z—Copper oleate followed by coal tar	228.1	299.0	250.3	227.6	127.3	138.7	157.0
AA—Copper oleate, 15 per cent in gasoline	203.1	228.0	155.6	178.7	66.1	101.7	99.8

[1] Average of 100 tests; every other figure in this table is the average of 50 tests.
[2] Line was disintegrated and gone.

It has been noticed that, with respect to tensile strength and flexibility, the copper paints and the tar-copper-oleate mixtures run "neck and neck." They differ widely, however, when their wearing quality is measured. The tar-copper-oleate mixtures, Y and Z, lead the entire series in this respect, while the copper paints, Q and R, take last place, as they did in the other series. This might be expected, since copper paint makes the lines harsh, and copper oleate, on the other hand, is smooth or waxy in consistency. Next to the tar and copper mixture is copper oleate alone, AA, then the Dutch method, L, which comes low in the series, because it, too, makes the lines to which it is applied harsh. The petroleum product No. 2, designated X, is here again very low, running only a little better than the white line, A, upon exposure in sea water.

TESTS WITH LINEN LINES.

MATERIALS TESTED.

Besides the tests with cotton lines at Woods Hole, just described, there were also conducted some tests of linen lines. As before, 10-ply linen, such as is used in salmon gill netting, was used. The lines were prepared and placed in the water along with the cotton lines on June 9, 1922, and samples were removed after the first, second, and third months, the test running in this case only three months. Linen lines are in practice of course never exposed continuously in the water. For purposes of experiment, however, it seemed that the effects of the preservatives could be brought out more certainly in this way, without the possible entrance of other complicating factors, if intermittent exposure had been attempted. Since linen lines do not wear at all well on the wearing-test machine and the preservatives applied to it increase stiffness very little, tests of these two factors were omitted, and only the tensile strength, shrinkage, and increase in weight were determined.

The preservatives and preservative methods tested were Dutch method, W; petroleum product No. 2, BB; and copper oleate, CC. Untreated linen line, T, was used as control.

TENSILE STRENGTH.

The results of determination of tensile strength before and after exposure are shown in Table 15 and in Figure 24.

TABLE 15.—*Tensile strength of linen lines exposed in sea water at Woods Hole, Mass.*

Symbol and treatment.	Unexposed.	Number of months exposed.		
		1	2	3
	Tensile strength in pounds.			
T—Not treated	[1] 55.2	48	27	27
W—Dutch method	43.0	56	20	34
BB—Petroleum product No. 2	49.0	44	12	8
CC—Copper oleate, 15 per cent in gasoline	48.0	48	43	51

[1] Average of 50 breaks; every other figure in this table is the average of 15 breaks.

Although the Dutch method here shows some merit, copper oleate easily leads, linen lines treated with it finishing the three months in the water with the original strength unimpaired. The petroleum product here, as elsewhere, failed to effect any noticeable preservation of the lines treated with it.

SUMMARY OF RESULTS OF WOODS HOLE EXPERIMENTS.

1. For cotton line seven preservatives and preservative methods and untreated line as control were tested at Woods Hole, Mass., being exposed from June 9 to December 9, 1922. The preservatives and preservative methods were two copper paints, two combinations of copper oleate and tar, the Dutch method, copper oleate, and petroleum product No. 2.

2. For linen lines three preservatives and preservative methods and the untreated line as control were tested, being exposed from June 9 to September 9, 1922. The preservatives and preservative methods were Dutch method, petroleum product No. 2, and copper oleate.

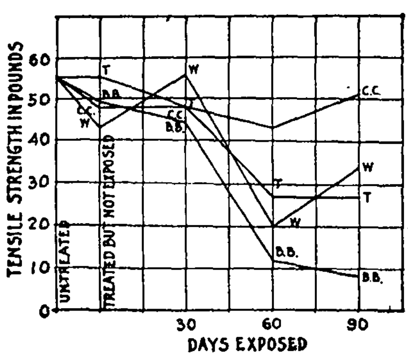

FIG. 24.—Tensile strength of linen lines exposed in sea water at Woods Hole, Mass.

3. Exposure in the water at Woods Hole had a much less severe effect on lines, treated or not, than at Beaufort.

4. In combinations of copper oleate and tar it made little difference whether the two were mixed and applied or applied separately.

5. These combinations of copper and tar effected about the same degree of preservation of tensile strength and stiffened the lines to about the same degree as the copper paints but were far superior to copper paints in mechanical wearing quality.

6. Copper oleate alone here, as elsewhere, produced a very flexible line; it held tensile strength during exposure about like the Dutch method for cotton lines. Copper oleate excelled in wearing quality but did not equal in this respect the combinations of copper oleate and tar.

7. The petroleum product No. 2 proved to be a poor preservative in all respects studied.

8. The Dutch method, in preservation of tensile strength and in flexibility, was intermediate in value between the best and poorest; in mechanical wearing quality it was inferior.

9. The copper paints preserved tensile strength well, greatly stiffened the lines, and wore poorly.

SERIES EXPOSED IN FRESH WATER AT PUT IN BAY, OHIO.

All the exposures of lines in water so far described were in sea water at Key West, Beaufort, and Woods Hole. It is important to determine how preservatives behave in fresh water also. Since Lake Erie is the seat of one of our greatest fresh-water fisheries, where the art of constructing and using fishing nets has been brought to a high degree of perfection, it seemed appropriate to make a series of experimental exposures in its waters. Accordingly, a series identical with the Woods Hole series in the lines and preservatives used was prepared and placed in the water at the U. S. Bureau of Fisheries hatchery at Put in Bay, Ohio, June 15, 1922. The series for cotton lines was exposed till December 15, 1922.

WATER CONDITIONS AT PUT IN BAY.

The temperatures of the water at Put in Bay are shown in Table 16.

TABLE 16.—*Temperature of water at Put in Bay, Ohio.*

Year and month.	Maximum.		Minimum.		Average.	
1922.	°F.	°C.	°F.	°C.	°F.	°C.
June	73	22.7	65	18.3	70	21.1
July	77	25.0	72	22.2	75	23.8
August	77	25.0	72	22.2	75	23.8
September	76	24.4	66	18.8	71	21.6
October	68	20.0	50	10.0	59	15.0
November	53	11.6	38	3.3	47	8.3
December	39	3.8	33	.5	35	1.6

It is well known that fresh water in Lake Erie is very severe in its effect on lines. A red slime becomes deposited on the nets in the summer season, and a strong deterioration of nets occurs at the same time. This red slime consists of hydroids, colonies of small animals that may or may not directly affect the nets. At any rate, decomposition of the samples was rapid, as will be seen, and the order of effectiveness of the different preservatives differed considerably from that of the salt-water experiments.

TESTS WITH COTTON LINES.

MATERIALS TESTED.

The preservatives and preservative methods tested for cotton lines were the Dutch method, L; copper paints, Nos. 1 and 2, Q and R; petroleum product No. 2, designated X; copper oleate in gasoline, AA; copper oleate followed by coal tar diluted with benzol, Y; and copper oleate mixed with coal tar and the whole diluted with benzol, Z. The shrinkage and increase in weight caused by the preservatives were noted; the data for these factors will be considered later.

TENSILE STRENGTH.

The tensile strength of the lines exposed at Put in Bay are given in Table 17 and are shown graphically in Figure 25.

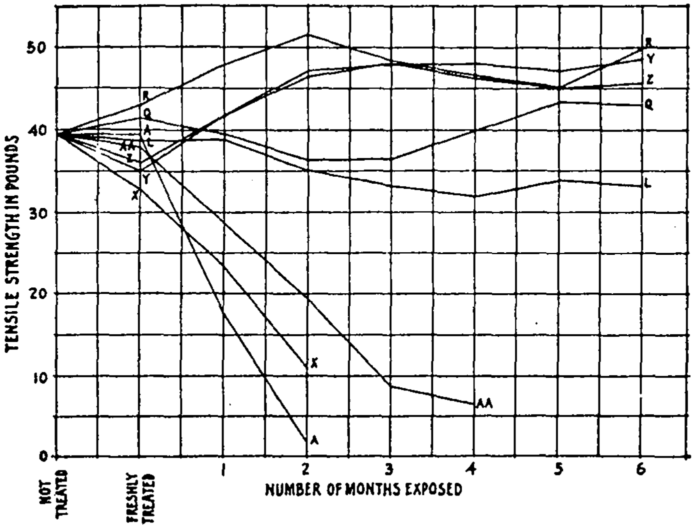

FIG. 25.—Tensile strength of cotton lines exposed in fresh water at Put in Bay, Ohio.

TABLE 17.—*Tensile strength of cotton lines exposed in fresh water at Put in Bay, Ohio.*

Symbol and treatment.	Unexposed.	Number of months exposed.					
		1	2	3	4	5	6
	Tensile strength in pounds.						
A—Whiteline, untreated control	[1] 39.3	12.3	1.7	([2])	([2])	([2])	([2])
L—Dutch method	38.6	40.0	38.0	27.0	34.1	34.0	33.0
Q—Copper paint No. 1	41.5	39.0	38.0	32.0	39.6	48.0	42.7
R—Copper paint No. 2	42.7	52.0	49.0	53.0	42.3	44.0	49.7
X—Petroleum product No. 2	32.9	26.0	11.0	([2])	([2])	([2])	([2])
Y—Copper oleate 15 per cent, benzol 35 per cent, coal tar 50 per cent	35.0	46.0	44.0	51.0	47.8	45.0	48.4
Z—Copper oleate followed by coal tar	36.0	42.0	47.0	50.0	40.6	42.0	45.6
AA—Copper oleate 15 per cent in gasoline	38.0	38.0	10.0	10.0	6.5	([2])	([2])

[1] Average of 60 breaks; every other figure in this table is the average of 15 breaks.
[2] Line was disintegrated and gone.

Here, as at Woods Hole, the copper paints, Q and R, run very close to the copper oleate and tar combinations. The copper paint No. 2, (R), containing, as it does, much more copper than No. 1, (Q), stands first; then come the copper and tar combinations, followed by copper paint No. 1. Both the copper paints, however, contain much more copper than either of the copper and tar mixtures. A striking difference from the Woods Hole series (and the other salt-water experiments) is found in the behavior of copper oleate alone and the Dutch method. In all the salt-water tests, without exception, copper oleate preserved better than the Dutch method. Here, however, the Dutch method stands higher, comparing favorably with the copper paints and the copper and tar mixtures, while copper oleate, doing well the first 30 days, afterwards fails rapidly.

It seems likely that the cause of this peculiar difference lies in the comparative solubilities of the copper compounds present. The Dutch method deposits copper tannate, which appears to remain in the lines; but the copper oleate was not very plainly visible in the lines returning from these fresh-water experiments as it was in the salt-water series. It may be that the copper oleate is too soluble in fresh water and gradually dissolves out, while the tannate is less soluble. If this is so, why the reverse condition of results from salt water? Copper oleate appears to be less soluble in salt water than in fresh. A certain degree of solubility of the active ingredient may be necessary, for a totally insoluble material may be inert and ineffectual as a preservative. Sea water, being an electrolyte, precipitates many colloids—as it will precipitate soap. Copper oleate is a soap and is probably soluble to a small degree as such in fresh water, although not soluble to the same extent in salt water.

That a binder may hold the copper oleate in the lines and in that way prolong its preservative effect is shown by the copper oleate and tar combinations. The remedy indicated for the shortcoming of copper oleate in fresh water may be found in the use of a binder that will keep the copper oleate present and not greatly increase stiffness and weight. Experiments in this field are planned for the near future.

FLEXIBILITY.

The flexibility of the cotton lines exposed at Put in Bay was tested in the way previously described (p. 20), both before and after exposure. The results are given in Table 18 and are shown graphically in Figure 26.

TABLE 18.—*Flexibility of cotton lines exposed in fresh water at Put in Bay, Ohio.*[1]

Symbol and treatment.	Unexposed.	Number of months exposed.					
		1	2	3	4	5	6
	Number of oscillations.						
A—White line, untreated control	41.3	62.7	69.1	(2)	(2)	(2)	(2)
L—Dutch method	44.9	52.5	51.4	53.3	58.7	67.1	59.2
Q—Copper paint No. 1	31.1	34.1	38.7	39.5	44.2	45.0	46.8
R—Copper paint No. 2	29.4	16.3	22.1	21.3	30.1	37.4	37.3
X—Petroleum product No. 2	34.3	24.2	37.3	(2)	(2)	(2)	(2)
Y—Copper oleate, 15 per cent; benzol, 35 per cent; coal tar, 50 per cent	27.0	30.0	31.1	28.4	34.2	52.4	54.2
Z—Copper oleate followed by coal tar	35.3	30.5	34.1	49.7	49.2	40.5	58.0
AA—Copper oleate, 15 per cent, in benzol	43.1	69.7	74.0	73.5	78.3	(2)	(2)

[1] Every figure in this table is the average of 100 tests. [2] Line was disintegrated and gone.

The most flexible of all the lines exposed are those treated with copper oleate, AA; then comes untreated line, A, and that treated by the Dutch method, L. Considered together the lines treated with copper oleate and tar combinations, Y and Z, and copper paints, Q and R, are very stiff, though the stiffest is copper paint No. 2, R, and the most flexible is the combination, Z, which is copper oleate followed by tar, with copper paint No. 1, Q, and the mixed copper oleate and tar, Z, an intermediate. The petroleum residue, X, also markedly stiffens the lines.

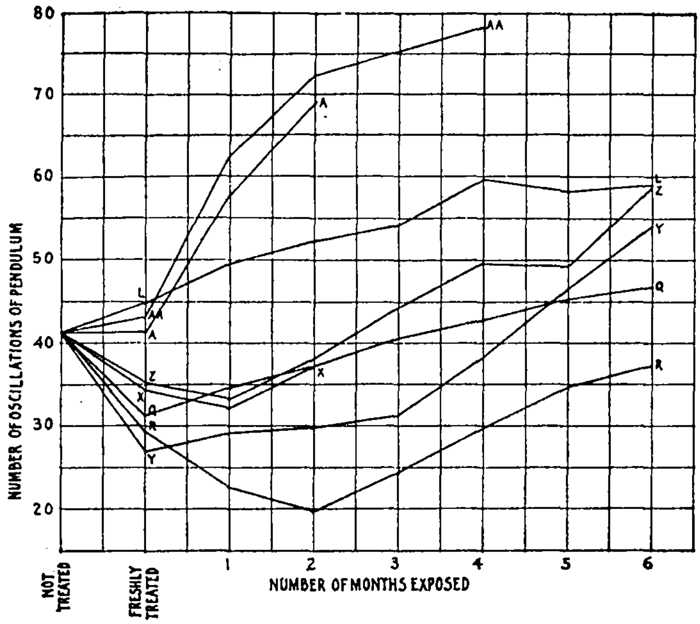

Fig. 26.—Flexibility of cotton lines exposed in fresh water at Put in Bay, Ohio.

The tendency toward increasing flexibility of all the lines is an indication of general deterioration; as they lose in strength and general quality they become more and more flexible.

WEARING QUALITY.

The results of the tests of wearing quality of the lines in the Put in Bay series are given in Table 19 and are shown graphically in Figure 27.

TABLE 19.—*Wearing quality of lines exposed in fresh water at Put in Bay, Ohio.*

Symbol and treatment.	Unexposed.	Number of months exposed.					
		1	2	3	4	5	6
	Number of strokes.						
A—White line, untreated control	[1]399.0	2.1	(2)	(2)	(2)	(2)	(2)
L—Dutch method	46.6	44.8	43.6	46.6	42.7	24.8	35.5
Q—Copper paint No. 1	23.0	41.7	28.9	29.8	34.8	31.1	31.5
R—Copper paint No. 2	89.0	25.6	29.2	24.8	19.2	16.3	15.3
X—Petroleum product No. 2	132.0	37.6	4.8	(2)	(2)	(2)	(2)
Y—Copper oleate, 15 per cent; benzol, 35 per cent; coal tar, 50 per cent	268.3	227.4	222.9	189.3	150.6	88.1	92.0
Z—Copper oleate followed by coal tar	228.1	231.2	274.9	130.0	153.4	121.8	111.5
AA—Copper oleate, 15 per cent in gasoline	203.1	180.8	18.1	8.6	4.2	(2)	(2)

[1] Average of 100 tests; every other figure in this table is the average of 50 tests.
[2] Line was disintegrated and gone.

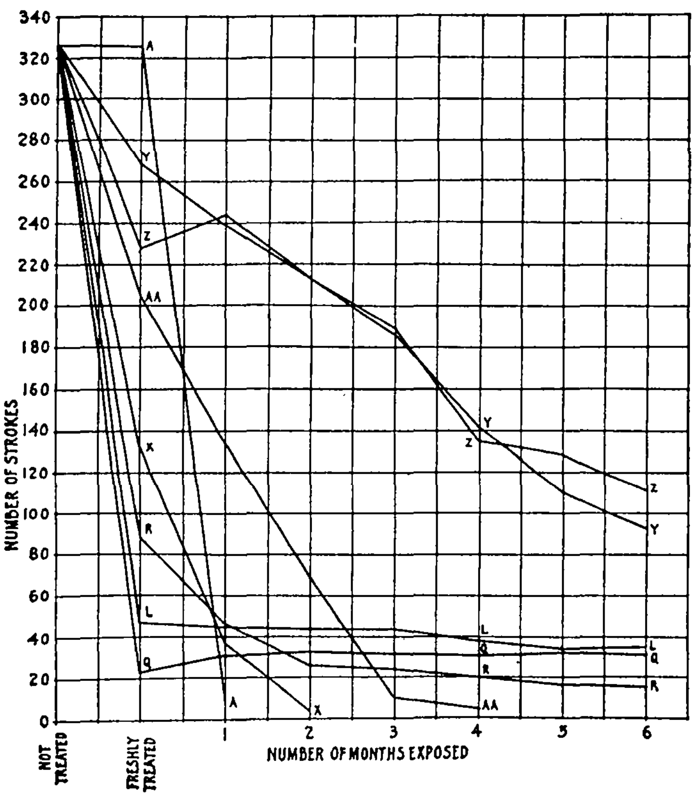

FIG. 27.—Wearing quality of cotton lines exposed in fresh water at Put in Bay, Ohio.

The leaders in this test are by long odds the lines preserved with the copper oleate and tar combinations which, even after three months' exposure, are still more resistant to wear than any of the others even before exposure, with the single exception of unexposed white line. This result agrees with the result at Woods Hole, where the copper oleate and tar combinations showed exceptional wearing quality. Running, as they do, very close to the copper paints in flexibility and tensile strength, they excel copper paints so much in wearing quality that their selection is already indicated for the heavier types of gear where wear is a consideration. Copper oleate alone, AA, since it failed to preserve tensile strength, of course failed also in wearing quality, because, as already pointed out, if tensile strength is impaired the lines will make a poor showing in wearing quality whatever the results might otherwise be. We already know from the other series that copper oleate is better in wearing quality than any other preservative studied, and we can therefore with assurance ascribe its failure here to failure to preserve the strength of the fibers.

The Dutch method, L, does not show a wearing quality that can be called satisfactory. It makes only 43 to 46 strokes on the wearing machine against 399 for fresh white line and 231 for lines freshly treated with copper oleate and tar. Nevertheless, the uniformity of results indicates good preservation, as was seen in its effect on tensile strength. The Dutch method is therefore in fresh water a good preservative in general for cotton lines, though it leaves much to be desired in the particular factor of wearing quality. The petroleum product No. 2, designated X, is no better in wearing quality than in other particulars—it fails consistently, as far as tested, and excels in no quality.

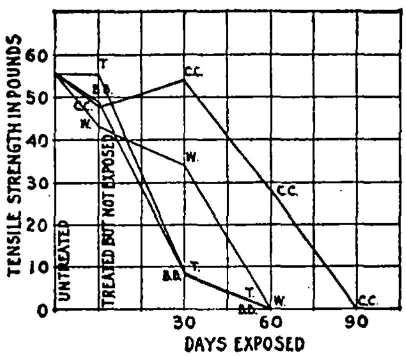

FIG. 28.—Tensile strength of linen lines exposed in fresh water at Put in Bay, Ohio.

TESTS WITH LINEN LINES.

MATERIALS TESTED.

A series of linen lines identical in material, preservatives, and preservative methods used with those at Woods Hole was exposed at Put in Bay for a three months' period. The line was 10-ply linen gill netting. The preservatives and preservative methods used were copper oleate, 12½ per cent concentration in gasoline and 5 per cent oil, CC; the Dutch method, W; petroleum product No. 2, designated BB.

TENSILE STRENGTH.

The tensile strength of these lines before and after exposure is given in Table 20, the same results appearing graphically in Figure 28.

TABLE 20.—*Tensile strength of linen lines exposed in fresh water at Put in Bay, Ohio.*

Symbol and treatment.	Unexposed.	Number of months exposed.		
		1	2	3
	Tensile strength in pounds.			
T—Untreated line, control	[1] 55.2	7.7	(2)	(2)
W—Dutch method	43.0	34.0	(2)	(2)
BB—Petroleum product No. 2	49.0	8.2	(2)	(2)
CC—Copper oleate, 15 per cent in gasoline	48.0	54.0	28.0	(2)

[1] Average of 50 tests; every other figure in this table is each the average of 15 tests.
[2] Line was disintegrated and gone.

In this series the only preservative that shows any considerable success is copper oleate, CC; all three of the other lines—that is, the untreated line controls, T, and the samples treated by the Dutch method, W, and with the petroleum product No. 2, designated BB—failed to appear at all after one month of exposure. Of course, linen gill netting in practice would not be exposed to such conditions; but all the lines received similar exposure, and copper oleate clearly preserved better than any of the others.

Just why copper oleate preserved better with linen line than with cotton relatively to the other preservatives is not apparent. The conditions at Put in Bay are worse for the lines, both cotton and linen, than they are at either Woods Hole or Beaufort. At Beaufort two of the linen samples—that is, the ones treated with copper oleate and by the Dutch method—came through 120 days with some strength left, and at Woods Hole the corresponding samples were in good shape after 90 days, those preserved with copper oleate still being equal in tensile strength to the original lines. Linen is like cotton in showing more rapid deterioration in Lake Erie than the Atlantic Ocean; but copper oleate preserved linen relatively better than it did cotton.

SUMMARY OF RESULTS OF PUT IN BAY EXPERIMENTS.

1. The samples exposed at Put in Bay, Ohio, showed a general tendency toward a more rapid deterioration than did similar lines exposed in sea water.

2. The exceptions to this statement were those lines treated with the copper paints and tar-copper-oleate combinations, which showed no deterioration of tensile strength in fresh or salt water in six months, and the Dutch method, which preserved cotton lines better in fresh water than it did in salt water.

3. For cotton lines the copper paints and the combination of copper oleate and tar gave splendid results, but both classes of the preservatives stiffened the lines greatly.

4. As between copper paints and the tar-copper-oleate combinations, the preservation of tensile strength was equal, although in wearing quality the tar-copper-oleate combinations greatly excelled.

5. The Dutch method gave excellent results on cotton lines in this series, preserving the samples for the entire six months' period and not causing excessive stiffness.

6. Copper oleate alone did not excel in the preservation of cotton lines in this fresh-water series, apparently because it dissolves in fresh water and is removed from the lines.

7. On linen lines copper oleate preserved better in this series than did the Dutch method—the reverse of the results on cotton lines.

OTHER CONSIDERATIONS OF IMPORTANCE IN JUDGING VALUE OF PRESERVATIVES.

VARYING RATE OF DECOMPOSITION OF LINES IN DIFFERENT LOCALITIES.

It is generally understood that lines decompose more rapidly in some localities than in others and more rapidly in summer than in winter, but no quantitative data on the subject have been published. For purposes of comparison the tensile strength records of the untreated cotton lines exposed in the several series are given in Figure 29. It will be noted that the line lasted over the entire six months'

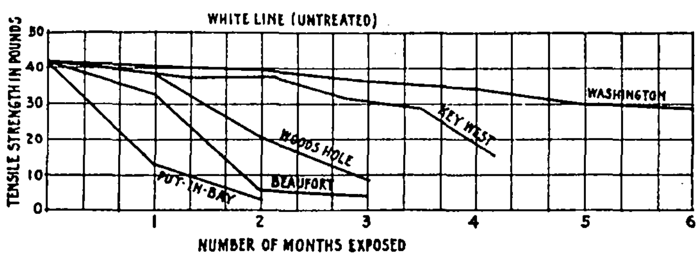

FIG. 29.—Varying rate of decomposition of cotton lines in different localities.

period of exposure to weather conditions at Washington, D. C., and over the entire period of 4½ months at Key West, Fla. At both Woods Hole, Mass., and Beaufort, N. C., the lines were entirely disintegrated and gone at the end of 4 months, though at the end of 4 months the line from Woods Hole showed a tensile strength of about 10 pounds and the one from Beaufort of about 3 pounds. In fresh water at Put in Bay the line showed a tensile strength of but about 2 pounds at the end of 2 months and at the end of 3 months was entirely rotten. The average specific gravity of the water at Key West for the entire period of exposure was 1.025, at Woods Hole 1.023, at Beaufort 1.019, and at Put in Bay about 1.000. Thus, considered roughly, the rate of deterioration of the exposed lines is directly proportional to the specific gravity (salinity) of the water in which they were exposed.

There is in all probability a relation also between the temperature of the water and the rate at which a line exposed in it will deteriorate; other factors being held constant the rate of deterioration of a line would no doubt bear an inverse relation to the temperature. The temperature records given for the localities of exposure do not show this relation here. Salinity differences complicate the results, and also, because the exposures were made in different seasons at the different places, the fluctuations in temperatures are very unlike.

INCREASE IN WEIGHT CAUSED BY APPLICATION OF PRESERVATIVES.

Among the properties of textiles that make them suitable for fishing is lightness. A light net is more easily and more rapidly handled than a heavy one, and consequently less labor is required to handle it. Since a net must support its own weight, the weight added to a net in the substance of a preservative adds just so much to the load to be carried by the net.

It is therefore important to determine the increase in weight caused by preservation and to select the preservatives that impart least weight to the nets, other conditions being the same. In all the series of experiments so far described in this paper this factor was determined by weighing the sample lines before and after treatment. These weighings were made on the analytical laboratory balance, but the lines were not dried to constant weight. It was found by experiment that, unless elaborate precautions were taken, the perfectly dried sample reabsorbed moisture so rapidly from the air that accurate weighing was impossible. Since it was impractical to use weighing bottles to prevent this and would be improper to heat the treated nets to the temperature required for drying, the samples were weighed in the air-dry condition.

Table 21 gives the results of the determinations of increase in weight of cotton and linen lines caused by the preservatives. These results are shown graphically in Figures 30 and 31.

TABLE 21.—*Increase in weight of cotton and linen lines caused by application of preservatives.*

COTTON LINES.

Symbol and treatment.	Per cent increase in weight.					
	Washington.	Key West.	Beaufort.	Woods Hole.	Put in Bay.	Average.
B—Copper oleate 7 per cent	11	16				13
C—Copper oleate 7 per cent, 5 per cent paraffin oil, 1-1000 cresol	15	26				20
D—Copper oleate 11 per cent	16	37				26
E—Copper oleate 11 per cent, 2 per cent paraffin oil	21	31				26
F—Coal tar 50 per cent, benzol 50 per cent	71	69	66			69
G—Pine tar 50 per cent, benzol 50 per cent	50	49	57			52
H—Coal tar and pine tar each 25 per cent, benzol 50 per cent	58	47	41			48
I—Quercitron and potassium bichromate	7	6	13			8
J—Petroleum product No. 1	51	52	41			48
K—Proprietary waterproofing material	17	17				17
L—Dutch method	21	9	13	23	19	17
M—Copper oleate 7½ per cent			9			9
N—Copper oleate 12½ per cent, 5 per cent paraffin oil, 1-1000 cresol			14			14
O—Copper oleate 12½ per cent			15			15
P—Copper oleate 12½ per cent, 5 per cent paraffin oil			19			19
Q—Copper paint No. 1			48	74	75	66
R—Copper paint No. 2			109	138	132	126
S—Gilsonite			46			46
X—Petroleum product No. 2			37	36	35	36
Y—Copper oleate 15 per cent, benzol 35 per cent, coal tar 50 per cent				58	56	57
Z—Copper oleate 15 per cent, followed by coal tar				59	62	60
AA—Copper oleate 15 per cent				18	18	18

LINEN LINES.

Symbol and treatment.	Beaufort.	Woods Hole.	Put in Bay.	Average.
U—Copper oleate 12½ per cent in gasoline, 5 per cent paraffin oil	30.8			30.8
V—Quercitron and potassium bichromate	15.6			15.6
W—Dutch method	26.2	31.2	29.8	29.0
BB—Petroleum product No. 2		35.7	39.4	37.5
CC—Copper oleate 15 per cent in gasoline		22.0	23.3	22.6

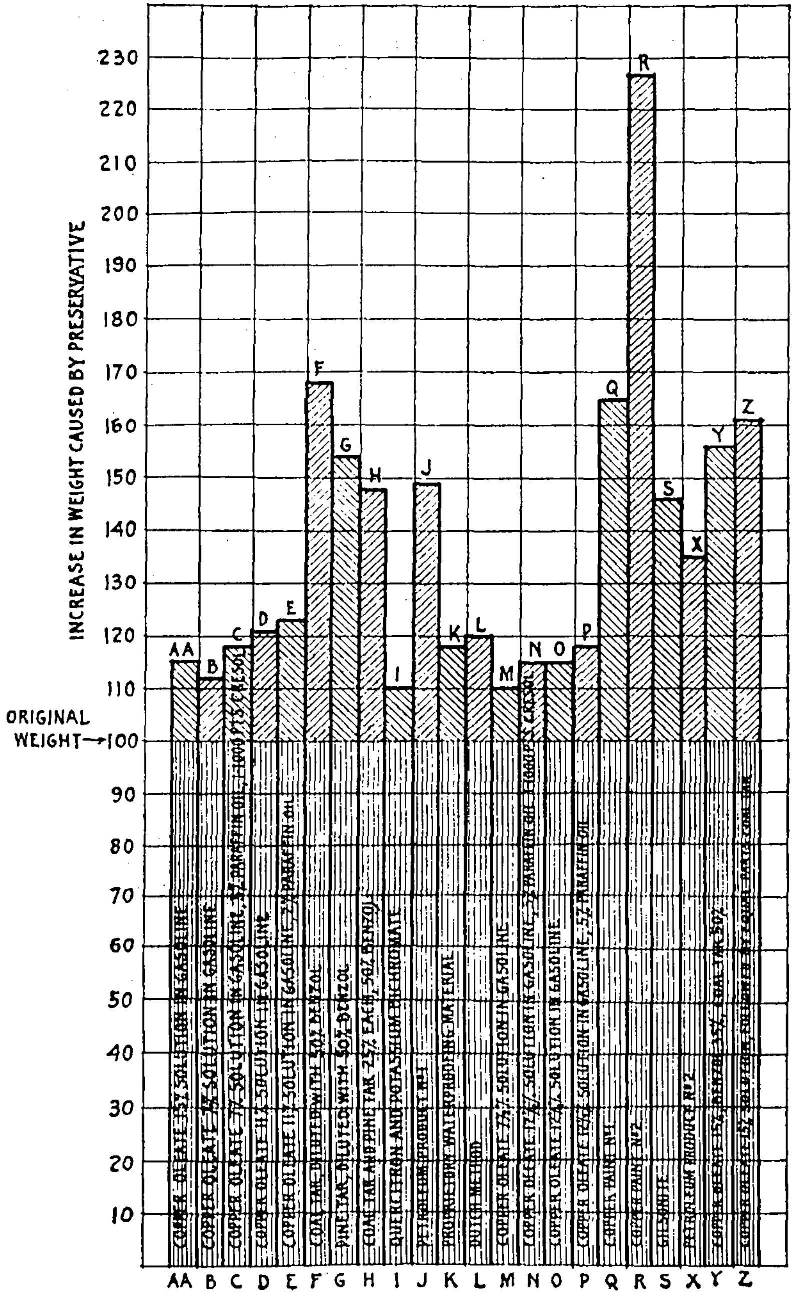

FIG. 30.—Increase in weight of cotton lines caused by one application of the various preservatives.

In Figures 30 and 31 the original weight of the line is represented by the height of the polygon up to 100. The diagonally hatched part above 100 represents the weight added by the preservative, and the total height of the polygon represents the total weight of the line after treatment.

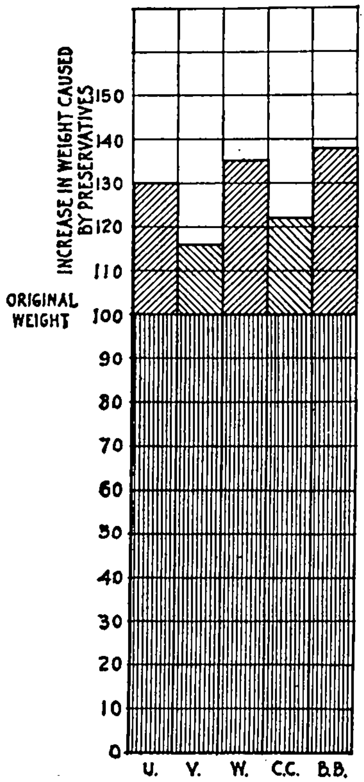

FIG. 31.—Increase in weight of linen lines caused by one application of various preservatives. U, copper oleate, 12½ per cent solution in gasoline, 5 per cent paraffin oil; W, Dutch method; V, quercitron and potassium bichromate; BB, petroleum product No. 2; CC, copper oleate, 15 per cent solution in gasoline.

It is readily seen that certain materials, such as tar and copper paint, very greatly increase the weight of the lines, while others, notably the tanning methods and copper oleate, add very little to the weight. Tar, which shows a considerable increase, would probably show even a greater increase in weight where it is applied by the hot method. Copper paint, which made such a good showing in preservation of tensile strength, here makes a very poor showing in that it causes a great increase in weight.

It was noticed in connection with the data on tensile strength that certain preservatives actually increased tensile strength by their binding effect on the fibers. The preservatives that have the greatest effect in this way are also those that increase weight most. The question then arises, Does the extra tensile strength imparted to the lines compensate for the added weight? Will the extra added strength carry the extra added weight? This question can be determined by examining the breaking length, which is the length of itself that a line will support. Table 22 shows the tensile strength in pounds and breaking length in feet of the untreated and treated lines before exposure; that is, the number of feet of line that will just support itself without breaking, calculated by dividing the weight per foot into the tensile strength in pounds. Similar figures are shown for the same lines after 30 days' exposure.

TABLE 22.—*Tensile strength and breaking length of all lines tested.*[1]

Symbol and treatment.	Freshly treated.		Exposed one month.	
	Tensile strength.	Breaking length.	Tensile strength.	Breaking length.
	Pounds.	*Feet.*	*Pounds.*	*Feet.*
A—White line, untreated control	39.3	32,600	30.4	25,200
B—Copper oleate 7 per cent	36.1	28,000	34.7	27,000
C—Copper oleate 7 per cent; 5 per cent oil, 1-1000 cresol	35.5	25,100	32.4	22,900
D—Copper oleate 11 per cent	36.1	23,300	37.6	24,600
E—Copper oleate 11 per cent, 2 per cent oil	31.4	21,000	35.0	23,200
F—Coal tar 50 per cent, benzol 50 per cent	35.4	17,900	44.6	22,700
G—Pine tar 50 per cent, benzol 50 per cent	35.2	19,500	44.4	24,500
H—Coal and pine tar 25 per cent each, benzol 50 per cent	37.4	21,800	48.6	28,300
I—Quercitron and potassium bichromate	39.3	28,100	39.2	28,000
J—Petroleum product No. 1	39.0	21,700	44.8	25,300
K—Waterproofing material	43.9	27,400	48.9	30,400
L—Dutch method	38.6	23,300	39.9	23,600
M—Copper oleate 7½ per cent	34.2	27,300	36.2	28,900
N—Copper oleate 12 per cent, 5 per cent oil, 1-1000 cresol	33.2	25,300	35.2	26,900
O—Copper oleate 12½ per cent	33.6	25,000	36.6	27,300
P—Copper oleate 12½ per cent, 5 per cent oil	36.3	26,200	37.2	26,900
Q—Copper paint No. 1	41.5	18,500	41.0	18,200
R—Copper paint No. 2	42.7	14,300	47.3	15,800
S—Gilsonite	35.5	21,500	28.2	15,700
X—Petroleum product No 2	32.9	20,400	35.0	21,700
Y—Copper oleate 15 per cent, benzol 35 per cent, coal tar 50 per cent	35.0	17,400	44.5	22 300
Z—Copper oleate followed by coal tar	36.0	17,600	40.0	19,400
AA—Copper oleate 15 per cent	38.0	25,700	40.0	27,000

[1] The figures herein are averages from all the series studied.

It will be seen that those lines treated with tar or copper paint are of high tensile strength, especially after 30 days, yet the breaking length, which takes added weight into account, is comparatively low. Unexposed, untreated cotton line has a breaking length of 32,600 feet. If the increased strength of the line caused by application of tar and copper paints were proportional to the increased weight, the breaking length should be at least equal to that of the untreated lines, 32,600 feet. It is seen that this is not true for any of the preservatives when freshly applied. After a month's exposure many of the lines, such as tar, show an improvement, because of increasing binding on the fibers in comparison with the white line, which begins to weaken very soon. The copper oleates here show up well, while the copper paints, by their excessive weight, give poor results.

It can be concluded from this section of the paper that weight is an important factor in net preservation; that although some preservatives, like tar and copper paint, increase the tensile strength of lines by binding the fibers together, this increase of strength does not compensate for the increased weight imparted to the lines. It may also be concluded that tar increases weight markedly and so does copper paint. Copper oleate and the tanning methods are best in this particular, while the petroleum products and gilsonite are intermediate.

SHRINKAGE CAUSED BY APPLICATION OF PRESERVATIVES.

Many substances applied to lines as preservatives cause some shrinkage. As stated in connection with the description of the experiments, the samples were always measured to length while under a strain of 2 kg. (4.4 pounds). The standard used was a steel tape 50 feet long. The measurements, being made before and after treatment, revealed, by difference, any change in lengths of the lines. Table 23 exhibits the results so obtained, which are also shown graphically in Figure 32.

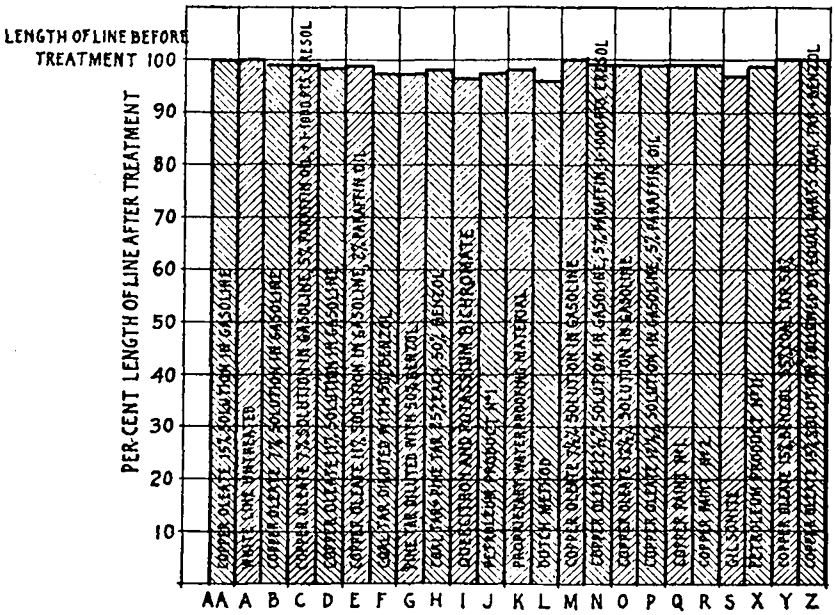

FIG. 32.—Shrinkage of cotton lines caused by one application of the various preservatives.

TABLE 23.—*Shrinkage of cotton lines caused by a single application of each of the various preservatives.*

Symbol and treatment.	Per cent shrinkage.					
	Washington.	Key West.	Beaufort.	Woods Hole.	Put in Bay.	Average.
B—Copper oleate 7 per cent	0.6	1.4	....	....	....	1.0
C—Copper oleate 7 per cent; 5 per cent oil, 1-1000 cresol.	.6	1.4	....	....	....	1.0
D—Copper oleate 11 per cent	1.4	2.1	....	....	....	1.7
E—Copper oleate 11 per cent, 2 per cent oil	.8	1.9	....	....	....	1.3
F—Coal tar 50 per cent, benzol 50 per cent	2.1	1.4	2.9	....	....	2.1
G—Pine tar 50 per cent, benzol 50 per cent	1.9	.9	2.9	....	....	1.9
H—Coal tar and pine tar each 25 per cent, benzol 50 per cent	1.4	2.2	2.4	....	....	2.0
I—Quercitron and potassium bichromate	2.4	5.2	3.5	....	....	3.7
J—Petroleum product No. 1	2.6	2.0	2.4	....	....	2.5
K—Proprietary waterproofing material	2.1	2.1	....	....	....	2.1
L—Dutch method	2.4	2.4	3.2	3.5	3.5	3.0
M—Copper oleate 7½ per cent	....	....	.1	....	....	.1
N—Copper oleate 12½ per cent, 5 per cent oil, 1-1000 cresol	....	....	.4	....	....	.4
O—Copper oleate 12½ per cent	....	....	1.1	....	....	1.1
P—Copper oleate 12½ per cent, 5 per cent oil	....	....	1.1	....	.3	.7
Q—Copper paint No. 1	....	....	2.5	.7	.2	1.2
R—Copper paint No. 2	....	....	.3	.83	....	.4
S—Gilsonite	....	....	2.7	....	....	2.7
X—Petroleum product No. 2	....	....	1.1	1.1	.8	1.0
Y—Copper oleate 15 per cent, benzol 35 per cent, coal tar 50 per cent	....	....	....	.4	.4	.4
Z—Copper oleate followed by coal tar	....	....	....	.4	.4	.4
AA—Copper oleate 15 per cent	....	....	....	.0	.0	.0

The results given are for only one application of the preservative. In practice, of course, some preservatives are repeatedly applied. Tar, copper paint, etc., can not well be applied repeatedly, because the accumulating substance increases weight and stiffness too much. Tanning materials, however, can be repeatedly applied, and it is just these that produce the greatest shrinkage, even on first application. This shrinkage is to be expected, for hot water is used in applying them. With repeated application, shrinkage becomes a rather serious objection to tanning extracts. The copper oleate, being applied cold in gasoline, produces very little shrinkage. In general, however, one application of any of the preservatives produces little shrinkage. On linen lines none of the preservatives used caused any measurable shrinkage.

TIME AND LABOR REQUIRED TO APPLY PRESERVATIVES.

These factors are, of course, of great importance. Where two preservatives are of the same value in all technical particulars, the one which is less expensive to apply is preferable. It sometimes happens that on off days the fisherman's time is worth little if it can not be employed on his nets and boats, and in large organizations the employees are sometimes without important work to do. In such cases the cost of material is the principal cost of preservation. The cost of copper oleate will be considered elsewhere.

The time required to apply the several preservatives and for the treated nets to dry may be expensive, especially in busy seasons, when time employed on nets is just so much time taken from fishing.

Table 24 sets forth the time required to dry the several preservatives after they have been applied.

TABLE 24.—*Time required for application and drying of preservatives.*

Preservative.	Number of applications.	Total time required for drying.
Copper oleate	1	30 to 45 minutes.
Pine tar 50 per cent in benzol	1	10 to 12 minutes.
Coal tar and pine tar 50 per cent benzol	1	20 to 24 hours.
Coal tar 50 per cent benzol	1	24 hours.
Tanning materials:		
Quercitron and potassium bichromate	3	12 to 18 hours.[1]
Dutch method	3	Do.[1]
Gilsonite	1	24 hours.
Petroleum products	1	36 to 48 hours.
Copper paint No. 1	1	No drying required.
Copper paint No. 2	1	Do.
Copper oleate-tar combinations	1	20 to 24 hours.

[1] Requires from four to six hours for each application to dry.

COLOR IMPARTED TO LINES BY PRESERVATIVES.

All the preservatives studied change the color of the lines. Just what the value of color in a line is and what color and shade would be preferable we do not know. There is a large literature on the subject of color vision in fishes, but results by different observers are quite inconsistent. Still less do we know of the reactions of fish to colors that they may distinguish. However, since many people who are interested in net preservatives have their own and very often decided, opinions on the subject, a statement of the colors produced follows:

Preservative.	Color of treated line.
Copper oleate	Apple green, sky blue, or strong brilliant green, depending on concentration of preservative.
Tar	Dark brown or black.
Copper paint	Dark coppery red.
Petroleum products	Black.
Gilsonite	Do.
Tanning materials:	
Quercitron and potassium bichromate.	Brown.
Dutch method	Dark brown.
Copper oleate and tar combination	Dark brown or black.

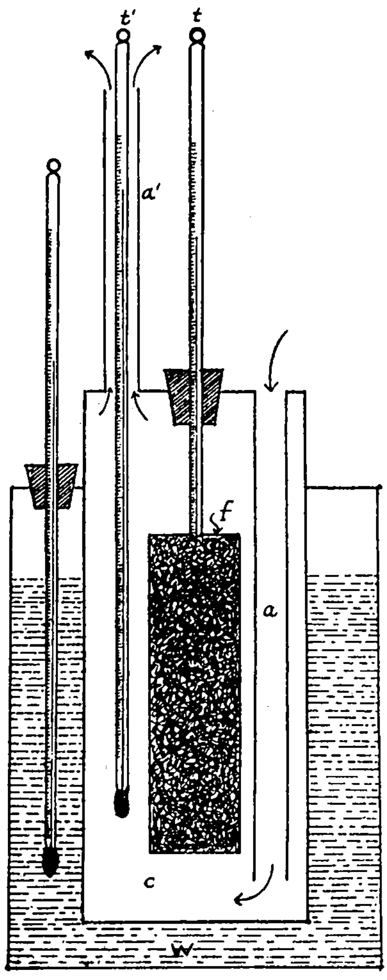

FIG. 33.—Apparatus used in testing the preservatives for tendency toward spontaneous heating.

SPONTANEOUS HEATING.

Spontaneous heating is commonly said by fishermen and others to cause the nets to rot. This heating is often attributed to the substance with which the nets are preserved. Experiments along this line have led the writers to suspect, however, that spontaneous heating of nets is caused by something other than the preservatives used.

APPARATUS USED FOR TESTING.

The apparatus used for these experiments (fig. 33) was made after the fashion of Mackey's spontaneous combustion tester. This consits, essentially, of a double-walled cylindrical water bath with a cover carrying two air circulation tubes, *a* and *a'*. The sample to be tested is placed in a cylindrical wire gauze or screen, *f*. A thermometer, *t*, extends into the sample. A second thermometer, *t'*, is suspended in the inner cylinder, *c*, through the air circulation tube *a'*. The water in the outer cylinder, *w*, is then heated to any arbitrary temperature and kept at that temperature for a period of three or four hours. The temperatures of the thermometers, *t* and *t'*, are noted at frequent intervals, and if the temperature of *t* in the sample exceeds that of *t'* in the air surrounding the sample, the difference may be taken as heat due to oxidation in the sample being tested.

LINSEED OIL.

Tests made were on cotton waste treated with the various preservatives studied. Two other tests were made upon samples of cotton waste that had been treated with linseed oil. Spontaneous heating is perhaps more likely to occur in the presence of linseed oil than of almost any other common substance. The tests with it were made, therefore, for the purpose of determining whether or not spontaneous heating would actually occur under the conditions set up for the experiments.

Twenty grams of cotton waste was moistened with 25 cc. of linseed oil and the waste allowed to dry somewhat and placed in the tester. The water was brought to boiling and the temperature of t and t' noted. The maximum temperature recorded by t was about 203° F. (95° C.). The temperature of the waste, shown by the thermometer t, rose at about the same rate as that of the surrounding air, shown by t'. When a temperature of 212° F. (100° C.) was reached, readings were made at intervals of one minute. The temperature rose 1, 1½, and 2° per minute up to about 266° F. (130° C.), when the differences became gradually larger, reaching a maximum between 300 and 345° F. (149 and 174° C.), when the differences were 14° F. (8° C.) per minute. The increments per minute then became gradually smaller, and a brown gas or smoke was noticeable above 368° F. (187° C.). The maximum temperature obtained in this experiment was 419° F. (215° C.). The waste was scorched to a brown color. The experiment with linseed oil was repeated with the same results as described in the preceding paragraph.

A third test with linseed oil was made but differed from the first two in that the temperature of the water in the outer jacket was maintained at 122° F. (50° C.) instead of 212° F. (100° C.). This temperature was held for about four hours, but the temperature of the waste saturated with linseed oil did not rise above that of the air surrounding it—about 113° F. (45° C.). It may therefore be concluded that a temperature higher than this is necessary to kindle spontaneous heating of linseed oil.

COPPER OLEATE.

A sample of copper oleate taken from the batch before it was blown was dissolved in benzol. Cotton waste was saturated with this benzol solution and allowed to dry, after which it was placed in the tester and the temperature of the water in the outer jacket brought to 212° F. (100° C.). This temperature was maintained for a period of three hours. The maximum temperature reached in the inner chamber was 194° F. (90° C.). The maximum temperature of the waste was also 194° F. (90° C.), proving that there was no elevation of temperature in the waste caused by the unoxidized copper oleate. This experiment was repeated under like conditions and the same results obtained as in the first case. Two other samples of waste that had been saturated with a benzol solution of the finished or oxidized copper oleate were tested in the same manner as described for the unoxidized samples. The maximum temperature obtained in each of these was 194° F. (90° C.), both in the sample of waste and in the air surrounding it.

The results obtained in all four of the above experiments would seem to indicate that there need be no fear of spontaneous heating of nets treated with copper oleate, either oxidized or unoxidized.

OTHER PRESERVATIVES.

Creosote oil: The substance as previously described as being used for a lubricant in the manufacture of copper oleate.

Heavy coal tar: A road tar diluted with an equal volume of benzol in order to thin it sufficiently for application.

Pine tar: Ordinary wood tar, thinned with an equal volume of benzol.

Light coal tar: A thin crude coal tar, containing all the substances found in crude coal tar with the exception of water and benzol.

Copper paint No. 1: A copper paint used as a net preservative.

All of the above products were tested by saturating cotton waste with each and placing it in the tester. In no case was there any evidence of spontaneous heating. The maximum temperature noted at any time in the air surrounding the sample was 203° F. (95° C.). Observed fluctuations in the temperature were in all probability due to air currents. At no time was the temperature of the waste over 200° F. (93° C.). The major portion of the time it was between 190 and 197° F. (88 and 92° C.). The water in the outer jacket was kept at boiling.

EFFECT OF HEAT ON COTTON LINES.

The question may here be raised as to how much heating is necessary to cause noticeable deterioration of the line. In order to answer this question, the following experiments were carried out:

Samples of No. 24 cotton line were heated in an electric oven in dry heat. One sample was heated for a period of two hours at a temperature of 212° F. (100° C.), another for two hours at 257° F. (125° C.), and a third for two hours at 302° F. (150° C.). These samples were subjected to tests for tensile strength and showed no appreciable weakening due to the heating. The sample that had been heated to 302° F. (150° C.) was slightly browned or scorched in appearance but was fully as strong as any of the other samples.

Other samples of the same kind of twine were heated in steam. One sample was heated with steam at 212° F. (100° C.), another at 239° F. (115° C.) under 10 pounds steam pressure, and a third at 257° F. (125° C.) under 20 pounds steam pressure. All samples were heated for two hours. Tests of tensile strength were also made on these lines, and again there was no noticeable difference between the lines that had been heated and those that had not.

The results of these experiments seem to indicate that a temperature much higher than any to which fish nets or lines are ordinarily subjected would have to be reached before any noticeable weakening of the threads would take place from the heat alone.

DISCUSSION OF RESULTS.

That some kind of heating occurs in nets in use seems certain. Since it is shown here that even linseed oil must be artificially heated to a comparatively high temperature before it continues to heat spontaneously, it seems necessary to discover some factor other than those that entered into the experiments to account for spontaneous heating of nets. In the case of fish nets, water, fish blood, slime, and fish oil, and also sunlight, must be taken into account. Bacterial decomposition might well cause an initial elevation of temperature, but it seems likely that the activities of the bacteria would be arrested and the bacteria killed before a temperature would be reached sufficient to kindle spontaneous heating of the oil. It should also be pointed out, as casting doubt on the belief that spontaneous heating commonly damages nets, that the high temperatures to which lines were experimentally exposed without damage would probably never be reached spontaneously.

It may also be that the damage done to nets by spontaneous heating is of the nature of supposition without foundation. That nets heat may be a fact, that they rot is certainly a fact, but that the one causes the other does not necessarily follow. Other and more widespread beliefs than this have turned out to be erroneous. Further investigation of the subject of spontaneous heating will be necessary before positive conclusion can be reached.

GENERAL CONSIDERATION OF VARIOUS PRESERVATIVES IN LIGHT OF DATA PRESENTED.

Data have now been presented concerning the effects of 23 preserving materials (or combinations and variations thereof) on cotton lines, and four on linen lines, with data on the untreated lines as controls. The data concern effects of weather conditions at Washington, D. C.; the sea water at Key West, Fla., Beaufort, N. C., and Woods Hole, Mass.; and fresh water at Put in Bay, Ohio, as compared with treated but unexposed lines held as controls. In all, 393 samples were measured to length, weighed, treated, measured and weighed a second time, exposed to the elements, and upon return were tested for tensile strength, wearing quality, and stiffness, and notes were taken on fouling, color imparted, and time required for treatments to dry. Where so many data are presented, bearing in so many tangled ways on the practical choice and improvement of preservatives, it will require close study to draw useful and reliable conclusions. All the more so, in that the requirements of nets for different classes of service are markedly different. The different preservatives will now be considered and discussed separately.

TAR.

Tar is the most commonly used preservative for fish nets in the United States. Coal tar is used more than pine tar; sometimes the two are mixed. They are usually applied hot, often in a metal vessel by direct heat from a fire, sometimes by the use of steam. The direct heat process applies tar very heavily to lines, stiffens them, and increases weight greatly. Steam tarring applies tar to a much lighter extent, sometimes scarcely more than coloring the lines. In the present experiments coal tar, pine tar, and a mixture of equal parts of the two were studied. The tar was diluted by the addition of an equal volume of benzol and applied cold.

COAL TAR.

The coal tar used was the 270° F. fraction, a thick, black, sirupy liquid. It contains many things, including creosote or the cresols, that are highly antimicrobic. Under conditions of exposure to weather it protects the lines well. At Key West, in sea water, it showed a good preserving effect on tensile strength. At Beaufort it held the lines in good condition for about two months, after which time a rapid deterioration took place. This, it is assumed, is accounted for by the fact that the creosote present at first preserves the lines, but when it has dissolved, the lines are no longer protected. In ability to resist mechanical wear coal tar is at first very good, but as the lines stiffen and weaken on exposure this quality rapidly disappears. Tar greatly stiffens the lines. Where an untreated cotton line swings 40 to 50 times, a tarred line swings only about 15 to 20 times. Tar also increases the weight of lines, under conditions of application herein described, to the extent of about 50 to 70 per cent.

There is a noticeable increase in strength in tarred lines over the white lines, to which it is applied. This increase in strength, caused by a cementing of the fibers, is not sufficient to compensate for the increase in weight. The breaking length of an unexposed tarred line is less than that of the white line.

In resistance to the accumulation of fouling by marine growth tar is poor, and the time required to dry the applied tar is 12 hours or more. Tar is cheap in material but is laborious and messy to apply. It colors the nets dark brown or black.

Coal tar is suitable as a preservative for heavy nets, and when applied in concentration is much better than nothing on two months' continuous exposure, after which it is comparatively worthless. Fortified with copper oleate, coal tar was an extraordinarily good preservative. This will be referred to later.

PINE TAR.

Pine tar behaves very much like coal tar, running a close second to it in most respects. It does not preserve tensile strength quite so well, but, on the other hand, is not quite so stiffening. Little can be said in favor of pine tar as against coal tar.

MIXED TAR.

The tars mixed were also similar to the straight tars, the properties of the mixture being usually intermediate between those of the separate components.

TANNING OR BARKING.

Next to tarring barking is the commonest preservative treatment applied in this country. The use of bark is principally confined to gear that can not be tarred, such as gill nets and light seines. The barking process usually consists of dipping the net in a hot decoction of oak bark, cutch, or other tanning extract, in water. Since, in a previous paper (Taylor, 1921) it was shown that barking alone is of no noticeable value as a preservative (though the gear may be well cleaned by it), experiments were restricted to the treatment of nets with a hot solution of quercitron, followed by a treatment with potassium bichromate, and the Dutch method. This latter method consists of treating the net with quercitron and following with a solution of 1 per cent copper sulphate in water, with 3 per cent of stronger ammonia water added. The experiments with quercitron, followed by potassium bichromate, were made in order to determine the effect of copper by comparison with the Dutch method.

Both tanning methods color the lines brown and by making them harsh greatly impair their ability to withstand mechanical wear or abrasion. Also, in their effect on stiffness, there is little difference, both stiffening the lines more than copper oleate but less than any of the other preservatives. They also shrink the lines more than any other preservative.

QUERCITRON AND POTASSIUM BICHROMATE.

Where the two methods begin to differ is in actual preserving effect on exposure to water, as shown by the tensile strength tests and also the wearing tests. The lines treated by quercitron and potassium bichromate at all places where tested did not last any longer than the untreated cotton lines. This method was therefore omitted from consideration in the later series.

THE DUTCH METHOD.

This method shows much merit. In the Key West, Beaufort, and Woods Hole series—that is, in all the sea-water tests—it had a preserving effect, as shown by tensile strength measurements, at first intermediate between copper oleate and tar. At the end it was still intermediate, though the copper oleate and tar had changed places. The order of tensile strength at first was tar, Dutch method, and copper oleate; later, copper oleate, Dutch method, and tar. In addition to its effect on tensile strength, the Dutch method also prevented fouling almost entirely.

On linen lines in sea water, where these two methods were also tried, the only preservatives worth considering were copper oleate and the Dutch method; quercitron and potassium bichromate did not show any preserving effect. The Dutch method and copper oleate both preserved to about the same extent at Beaufort, the lines lasting about four months' continuous exposure. At Woods Hole copper oleate was considerably better than the Dutch method, though the Dutch method showed merit.

In fresh water at Put in Bay the results were somewhat surprising. The Dutch method gave excellent results with cotton, easily outstripping copper oleate as far as tensile strength is concerned.

The linen lines treated by the Dutch method lasted only 60 days, while those treated with copper oleate lasted 90 days and were stronger than the linen lines preserved by the Dutch method.

As appearances now stand, the Dutch method in fresh water and for cotton lines is best; for linen lines in fresh water, copper oleate excels. It must be borne in mind, however, that only one series of experiments has been conducted. Before these conclusions are entirely trustworthy it will be necessary to carry out many more tests.

In salt water the Dutch method proved itself to be a very good preservative, but not the best. Lines preserved by it are strong, light, flexible, but wear easily from mechanical abrasion and shrink considerably, and the method is somewhat troublesome of application. Since the quercitron and potassium bichromate method and the Dutch method are similar, except for the absence of copper from the one and the presence of it in the other, it is clear that the preserving effect of the Dutch method lies in the copper and not in the tanning.

COPPER PAINT.

This material, long used for the bottoms of boats and ships to prevent the entrance of marine borers and to prevent also the attachment of fouling by barnacles and other growths, has been introduced only recently as a preservative of fish nets. The two commercial samples tested in these experiments are regularly sold for the purpose. One (Q) is a product prepared for fish nets by a considerable thinning. It contains much less copper oxide than the ship's paint. Accordingly, its properties that depend on body—that is, stiffness and weight—are somewhat less extreme than those of the straight ship's paint (R), the other sample tested. This latter contains very much more copper. It stiffens lines and increases their weight more than the other copper paint. The copper oxide present gives to lines treated by either of these paints a harshness that greatly reduces the wearing quality of lines treated by it. It is in this particular that they are at a great disadvantage when compared with other preservatives. They cause very little shrinkage but increase the weight from 60 per cent (Q) to 125 per cent (R). They both impart to nets the familiar reddish or coppery color that is seen on ships' bottoms painted with them. They are expensive but are not very troublesome to apply, as the nets are to be put into service in water without waiting to dry.

Both copper paints proved themselves to be most excellent preservatives of tensile strength under all conditions tested, both in salt and fresh water, being usually the strongest lines of all after exposure. They add something to the tensile strength of unexposed lines, but this increase is not sufficient to compensate for the added weight, as shown by the breaking length data. R, containing as it does a larger proportion of copper, is more effective under very severe conditions than Q, which contains less copper. When compared with the lines treated with copper oleate, which contained very much less copper, it appears that the large deposits of copper in the paints are unnecessary. Copper paints entirely prevented fouling in all the experiments.

In summary, copper paint is an excellent preservative of tensile strength and in preventing fouling, but is seriously lacking in wearing quality. It stiffens the lines and increases their weight and is decidedly expensive. It is unsuitable for gill nets and light seines.

PETROLEUM PRODUCTS.

These two materials, J and X, submitted for test, are prepared from petroleum from the Western States. They are black tarry liquids, J being heavier than X. X was prepared thin so as to be suitable for gill nets. They impart to the line a brown color, penetrate well, and as far as appearances go might readily be taken as good substitutes for tar. In the trials, however, they fail to show any preserving quality worth considering. The tensile strength of lines treated by them rapidly diminishes on exposure, the stiffness is greatly increased, and the wearing quality, while good in the unexposed lines, rapidly disappears on exposure. The failure of these materials was equally rapid on cotton and linen lines.

GILSONITE.

This material, also called Uintaite, coming as it does from the Uinta Mountains of Utah, is an asphalt, similar to Trinidad asphalt. It is sold under a proprietary name as a net dip, and this proprietary product was the one tested in this work. It is a black sirupy liquid of a bituminous odor. When applied to cotton twine, it dries in about 24 hours, leaving the lines colored dark brown or black and of a stiffness as great as that produced by tar or copper paint. It increased the weight of No. 24 cotton twine when dipped 48 per cent, which is similar to the increase caused by tar.

As might be expected from the results already given, which show that mere waterproofing or covering lines is not in itself adequate to preserving them against deterioration on exposure, gilsonite fails to show any preserving effect. At Beaufort, where it was exposed, it was little better than no preservation as far as tensile strength was concerned. In resistance to mechanical wear gilsonite compared well at first with other preservatives, but this resistance soon disappeared on exposure of the samples. This substance, if fortified with copper oleate or some other toxic material, might be effective; but if it costs much more than tar, little if any advantage would be gained by substituting it for tar. Because of general failure and disintegration of lines treated by it gilsonite may be dismissed as of no value as a net preservative.

COPPER OLEATE.

In our experiments this substance is tested for the first time as a net preservative. It has been tried in various concentrations and combinations, and, as far as our experiments go, it shows characteristics that should make it valuable for preserving nets. If tensile strength of lines after exposure is alone taken as a measure of its preserving effect, copper oleate gave good results, though not always the best. In the Key West series it kept the lines up to their original strength for four and one-half months. At Beaufort the only preservatives that resisted six months' exposure were copper oleate, copper paint, and the Dutch method. Because of a binding effect on the fibers the tensile strength of the lines treated with copper paint was greater than that of lines treated with copper oleate. At Woods Hole again all those lines that endured six months had copper in some form in them. Those preservatives that contained a protecting body in addition to the copper lasted better than those treated with copper oleate alone. At Put in Bay in fresh water copper oleate alone did not give encouraging results, but combined with tar as a binder it gave excellent results. The copper oleate without binder seems to disappear from the lines rather rapidly in the fresh water of Lake Erie. In none of the foregoing experiments was copper oleate applied a second time to the sample. The amount of copper per yard of line was very small in comparison with that in lines treated with copper paint, yet in preserving effect it occupied second place when it did not occupy first. In the Key West and Beaufort series, where different concentrations (7, 7½, 11, and 12½ per cent) were tried, solutions of copper oleate in gasoline, the higher concentrations, gave in every case better results. The addition of a small quantity of cresol effected no improvement, but the small quantity of oil seemed to increase the preserving effect. It is probable, therefore, that still higher concentrations than we used or repeated applications of copper oleate will give even better results and should equal any other preservative tried.

Copper oleate does not stiffen lines to which it is applied to an objectionable degree. In fact, it appears to be quite suitable for gill nets and other soft gear, where flexibility is essential. Lines treated with it made about three times as many swings, acting as pendulums, as lines treated with tar. The weight imparted to lines by the application of copper oleate is insignificant, being only about 16 per cent of the original twine. In these two particulars—that is, flexibility and weight—copper oleate greatly excels tar and copper paint. In ability to withstand mechanical wear, lines treated with copper oleate are better than any other treated lines tested. In this particular, also, it is far ahead of copper paint, which causes excessive wear.

Copper oleate prevented the attachment of marine growths to the lines exposed at all places, in this particular being equaled only by copper paint. Copper oleate when used alone, dissolved in gasoline and with or without oil, imparts to the lines a color that varies between azure and green as concentration varies. This color is said by some to be desirable. Japanese fishermen have introduced in the northwest the practice of dying green their gill nets used for salmon. The acceptability to different fishermen of the color imparted by copper oleate will be greatly influenced by their customs and their notions of fish behavior.

In ease of application and time required to dry copper oleate is equal to any other preservative tested. When dissolved in gasoline or benzol in the proportion of 1 to 2 pounds of copper oleate to 1 gallon of solvent, the lines or nets need only be dipped in it and spread out to dry. Drying requires about one-half hour for cotton lines and two or three hours for linen or hemp. Applied in gasoline with a little mineral oil, then, copper oleate answers well all the principal requirements of a good net preservative. When copper oleate alone dissolved in benzol is applied to cotton twine, the copper oleate seems to creep to the surface of the twine as the solvent evaporates. The addition of about 1 pound of mineral oil or creosote to each 10 pounds of copper oleate prevents this creeping. Creosote seems preferable to oil as being cheaper and in possessing a toxicity of its own.

The combination of copper oleate and tar preserves the nets better than either copper oleate or tar alone. After six months' exposure in both fresh and salt water the samples of cotton line preserved with these combinations were equal in strength to the original unexposed samples. It made little difference whether the copper and tar were applied separately, or mixed. This being so, the choice would be the mixture that would require less labor in being applied. This combination is similar to copper paint in preserving effect and to tar in weight and stiffness. In wearing quality it greatly excels copper paint. It would be a suitable preservative for heavy gear subject to continued severe exposure, such as traps and pound nets. Directions for applying this combination are as follows:

Dissolve 1 pound copper oleate in 1 gallon of benzol (gasoline is not suitable for this purpose). Stir in, cold, 1 gallon of coal tar, more or less, according to the stiffness and weight that is allowable. Dip the net in this combination cold and dry. Avoid fire.[4]

CHEMICAL PROPERTIES AND MANUFACTURE OF COPPER OLEATE.

Cupric oleate $Cu\ (C_{18}H_{33}O_2)_2$ is a green substance of the consistency of beeswax, insoluble in water, soluble in alcohol, ether, benzol, gasoline, carbon tetrachloride, turpentine, oils, etc., forming emerald green solutions. It contains, on the basis of the formula given, 10.15 per cent copper, by weight, though the percentage of copper in commercial preparations may vary between wide limits. It has a metallic coppery taste and is poisonous when taken internally, though external exposure to it is apparently harmless.

Copper oleate may be made in a number of different ways. It is precipitated when sodium oleate and any soluble copper salt are brought together in aqueous solution. When prepared in this way, it is gummy and contains much water that is removed only with difficulty. Cupric oxide dissolves in hot acid with formation of copper oleate and water, but it is difficult or impossible to carry the reaction to completion. Copper acetate and oleic acid combine at an elevated temperature, whereby copper oleate is formed and acetic acid driven off. The latter may be condensed and recovered. This method produces a good product, entirely soluble, but some acetic acid usually remains. Moreover, copper acetate is expensive.

The method employed in our production of copper oleate was to treat copper carbonate (containing also copper hydroxide) with oleic acid. In this reaction carbon dioxide and water are produced, and both are driven off by heat. Both reagents are obtainable in commerce in large quantities at a low price. The current (December 30, 1922) price of copper carbonate is 20 cents per pound, and oleic acid (the red oil of commerce) is 10 cents per pound. The exact procedure as followed in the laboratory in making this material is as follows:

Into a 5-gallon copper steam-jacketed kettle put 4 pounds of dry copper carbonate. Moisten this with enough red oil (about 1 quart) to make a paste; knead the paste with a wooden pestle until all lumps are crushed and the mass is of uniform consistency. Stir in more oil. As the oil is added large quantities of gas are generated, and constant stirring is necessary to keep the contents from running over the sides of the kettle. As the foaming subsides more oleic acid is put in until 15 pounds in all have been added. Steam is now cautiously admitted to the jacket, and with constant stirring the mass is kept from foaming over. A thermometer is kept in the mass. When the boiling point of water is reached, bubbles of steam escape rapidly. This bubbling may continue for two hours or more, until

[4] Net and twine manufacturers, or others who might be interested in the regular application of this combination, should take notice that continued breathing of the vapors of benzol are harmful, and workers should be protected accordingly by adequate ventilation of workrooms.

all the water is driven off, during which time the temperature does not rise far above 212° F. (100° C.). When bubbles of steam cease to escape, the temperature will rise slowly until 45 pounds' pressure of steam is maintained in the jacket, the copper oleate comes to a temperature of 257 to 268° F. (126 to 132° C.), and the mass is a thick green liquid. When this temperature is reached, an air hose nozzle is so placed that air is blown in and bubbles through the hot mass from the bottom. Stirring now helps to incorporate the air bubbles in the mass and to accelerate oxidation. As the mass absorbs oxygen, it becomes very viscid, so that a stick inserted in it and brought out carries a sticky bulk which in large part hangs without dropping. The blowing requires about one-half hour. The blowing of air is, of course, for the purpose of oxidizing the mass with as much oxygen as it will spontaneously absorb at this elevated temperature, so as to diminish the likelihood of spontaneous heating of fish nets to which it is applied.

When the consistency just described is reached, the batch is considered finished, a lot sample is taken, and to the batch is added the amount of oil necessary to prevent creeping. If oil is used, it should be mineral lubricating oil in the proportion of 3 pints for the batch as described. Later experiments, however, indicate that creosote answers the same purpose more cheaply and more effectively. Creosote is a good preservative itself; it prevents the copper oleate from creeping to the surface of lines and can be bought for 50 cents per gallon or less. If creosote is used, 1½ to 2 pints to the batch quantity described is sufficient. The creosote used in the work herein described has the following properties: A thin mobile brownish but rather transparent liquid; specific gravity, 980; smell, smoky. It is the grade used for preserving wood.

When the oil or creosote has been added and thoroughly mixed into the mass, the latter is poured into cans or other containers and set aside to cool. A record is kept of each batch, which is designated by number. If cans are used, they may be of the friction-top type. The contents of a 5-pound can will, when dissolved in 5 gallons of gasoline, treat between 50 and 60 pounds of cotton net. When dissolved in 2½ gallons of gasoline, it will treat 25 to 30 pounds of net with a comparatively heavy deposit of the preservative, suitable for severe conditions. For combining tar the contents of a 5-pound can are dissolved in 5 gallons of benzol and 5 gallons of coal tar are added and mixed, making about 10½ gallons of a preservative, suitable for traps and other gear, subject to the severest exposure. The nets are dipped in the mixture cold and are hung out to dry. Drying takes about 24 hours. It may also be applied separately to the lines, as will be described below, the lines then to be tarred in the usual way.

METHOD OF APPLYING COPPER OLEATE TO NETS.

The copper oleate as canned is dissolved in gasoline. If it does not already contain the oil or creosote, one of these must be added in the quantity indicated. The cold, waxy, copper oleate dissolves rather slowly in gasoline, but the can may be put in boiling water for a few minutes, until the copper oleate is liquefied; it then dissolves quickly. The gasoline solution should be contained in a metal vessel (a galvanized-iron washtub, for example); the net is dipped into this mixture and hung (not piled) to dry. Any unused portion of the copper oleate in gasoline may be kept indefinitely in a tightly corked can, such as a 10-gallon oil can. For larger quantities a steel gasoline barrel is suitable. The treatment may be repeated as often as seems desirable without danger of injury to the twine.

GRADING THE SEVERAL MATERIALS AS ALL-ROUND PRESERVATIVES.

In the experimental part of this paper it has been shown that the several materials studied differ in value as net preservatives—in one particular respect one preservative may excel, in another some other preservative. The impression may have been given that in most respects copper oleate is best. But, just how much better is one preservative than another, considered generally? Some systematic and impartial method of attaching values to the different factors—such as tensile strength, stiffness, and wearing quality—by which to grade the several preservatives accordingly is desirable. Can we not derive a figure that is made up of the several values of tensile strength, wearing quality, flexibility, etc., that will give an indication of the all-round value of each preservative?

In deriving such a figure it is impossible to avoid making assumptions that are more or less arbitrary. It is also necessary to ignore the obvious fact that for different purposes and classes of nets the relative weights of the different factors are quite dissimilar. For example, in gill nets the necessity of flexibility absolutely dominates the choice of material and preservation, while in pound nets flexibility is of no great importance, but preservation of tensile strength, ability to withstand chafing or abrasion, and resistance to fouling by marine growths are decisive factors.

In selecting a suitable preservative, therefore, one can not avoid a consideration of the relative importance of the several factors for the particular purpose the net is intended to serve. Nevertheless, our new preservative, copper oleate, is proposed for all classes of nets. If it can make a good score in all or most of the several requirements that make it suitable for many different purposes, it is more desirable than a preservative that excels for some limited purpose and is useless for others.

The following method of grading the preservatives for all-round use on cotton lines involves the minimum number of arbitrary assumptions: (1) The breaking length of the treated line was first calculated; that is, the length of line that will just hold itself up. (2) This figure was then reduced to the same extent as the shrinkage was found to reduce the length of cotton lines on application of the preservative. (3) This figure was then multiplied by a factor that, in the case of white untreated line, brings the breaking length to 100. Thus, the samples were compared with white line as a standard of excellence. (4) The number of strokes on the wearing tester was multiplied by a factor that, in the case of white untreated line, brings the number of strokes to 100. Here, again, the samples were referred to white line as a standard. (5) The number of pendulum oscillations of the several samples (flexibility) was multiplied by a factor that, in the case of white untreated line, gives 100 oscillations. This factor is also referred to white line as a standard. We thus take into the reckoning tensile strength, increase in weight, shrinkage, resistance to wear, and flexibility, and by multiplying each by a factor, that, in the case of white line, brings each figure to 100 we attach the same weight to the factors, and at the same time refer all samples to the one standard of excellence for fishing purposes, the new white line. The ideal preservative is that one that most closely keeps its twine like new white line for the longest time, and our composite score by its magnitude indicates the relative ability of the preservatives so to keep the lines. It was not practicable to include in the score resistance to fouling, because exact numerical expression for this factor was lacking. Allowance for it would raise the values for copper oleate and copper paint alike with respect to all the others, for only these two preservatives prevented fouling.

The new untreated, unexposed cotton line, No. 24, cable-laid, hard-finish, scored in the way described 300, or 100 for each of the three different factors, derived as follows:

Let

T=tensile strength in pounds of sample.

W=weight in pounds per 100 feet.

$\frac{T}{W}$=breaking length in hundreds of feet.

S_1=original length, in hundreds of feet, of sample before treating.

S_2=length, in hundreds of feet, of sample after treating.

$\frac{S_2}{S_1}\times\frac{T}{W}$=breaking length, in hundreds of feet, of sample after treating.

F=flexibility=number of swings of pendulum.

A=number of strokes on wearing machine.

For white line:

$\dfrac{100}{\frac{S_2}{S_1}\times\frac{T}{W}}=F_1$=the factor that brings the shrunken breaking length of white line to a value of 100. This white-line factor is used in bringing the shrunken breaking length of treated line to a common standard.

$\frac{100}{F}=F_2$=factor that brings the flexibility of untreated white line to a value of 100. This white-line factor is used for the treated line.

$\frac{100}{A}=F_3$=factor that brings the wearing ability of white line to a value of 100.

Then, the full score of any sample is the sum of the three separate scores, shrunken breaking length, flexibility, and wearing ability,

$$\frac{S_2}{S_1}\times\frac{T}{W}\times F_1+FF_2+AF_3.$$

In Table 25 are given the numerical values of the scores of all lines in the Beaufort and Woods Hole series. The same data are presented in graphic form for the several preservatives in Figure 34. It is seen that treatment by any preservative whatsoever causes a reduction in the score.

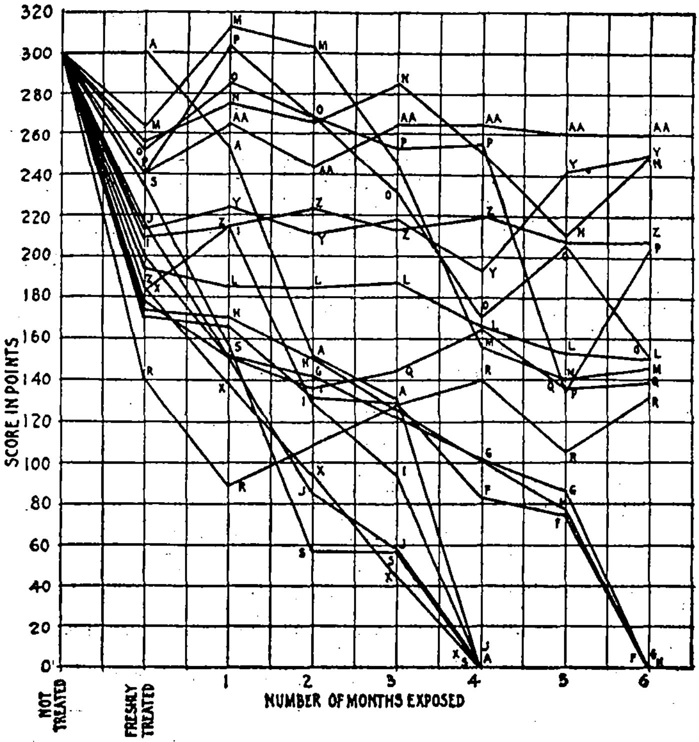

FIG. 34.—Scores of the several preservatives showing their relative values applied to cotton line, tensile strength, wearing quality, flexibility, shrinkage, and increase in weight considered. New untreated white cotton line is the standard, scoring 300.

TABLE 25.—*Scores of cotton lines at Beaufort, N. C., and Woods Hole, Mass.*

Symbol and treatment.	Tests.	Unexposed.	Number of months exposed. 1	2	3	4	5	6
A—White line, untreated control.	Breaking length...	100.0	92.0	32.5	13.5	......	......	......
	Wearing quality..	100.0	19.8	5.1	2.7	......	......	......
	Flexibility........	100.0	140.0	114.0	115.0	......	......	......
	Total.......	300.0	251.8	151.6	131.2	......	......	......
F—Coal tar 50 per cent, benzol 50 per cent.	Breaking length...	55.0	72.0	70.0	57.0	36.0	28.0	......
	Wearing quality..	55.0	48.5	16.6	32.2	9.7	4.2	......
	Flexibility........	60.5	46.5	46.0	40.0	39.0	43.5	......
	Total.......	170.5	167.0	132.6	129.2	84.7	75.7	......
G—Pine tar 50 per cent, benzol 50 per cent.	Breaking length...	60.0	76.5	79.0	57.0	20.1	4.9	......
	Wearing quality..	45.0	40.0	27.6	21.2	16.2	......	......
	Flexibility........	72.0	36.4	36.0	44.0	66.5	82.5	......
	Total.......	177.0	152.9	142.6	122.2	102.8	87.4	......
H—Coal tar 25 per cent, pine tar 25 per cent, benzol 25 per cent.	Breaking length...	67.0	78.0	84.0	60.0	50.0	29.0	......
	Wearing quality	47.5	48.5	30.4	26.1	12.3	2.8	......
	Flexibility........	58.5	43.5	36.0	40.0	39.8	46.5	......
	Total.......	173.0	170.0	150.4	126.1	102.1	78.3	......
I—Quercitron mordanted with potassium bichromate.	Breaking length...	86.0	94.0	43.0	5.2	......	......	......
	Wearing quality..	14.3	12.7	......	......	......	......	......
	Flexibility........	109.0	108.0	87.0	89.5	......	......	......
	Total.......	209.3	214.7	130.0	94.7	......	......	......

TABLE 25.—*Scores of cotton lines at Beaufort, N. C., and Woods Hole, Mass.*—Contd.

Symbol and treatment.	Tests.	Unexposed.	Number of months exposed. 1	2	3	4	5	6
J—Petroleum product No. 1	Breaking length	66.5	69.5	41.0	15.0	......	......	......
	Wearing quality	79.5	35.1	......	......	......	......	......
	Flexibility	70.0	44.0	44.0	44.0	......	......	......
	Total	216.0	148.6	85.0	59.0	......	......	......
L—Dutch method, quercitron mordanted with ammoniacal copper sulphate.	Breaking length	71.5	75.0	71.0	66.5	44.0	29.6	28.5
	Wearing quality	13.4	16.1	18.8	26.4	18.2	4.5	3.3
	Flexibility	108.5	94.5	95.5	94.5	104.0	119.0	118.5
	Total	193.4	185.6	185.3	187.4	166.2	153.1	150.3
M—Copper oleate 7½ per cent in gasoline.	Breaking length	84.0	88.5	89.0	72.0	40.5	24.8	23.6
	Wearing quality	33.4	45.5	40.2	36.5	3.6	2.3	1.7
	Flexibility	146.0	179.0	174.0	137.0	112.0	113.0	120.0
	Total	263.4	313.0	303.2	245.5	156.1	140.1	145.3
N—Copper oleate 12½ per cent in gasoline, 5 per cent paraffin oil, 1-1000 parts cresol.	Breaking length	77.5	83.0	79.0	79.0	59.5	51.0	28.2
	Wearing quality	36.0	44.5	33.2	42.5	22.4	12.1	64.5
	Flexibility	143.0	148.0	154.0	165.0	170.0	152.0	158.0
	Total	256.5	275.5	266.2	286.5	251.9	215.1	250.7
O—Copper oleate 12½ per cent in gasoline.	Breaking length	77.0	84.0	91.5	68.5	48.5	52.0	20.0
	Wearing quality	54.0	54.0	40.5	35.0	11.4	13.6	1.4
	Flexibility	121.0	147.0	137.0	128.0	110.0	141.0	139.0
	Total	252.0	285.0	269.0	231.5	169.9	206.6	160.4
P—Copper oleate 12½ per cent in gasoline, 2 per cent in paraffin oil.	Breaking length	80.0	82.5	84.5	82.5	66.0	43.0	37.4
	Wearing quality	40.0	65.0	44.5	37.4	34.5	3.6	11.7
	Flexibility	120.0	155.0	139.0	134.0	156.0	85.0	156.0
	Total	240.0	302.5	268.0	253.9	256.5	131.6	205.1
Q—Copper paint No. 1	Breaking length	57.0	56.0	56.0	55.0	58.0	48.0	40.6
	Wearing quality	65.0	15.3	11.3	15.0	14.1	9.9	6.6
	Flexibility	75.5	80.0	69.5	76.0	93.0	79.0	92.0
	Total	197.5	151.3	136.8	145.0	165.1	136.9	139.2
R—Copper paint No. 2	Breaking length	44.0	45.0	48.5	48.5	67.0	40.5	43.2
	Wearing quality	25.0	6.6	5.0	5.2	3.9	4.4	4.1
	Flexibility	71.0	37.5	55.5	74.5	70.0	71.0	84.5
	Total	140.0	89.1	109.0	128.2	140.9	115.9	131.8
S—Gilsonite	Breaking length	66.0	48.0	14.4	6.4	......	......	......
	Wearing quality	79.0	58.5	......	......	......	......	......
	Flexibility	88.5	51.0	43.5	51.5	......	......	......
	Total	233.5	157.5	57.9	57.9	......	......	......
X—Petroleum product No. 2	Breaking length	63.0	74.5	27.2	14.0	......	......	......
	Wearing quality	37.4	19.1	9.7	4.2	......	......	......
	Flexibility	83.0	45.0	58.5	27.1	......	......	......
	Total	183.4	138.6	95.4	45.3	......	......	......
Y.—Copper oleate 15 per cent, benzol 35 per cent, coal tar 50 per cent.	Breaking length	53.5	66.0	64.5	72.5	65.5	76.5	71.5
	Wearing quality	76.0	84.0	79.5	76.0	51.0	32.4	36.8
	Flexibility	85.5	74.0	75.0	70.0	77.0	134.0	142.0
	Total	214.0	224.0	211.0	218.5	193.5	242.9	250.3
Z—Copper oleate 15 per cent in gasoline followed by coal tar.	Breaking length	54.0	57.0	58.5	72.0	59.5	74.5	66.0
	Wearing quality	64.0	84.5	70.5	64.5	36.0	39.0	44.5
	Flexibility	65.5	72.5	94.5	77.0	115.0	94.0	97.5
	Total	183.5	214.0	223.5	213.5	220.5	207.5	208.0
AA—Copper oleate 15 per cent in gasoline.	Breaking length	79.0	88.0	77.0	77.0	81.5	63.0	65.0
	Wearing quality	57.5	84.0	44.0	52.5	18.6	28.8	28.2
	Flexibility	104.1	112.0	123.0	137.0	166.0	170.0	169.0
	Total	240.6	264.0	244.0	266.5	266.1	261.8	262.2

The only lines that at any time make a higher score than white line are the line, M, treated with copper oleate, after the first and second month, and P, another line treated with copper oleate, after the first month. The Dutch method, L, makes a good score. The copper paints, Q and R, at first make a poor showing because of excessive weight and low wearing ability, but because of a good preserving effect they occupy a high place, compared with others, after three months. The tarred lines, F, G, and H, all make similar scores but are intermediate between the better and poorer preservatives. In Figure 35 these lines are grouped for a more convenient interpretation.

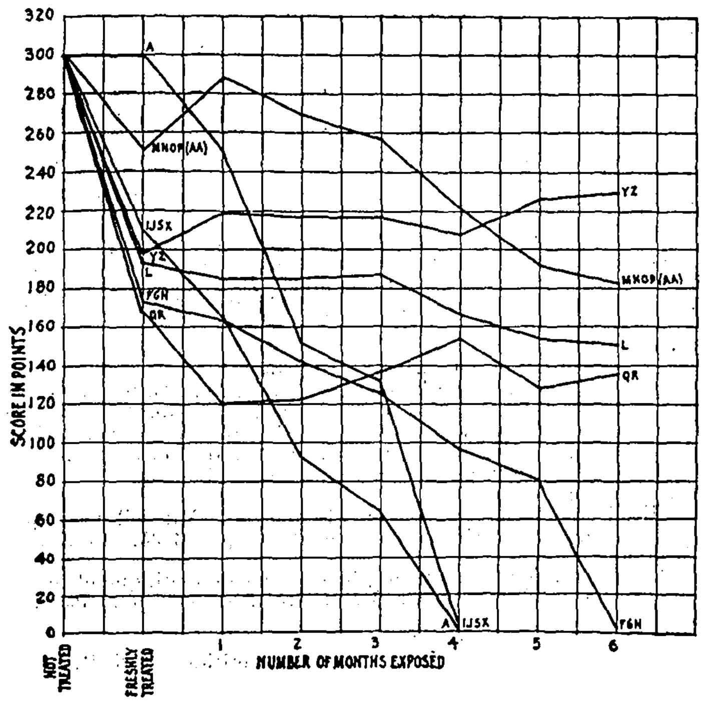

FIG. 35.—Scores of the preservatives shown in Figure 34, with the preservatives having a similar effect grouped.

The samples treated with copper oleate easily lead as all-round preservatives when rated by the method described, the copper paints and the Dutch method show merit, the tarred samples are somewhat better than nothing, and the quercitron and potassium bichromate method and three proprietary preservatives do not score at any point as high as the plain white line.

The striking fact, already mentioned, is again evident in this connection, that those preservatives that contain copper in some form deposited in the lines are best—copper oleate, the copper paints, and the Dutch method. It is plain that in the Dutch method copper is the active ingredient, for in the quercitron and potassium bichromate method the same tanning extract mordanted without copper is ineffective. Since copper seems essential in a net preservative, the form that carries with it fewest incidental objections, such as stiffness, increase in weight, and wearing quality, is preferable. Copper oleate is undoubtedly best in all these particulars.

TABULAR SUMMARY.

For convenient reference and comparison a summary of the properties of the various preservatives is given in Table 26.

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TABLE 26.—*Summary of properties of net preservatives.*

Preservative.	Tensile strength.	Wearing quality.	Flexibility.	Shrinkage.	Increase in weight.	Fouling.	Time required for application.	Color.	Value as a preservative in fresh water.
Copper oleate without binder.	Causes immediate diminution by lubrication of fibers; thereafter tensile strength remains constant over long period; excellent preservative.	Preserves wearing qualities over long periods in salt water, but not in fresh water.	Flexibility considerably increased immediately after treating; this flexibility decreases after two or three weeks to an equality with untreated line; twine remains soft and pliable; suitable for gill nets.	Shrinkage very small; causes about 0.5 to 1.5 per cent decrease in length after one application.	Increase in weight not great; average of all lines treated shows about 16.5 per cent gain in weight, as applied.	Very little fouling; a few barnacles were in evidence, but no hydroids or other growth appeared on 4 months' exposure.	Lines or nets can be treated in short time; should be immersed for 5 or 10 minutes and will dry in about one-half hour.	Color varies from a light green to a darker bluish green, depending upon concentration of the preservative.	Used alone on cotton lines it is not of much value; on linen line results are much better.
Tar (pine, coal, and mixed).	Immediate diminution of tensile strength followed by marked increase, which drops off after two months in salt water.	Very good on freshly treated lines but diminishes rapidly on being exposed; exposed lines not so good as copper oleate.	Very stiff; fewer oscillations of pendulum than any other preservative.	Shrinkage not great, but a little more than copper oleate; averaged 2.22 per cent on one application.	Increase in weight very high, especially in case of coal tar; average increase 56.8 per cent when applied from 50 per cent benzol solution.	Lines contained heavy growth of hydroids and barnacles.	Much labor and time required to treat line; from 24 to 36 hours required for drying.	Dark brown or black.	No experiments with tar alone have been made in fresh water.
Copper paint Nos. 1 and 2.	Slight immediate increase followed by marked increase, which remains quite constant even after long exposure; good preservative.	Poor resistance to mechanical wear.	Causes immediate stiffening, but not to as great a degree as tar; copper paint No. 1 remains fairly constant, while copper paint No. 2 continues to grow stiffer.	Very little shrinkage; about 0.5 per cent on one application.	Greatest increase in weight of all preservatives studied; copper paint No. 1, 65 per cent; copper paint No. 2, 127 per cent.	No fouling of any sort after 6 months' exposure.	Not much labor or time required; drying before use unnecessary.	Dark red.	Tensile strength undiminished at end of 6 months' exposure; no difference in behavior in fresh or salt water.
Petroleum product Nos. 1 and 2.	Very little immediate change; product No. 1 shows marked increase after a short time; product No. 2 shows little change; both decrease very rapidly on being exposed; poor preservative.	Product No. 1 when freshly applied resists mechanical wear better than any other preservative; product No. 2 resists wear only moderately well; about one-half as well as No. 1; on exposure both rapidly lose resistance to wear.	Causes considerable stiffening which increases for 3 or 4 weeks and then remains constant.	Shrinkage about 2 per cent on one application.	Increase in weight averages about 41.9 per cent.	Lines contained heavy growth of hydroids and barnacles; preservative seems to have no antifouling quality.	24 to 36 hours required for drying.	Black.	No value as a preservative for fresh water.
Gilsonite.	Slight immediate decrease followed by rapid decrease during time of exposure; poor preservative.	Resistance to mechanical wear very good when freshly treated, but this quality soon disappears when the line is exposed.	Causes a little immediate stiffening and grows gradually stiffer for about 4 weeks; about like tar.	do.	Increase in weight 46 per cent.	Lines exposed for short time are laden with heavy growth of hydroids and barnacles.	Requires but little time to apply, but is rather slow drying; about 24 hours required.	do.	Not tried in fresh water.
Tanning extract (quercitron) with potassium bichromate as a mordant (copper omitted).	No immediate change in tensile strength; little change noticed on Key West and air conditions lines, but strength decreased rapidly on Beaufort lines; poor preservative as used.	Very poor.	Flexibility of line little affected.	Considerable shrinkage as compared to most other treatments, this line showing 3.48 per cent decrease in length on one application.	Very little increase in weight; about 10 per cent.	Lines carried heavy growth of hydroids and barnacles.	Two treatments with the extract and one treatment with the mordant; about 24 hours required for entire process, including time of drying.	Brown.	No experiments.
Dutch method.	Practically no immediate change; experimental lines at all places endured 6 months with some tensile strength remaining; good preservative, especially for cotton lines.	Poor.	Flexibility of line very little affected.	Shrinkage comparatively large, as with most preservatives applied hot; decrease in length 3.6 per cent on one application.	Increase in weight 20 per cent.	Not much fouling after 5 months' exposure in sea water at Beaufort, N. C.	Time required same as that of tanning extract listed above.	Dark brown.	Better in fresh water than in salt water for cotton, but not as good as copper oleate for linen in fresh water.
Copper oleate-tar combinations.	Slight immediate decrease followed by marked increase which remains quite constant through long exposure; strength after 6 months unimpaired.	Is exceeded only by the white untreated line; wearing qualities excellent even after long periods of exposure.	Depends on percentage of tar used; where 50 per cent of tar is used the flexibility is about equal to that of copper paint; after 2 or 3 months' exposure it becomes very much more flexible than copper paint.	Shrinkage very little, about 0.5 per cent.	Great increase in weight; about 60 per cent.	No fouling in any experiments.	24 to 30 hours.	do.	Preserving effect on 6 months' exposure same for fresh and salt water.

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O

AQUATIC PLANTS IN POND CULTURE.[1]

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CONTENTS.

POND CULTURE AND ITS APPLICATION.

Among the fresh-water fishes most desirable for food purposes and for sport-fishing there are certain species, such as the basses, crappies, sunfishes, and catfishes, that are not susceptible to manipulation for the taking and impregnation of their eggs, but must be allowed to mate and select nests, on which the spawn is deposited, fertilized, and hatched in the natural way. For the cultivation of these species, therefore, it is necessary to provide surroundings fulfilling their requirements, and at the same time permitting control of the fish, which purpose is accomplished by the maintenance of natural or artificial ponds. These ponds are stocked with the maximum number of adult fish, and the young hatch in numbers abnormal for the volume of water in which they are contained, there to be reared for a few weeks or months and then distributed to other waters as desired. The pond itself affords sustenance to

[1] Appendix II to the Report of the United States Commissioner of Fisheries for 1923. B. F. Doc. 948. The first edition of this paper, Bureau of Fisheries Document No. 643, was published in 1909, and various reprints have been issued.

the young, and therefore the pond is the direct object of attention in order to produce the maximum number of fish. Fish culture under these conditions is consequently intensive pond culture, and in the United States the term "pond culture" distinguishes this branch of fish culture from the propagation of all fishes whose eggs can be expelled and fertilized artificially or which are incubated in hatching houses by the use of special apparatus and equipment. The species to which it is applied are chiefly the black basses, crappies, sunfishes, and catfishes.

The propagation of the Salmonidæ, notably the trouts, approaches pond culture in the fact that several species are often reared in ponds, whereas the other fishes hatched in special equipment are usually distributed as fry as soon as the yolk sac is absorbed. However, although the cultivation of the trouts in this country may require ponds in which to rear the young, the different service the ponds perform and the different management required place American trout-rearing methods outside the proper definition of pond culture.[2] In Europe the case is not wholly similar; although in a few instances American methods have been adopted, the term "pond culture" usually embraces the rearing of trout by much the same methods as are in the United States pursued only with fishes that can not be artificially spawned; that is, the young trout may not be fed artificially but often subsist in large part upon the natural food supply induced by culture of the ponds.

IMPORTANCE OF AQUATIC PLANTS IN POND CULTURE.

Since the young of the species of fishes to which pond culture is applied in the United States can not be successfully confined in the troughs or small ponds of the American trout breeder and do not accept artificial food, they must depend for sustenance upon minute forms of animal life found in the waters and upon one another. At a very tender age they develop cannibalistic tendencies, and even where there is apparently an abundance of natural food they may reduce their own numbers 60 to 80 per cent within a month or six weeks from the time of hatching. It is therefore necessary in pond culture to provide not only sufficient natural food to satisfy the physiological requirements of the young fish, but, so far as possible, an abundance that will divert them from the tendency to devour one another.

[2] It may not be amiss here to point out the distinction between trout culture by American methods and pond culture proper by reference to the procedure and the conditions at an American trout hatchery. Trout are not dependent upon natural food and do not require a natural environment. It is customary to rear them in wooden troughs or in small rectangular ponds of earth, wood, or concrete, through which there is a constant flow of water containing no visible plant or animal life. The water supply may come directly from a spring or from an artesian well. At many of the most successful commercial trout establishments in the United States the troughs and rearing ponds are supplied with water from artesian wells from 25 to 100 feet in depth. As the daily feeding of a large number of fish in a confined area necessitates frequent cleaning, any seeds or spores of vegetation introduced by the water supply have little or no opportunity to obtain a foothold. The trout fry will eat artificial food from the time the yolk sac has been absorbed, and by a judicious arrangement of troughs, tanks, or small ponds the trout raiser can maintain a very large number of fish within a comparatively small compass until they are of satisfactory size for distribution or for market. His dependence is artificial food or the artificial introduction of natural food, and without these means he would be powerless to conduct operations on an extensive scale. In American trout culture aquatic vegetation, so essential in pond culture, is but a negative factor.

Through the necessity for natural food, then, comes the primary importance of aquatic plants in pond culture. All animal life is dependent, directly or indirectly, upon plant life, the minute forms as well as many of the larger feeding directly upon plants, and the herbivorous species in turn serving as food for the carnivorous. In the beginning the young fishes feed upon water lice, nymph larvæ, and other minute forms. As they develop in growth they feed upon small crustaceans, insect larvæ, and other forms that are not ordinarily abundant except in an environment with abundant vegetation. Aquatic plants are therefore the food-producing agency in pond culture and are accordingly indispensable. It is also obvious that by a judicious selection of plants the quantity of food can be maintained at the maximum, with corresponding results in the production of young fish.

It is the consensus of opinion among pond culturists that plants are essential also for the proper aeration of the water. At a trout hatchery the fish are supplied with the necessary air by means of a constant flow of water; in pond culture the volume of water supply is often little, if any, more than enough to compensate for evaporation and leakage, and the oxygenation from this source is limited. The balanced aquarium is a well-recognized illustration of the value of plants as oxygenators. Although there are many factors entering into the aeration of the waters at a pond-culture station that do not apply to the balanced aquarium, and it may be assumed that the larger the body of water the more must other factors than those of the balanced aquarium be considered, there can be no doubt as to the rôle of vegetation in the aeration of shallow ponds of limited area.

It is perhaps superfluous to add that submerged plants bind the bottom soil together, thus acting as a deterrent to turbidity from that source; and that plants doubtless facilitate clarification when the water of a pond has become turbid with surface drainage after a rain or from other external causes of a temporary character. As an evidence of this the numerous reservoirs or "tanks" in the West, which are devoid of vegetation and in which the water is constantly roiled, may be cited. It is possible that in some instances the absence of vegetation is due to the constantly roily water, a condition elsewhere referred to; but control tests in aquaria demonstrate that in an aquarium containing Cabomba the water is clarified much more quickly than in one in which there is no vegetation.

Some other advantages of aquatic plants that are of more or less importance may be mentioned, such as shade, shelter from predacious birds, and refuges for the smaller fishes from the larger ones and from each other. The ornamental feature of some plants in some places is of minor importance from the viewpoint of the fish-culturist, but all of these have been given consideration.

OBJECTIONABLE ASPECTS OF POND VEGETATION.

Notwithstanding their essential importance in fishponds, however, and the careful effort requisite to the securing of suitable vegetation, in one aspect nearly all aquatic plants are to the pond culturist wholly a nuisance and a necessary evil. The seining of the ponds, to obtain the young fish for distribution to waters they are intended to stock, or for other purposes, can not be accomplished while thick plant growth is present to entangle the fish and interfere with the operation of the seine, and there is thus a periodical necessity of clearing away or at least reducing all gross vegetation. This process is laborious and expensive; the cost of operating a pond-culture station is, in fact, largely the cost of this periodic clearance of the ponds and varies with the characteristics of the predominating species of plants. Methods in practice at several stations are described in a later portion of this paper.

Particular kinds of vegetation may be objectionable also in specific ways other than with reference to the difficulties of removal at seining time. Large-leaved plants may offer too much shade to permit other plants and the requisite animal life to thrive; plants of persistent growth may take possession of the ponds and crowd out species more desirable; or plants not in themselves objectionable may not be desired because other obtainable plants are more desirable for the same qualities. The question becomes one of control. Wherever there is soil bottom vegetation is voluntary, springing up immediately even in artificial ponds, and any attempt to prevent the entrance by natural agencies of water plants common to a region is fraught with much the same difficulties that are encountered in the attempted exclusion of weeds from a garden. It remains to secure the balance that will bring the conditions nearest to the ideal.

AQUATIC PLANTS AT THE POND-CULTURE STATIONS OF THE BUREAU OF FISHERIES.

With its wide geographic range the Government work in pond culture naturally embraces a variety of conditions and affords interesting and profitable comparisons. The climate, the quality and temperature of the water, the character of the soil, as well as other factors, make the management of each pond-culture station a separate problem. The inevitable dependence upon a natural food supply for the young fish, however, concentrates the efforts in such work about the great factor of vegetation and, next to water supply, makes the selection and control of aquatic plants in ponds the most important question with which the pond culturist has to contend. The popularity of the basses, crappies, and sunfishes, moreover, and the feasibility of increasing their numbers by cultivation make pond culture a subject of especial interest to people everywhere in the United States, and the Bureau of Fisheries is constantly receiving inquiries and requests for information. The following notes are therefore thought to have interest and value not only to the professional fish-culturist but to the public generally. They represent efforts to collect specimens of all the aquatic plants found at the various pond-culture stations of the bureau, with observations of the respective superintendents as to the particular value of the desirable species and the objectionable characters of the undesirable. It is hoped thus to aid in determining the relative value of each, or at least to afford data that will be useful in future work, at the same time emphasizing the fact that present knowledge of the subject is all too limited. These notes are not based upon biological or other scientific investigation, but are gained from the observations and experience of practical fish-culturists. They are presented, moreover, as pertaining only to the particular field of pond culture conducted by the bureau. Their application beyond this is yet to be determined.

It may be assumed that all aquatic plants harbor a certain amount of minute animal life. In the following descriptions, therefore, the term "food producer" is applied to plants conspicuous for the large quantity of small animal forms living or breeding thereon. The term "oxygenator" is applied to plants believed to be especially useful in keeping water in a proper condition by throwing off oxygen. The word "shelter" is applied to plants that afford the small fish a hiding place and protection from the large ones and serve as an aid to the prevention of cannibalism among the fishes. The term "ornamental" is used to designate those plants that extend above the surface and beautify the ponds. The depth of water in which the plants are found as here mentioned applies to the ponds of the respective stations in question. It is recognized that some of the plants thrive in much deeper ponds and lakes. In most instances the plants described under the various station heads are indigenous, having appeared voluntarily. There are no records to show to what extent plants have been introduced, but undoubtedly some of the more desirable plants have been introduced, largely through transfer from one station to another.

Common names of the plants are given, but as these are often of restricted local application the botanical nomenclature also is used, and for more ready identification figures have been inserted for almost every species. All but one of the cuts are copied from Britton and Brown's Illustrated Flora of North America. The figure of Chara is taken from the Text Book of Botany by Strasburger, Noll, Schenk, and Schimper. The geographical range of the respective species likewise is taken from these authorities.

For the identification of a large number of these plants the bureau is indebted to Messrs. J. N. Rose and G. H. Shull, of the United States National Herbarium, Smithsonian Institution, and also to the division of botany, Department of Agriculture.

COLD SPRINGS, GA.

At this station the water supply comes from a large spring, and the maximum water temperature is about 82° F. The water contains only a trace of lime, and as a result some difficulty has been experienced in stocking the ponds with aquatic plants, but efforts in this direction have resulted as follows, as reported by a former superintendent:

For ponds with fairly fertile bottoms with an admixture of muck and clay, the foxtail (*Myriophyllum spicatum*) excels all other species. It makes an ideal growth, affords abundant cover for the fish and for the minute life upon which the fish feed, and is apparently a good oxygenator. At the same time it offers but little obstruction to seining operations owing to its slender, feathery growth. Even for ponds having rich muck bottom it has been found most satisfactory, though in such ponds considerable work is required to remove it when preparing for seining.

For ponds with sterile bottoms of clay, sand, or gravel, where foxtail will not thrive, parrot-feather (*Myriophyllum proserpinacoides*) attains an excellent growth and affords abundant lodgment for minute aquatic life and for the alevins; it also provides a sufficient amount of shade for the brood fish and suitable cover for their nesting places. Large-mouthed black bass seem to prefer the fibrous roots of these plants to all other nesting materials. Both plants disappear from the warmest parts of the ponds by midsummer and are replanted in the fall or following spring. Near the inflow, especially of ponds that are abundantly supplied with water, the plants thrive throughout the year. The parrot-feather is more susceptible to high temperatures than the foxtail. These two plants have proved so

FIG. 1.—Spiked water milfoil (*Myriophyllum spicatum*). Found in deep water, Newfoundland to Manitoba and the Northwest Territory, south to Florida, Iowa, Utah, and California. Commonly known as foxtail. (After Britton & Brown.)

FIG. 2.—Chilean water milfoil (*Myriophyllum proserpinacoides*). Native of Chile, introduced in various localities in the United States, where it is known chiefly as "parrot-feather." (After Britton & Brown.)

satisfactory at Cold Springs that there has seemed little occasion to experiment with other species.

FISH LAKES, WASHINGTON, D. C.

Although the Fish Lakes at Washington are no longer maintained, observations upon the characteristics of the plant life are valuable for purposes of comparison. The bottoms of the ponds were of dark fertile soil, the maximum water temperature was about 87° F., and the plant growth was extremely dense. Whether the elimination of some of this luxuriant growth would have resulted in a decrease in the production of young fish is theoretical. This station had been in operation nearly 30 years, and the lakes contained an unusually large number of plants when these observations were made.

The hornwort (*Ceratophyllum demersum*) is especially good as a food producer and shelter, is fairly good for shade, is a good oxygenator and a good aquarium plant, has little root anchorage, and will grow over hard bottom. It is found in 2 to 4 feet of water, extending to the surface, but not above it. It was considered the best plant in the ponds.

Fanwort (*Cabomba caroliniana*) also is especially good as a food producer, as a shelter, and for aquarium work, and is given second place. It is regarded as a good oxygenator and as fairly good for

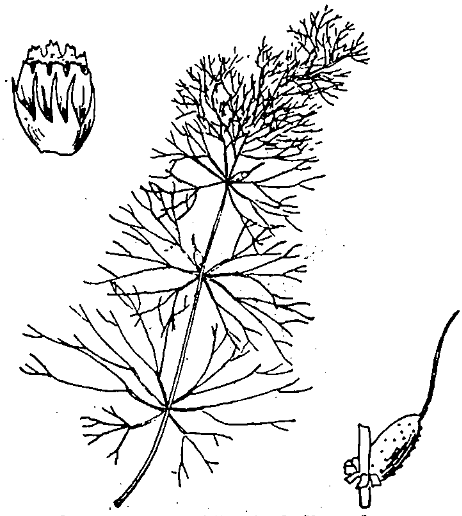

FIG. 3.—Hornwort (*Ceratophyllum demersum*). Found in ponds and slow streams throughout North America, except extreme north. (After Britton & Brown.)

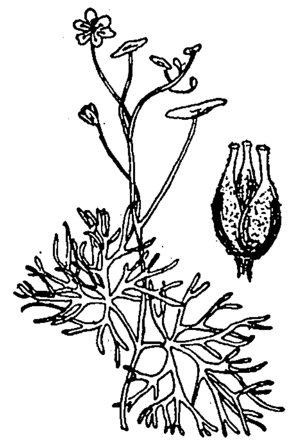

FIG. 4.—Fanwort (*Cabomba caroliniana*). Found in ponds and slow streams, southern Illinois to North Carolina, south to Florida and Texas. (After Britton & Brown.)

shade and, like the hornwort, has little root anchorage and will grow on hard bottom. It is found in 1 to 4 feet of water and extends nearly to the surface.

FIG. 5.—Curled-leaved pondweed (*Potamogeton crispus*). Found in fresh, brackish, or even salt water, Massachusetts to Pennsylvania and Virginia. Also in Europe. (After Britton & Brown.)

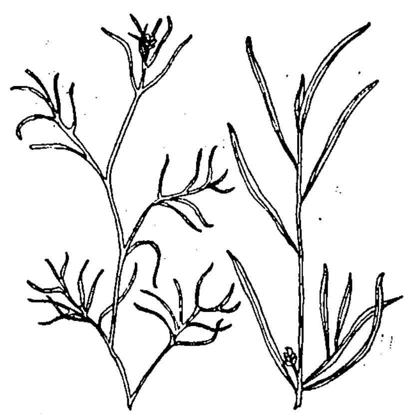

FIG. 6.—Leafy pondweed (*Potamogeton foliosus*). Niagara Falls to Michigan and California. (After Britton & Brown.)

The curled-leaved pondweed (*Potamogeton crispus*), a good food producer, oxygenator and aquarium plant, good for shelter, shade, and ornament, is one of the earliest plants to put forth shoots, and is therefore valuable for early spawning fishes, such as the goldfish and carp. It is found in 2 to 5 feet of water, reaching to the surface.

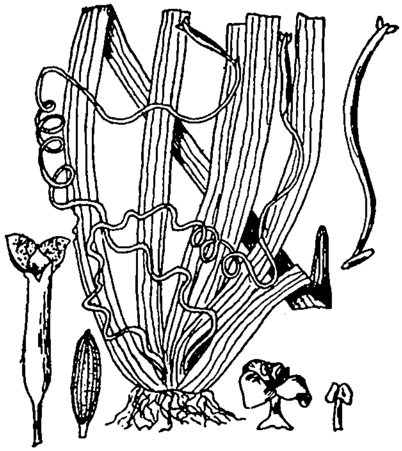

FIG. 7.—Wild celery, or eelgrass (*Vallisneria spiralis*). In quiet waters, New Brunswick to Florida, west to Minnesota, Iowa, and Texas. (After Britton & Brown.)

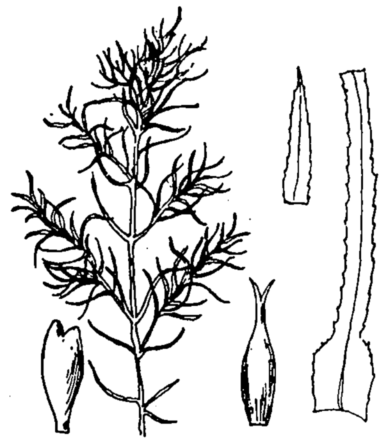

FIG. 8.—Slender Naias (*Naias flexilis*). Found in ponds and streams throughout nearly all North America. (After Britton & Brown.)

Another Potamogeton (*foliosus*), the leafy pondweed, also good as a food producer and oxygenator and for shelter, is found in 2 to 4 feet of water, extending to but not above the surface.

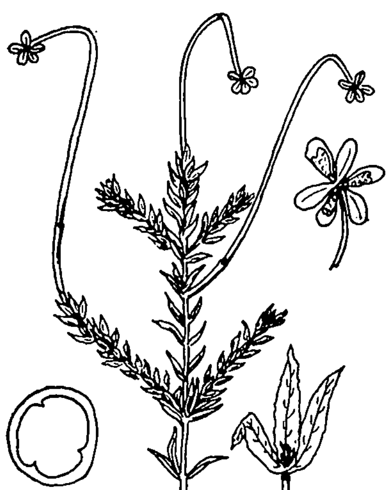

FIG. 9.—Waterweed (*Philotria canadensis*). Found nearly throughout North America, except extreme north. (After Britton & Brown.)

FIG. 10.—Water stargrass (*Heteranthera dubia*). Found in still water, Ontario to Oregon, south to Florida and Mexico. Also in Cuba. (After Britton & Brown.)

The wild celery, or eelgrass (*Vallisneria spiralis*), is found to be a good oxygenator and is a desirable plant because of its early growth. It is also good for shade and shelter and is an excellent aquarium plant. It is found in 2 to 4 feet of water, extending to but not above the surface.

The slender naias (*Naias flexilis*), which is a good food producer, is good for shelter, is regarded as a fair oxygenator, is somewhat ornamental, and is a fairly good aquarium plant.

The six plants so far mentioned have been listed in the order of esteem as held by the superintendent of the Fish Lakes. The remainder of the list for this station does not follow any particular order, but, as before, the good or bad qualities the superintendent believed the plants to possess are noted in each case.

The waterweed (*Philotria canadensis*), which grows in 2 to 4 feet of water, extending to, but not above, the surface, is a good food producer and a good oxygenator, is good for shelter, and is valuable

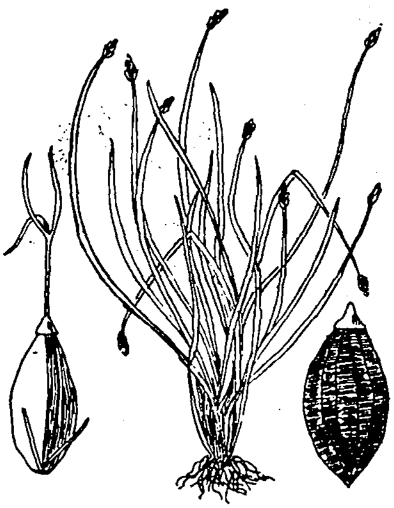

FIG. 11.—Needle spike-rush (*Eleocharis acicularis*). Found in wet soil throughout North America, except in extreme north. Also in Europe and Asia. (After Britton & Brown.)

FIG. 12.—Tuberous white water lily (*Castalia tuberosa*). Lake Champlain west through Great Lakes to Michigan, south to Trenton, N. J., Meadeville, Pa., and eastern Nebraska. (After Britton & Brown.)

for its early growth. It also makes a good aquarium plant, but is dangerous in ponds, however, owing to its dense growth.

Water stargrass (*Heteranthera dubia*) has the same merits as the waterweed, being a good food producer, fair oxygenator, and excellent for the shelter it affords and for its early growth. It is found in water 1 inch to 4 feet deep.

The needle spikerush (*Eleocharis acicularis*) is of very little value except for its early growth. The fine, smooth culms are very easily cleaned by the large-mouthed black bass, which cast their spawn upon them.

One of the water lilies (*Castalia tuberosa*), which furnishes shade and shelter, is ornamental and of value because of its early growth. It serves as a good protection to young fish from predacious birds.

Floating heart (*Limnanthemum nymphæoides*), although but fairly good as a food producer, is excellent for shade, shelter, and ornament and is fairly hardy.

The fennel-leaved pondweed (*Potamogeton pectinatus*) is somewhat objectionable on account of its excessive growth. It is, however, a good food producer and a fair oxygenator and is fairly good for shelter. It is found in 1 to 4 feet of water.

The pickerel weed (*Pontederia cordata*), found in 6 to 12 feet of water, is not especially valuable in fish culture, although it has some merit for ornamental qualities, for shade, and for shelter. It is not thought to be a good oxygenator or food producer.

The two duckweeds (*Spirodela polyrhiza* and the more common *Lemna minor*) are not highly esteemed, though not especially objectionable. The larger form is quite ornamental, and both are of early growth. For fish-cultural purposes, however, their poor qualities as food producers and oxygenators make them insignificant.

The water clover (*Marsilea quadrifolia*) is excellent for shade and shelter and is ornamental and of early growth. It is objectionable

FIG. 13.—Water lily, or floating heart (*Limnanthemum nymphæoides*). Naturalized in ponds, District of Columbia. Native of Europe and Asia. (After Britton & Brown.)

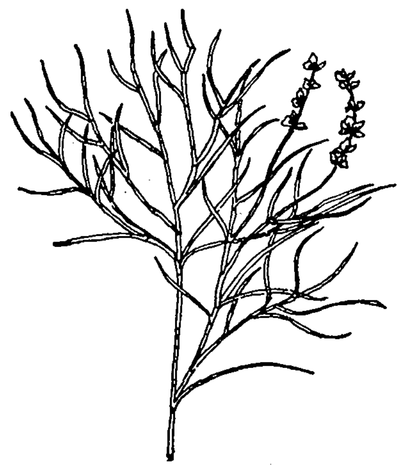

FIG. 14.—Fennel-leaved pondweed (*Potamogeton pectinatus*). Found in fresh, brackish, or salt water, Cape Breton to British Columbia, south to Florida, Texas, and California. Also in Europe. (After Britton & Brown.)

in shallow ponds, however, completely covering the surface to a depth of about 2 feet.

At this station the limeweed (*Chara*) is valued as a food producer, harboring the small forms that are especially good as food for young fish, and as an oxygenator it is found remarkable. It is fairly good for shelter and as an aquarium plant.

The spatterdock (*Nymphæa advena*) is valued chiefly as an ornament and for the shade and shelter it affords. It is also of early growth, but it is a poor food producer on account of its long, smooth stems, which do not provide favorable breeding places for insect larvæ or other minute animal life. It is found in 1 to 4 feet of water.

The long-leaved pondweed (*Potamogeton lonchites*) does not rank with the two other Potamogetons mentioned here, being but fairly good in any of the important respects.

The water chestnut (*Trapa natans*), though fairly good as a food producer and for shelter, shade, and ornament, is of negative value in fish culture.

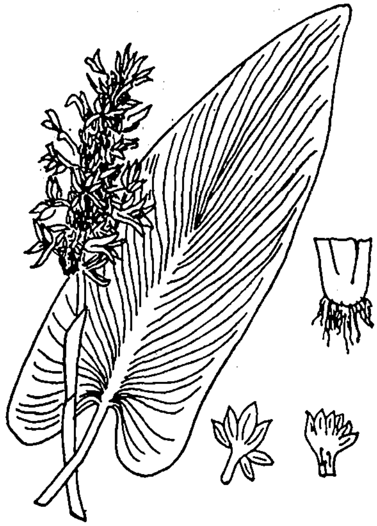

FIG. 15.—Pickerel weed (*Pontederia cordata*). Borders of ponds and streams, Nova Scotia to Minnesota, south to Florida and Texas. (After Britton & Brown.)

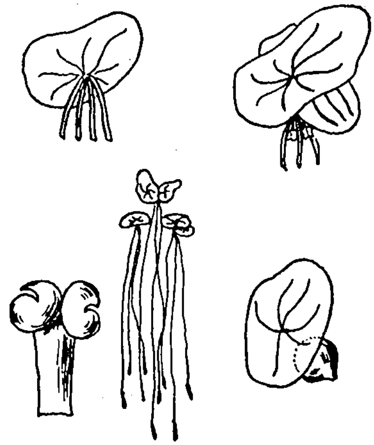

FIG. 16.—Greater duckweed (*Spirodela polyrhiza*). Found in rivers, ponds, pools, and shallow lakes, Nova Scotia to British Columbia, south to South Carolina, Texas, northern Mexico, and Nevada. Widely distributed in the Old World and tropical America. (After Britton & Brown.)

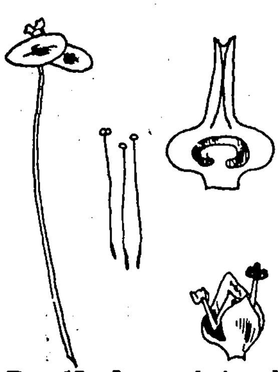

FIG. 17.—Lesser duckweed (*Lemna minor*). Found in ponds, lakes, and stagnant waters throughout North America below 58° N. lat. Also in Europe. (After Britton & Brown.)

FIG. 18.—Water clover (*Marsilea quadrifolia*). Found along the shores of Bantam Lake, Litchfield County, Conn., whence it has been introduced into various parts of the country, notably eastern Massachusetts. Native of Europe and Asia. (After Britton & Brown.)

The lotus (*Nelumbo lutea*) is troublesome to the pond culturist, having bulbs extending 3 feet into the mud and being accordingly difficult to remove when not desired. It is, however, very ornamental, good for shade, and fairly good for shelter.

Had it been possible the waterweed, the water chestnut, the fennel-leaved pondweed, the duckweeds, and the water clover would have been eradicated. In ponds maintained for angling, however, rather than for propagating purposes, these plants should not prove unde-

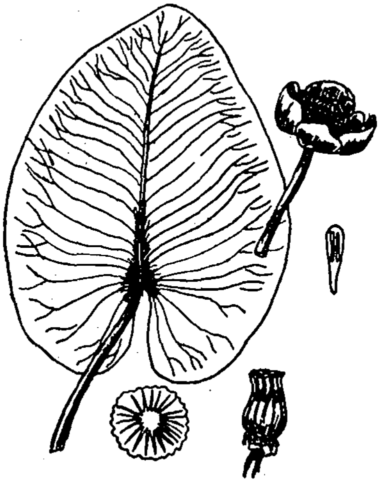

FIG. 19.—Large yellow pond lily (*Nymphæa advena*). Found in ponds and slow streams, New Brunswick and Nova Scotia to Rocky Mountains, south to Florida, Texas, and Utah. Called also spatterdock. (After Britton & Brown.)

FIG. 20.—Long-leaved pondweed (*Potamogeton lonchites*). Found in ponds and slow streams, New Brunswick to Washington, south to Florida and California. (After Britton & Brown.)

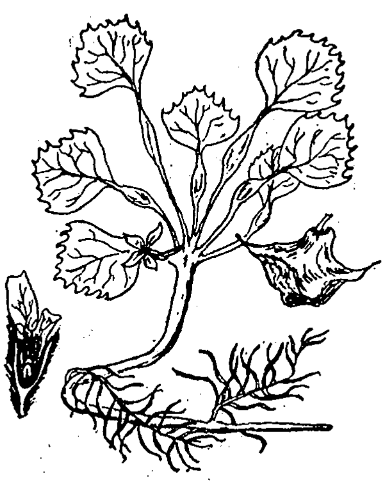

FIG. 21.—Water chestnut (*Trapa natans*). Naturalized in ponds, eastern Massachusetts and near Schenectady, N. Y. Native of Europe. (After Britton & Brown.)

FIG. 22.—Lotus (*Nelumbo lutea*). Found locally in Ontario and southward to Florida, west to Michigan, Indian Territory, and Louisiana. (After Britton & Brown.)

sirable except in depths of less than 4 feet; though not without due consideration of local conditions should the fennel-leaved pondweed and the water clover be introduced, owing to their dense growth at the surface even in deep water.

WYTHEVILLE, VA.

Here the pond bottoms consist of a rich loam to a depth of 12 inches, and the range in water temperature during the summer months is from 70 to 85° F. The following list of plants gives the opinion of a former superintendent as to their respective qualities and characteristics. The preceding lists have not included semi-aquatic or border plants, but arrowhead (*Sagittaria longirostra*) and water plantain (*Alisma plantago-aquatica*) are given an important place among the plants at this station. A more careful investigation may lead to the conclusion that certain semiaquatic plants are equal in value to some of their exuberant companions of the deeper water.

The curled-leaved pondweed (*Potamogeton crispus*, fig. 5) is considered the most desirable plant at this station. Its roots are on

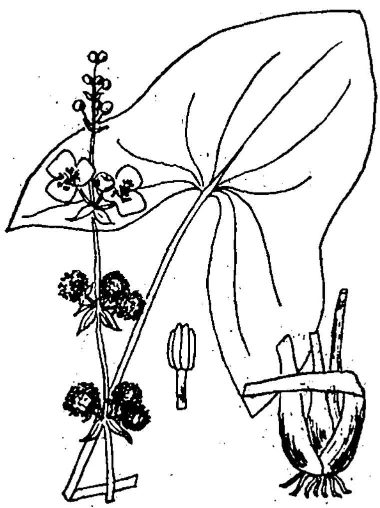

FIG. 23.—Long-beaked arrowhead (*Sagittaria longirostra*). Found in swamps and along ponds, New Jersey and Pennsylvania to Alabama. (After Britton & Brown.)

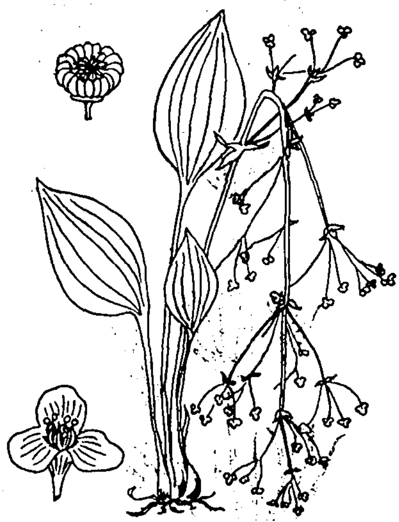

FIG. 24.—Water plantain (*Alisma plantago-aquatica*). Found in shallow water or mud throughout North America. Also in Europe and Asia. (After Britton & Brown.)

muck bottom in water up to 6 feet deep, and it throws up a slender stalk about 2 inches above the surface, on the tip of which is a small white blossom. The plant grows luxuriantly both in summer and winter and flourishes in both cold and warm water ponds. It furnishes abundant shade and protection and is a good breeding place for aquatic insects. It is also easy to control and can be removed from the ponds without injury to the fish. Its only objectionable character is that where the soil is fertile it grows more luxuriantly than is desirable.

The waterweed (*Philotria canadensis*, fig. 9) exhibits the same characters here as at the Fish Lakes station, but is more highly esteemed, being given second place.

The parrot-feather (*Myriophyllum proserpinacoides*, fig. 2), rooting in muck bottom in water up to 6 feet deep, reaches to the surface and throws up a slender stalk about 2 inches above, with a small white blossom at the tip. Because of its value as a shade for fish and as a breeding place for aquatic life this plant is ranked third in importance at this station. It is also an excellent plant for aquaria.

The arrowhead (*Sagittaria longirostra*) is but semiaquatic, but forms a valuable shade and shelter for the young fish. It can also be removed easily and is not difficult to control. It usually roots in soft clay up to 2 feet and throws up a slender stalk with white blossoms above the surface. The leaves are killed by the first frost, and the plant branches out from the rootstocks in the spring.

The water plantain (*Alisma plantago-aquatica*) is another border plant, being found about the edges of ponds in water only 4 to 6 inches deep, its leaves floating on the surface. It is valuable for the same characters exhibited by the arrowhead.

The Chara at this station is a large form with long, slender internodes, growing in all ponds, whether they are fed by spring or creek water. It is an excellent food producer, but grows so densely that the fish can with difficulty get through it, and it is so heavy that it will not float when cut loose from the bottom. When a pond is drawn, it settles down like a blanket, entangling the young fish so that it must be picked over by hand in order to extricate them. Its objectionable characters, in fact, are so great that it is only by comparison and on negative grounds that its merits are admitted by the superintendent.

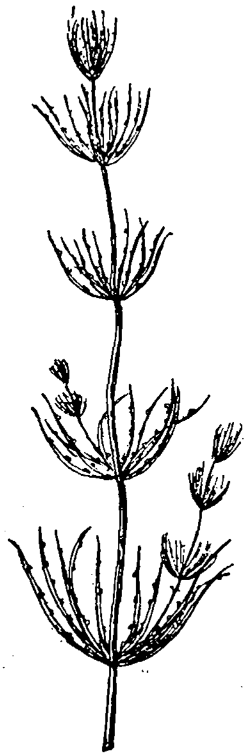

FIG. 25.—*Chara fragilis.* A common form of Chara. (After Strasburger, Noll, Schenck, & Schimper.)

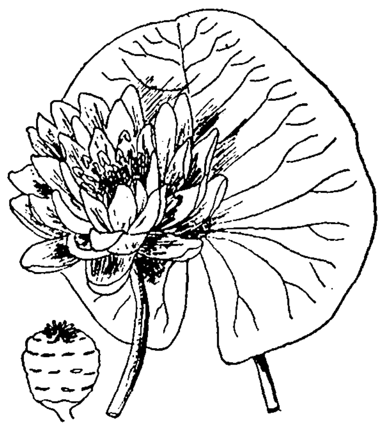

FIG. 26.—Sweet-scented white water lily (*Castalia odorata*). Found in ponds and slow streams, Nova Scotia to Manitoba, south to Florida and Louisiana. (After Britton & Brown.)

A number of years ago the ponds at Wytheville were well stocked with curled-leaved pondweed, waterweed, and limeweed, with a few water lilies (*Castalia odorata*) scattered here and there; but water lilies increased from year to year until they took complete possession of several of the ponds. They became so dense as entirely to exclude the light from the ponds, and in consequence all the submerged plants, including the Chara, were killed, leaving nothing below the lily pads for the protection of the young fish. During the period when Chara was present in great abundance and was regarded as a nuisance and the lily as a desirable plant, some of the bass ponds annually yielded an average of about 25,000 young fish each, but after the lilies took the place of all other plants the annual production dwindled to less than 2,000 fish to a pond. One is therefore forced to the conclusion that the water lily is a dangerous plant, especially in ponds having soft, fertile bottoms, and that without the submerged plants successful bass culture is impossible. By contrast, Chara, with its merit of being an excellent food producer, comes into better esteem in spite of its objectionable qualities.

NORTHVILLE, MICH.

At the Northville (Mich.) station Chara took possession of the ponds almost immediately after completion. A few other plants have obtained a foothold, but not in appreciable quantities. The ponds are devoted to the production of small-mouthed black bass, and the results have been quite successful. A former superintendent stated that he knew of no other plant than Chara so productive of fish food of the sort acceptable to the young bass, and the objectionable characters of the plant did not, in his opinion, offset its merits.

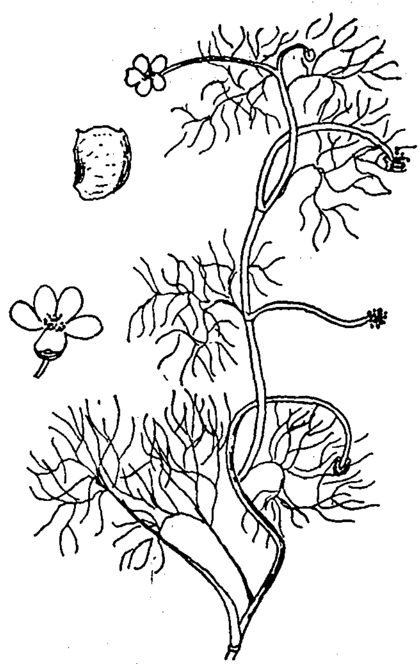

FIG. 27.—White water crowfoot (*Ranunculus aquatilis*). In ponds and streams, Nova Scotia to British Columbia, south to North Carolina and California. Also in Europe and Asia. (After Britton & Brown.)

MAMMOTH SPRING, ARK.

At the Mammoth Spring (Ark.) station, established in 1905, a portion of the bottoms of three ponds is composed of a heavy muck—the remains of an old swamp bed—and in these portions there immediately sprang up Chara, Elodea, *Ranunculus aquatilis*, Ceratophyllum, Myriophyllum, and Potamogeton, the relative abundance of each being in about the order named. The entirely new ponds and those parts of the others newly excavated are of a clay and gravel mixture. It appears from the report of the first superintendent that an attempt was made the first two seasons to establish *Ranunculus aquatilis* and Elodea in these latter, but that they were crowded out by Chara, with results in all ways satisfactory. The superintendent had no preference for any particular plants.

At this station, on April 30, 1908, a pond 18,000 feet in area was stocked with 20,000 (actual count) small-mouthed black bass fry. On

June 24, eight weeks later, there were removed from this pond 6,000 fingerlings, ranging in length from 3 to 4 inches. The rapid growth and large number of fingerlings reared is attributed to the presence of exceptional quantities of small amphipod crustaceans (Gammarus), which are a valuable fish food; and the abundance of this food, although attributable to the quality of the water, seems to be dependent also upon the presence and character of the aquatic vegetation.

The present superintendent believes that of all of the plants above mentioned Myriophyllum has proved to be the most satisfactory. "Its growth is abundant and the stalk being rather tender it is easily removed from the ponds with rakes or grass hooks attached to long handles, whenever it is desired to prepare for seining operations. After a pond has been allowed to season this plant is easily reestablished by simply covering a handful of the stalks with a shovel full

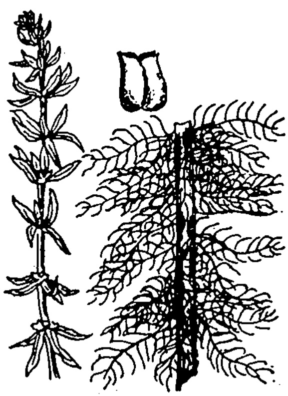

FIG. 28.—Various-leaved water milfoil (*Myriophyllum heterophyllum*). Found in ponds, Ontario and New York to Florida, Texas, and Mexico. (After Britton & Brown.)

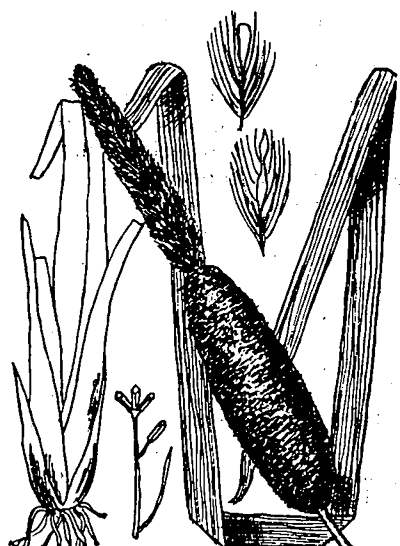

FIG. 29.—Cat-tail (*Typha latifolia*). Found in marshes throughout North America, except in extreme north. Also in Europe and Asia. (After Britton & Brown.)

of earth at intervals of from 3 to 6 feet. If this is done in the late summer or early fall, there is a fine stand of vegetation by the following spawning time in March and April." While some of the other plants are still there, he would prefer the one species only.

SAN MARCOS, TEX.

At the San Marcos (Tex.) station one of the milfoils (*Myriophyllum heterophyllum*) is preferred to all other water plants. A former superintendent stated that here some of the water lilies, Chara, and the cat-tail (*Typha latifolia*) would, if permitted, crowd out all other plants of value. He regarded frogbit (*Rhizoclonium horsfordi*), because of its exuberant growth, as the most objectionable of all the plants found in the pond. He believed water plants essential in pond culture, but suggested that ponds be constructed with sand and gravel bottoms with the view to keeping them free of all aquatic vegetation, except in selected places where the plants were to be walled in with concrete, the walled-in portions to be filled in with earth of the richness required by the plants selected.

At the Mill Creek station of the Michigan Fish Commission for the propagation of both large-mouthed and small-mouthed black bass Chara is the principal plant, and it is quite satisfactory to the superintendent as a food producer. At one time, he asserts "the Potamogeton drove Chara out and I could not raise 100 fish where before the Chara went I could raise 1,000."[3]

RÉSUMÉ OF OBSERVATIONS.

The various estimates of the commoner plants as found at the different stations, together with the differences in condition and environment, make generalization difficult. The foregoing observations seem to show, however, first of all that the fish-cultural value of a species is chiefly a matter of the growth it attains. Its merits as food producer, shelter, and oxygenator are determined by the kind and quantity of its foliage, stems, and roots, and so likewise are its demerits, few plants being objectionable in themselves for any reason other than growth that is overabundant or overpersistent.

The growth of plants, however, being a matter of environment, depends chiefly, in the case of rooted species, upon the character of the bottom soil. Species most desirable in one locality may be obnoxious in another where by reason of the fertile soil the growth becomes dense and difficult to control. In his paper entitled "The biological relation of aquatic plants to the substratum" Dr. Raymond H. Pond[4] shows by experiment that *Vallisneria spiralis*, *Ranunculus aquatilis tricophyllus*, *Elodea canadensis*, *Myriophyllum spicatum*, *Potamogeton obtusifolius*, and *P. perfoliatus*, hence probably all rooted aquatics, are for optimum growth dependent upon their rooting in the substratum, and his conclusions are abundantly confirmed by observations in the ponds here described. It would seem, however, that his application of the fact to fish culture might be put differently. Although it is true that good soil is to be sought, it should be added that for very rich soil it is important to avoid, if possible, plants with a tendency to rankness.

The quality of the water is a factor that may entirely control the conditions of fish culture. At Cold Springs, Ga., where the water is soft, it is impossible to obtain a permanent growth of vegetation, and the ponds must accordingly be restocked from time to time. Two species of Myriophyllum are the only plants that have been successfully maintained through a season. It sometimes happens also that even with exuberant vegetation there is a dearth of animal life, and this might be ascribed to some property or deficiency of the water, just as is the abundance of certain amphipods and other crustaceans that are an important food for young fish, these forms being known to thrive and multiply best in water containing lime.

[3] Dwight Lydell in Transactions of the American Fisheries Society for 1905, p. 198.
[4] Report U. S. Fish Commission 1908 (1905), pp. 483–526.

A further quotation from Doctor Pond, in reference to Ceratophyllum, is of interest in this connection. This nonrooted plant he shows to be dependent primarily upon the nutrient salts in solution in the water, and thus a competitor of many of the small forms of life which derive their sustenance from the same source. A pond filled with Ceratophyllum, therefore, would be expected to contain fewer of these forms and, consequently, of the forms that live upon them. From this it would seem to follow that the water best suited to Ceratophyllum would not contain sufficient food for young fish if that plant were the predominant species, and if this reasoning is correct the value of Ceratophyllum would depend upon the presence of sufficient rooted vegetation to offset the effects of competition. Such may have been the conditions at the Fish Lakes, where there were an unusually large number of species of rooted plants, above all of which, however, the superintendent believed Ceratophyllum to be the best.

No particular species of aquatic plant can be said to be always desirable. The endless interrelations of plant and animal life and physical surroundings make the problem a special one for each locality. It should be noted, however, that according to the data here presented great caution should be used as to the introduction of pondweeds, waterweed, water clover, water lilies, frogbit, and cat-tail. The last two can not be regarded as desirable in any fishpond. Chara, indigenous at some stations, is in most cases so much in favor as a food producer that, notwithstanding its objectionable characters, it is considered the best plant for fish-cultural purposes. It should be borne in mind, however, that at the stations where this plant is a favorite the ponds are of more recent construction than at Wytheville, for instance, where Chara became especially troublesome.

The introduction of the water lily (*Castalia odorata*) into the ponds at Wytheville, with the result of apparently crowding out two other aquatic plants, and the somewhat similar experiences at San Marcos, Tex., and at Mill Creek, Mich., suggest that the partial elimination of one species by the introduction of another may at times be advantageously attempted, and that with a full knowledge of the effects of given combinations of species a desirable balance of vegetation could be maintained by this means. This question also, however, enters the broad field of plant physiology.

Heretofore some of the lower forms of vegetation, algal growths, frequently described as "frog spittle," "water moss," and "slime," have entered into pond culture only as an element of water supply, their effect upon fish life being regarded as negligible. Observations [5] of Dr. Emmeline Moore, in behalf of the United States Bureau of Fisheries, demonstrate that this view as to the value of some species of algæ is entirely erroneous, and that in the early stages of the young fishes—particularly the first two or three weeks—their food consists largely of animal life whose food during the same period consists largely of certain species of algæ. This opens a broad field of investigation. The spirogyra, so obnoxious to the fish-culturists, is not included in Doctor Moore's list of food-pro-

[5] Dr. Emmeline Moore: The Food Which is Eaten by the Food Which the Fish Eat. Paper read at the Forty-ninth Annual Meeting of the American Fisheries Society, Louisville, Ky., Oct. 10, 1919.

ducing algæ, but it has been generally recognized by fish-culturists that spirogyra is an oxygenator. Further investigation may show that all of the algæ contribute to the sustenance of young fish. The recognized food-producing value of some species of algæ suggests great possibilities in supplying food to the young fish during the first two or three weeks, and especially so at pond-culture stations like the one at Bullochville, Ga., where the water is so soft that it has been difficult to maintain an adequate amount of plant life. A definite knowledge of the relations of all of the various species of algæ to fish production is much to be desired.

METHODS OF CONTROLLING AQUATIC VEGETATION.

ELIMINATION OF UNDESIRABLE PLANTS.

Plants that are in themselves objectionable should, of course, be eliminated for all time. There is, however, no known method of eradicating the higher forms of vegetation from ponds without destroying the fish, unless it be possible first to draw off the water. When this is done, certain forms of plants die from exposure and the roots of others can be grubbed out. Cat-tails have a root stalk habit of growth. If the plants are constantly cut, the root stalks will become weaker and weaker due to the loss of the food manufacturing leaf surface. If constant cutting is persisted in, the root stalks will starve out after two seasons.

In view of their recently recognized importance as food producers, it may be assumed that, until seining operations commence, the presence of certain species of algæ will be encouraged, and that in fishponds generally the removal of algæ will not be attempted until after the young of basses or sunfishes are a month old. However, there are times and places where it is desirable to destroy the more obnoxious forms, and this may be accomplished by means of copper sulphate, according to the method of Moore and Kellerman for the disinfection of municipal water supplies.[6] This method has been successfully adapted, not only to pond culture but also to waters containing trout, as is set forth in a report of experiments at the White Sulphur Springs station of the Bureau of Fisheries.[7] The latter application of the method is of especial interest, for the reason that trout are more than ordinarily susceptible to the toxic properties of copper.

CHECKING SUPERABUNDANT OR UNDESIRED GROWTH.

To prevent superabundance of some vegetation or to make less objectionable the presence of troublesome species that can not be eradicated, it is sometimes desired to check the growth of the plants. Mr. Kellerman states, in a letter, that in water not unusually hard the waterweed (*Philotria canadensis*), Chara, and several species of Potamogeton may be considerably checked in growth by treating the

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[6] Moore and Kellerman: Copper as an Algicide and Disinfectant in Water Supplies. Bulletin 76, Bureau of Plant Industry, Department of Agriculture. (See p. 12.)

[7] Marsh and Robinson: The Treatment of Fish-Cultural Waters for the Removal of Algæ. Bulletin, U. S. Bureau of Fisheries, Vol. XXXVIII, 1908 (1910), part 2, pp. 871–890.

water with copper sulphate in the proportion of 8 pounds to 1,000,000 gallons of water. In limestone regions, however, or where the water contains a large amount of organic matter, the proportion of copper must be increased, and the method is then not applicable to fish culture because a solution of the necessary strength is fatal to most fishes. It is doubtful if any fish-culturist has attempted to retard the growth of plants by this method.

It is possible to retard the growth of plants in small ponds by keeping the mud thoroughly stirred up. Submerse plants require light in order to thrive. The result is analogous to natural conditions in streams like the Potomac River during seasons of frequent heavy rains, when the water is almost constantly roily and in consequence the growth of vegetation very much less exuberant than in dry seasons, when the water is comparatively clear. In ponds where much mud is carried in and held for a considerable length of time in suspension the growth of both algæ and the higher plants is rendered practically impossible. The same variations in vegetable growth are noticeable where suction dredges have discharged their mud into streams formerly clear. This means—roiling of the waters—has been used with success in small natural ponds maintained for other purposes but is not known to have been applied to pond culture.

Experience at various pond-culture stations shows a carp to be quite efficient in checking the growth of vegetation if given access to it early in the spring before it becomes excessive. At the Fish Lakes station several carp were placed in one of the partitions of a bass pond containing *Ceratophyllum demersum*, *Philotria canadensis*, *Potamogeton pectinatus*, *Potamogeton foliosus*, *Vallisneria spiralis*, and Nymphæa. When the pond was drawn in the fall, the bottom in this partition was absolutely destitute of any kind of vegetation. The following season carp were not introduced into this pond, and the aquatic growth became as abundant as formerly. Observations at the Erwin station in one of the large ponds where a number of adult carp were confined revealed a great scarcity of aquatic growth, although similar ponds adjoining, which contained bass and other fish, were well supplied. The plants most abundant in this pond were *Philotria canadensis* and *Potamogeton crispus*.

At the Cold Spring Harbor State fish hatchery on Long Island the water supply is taken from a long, narrow pond which collects the springs in the immediate vicinity. For many years a number of carp have been confined in this supply pond for the purpose of keeping it free from vegetation, especially algæ, with very satisfactory results. In this instance it was particularly objectionable because it clogged the screens in the hatching troughs.

The introduction of carp into breeding ponds with other fish is, however, inadvisable for various reasons, the one of present concern being that carp work chiefly on the roots of plants and in mud-bottom ponds keep the water constantly roiled, a condition unfavorable to the breeding of all pond fishes with the possible exception of the crappie. It is very probable, moreover, that the roiliness of the water is itself partly responsible for the retardation of vegetable growth now credited to the presence of carp.

FIG. 30.—Pond after water has been drawn off and the Chara raked into piles.

REMOVAL OF VEGETATION TO PERMIT SEINING.

For the removal of vegetation in ponds preliminary to the periodical seining operations the pond culturist must depend upon mechanical methods of clearing away the foliage. It is customary to begin the removal of the young fish for distribution soon after their yolk sac is absorbed, or after the fry have been feeding but two or three weeks. At this season the growth of vegetation is not so exuberant as later in the summer, and the first crop of fish may sometimes be collected by seining around the edges of the ponds without the preliminary clearing away of the vegetation. Often, however, the shallower portions of the ponds must be cleared before even the first crop of fish can be removed. Later the fish will have sought the deeper portions, from which they can not be removed without first drawing off the water. In the latter process the foliage, if left, would settle down as the water diminished, entangling the young fish or smothering them, and it is accordingly necessary to clear away the plants before drawing off the water. The methods of removing the foliage are thus reduced to a mowing process under water, varied and adapted as conditions and circumstances may demand and ingenuity may devise. The methods and apparatus here described have been employed at pond-culture stations but are also applicable to natural ponds where the character of the bottom permits of seining operations.

At the Fish Lakes station the removal of the aquatic foliage was accomplished by mowing with ordinary scythes such as are used in a hayfield. The shallower portion of a pond was mowed first, and the water was then partially drawn off, so that it did not reach above the armpits of the mowers, its average depth being from 3 to 4 feet. The cut foliage rose to the surface and was carried to the shore in boats.

When it is desired to transfer young fish from the ponds at Northville, Mich., the slash boards are removed from the overflows and the water drawn down. As it recedes from the banks a few feet, men rake the Chara into piles, taking care that no young fish are destroyed in the operation, and continue this process until all the water and young fish are confined to the kettle of the pond. It was formerly customary to remove the vegetation by the use of teams, but experiments show that if left exposed for two weeks the Chara settles and finally disappears after the pond has been refilled. The presence of this decaying vegetation ought to stimulate the breeding of more or less insect life for young fish to feed upon.

The method of separating plants and young fish at the Mill Creek station of the Michigan Fish Commission is described by the superintendent, in substance, as follows: A space 10 feet wide around the pond is first cleared of foliage with a common iron-toothed garden rake, a piece of galvanized-wire netting of one-fourth-inch mesh being fastened to the back of it to prevent its becoming entangled in the weeds. (Any tinsmith can solder the wire cloth to the iron back.) After this has been done a homemade rake is used to remove the foliage from the deeper water of the pond. The rake is of rude construction, consisting of a cedar pole 8 feet long and 4 or 5 inches in diameter, provided with teeth 6 inches apart and 12 inches long, made of oak or some similarly strong material. At a proper angle with the teeth are two handles about 20 inches in length, inserted as shown in Figure 31. The handles of an old plow can be utilized for the purpose. A crotch line is attached to the ends of the rake, which is operated by three men, one with waders, who stands between the handles and manipulates the implement, and two on the shore to pull it. A fourth man looks over the weeds, sorts out the fish, and pitches the growth upon the bank as it is brought ashore. When not loaded, the rake is easily floated out into the pond. To rake the bottom, the operator sometimes must put his hands and arms under water; and as he wades out with the rake he determines by the density of the moss how far it is necessary to go to secure a rakeful. Ordinarily this is about 20 feet beyond the area that was cleaned with the hand raking, but farther if the weeds are not thick. The rake is moved through the weeds slowly to allow the fish to escape, but on reaching the open space made by the garden rake it can be moved more rapidly, so that as it comes ashore, with water rushing around either end, any fish that may be ahead of it will usually escape into the pond. The few that may become entangled are

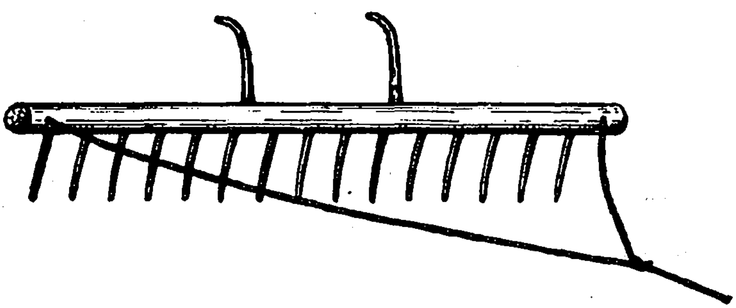

FIG. 31.—Rake devised by Dwight Lydell, and in use for removing vegetation at the Mill Creek station of the Michigan Fish Commission. (For description see text.)

released by swift handling of the weeds as they are brought ashore. After the first raking is completed a seine is used to remove all fish that may be in the cleared space. Then the rake is used again farther out in the pond, the process being repeated until the pond has been thoroughly cleared of vegetation or the desired number of fish have been obtained.

At the Wytheville station a boat is employed in the removal of the aquatic vegetation from portions of the pond where the growth is most dense. Fastened to each end of the boat is a cleat, through which is a hole about 2 inches in diameter, or of sufficient size to hold a stake loosely fitted in it, the stakes being driven into the bottom of the pond for the purpose of holding the boat steady while the vegetation is being pulled by the rakes. The loosened mass is then loaded into the boat. After the pond bottom has been gone over in this manner the sluices are opened, and men following the water as the pond is drawn pull by hand the remaining vegetation and stack it in piles. If any patches of Chara are found where the fish are apt to lodge, these are reached with rakes and thinned to release the fish. After the fish have been removed and while the pond bottom is still wet the piles of Chara are removed to the shore with pitchforks. In the removal of such plants as water lilies, rushes, cat-tails, etc., the ordinary scythe is used, but this method is resorted to as little as possible because of the tracks made in the bottom of the pond and the muddying of the water.

At the Mammoth Spring station the method of drawing ponds and removing vegetation is somewhat similar to that pursued at Northville. If it is desired to remove fish less than 2 inches in length, all of the vegetation is raked out upon a raft and poled to the bank for subsequent removal by horse and wagon. If larger fingerlings are in the pond, the vegetation is first cleared as thoroughly as possible by a similar method from a space about 100 feet in diameter around the outlet drain. A channel is then cleared from the outlet of the pond to its inlet. Ordinarily this preliminary work requires the services of two men to each pond for two days. The ponds range from three-fourths to 1¼ acres in area. On the third day the water is drawn down to the cleared space near the outlet. As it recedes the Chara is raked into windrows, the men working in from 1 to 2 feet of water, thus keeping a clear channel ahead of the water line. Windrows are preferred to stacks, because the fish have a means of retreat through the channel formed between the rows.

Four or five men are engaged in the work at pond-drawing time. Perhaps by 3 p. m. of the third day the water will have been drawn down to the "kettle," the 100-foot cleared pool. If the pond contains adult fish, they are at this time removed by sweeping a coarse-meshed seine through the pool. The following morning the water temperature and other conditions are favorable for the removal of the fingerling stock.

A raft is preferred to a boat, because it will carry a large load of vegetation and the water quickly drains from it. It is homemade, 12 by 16 feet. The outer framework of 2 by 12 inch planks is fastened together by 6-inch bolts and then the inner planks are slipped into place. The raft is supported by six 10-gallon iron-bound kegs wired to the framework. The round holes in the center of each end plank are for the insertion of stakes to hold the raft in place while loading.

The claim of superiority of a raft over the boat ordinarily used for the same purpose seems well founded and leads to the suggestion that a shallow scow of dimensions to suit conditions, with deck and side rails, would also allow the water to drain off as the deck is loaded with vegetation and would be more easily handled. Rapid movement in the comparatively small ponds of the fish-culturist not being essential, trucks might be attached to the bottom of the scow for convenience in drawing it ashore or from one pond to another.

At the San Marcos station the removal of aquatic vegetation is accomplished with an ordinary scythe, the men going into the water and cutting the growth as closely as possible. For cutting the heavier vegetation at a distance from the embankments a scythe is sometimes attached to a piece of three-quarter-inch iron piping from 10 to 30 feet in length, the latter being spread at the end to hold the shank of the scythe, which is riveted to it with two small bolts. Hand rakes, especially made from 4-tined hayforks, are then used, care being taken to examine each rakeful of foliage for young fish. An especially made iron rake shown in Figure 32 has also proved a very effective implement. The main bar, 3 inches in diameter and 8 feet long, is set with 15 teeth 15 inches long and forms the diagonal of a square frame, at the two remaining corners of which is fixed an iron ring. With a strong rope through each ring, the rake is drawn from one side of the pond to the other, making an 8-foot swath. Two men are usually required on each side of the pond to manipulate the rake.

At the Cold Springs (Ga.) station there is but one pond in which vegetation (Myriophyllum) is sufficiently dense to necessitate its removal prior to seining for the young fish. In this pond it grows

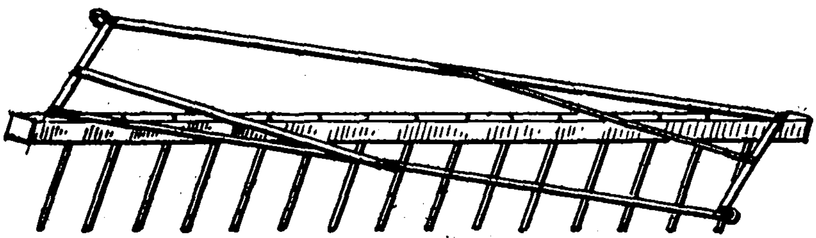

FIG. 32.—Iron rake in use at San Marcos (Tex.) station. (For description see text.)

exuberantly from bottom to surface and is removed by the use of a wire, about the size of a telegraph wire, loaded with weights and pulled through the pond much as a seine is hauled, except that it is jerked vigorously from side to side. In this way the tender growth of the Myriophyllum is easily severed. It is then dragged ashore with a long rake similar to the one in use at San Marcos.

Owing to the necessity for periodically removing the aquatic foliage at pond-culture stations and the expense involved in the present methods of performing this task, it is obvious that here also is a field for experimentation, but that in this, as in other efforts of the fish-culturist to effect economies, each station has its own problems.

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ARTIFICIAL PROPAGATION OF WHITEFISH, GRAYLING, AND LAKE TROUT.[1]

By GLEN C. LEACH, *Assistant in Charge of Fish Culture.*

CONTENTS.

THE WHITEFISH.

RANGE.

The common whitefish (*Coregonus clupeaformis*) is eminently a lake fish. It exists throughout the Great Lakes region and is especially abundant in Lakes Erie, Huron, Michigan, and Superior. The eastern limit of its range is Lake Champlain, and it is found in Lake Winnipeg, and possibly farther west. It is landlocked in Otsego Lake, N. Y. Efforts to introduce it into new waters in the States of the Pacific coast have not been successful. It has been established in Flathead Lake, Mont., Lake Coeur d'Alene, Idaho, and possibly other waters in the Rocky Mountains.

DESCRIPTION.

The body of the common whitefish is rather long and compressed, and the back, especially in adults, is arched in front; the greatest depth is about one-fourth the body length. The head is small and

[1] Appendix III to the Report of the U. S. Commissioner of Fisheries for 1928. B. F. Doc. No. 949. This document represents a revision and enlargement of the chapters on "The Whitefish," "The Graylings," and "The Lake or Mackinaw Trout" from A Manual of Fish-Culture, Based on the Methods of the United States Commission of Fish and Fisheries, with Chapters on the Cultivation of Oysters and Frogs, revised edition, published in 1900.

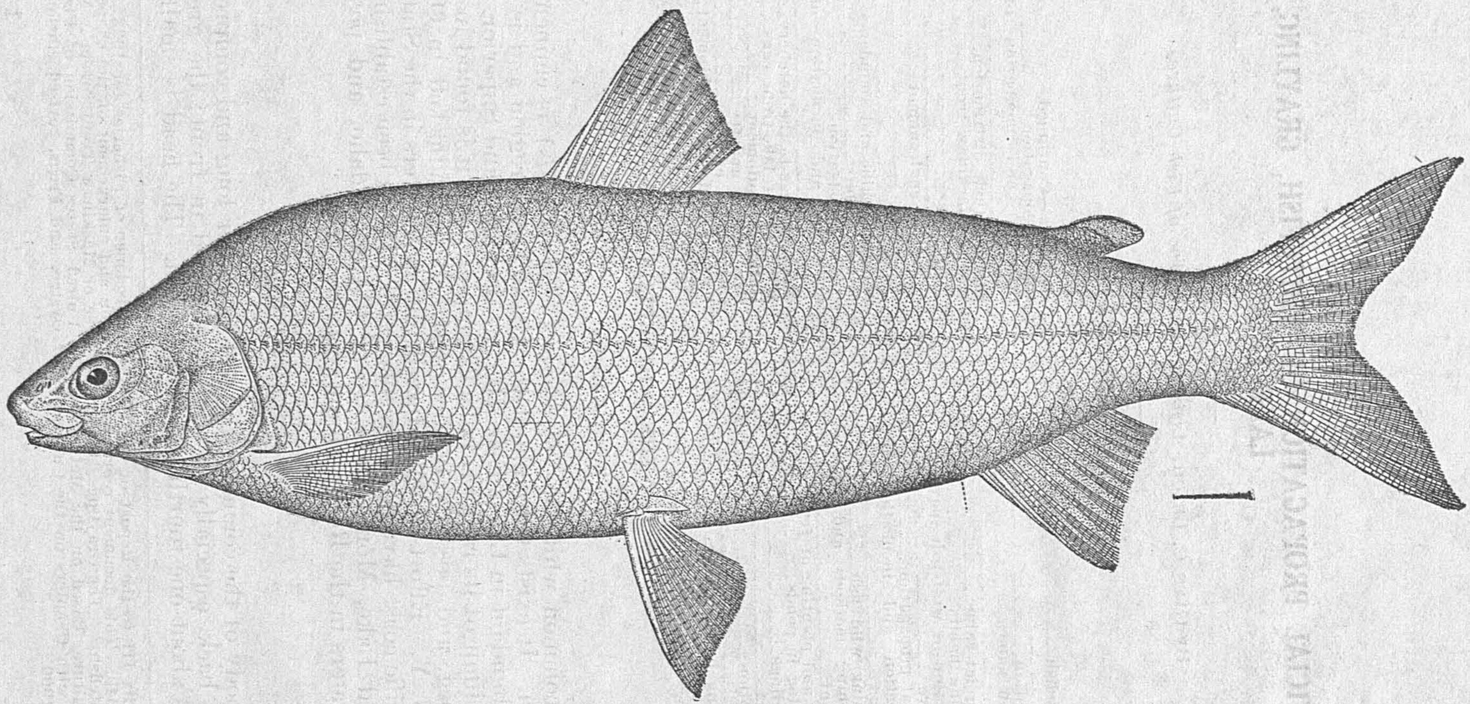

FIG. 1.—Common whitefish, *Coregonus clupeaformis*.

short, contained about five times in the length of the body; the snout is blunt; the mouth is small and nearly horizontal with the lower jaw included; the maxillary is short and broad, reaching to a point near the pupil; the mandible extends to a point under the posterior edge of the eye. The eye is small, its diameter being about one-fifth the length of the head. The rays in both the dorsal and anal fins number 11. The number of rows of scales along the side of the body varies from about 82 to 92, with about 11 above the lateral line and 8 below. The gill rakers number about 28, of which 10 are on the upper arm of the gill arch; the longest are contained about twice in the length of the eye. The general color of this fish is a satiny white, with a faint olive-green shade on the back. The fins are uniformly white, except the caudal, which normally has a dark edge.

COMMON NAMES.

This fish has a number of common names in different parts of its range. It is the whitefish par excellence of the United States and Canada. As found in Otsego Lake, N. Y., it is inappropriately called "Otsego bass." In allusion to its humped back it is called "high-back whitefish," "bowback whitefish," "buffalo-back whitefish," and other similar names in Lake Superior.

HABITS.

Although more is known of the habits of this species than of any other member of the group, many phases of its life are still obscure, as it remains in deep water most of the time. Besides the regular annual movements of the schools to the spawning grounds there are other well-marked migrations in some lakes. Whether these depend on food, temperature, enemies, or other causes is not known. Owing to its small, weak mouth, it is seldom taken with a baited hook. It subsists on minute animal food, chiefly crustaceans, mollusks, and insect larvæ. The food of the fry and young fish is almost wholly small crustaceans.

COMMERCIAL VALUE.

The whitefishes are by far the most important group of fresh-water fishes of North America, probably of the world. The common whitefish is the best of the tribe, but some of the others nearly equal it in merit, and all are more or less esteemed as food. The common whitefish reaches a larger size than any other species of whitefish in the United States. Examples weighing over 20 pounds have been taken, but the average weight is under 4 pounds. Among the fishes of the Great Lakes the common whitefish ranks next in value to the ciscoes and the lake trout. In 1917 the catch in the United States amounted to about 6,288,000 pounds, having a value of $731,519. If to this is added the yield of ciscoes and other species of whitefish, the aggregate is over 54,000,000 pounds, having a value of nearly $2,600,000. The market value of the whitefishes taken in 1920 in the British Provinces was reported as $1,315,932, a sum representing about 20,356,000 pounds.

Whitefish fishing is done chiefly with gill nets set at or near the bottom in comparatively deep water, although considerable quantities of whitefish are also taken in pound nets, trap nets, and seines. A very large part of the catch reaches the market in a fresh condition, although considerable quantities formerly were salted. The leading centers of the trade are Chicago, Detroit, Sandusky, Cleveland, Erie, and Buffalo, whence the fish are shipped frozen or in ice to all parts of the country.

SPAWNING HABITS.

The spawning season of the whitefish in the western end of Lake Erie begins the early part of November and continues into December. At this season there is a general movement of the fish to shoal parts of the lakes, similar to the migration of anadromous fishes from the ocean to the rivers. Some of the foreign whitefish are typical anadromous species. After spawning the fish return at once to the deeper water.

The spawning habits of whitefish confined in pens have been observed. The fish rise to the surface, occasionally in pairs, and rarely in trios of one female and two males, the female emitting a quantity of spawn at each rise. The males, always the smaller fish, persistently follow the female and discharge milt at the same time the eggs are emitted.

Whitefish reach maturity in the third or fourth year. A full-grown specimen deposits from 10,000 to 75,000 eggs, depending on its size. A rule for determining the approximate spawning capacity is to allow 10,000 to 12,000 eggs for each pound of the fish's weight. The eggs are one-eighth of an inch in diameter and are of an amber color. They swell somewhat after impregnation. The number per quart varies from 36,000 in Lake Ontario to 40,000 in Lake Erie.

DESTRUCTION OF WHITEFISH SPAWN IN NATURE.

In nature the eggs of the whitefish are subjected to the attacks of many enemies for nearly five months. The mud puppy (*Necturus maculatus*), commonly known as "lizard" or "water dog" by the people along the lakes, is especially destructive. During the winter months many of these animals are pumped up with the water supply of the Put in Bay station. The stomachs of a considerable number of them contain whitefish and cisco eggs.

Another voracious destroyer of whitefish eggs is the common yellow perch (*Perca flavescens*). The deck of a boat has been seen covered with the eggs of whitefish and cisco pressed out of the stomachs of perch taken the last of November from gill nets on the reefs, where they had gone to feed on the eggs.

The various smaller Cyprinidæ and some other fishes, crawfish, and wild fowl make the eggs of fishes a considerable portion of their diet, and those eggs that require the longest period in hatching suffer most.

ARTIFICIAL PROPAGATION.

The artificial propagation of whitefish has long since passed the experimental state and has attained a high degree of perfection. The work can be carried on with great facility, and its value is especially apparent when it is considered that under natural conditions only a very small percentage of the eggs hatch, whereas

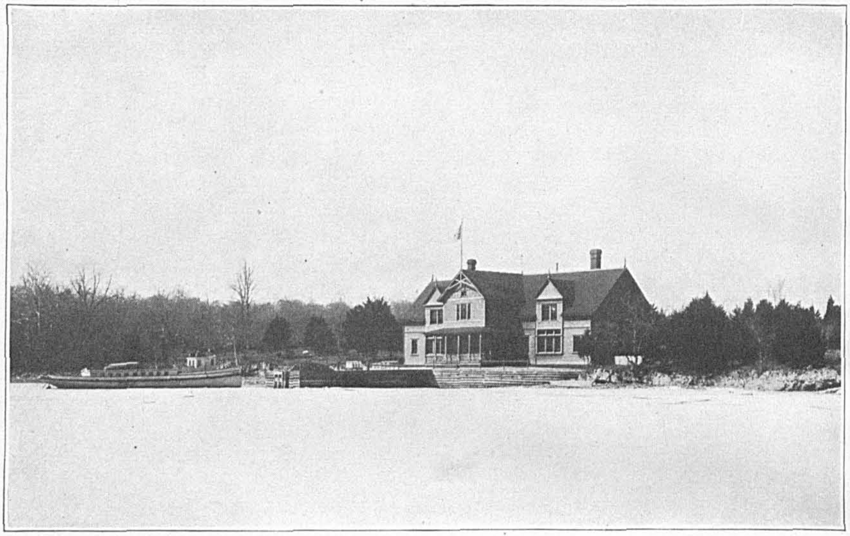

FIG. 2.—Put in Bay (Ohio) hatchery.

FIG. 3.—Collection of whitefish eggs, Put in Bay, Ohio.

through artificial propagation from 75 to 95 per cent are productive. Practically all the eggs taken for hatching purposes are obtained from fish caught by the commercial fishermen and otherwise would be lost or sent to market with the fish.

The methods of culture hereafter referred to are those pursued at the Put in Bay (Ohio) station, but they do not differ in any essential particular from those in general use. In the fiscal year 1921 the Bureau of Fisheries hatched and planted 420,450,000 whitefish fry.

COLLECTION AND INCUBATION OF EGGS.

The taking, impregnating, and handling of whitefish eggs are simple processes, though they require great care at every stage. Eggs are often injured by undue haste in stripping, and many are lost by allowing them to fall too great a distance into the spawning pan. The eggs are very delicate when first taken and before the absorption of water has made the investing membrane tense, and if roughly treated they will be seen to be ruptured as viewed under the microscope. With care about four-fifths of the eggs will hatch. While scarcity of milt may lead to nonfertilization of the eggs, the manner in which the milt is brought in contact with the eggs is a more common cause of failure.

The eggs supplied by each spawn taker should be examined daily. If it is found that a considerable number have ruptured yolks, it may be taken for granted that the spawn taker has handled the fish and eggs roughly, and if many are unimpregnated it is evident that he did not use sufficient milt, or that it was not properly applied to the eggs. Eggs or milt taken from fish that have been dead for any length of time should not be used.

At Put in Bay eggs are obtained from fish captured in pound nets and gill nets, often at considerable distances from the station. The spawn taker, who is employed to take the eggs from the fish as they are lifted from the nets into the boat, has with him two or three 6-quart pans, coated with asphaltum varnish to prevent rusting, in which he takes the spawn, a wooden keg or tin can holding from 10 to 15 gallons, a 10-quart wooden pail, and a tin dipper. He is clothed in waterproof garments, and his left hand is covered with a woolen mitten for convenience in handling the fish.

After several ripe females and some ripe males are collected a female is taken up and the body slime, which would interfere with impregnation if allowed to fall into the pan, is carefully removed. The spawn taker then grasps the fish firmly in his left hand just forward of the tail. The right hand is placed under the fish just back of the pectoral fins, and the fish is held firmly against the body, with the vent 4 or 5 inches from the bottom of the pan. This position of the fish's body brings pressure on the abdomen, facilitates the flow of the eggs through gravity, and prevents them from being injured by falling too far.

On applying a gentle pressure the eggs will flow in a steady liquid stream about a quarter of an inch in diameter, and a considerable portion of them can be ejected before the hand need be moved. As soon as the stream slackens the hand is moved slowly toward the vent, but only sufficiently to keep the eggs flowing steadily. When the stream finally stops, the hand is placed in its former position and the process repeated until all good eggs have been secured. If, as is frequently the case, a considerable number of white eggs appear when nearly all the ripe eggs have been emitted, the effort should cease.

In the dry process of impregnation, which is now generally conceded to be superior to the wet process of fertilization, the pan in which the eggs are taken is dampened by dipping it in water before stripping begins. After one or two females have been manipulated the milt from one or two males is added to the eggs, this being done by grasping the fish between the thumb and fingers 2 or 3 inches forward of the vent and moving the fingers toward the opening. The milt comes in a stream, an average fish yielding about a teaspoonful. If ripe males are scarce, the fish is laid aside, as a considerable amount of additional milt may be secured from it a few minutes later in case it is needed.

When the pan is one-third to one-half full of spawn and milt, the spawn taker stirs the eggs gently to incorporate them thoroughly with the milt, using for the purpose the tail of a fish from which the slime has been carefully removed. The pan is then partly filled with water and the mass stirred again very gently. After standing two or three minutes the water is poured off and fresh water added, this operation being repeated until the water flows off clear. The eggs are then poured into a keg or can that has previously been filled with water and the mass again stirred very gently. It is necessary to change the water on the eggs at least once an hour, oftener if the weather is warm, and they should be stirred gently to the bottom of the keg every 30 minutes until placed in running water in the hatchery.

After finishing his work the spawn taker delivers the eggs to the man in charge of field operations, who cares for them until the arrival of the collecting steamer, when they are taken on board and transported to the hatchery, some two to five hours having elapsed since they were taken. At the station the eggs are kept in the kegs in which they were placed by the spawn taker, and in the meantime the water is changed once every hour until the next morning, the mass being stirred to the very bottom whenever a change is made. In this way the eggs are hardened with less injury than would result if they were immediately placed in the jars.

Formerly, in shipping eggs from distant field stations, they were kept in running water in kegs, under the care of a watchman, but experience has demonstrated that it is much better to ship them in cases on trays. After being in water from 8 to 10 hours whitefish ova may be safely placed two or three layers deep on trays and shipped to an indefinite distance. If the air temperature is as high as 55 to 60° F., the case must be supplied with ice; if it is below 32° care must be taken to prevent freezing.

The field shipping cases are usually constructed of lumber three-fourths of an inch thick and of sufficient depth to hold 20 trays. The bottom tray and the top tray are not used for eggs. Cleats at the four inner corners hold the trays about 1¼ inches from the sides of the case.

A *tray board* is a convenience in spreading eggs on the trays. This consists of a smooth board some 4 inches greater in length and width than the egg trays, with a raised rim one-half inch high and water-tight. The tray is placed in the tray board, which has previously been filled with water. The eggs are poured on the partly submerged tray and at once spread evenly over its surface. For longer distances greater precautions must be taken and a packing case that has space for proper insulation and ice used. Several modifications of this type of case are in general use in fish-cultural work.

After the eggs are placed on trays and drained they are covered with a thickness of mosquito netting that has been well washed and left damp. If the eggs are to go by express, unaccompanied by a messenger, directions stating that they must be kept cool but not permitted to freeze are fastened to the case. Whitefish eggs, accompanied by an attendant, have been safely shipped from Northville, Mich., to Australia. Where eggs are to be shipped from one station to another, in care of a messenger, the regular field cases are used.

The trays used at the station are 18 inches square and are made of white pine ¾ by 1 inch, mortised together at the corners, with the widest side of the strip horizontal. Cheesecloth or linen scrim is tacked on the bottoms of these frames with galvanized or copper-coated tacks, the cloth being stretched very taut to prevent its sagging after being wet and dried. The tacks are spaced 2½ to 3 inches apart, so that in a year or two the cloth may be retacked between the spaces to take up the slack. As the trays are square, they fit into the cases either way, thus saving time in packing. Square cases are also more convenient to store and for general handling. One of these trays will hold 100,000 whitefish eggs.

Where the eggs have to be retained in the field for several days they are sometimes kept in floating boxes adapted for the purpose, but unless the conditions are very favorable it is far better to place them on trays, sprinkling them lightly once in two or three days. (See description of floating box on p. 23.)

When taken from the kegs and trays at the hatchery, the eggs are passed through a screen with meshes sufficiently large to permit the passage of a single egg in order to remove scales and other foreign substances that may be present. The screen is floated in a washtub partly filled with water, with the wire netting well submerged.

Wooden kegs are preferred to tin cans for handling eggs and fry, as their contents are not subjected to sudden changes in temperature and can be readily examined, and as the water can be more easily poured off without risking the loss of eggs. Kegs are also much lighter, cost only a sixth as much as cans, and last longer. For shipment in wagons or by rail, however, tin cans made with covers are indispensable. The kegs should be of white pine, made large enough to hold about 15 gallons, and painted on the outside but not inside. They should be provided with iron drop handles.

PENNING WILD FISH.

The uncertainty of climatic conditions and the liability of failure to obtain spawning fish during the severe storms occurring in November make it desirable, whenever practicable, to capture fish when the weather is favorable and place them in pens to ripen. If the fish are driven off their spawning grounds by heavy storms, they do not return in large numbers during the spawning season, and the only way to insure a satisfactory supply of eggs is to pen the fish. Penning has been abandoned in most of the Great Lakes fields, because most of the fish are taken by gill nets. Since pound nets are seldom used, the green fish can not be obtained. Most of the fishing boats take their own eggs and deliver them to the bureau's agent in charge of the field.

The pens are usually made about 16 feet long, 8 feet wide, and 5 feet deep and are placed end to end in two rows, with a plank walk between as a convenience in caring for them. A partition is placed in the center of each pen, dividing it into two compartments, each 8 feet square. In each compartment is a false bottom held down by two 2 by 4 pieces fastened to the sides. When the fish are to be removed the false bottom is raised and held at any desired height by inserting pins in the 2 by 4 pieces and the sides of the pens. The fish must be handled as little and as gently as possible, otherwise the eggs will form into a hard mass and never ripen. One cause of injury is the scoop net with which they must be handled, the knots and twine being so hard that they injure the delicate scales of the whitefish in their violent struggles when taken from the water.

Although crates or inclosures of wood construction have been very generally used by the Bureau of Fisheries for penning whitefish, retaining inclosures of cotton webbing are proving very satisfactory in Lake Ontario.

HATCHING METHODS AND EQUIPMENT.

The water supply in the hatchery at Put in Bay is obtained through a pipe extending 75 to 100 feet into Lake Erie, the water being elevated by pumps to supply tanks in the loft of the hatchery, whence it is distributed by the usual methods of piping. Two circular galvanized-iron supply tanks are used, each having a capacity of approximately 18,000 gallons. These tanks are necessary in order to give equal pressure in the pipes and to provide an even supply of water to the whitefish batteries. In the event of being obliged to suspend pumping operations for a short time, there will be sufficient water in the supply tanks to care for the eggs for a period of several hours. A float connected with the throttle valve of the pumps is so arranged in the tanks as to maintain a steady water level therein.

Whitefish eggs are hatched in the open-top McDonald, Downing, and Chase jars, the Downing and Chase jars being more generally used. On arrival at the hatchery the eggs are taken from the shipping-box trays and placed in tubs of water to harden. After remaining in the tubs from 12 to 14 hours, during which time the water is changed once an hour, the tub of eggs is placed on a movable stand and the eggs measured into jars by means of a dipper. The jar is first filled with water and a shallow funnel with an outlet extending well into the jar inserted, so that the water will stand as high in the funnel throat as possible. In this way the eggs are not subjected to a fall from the dipper to the jar.

From this stand the jars are passed to a man who sets them up on the battery. Tin tubes are placed in the jars and connected with faucets supplying the water by rubber tubes. In the battery described each jar on the top row is provided with a water supply of

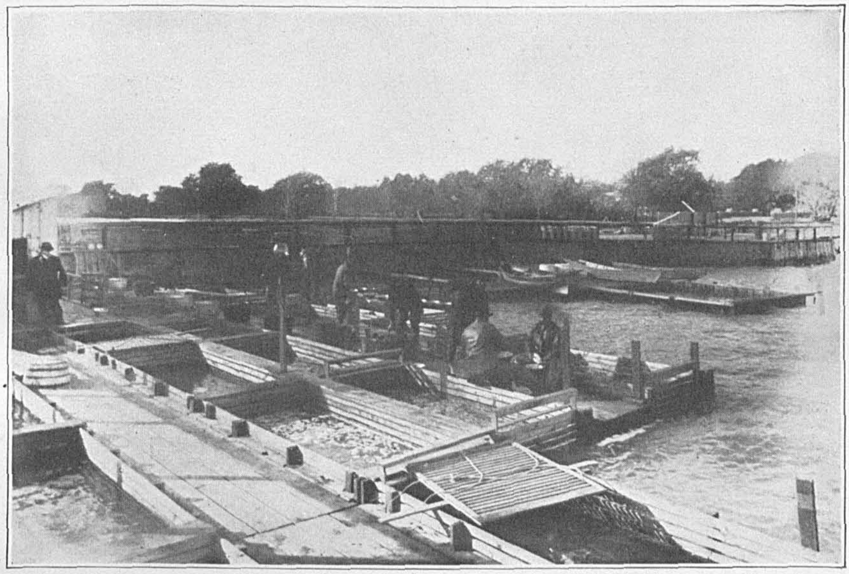

FIG. 4.—Pens used in holding whitefish, Put in Bay, Ohio.

FIG. 5.—Interior of Put in Bay (Ohio) hatchery showing whitefish troughs and battery.

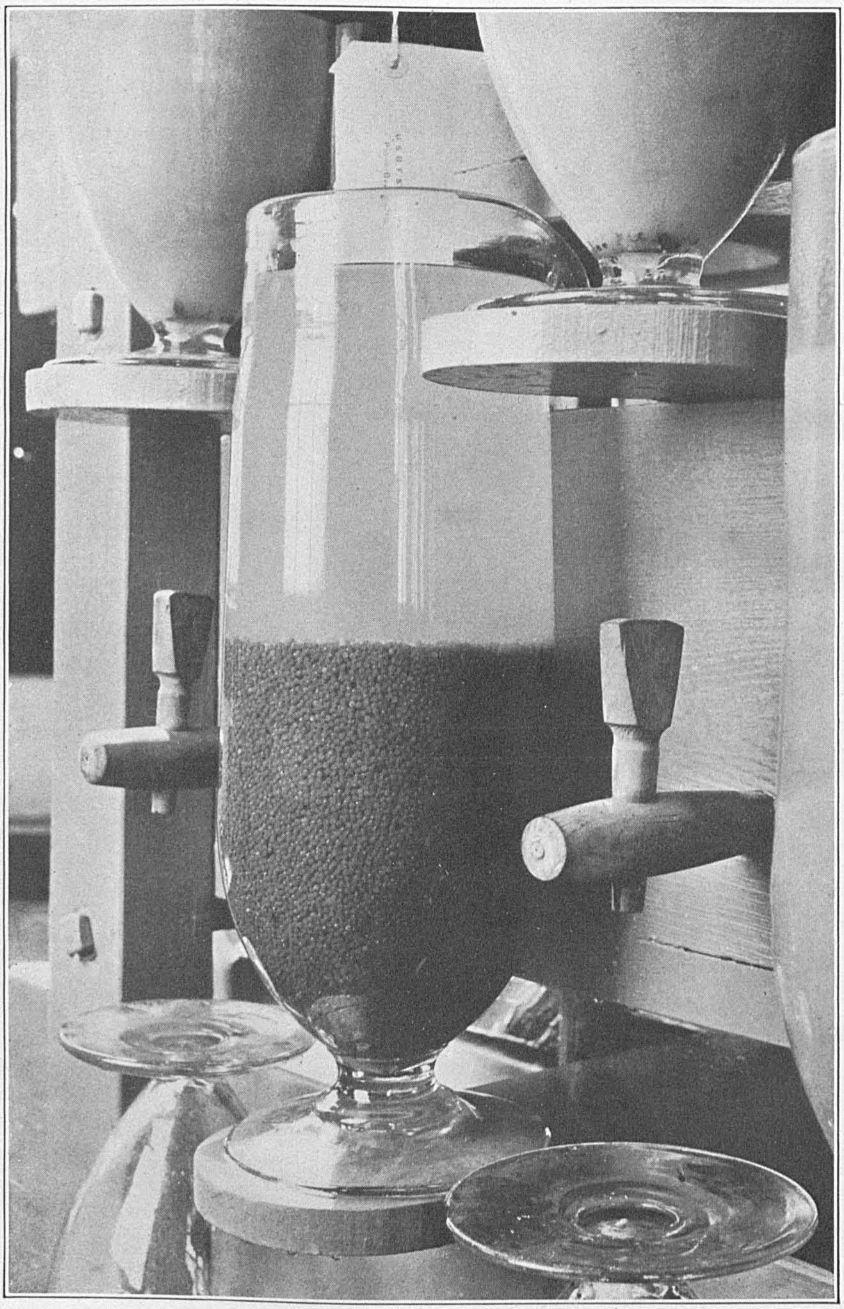

FIG. 6.—Close-up of open-top Downing hatching jar.

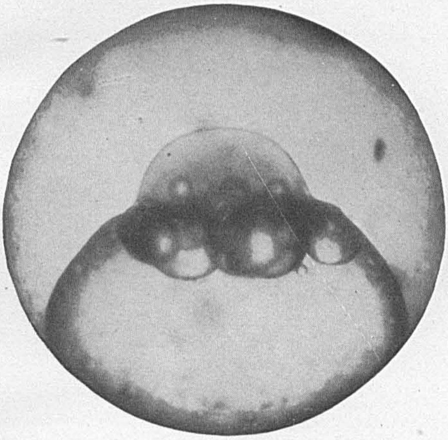

FIG. 7.—Unfertilized whitefish egg 24 hours old.

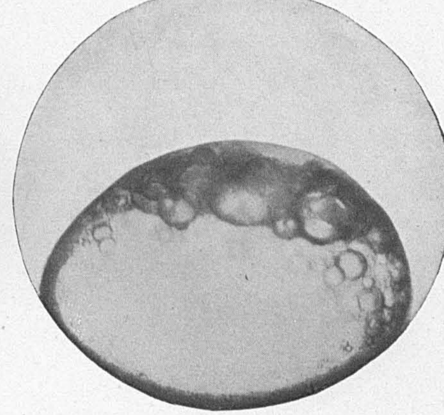

FIG. 8.—Fertilized whitefish egg 6 hours old, germinal disks forming, no segmentation having taken place.

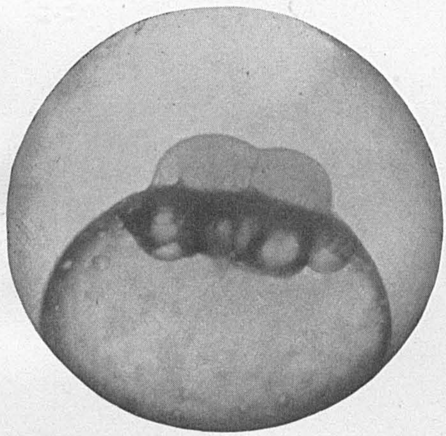

FIG. 9.—Whitefish egg, 12 hours, showing first cleavage, water 38°.

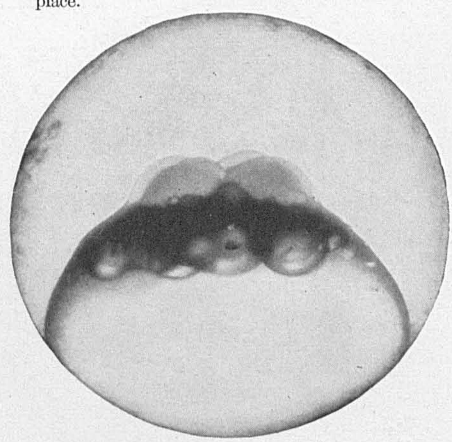

FIG. 10.—Whitefish egg, eighteenth hour, water 38°, showing second segmentation, four cells formed.

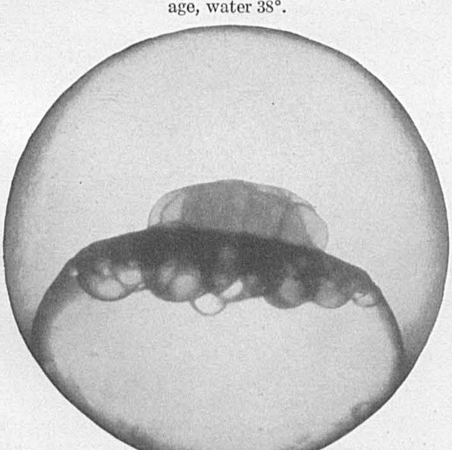

FIG. 11.—Whitefish egg, 24 hours, water 38°.

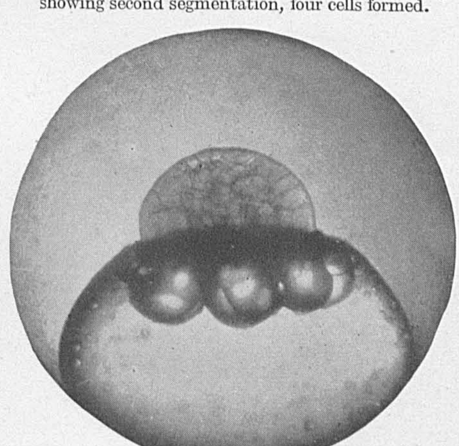

FIG. 12.—Whitefish egg, 48 hours, water 38°.

DEVELOPMENT OF THE WHITEFISH EMBRYO.

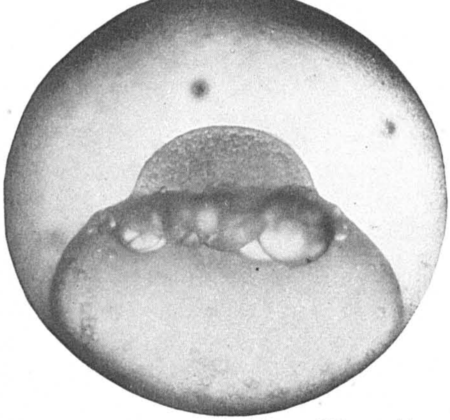

FIG. 13.—Fertilized whitefish egg, 72 hours old, showing segmentation well advanced.

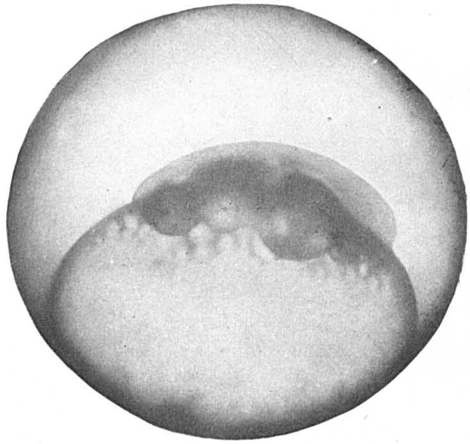

FIG. 14.—Whitefish egg, seventh day, embryo beginning to show.

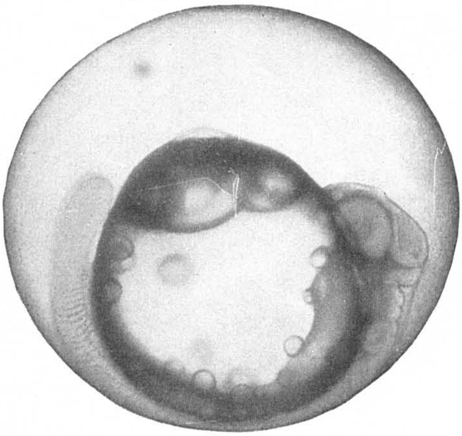

FIG. 15.—Whitefish egg, 43 days old, showing embryo.

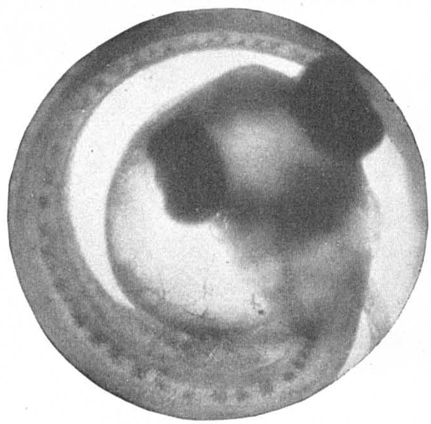

FIG. 16.—Whitefish egg, 90 days old, showing embryo.

FIG. 17.—Whitefish egg, yolk sac ruptured by rough handling, 24 hours old.

FIG. 18.—Whitefish egg with triple disks.

DEVELOPMENT OF THE WHITEFISH EMBRYO.

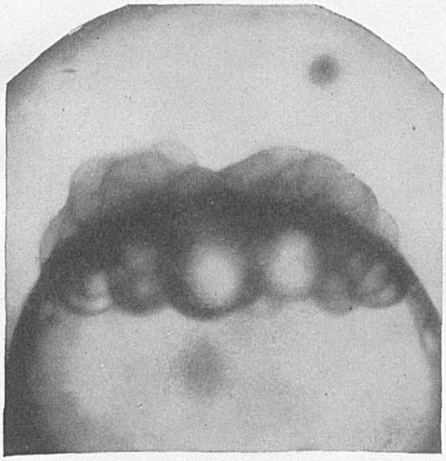

FIG. 19.—Whitefish egg, showing twin disks, 3 days old.

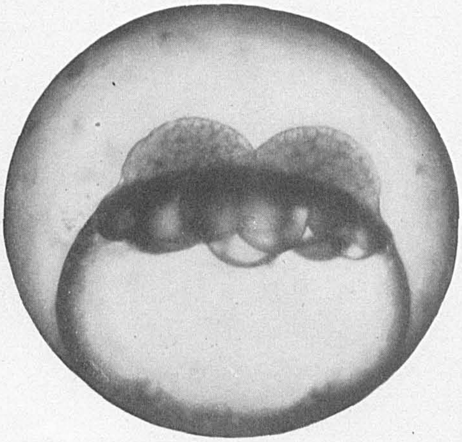

FIG. 20.—Whitefish egg, showing twin disks, 6 days old.

FIG. 21.—Whitefish egg, showing twin disks, 7 days old.

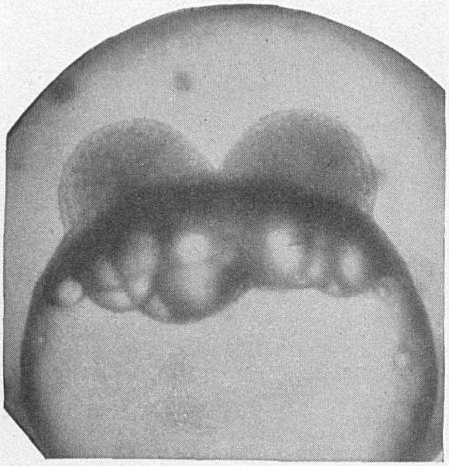

FIG. 22.—Whitefish egg, showing twin disks, 8 days old.

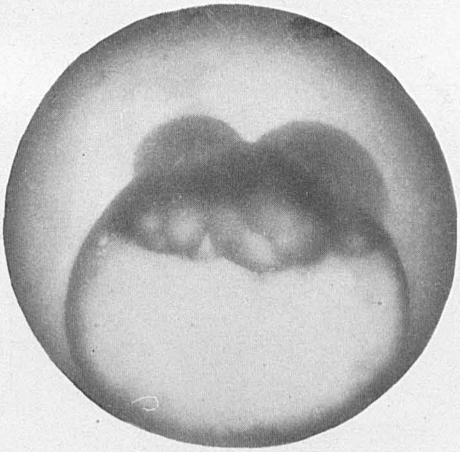

FIG. 23.—Whitefish egg, showing twin disks, 13 days old.

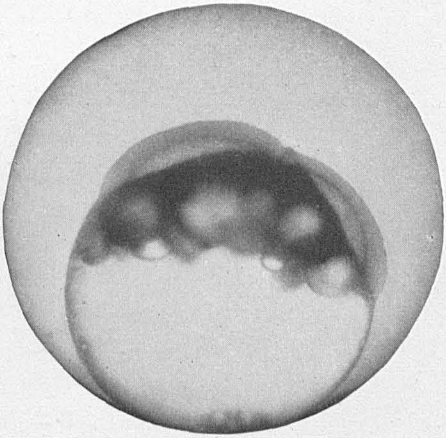

FIG. 24.—Whitefish egg, showing twin disks, 15 days old.

DEVELOPMENT OF THE WHITEFISH EMBRYO.

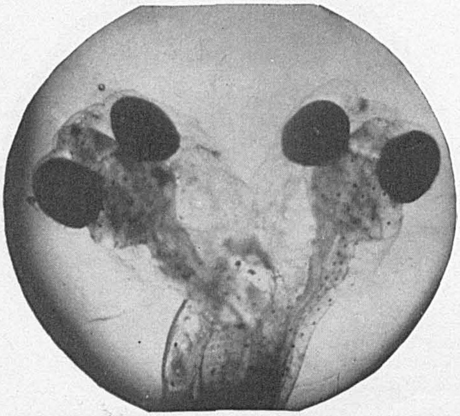

FIG. 25.—Double-headed whitefish fry, just hatched.

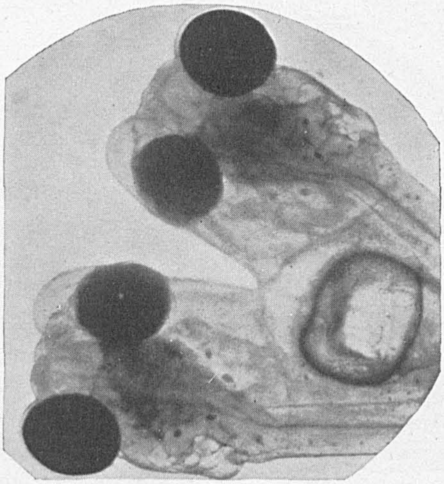

FIG. 26.—Double-headed whitefish fry.

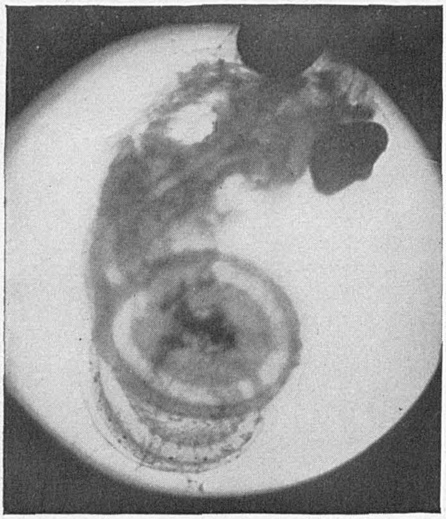

FIG. 27.—Curved spine, a common deformity of whitefish fry.

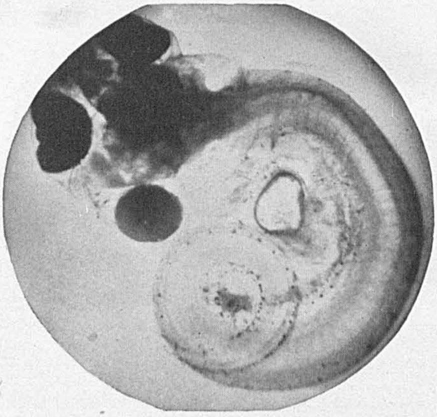

FIG. 28.—Whitefish fry just hatched, three-eyed, curved spine.

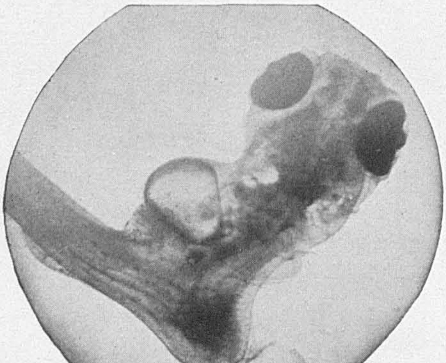

FIG. 29.—A common deformity of whitefish fry.

FIG. 30.—Four-eyed whitefish fry.

DEVELOPMENT OF THE WHITEFISH EMBRYO.

approximately 5 quarts per minute at the beginning of incubation, which amount is reduced to 4 quarts later on. This water supplies in turn the succeeding rows of jars in the battery. For this reason the jars on the upper row should never be removed without making provision to supply those below.

In a mean water temperature of 35° F. the eye spots of the fish are visible to the unaided eye in about 40 days, and the entire incubation period averages 133 days. The food sac is absorbed in from 5 to 10 days after the fry have hatched, the time varying somewhat with the period of incubation.

The microscope is a great aid in whitefish culture, enabling the operator to determine the exact percentage of dead eggs and, to a great extent, the cause of their loss, allowing him to remedy some if not all of the evils. For examining eggs in their early stages the microscope is placed horizontally, the eggs being held in a cell filled with water. This may be made easily by fastening two ordinary glass slides to a strip of wood one-eighth of an inch thick, with a portion cut away to form a receptacle for the eggs. The wood is thoroughly saturated with asphaltum varnish, and after drying the sides should receive a thin coat, the sides being laid on and placed under pressure to dry. When dry, an additional coat to the outer joints of contact will guard against possible leaks. Such cells are not satisfactory and a good examination of the eggs can not be made with them. Most optical houses are able to supply what is known as "watch crystals" that are made especially for this purpose.

If the egg be examined six to eight hours after being fertilized, the germinal disk will be found to have contracted to a saucer-shaped cap, extending over about one-fifth the surface of the yolk. It is smooth and even, gradually thinning to a sharp outer rim, with a thickness of about one-fifth its diameter in the center of the cap. Segmentation not having commenced at this stage, the impregnated eggs can not be distinguished from the unimpregnated ones. At 18 hours segmentation will be well advanced and the disk will have contracted into six or eight rounded nodules of uneven size, with well defined valleys between, the sharp rim having disappeared. At 24 hours, which is the best time to determine the percentage of live eggs, the disk will present a somewhat similar appearance except that it will be divided into 25 or more segments, easily seen under the glass. The disk of the unimpregnated egg of the same age forms an almost exact hemisphere, is perfectly smooth in appearance, and is therefore easily distinguishable from a live egg. Segmentation now proceeds rapidly, and at 72 hours the cell looks about the size of a mustard seed under a 1-inch objective, the most suitable power to use in this work.

During the entire period of incubation, but more especially in its early stages, the eggs should be worked as gently as possible, only enough water being used to give them sufficient motion to prevent "banking." Just at the commencement of incubation they require about 5 quarts of water to the jar per minute, but later they can be run with a quart less per minute. For the first week or more the eggs require constant watching, and although the whitefish egg is not considered adhesive, agglutination will ocasionally occur when the water becomes roily, and unless the banks thus formed are separated by gentle stirring with a feather (the long feathers of a turkey wing are suitable) the eggs forming the pack will soon die and form a mass in the jar.

In a few days, varying with the water temperature, the unimpregnated and other dead eggs begin to fungus; that is, a fungous growth develops upon them and they rise to the top of the egg mass. Such eggs must be removed with a siphon immediately, and if live ones are among them they should be set up in what are termed hospital jars, where the dead eggs and the live ones can be more readily separated. The dead eggs are drawn off every day to prevent them from becoming loaded with silt from the water and sinking into the mass of live ones, from which it is difficult to separate them.

A long-distance siphon is used for removing dead eggs from the jars, saving much labor. In its construction the short end of an ordinary siphon, consisting of a thin ¼-inch brass tube a foot long bent into the form of a gooseneck, is attached to a piece of common rubber tubing 3 or 4 feet long and ⅜ inch in diameter inside. This is connected with a rubber tube of the same size and sufficiently long to reach the entire row of jars in the battery. Hose connections are made by the use of a thin brass nipple of the same interior diameter as the piece of rubber tube to which it is joined. The other end of the long tube is connected to and through the center of a wooden float some 12 inches in diameter and 1 or 2 inches thick by means of a piece of brass tubing. The tube is bent to a quarter circle to prevent the rubber from kinking, and the float is set in a tub. When it is desired to siphon eggs into the jars, a short siphon is placed in the supply trough and started and is then connected with a long siphon. When the tub becomes filled with water, it runs over the rim and into the waste ditch, the eggs settling to the bottom. By means of this siphon an entire battery can be operated without moving the tub. It is necessary, however, to exercise care in siphoning eggs from the jars on the top row, as the suction becomes very strong and is apt to draw off the good eggs. The suction may be reduced by gently pinching the rubber tube.

For convenience and economy of space and water the hatching jars are arranged in tiers, constituting what is known as a *battery*. The structure of a battery, with its system of supply troughs, jars, and other attachments, may be understood by reference to Figures 5 and 31.

The troughs of the battery are usually constructed of white pine or cypress 1½ inches thick. If it is necessary to make the troughs longer than the usual cuts of lumber, the joints should be squarely butted, and these and all other joints in the troughs should be put together with white lead. At the splice a patch is placed on the inside of each trough and screwed to the two ends, white lead being used freely underneath. As a further strengthening measure a cross piece 5 inches high is placed inside. The ends of the troughs are rabbeted in place and the side pieces nailed to the bottom. At the end of each trough in the bottom is a 1½-inch hole, supplied with a plug, for use in cleaning the troughs. At the alternate end of each trough, commencing at the top, is a saw cut 1½ inches deep and 6 inches wide, into which is fitted a galvanized iron or tin overflow spout to conduct surplus water to the next trough below. The lengths of the troughs vary according to the size of the battery. Their inside dimensions are 10½ inches deep and 8 inches wide.

At the proper distance apart along the sides of the troughs are holes for the wooden faucets; for ease in manipulating the jars these holes should be 7¼ inches on centers and 3 inches above the inside bottom of the trough. The best faucets are the Crandell with the tin key. The faucet is connected with the tin tube by a piece of white or red rubber tube 8 or 10 inches long and ½ inch in diameter. The tin tube is ⅜ of an inch in diameter and 20 inches long; three short legs are soldered to the lower end to hold the tube above the bottom of the glass jar.

The troughs are placed one above another at a proper distance to accommodate the type of jar used. They are held together by a support made of 4 by 4 timbers, so placed that a row of 6 jars is installed between each set of stanchions. At the Put in Bay hatchery there are 6 rows of jars, making 36 jars between each set of stanchions. This type uses the stagger system in placing the jars on the battery, by which method each jar of the top row supplies the next jar immediately underneath. The troughs are held together in the stanchions by the use of ½-inch bolts, with nuts and washers at each end, which also act as a support to the trough. Beginning at the top trough the water supply enters one end, supplying each jar on the top row, which in turn discharges into the next trough below. The surplus water passes through the tin overflow at the opposite end and into trough No. 2, which projects from 8 to 10 inches on one end beyond the top trough. This alternate system is continued until the water is finally conducted into the receiving tank located at the end of the battery. This tank is 24 inches deep, 3 feet wide, and of sufficient length to receive the water supply from two batteries. Provision is made at one end of the tank for a screen and an overflow for the diversion of part of the water. The water remaining passes into a series of fry tanks arranged at right angles to the receiving tank, connection between them and the fry tanks being made by means of a 2-inch pipe set 1 foot below the surface of the water and provided with a stopcock. At the Put in Bay hatchery four fry tanks, set in series of two, receive their water supply from the retaining tank. Each fry tank is provided with a screen near its lower end and a similar connection is made between the fry tank and the receiving tank. The fry tanks are 24 inches high, 3 feet wide, and usually 16 feet long.

These screens are made of brass wire cloth, 60 meshes per inch, tacked to a heavy frame. The screen is pulled very tight before it is fastened so as to present a smooth surface to the air jets. The screens should never be painted. The screen frames are held in place by bolts that pass through the frames and into the projecting cleats in the trough. They are not put in place until the fry commence to hatch. If the air pipes are large and are run fairly straight to the screens, an air pressure of from 5 to 8 pounds will be sufficient to keep the screen free from eggshells.

At the Cape Vincent (N. Y.) station a modification of the battery described in the foregoing pages has given excellent satisfaction. (See fig. 31.) It carries six tiers of jars, and where vertical space is available it may be made to accommodate a larger number of jars in proportion to the floor space occupied. The troughs in this battery are made of 1⅝-inch cypress. They are 12½ inches wide, 9¾ inches deep on the feed half, and 6 inches deep on the catch end. The shelves, which are also made of cypress 1¼ inches thick, are 8½ inches wide, and between the uprights they are supported by steel brackets. The condensation from the jars is drained into the troughs through a groove cut along the outer edges of the shelves. At one end of each trough is a galvanized iron overflow. The supply of water to the batteries is regulated by automatic Ford tank valves, and the discharge, after entering the catch box, is carried to the basement sewer. When the fry are hatching the water is carried, as shown, to the fry building, and under the whole length of the batteries galvanized pans are provided to catch the drip, which drains into the basement sewer. There are 11 jars on each shelf between the uprights, making 198 jars in all on each side of a battery, or 398 jars per battery.

This type of battery is compact and neat in appearance. By means of the grooved shelves and drip pans the floors are kept dry, and, as each trough is provided with a drain plug, they may be scrubbed at any time without interfering with the operation of the jars, the attendant stepping along the jar shelves. At all the bureau's hatcheries it has been found best to use the natural water supply without attempting to modify its temperature, but good results in the incubation of whitefish eggs can not be expected in a water temperature much above 50° F. In early November, when the whitefish spawning season in Lake Erie begins, the water in the Put in Bay hatchery ranges from 40 to 48°. About December 1 it drops to approximately 35 to 38°, and after the lake freezes, or as soon as ice in any appreciable quantity forms, the temperature of the water passing through the jars remains uniform at 32½°. Around the middle of March, when the lake is usually free from ice, the water temperature rises slightly. The fry begin hatching about this time, and as a rule the incubation period is completed in the first week of April.

Every year prior to the opening of the spawning season the interior surfaces of all troughs and tanks are well covered with asphaltum varnish. As a first coating, when the wood is new, white lead and oil are applied, followed by two coats of varnish, the latter consisting of one part turpentine to two parts asphaltum. The best asphaltum pitch is used for filling the cracks and joints, first softening it with paraffin to the consistency of chewing gum, or so that it will not break in cold water. This pitch holds firmly to the wood and keeps its place in warm weather. Other pitches that have been tried are likely to run in warm weather and to harden with use, breaking when cold. All jars, tubes, troughs, etc., should be kept scrupulously clean.

CARE AND PLANTING OF FRY.

When the fry hatch, they immediately leave the jars and follow the course of the running water, those in the upper tiers going through the succeeding jars, and all finally reaching the fry-collecting tank at the bottom, whence they are carried to the main collecting tanks. It has been urged by some that it is injurious for the fry to pass down through the lower jars with the complement of eggs, but in practice this has not been the case.

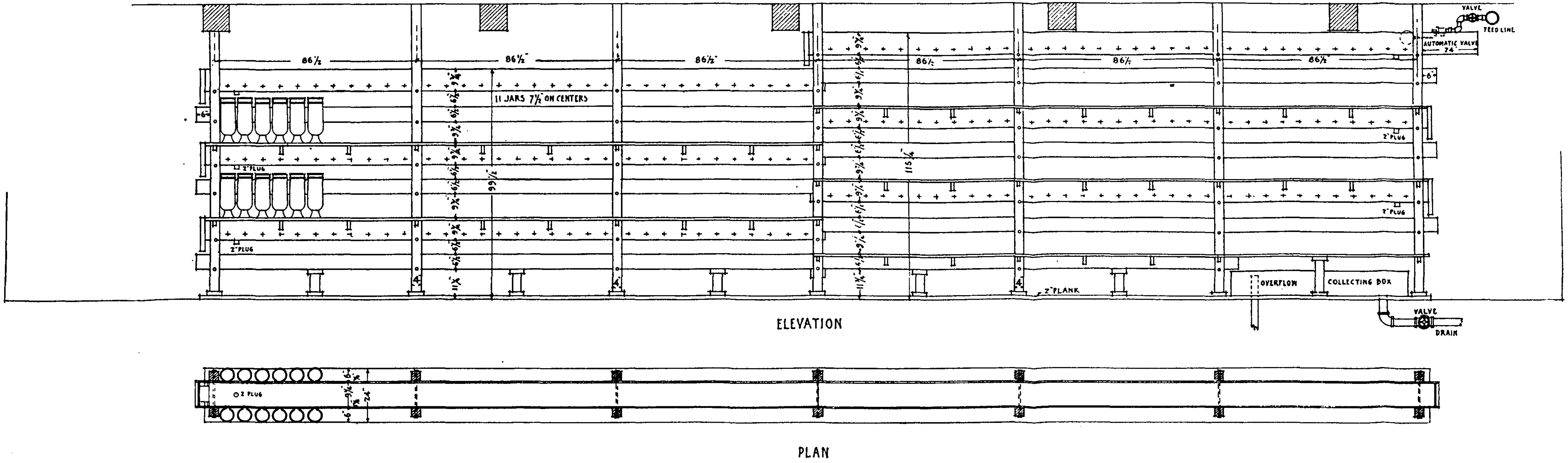

FIG. 31.—Whitefish battery, Cape Vincent, N. Y.

Clogging through an accumulation of eggshells and impurities in the water may be prevented by an air jet, which can easily be arranged for by installing an air pump and carrying the connecting pipe along the side of each tank on the inside of the screen, thence at right angles parallel to the screen and about an inch distant from it. This cross pipe should be perforated on one side with holes one-thirty-second of an inch in diameter and 3 inches apart, the perforations opening toward the screen and upward at an angle of about 45°. When the air is turned on, an apparently solid mass of bubbles will rise along the whole surface of the screen.

With such an arrangement the screen will need no attention for hours, or even days, at a time, whereas without the air jet one or more men must be employed to keep the screens clear. Moreover, many of the fry are unavoidably killed by being forced against the screens and by the work of the men in keeping them free. The thorough aeration of the water indirectly accomplished by use of the air jet is very beneficial when large numbers of fry are passing over, and twice as many can be safely handled in troughs thus equipped.

At Put in Bay, where the fry are planted as soon as hatched, they are dipped from the fry tanks into kegs and transported to the natural spawning grounds on the reefs. From 50,000 to 100,000 fry are carried per keg, according to the distance to be traveled, and when they are to be carried any considerable distance fresh water is added every hour.

Where facilities are available it is advisable to hold the fry in tanks until they have absorbed the yolk sac before planting them, as they are better able at that time to care for themselves than when planted at a very early age. In the spring of 1896 about 1,000 whitefish fry were held in a station trough until late in April, with no food supply except the Entomostraca and other minute life coming into the troughs with the water pumped from the lake. The fish attained a considerable growth and were remarkably active. Cannibalism was of frequent, though not of general occurrence. Toward the close of the period through which they were held numbers were observed to have seized another fry by the tail and swallowed as much of the body as possible; this, of course, being very little. In every instance noted a larger fish had attacked a smaller one, the victim being dead and his destroyer swimming about actively with the body trailing along his side. Had these fry been regularly supplied with food it is probable that no cannibalism whatever would have occurred.

REARING IN PONDS.

Few attempts have been made to raise whitefish in ponds, but the experiments conducted lead to the belief that under favorable conditions the species can, to some extent, be reared in artificial ponds, success along this line, of course, implying an abundance of good cold water and suitable ground for the construction of deep ponds. Such an undertaking would not be practical nor feasible at any of the bureau's hatcheries where millions of fish are liberated.

The outcome of an experiment undertaken in 1882 along this line at the Northville (Mich.) station was successful. Three-year-old whitefish, from 3 to 4½ pounds in weight, plump and healthy, were produced, and from them a large number of eggs were taken, a fair percentage of which were fertilized. The fish were treated as are young trout, being fed wholly on liver.

Equally succcessful tests have been made in Europe with one of the native whitefishes (*Coregonus lavaretus*), and noteworthy results have been attained in the rearing of whitefish under private enterprise in ponds at Warren, Ind. It has been found that in rearing the fry the water temperature should not exceed 55° F. and that a temperature of 65° is fatal.

THE GRAYLINGS.

The grayling is one of the most attractive and gamy of the freshwater fishes. Three species have been described from North American waters—*Thymallus signifer* of Alaska and the Mackenzie River region, *T. montanus* of Montana, and *T. ontariensis* of Michigan. They are all closely related to the Salmonidæ in habits and general appearance but differ in the character of the skeleton.

RANGE.

The Arctic grayling (*Thymallus signifer*) is found from the Mackenzie River westward through Alaska and north to the Arctic Ocean. The Montana grayling (*T. montanus*) originally existed only in the streams emptying into the Missouri River above the Great Falls, principally in Smith or Deep River and its tributaries and the three forks of the Missouri—the Jefferson, Madison, and Gallatin Rivers—and their affluents. Its range has since been considerably extended through the agency of fish culture. The Michigan grayling (*Thymallus ontariensis*) was formerly found only in certain streams of Michigan, though the type specimen is said to have come from Lake Ontario. Though once abundant in many streams in the southern peninsula of Michigan, it has now entirely disappeared from the waters of that section. The opinion is expressed by observers that the introduction of the nonindigenous brook trout and rainbow trout has been a factor of importance in their disappearance. Grayling still occur in the Otter River and possibly in other streams in the northern peninsula of Michigan.

DESCRIPTION.

In Montana waters its body is elongated, compressed, the depth contained four and one-half times in the length. The subconic head is of moderate size and its length is one-fifth that of the body. The dorsal outline from snout to tail is a uniform gentle curve, highest at the beginning of the dorsal fin. The mouth is oblique, terminal, and of moderate size; rather feeble teeth, of uniform size, occur on jaws, palatines, and vomer. The short and stiff gill rakers number 17. The eye is large, exceeding length of snout, and is contained three and one-half times in length of head. From 82 to 85 scales are found along the lateral line, 8 rows above and 10 rows below the line. The dorsal fin is long and high and contains 18 to 21 rays; both its length and height equal the depth of body. The caudal is strongly forked. The coloration is gorgeous. The color of the back

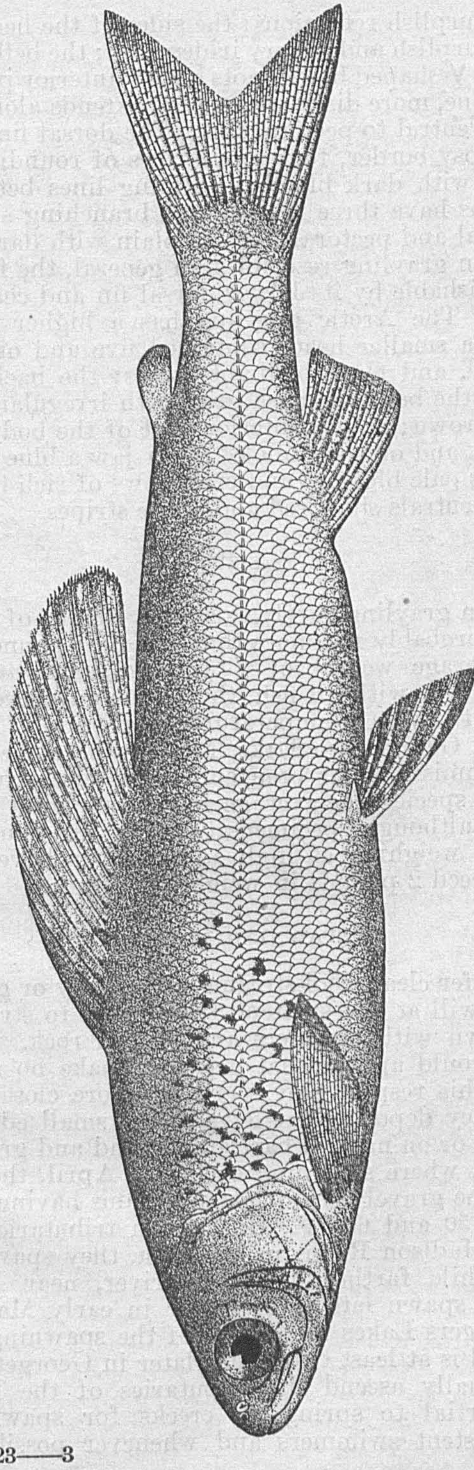

FIG. 32.—Montana grayling, *Thymallus montanus*.

is gray, with purplish reflections; the sides of the head and body are lighter, with purplish and silvery iridescence; the belly is pure white; there are a few V-shaped black spots on the anterior part of the body; a dark heavy line, more distinct in males, extends along upper border of belly from ventral to pectoral fins. The dorsal fin is richly variegated with a rosy border, four to six rows of roundish rosy spots in whitish areas, with dark blotches forming lines between the spots. The ventral fins have three rose-colored branching stripes along the rays. The anal and pectoral fins are plain with dark border.

The Michigan grayling resembles, in general, the fish of Montana, but is distinguishable by its larger dorsal fin and certain differences in coloration. The Arctic grayling has a higher dorsal fin with 22 to 24 rays, a smaller head, contained five and one-half times in length of body, and more brilliant colors; the back and sides are purplish gray, the belly blackish gray with irregular white blotches, and the head brown; on the anterior part of the body are five or six deep blue spots, and on each side of lower jaw a blue mark; the dark gray dorsal has pale blotches and cross rows of rich blue spots edged with red; the ventrals show red and white stripes.

SIZE.

The Michigan grayling rarely exceeds a weight of 1½ pounds, and the average is probably not more than one-half pound. In Montana waters the average weight of *Thymallus montanus* is somewhat greater. As is true with all fish, the size is governed to a considerable extent by the water temperature, food supply, and other local conditions. In Georgetown Lake, Mont., where the Montana Fish and Game Commission has been eminently successful in its efforts to establish the species, the average weight is placed between 1½ and 2 pounds, and although specimens taken in the South Fork of the Madison River weighing as high as 3 pounds have been recorded they seldon exceed 2 pounds in weight.

SPAWNING HABITS.

Grayling prefer clear, cool streams with sandy or gravelly bottom, although they will at times extend their range to streams where the bottom is strewn with bowlders and broken rock. Unlike salmon and trout, it would appear that grayling make no attempt at nest building. In this respect they, perhaps, more closely resemble the whitefish, as they deposit their eggs in the small eddies formed by roots and rocks or on natural barriers of sand and gravel.

In Michigan, where spawning occurs in April, the eggs are normally laid in the gravel beds of clear streams having a temperature range between 50 and 60° F. In certain tributaries of the headwaters of the Madison River, in Montana, they spawn in February and March, while farther down the river, near McAllister and Ennis, the fish spawn late in April or in early May. In Ashley, Ronan, and Rogers Lakes the height of the spawning season occurs late in May and is at least two weeks later in Georgetown Lake.

Grayling usually ascend the tributaries of the larger streams, being very partial to spring-fed creeks for spawning purposes. They are persistent swimmers and whenever possible will ascend

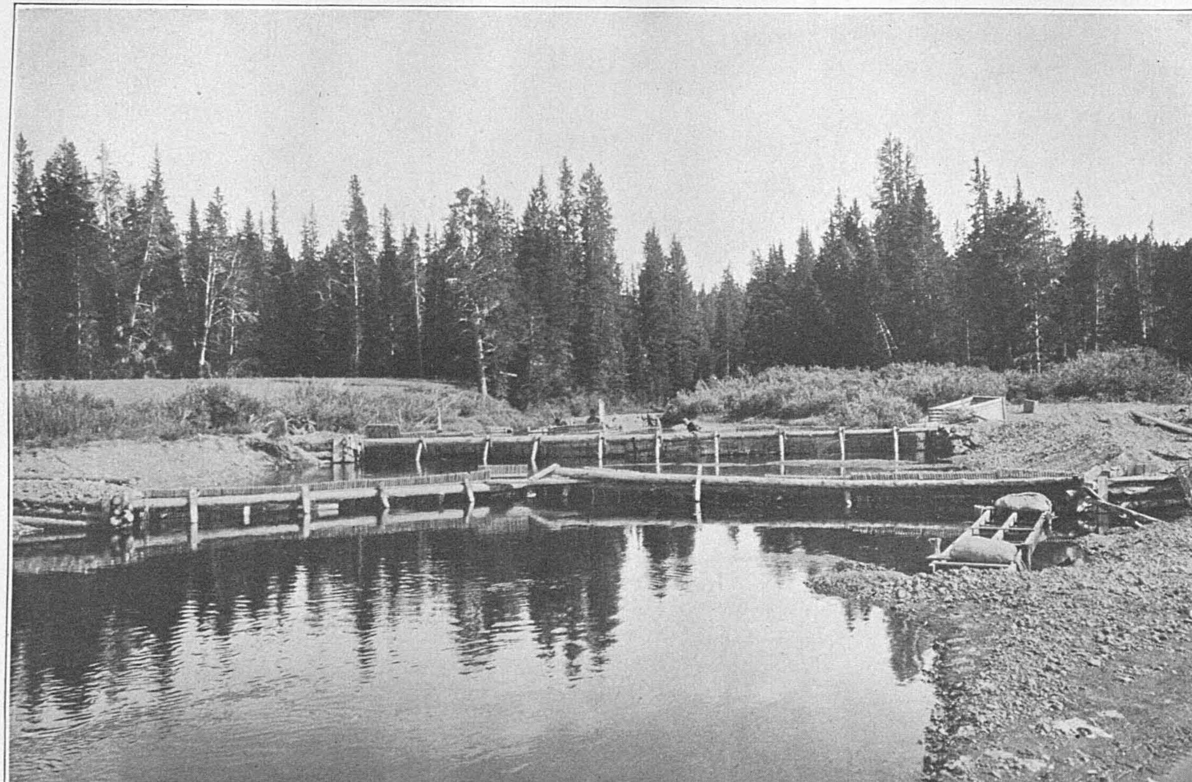

FIG. 33.—Improvised racks are placed across streams to prevent ascent of fish.

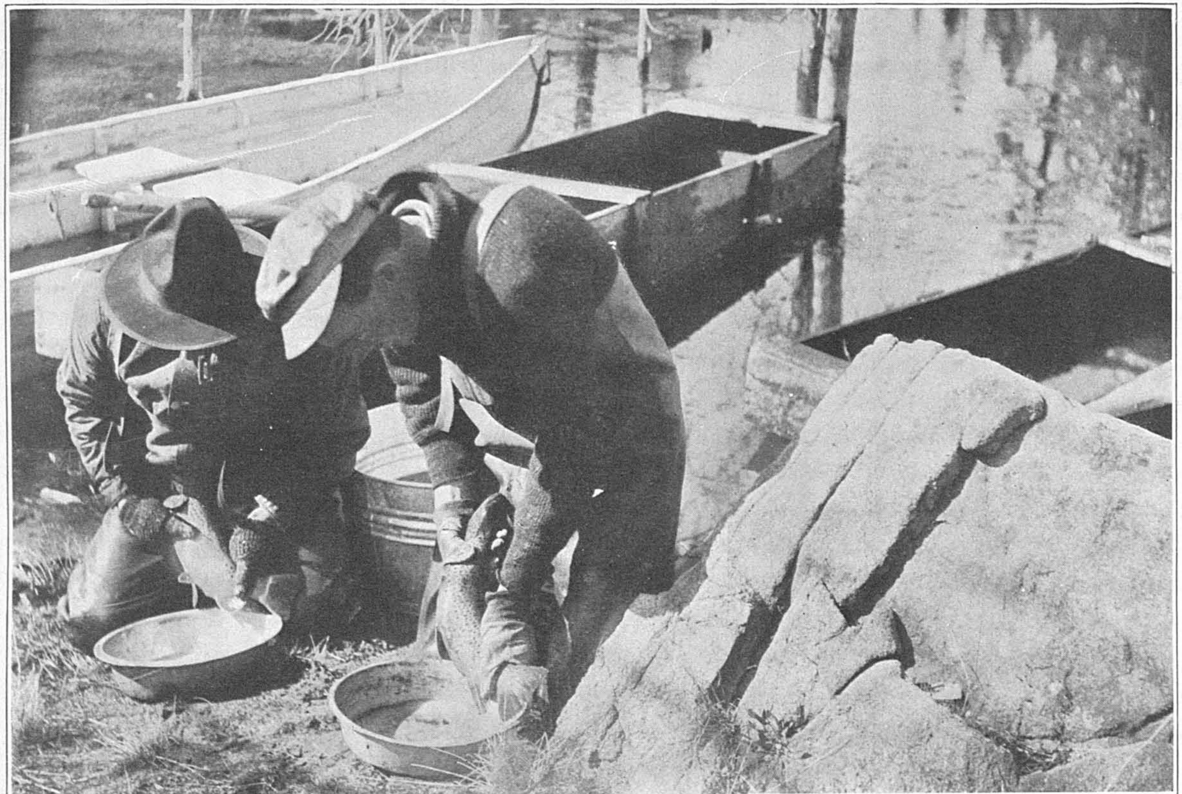

FIG. 34.—Taking eggs at a field station.

to headwaters. On numerous occasions they have been observed passing artificial or natural barriers that the native blackspotted and rainbow trouts after repeated attempts have failed to surmount. They prefer streams of a rather sluggish current and containing deep pools, with sandy or gravel bottoms. In Montana streams they usually spawn in a water temperature of 50 to 52° F.

ARTIFICIAL PROPAGATION.

Grayling were first artificially propagated in Michigan in 1874, but the work was never vigorously or regularly prosecuted. It has recently been taken up again by the Michigan fishery authorities. The propagation of this species in Montana was not attempted until 1898, but it has been systematically conducted and has been attended by strikingly good results. It is a noteworthy fact that the species has been successfully established in many waters of the State where it is not indigenous. In this connection Georgetown, Ronan, Rogers, and Ashley Lakes are prominent examples, while more recently it appears that plants of grayling made in waters of the Glacier and Yellowstone National Parks are also yielding material results.

The establishment of the grayling in these and other waters of the State will perhaps serve as a balance against their depleted numbers or entire disappearance in waters where they are indigenous, a condition that has been brought about by the improper methods of fishing formerly permitted and possibly also by the introduction of other nonindigenous fishes.

At the present time artificial propagation of the grayling is practically confined to the work being done by the Montana Fish and Game Commission, and the methods of culture herein described are those pursued and recommended by that commission. The grayling required for the work are captured in a modification of the ordinary upstream trap, formed by placing a rack or barrier across a stream the fish ascend for spawning, and installing, 2 rods or more downstream from that point, another rack containing one or more V-shaped openings. The fish pass through these openings on their upstream journey and are trapped between the racks. Pending the development of the eggs and sperm, it has been found necessary to hold the fish in an inclosure of this kind on a natural bottom, as experience has demonstrated that grayling segregated as to sex or ripeness in wooden pens similar to those used in salmon and trout propagation invariably produce eggs of an inferior quality.

COLLECTION AND INCUBATION OF EGGS.

Unlike practically all other species of fish eggs artificially handled, the eggs of the grayling produce better results when taken by the *wet* method of fertilization, which consists in stripping the eggs into a vessel containing a small amount of water. In the so-called dry method of fertilization the eggs are expressed from the fish into a receptacle that is moist but from which all water has previously been drained. The manner of stripping the males and the females differs in no way from that employed in the propagation of other species of eggs artificially manipulated. A peculiarity of the Montana grayling that has not been mentioned in connection with grayling propagation elsewhere is the comparatively small amount of milt produced by the males.

When first taken the eggs are of a pale yellow hue and are almost transparent, resembling a drop of honey. They are about one-sixth inch in diameter, nonadhesive, and, because of the presence of a comparatively large oil globule, they are semibuoyant. The average egg production is about 3,000 per pound weight of parent fish. The eye spots, small gilt specks with a minute black pupil, appear in from three to five days, and the eggs hatch in from 12 to 15 days in a water temperature around 50° F.

The eggs may be successfully incubated in the trays or baskets ordinarily used in salmon and trout work, but, because of their buoyant tendency, the Downing jar has been found more satisfactory during the early stages of development. Approximately 125,000 eggs are placed in a hatching jar and held to the eyed stage, at which time it is customary to transfer them to trays for the completion of incubation.

A peculiarity in connection with the development of grayling eggs is the appearance on the green eggs during the first day of an opaque spot, which gradually enlarges until one-half the surface of the egg is covered, giving it somewhat the appearance of a dead egg. This cloudy condition is of short duration and by the end of the third or fourth day is no longer visible. The embryo becomes active in the egg before the eye spot can be seen by the unaided eye.

Eyed grayling eggs can be transported without difficulty when properly packed. Any of the methods in general use may be successfully applied in the preparation of grayling eggs for shipment.

FRY AND THEIR DISTRIBUTION.

The percentage of fry produced from grayling eggs in Montana is low, as a rule, seldom exceeding 50. The young fry are provided with a very small yolk sac. On emerging from the egg they are comparatively helpless and show little signs of animation until the sac is practically absorbed at the end of the first week. They are then free-swimming, about one-half inch long, and quite slender and delicate, resembling the fry of whitefish or shad. At this period they move about in search of food but are never as active as are salmon or trout fry at a similar age.

It is customary to distribute the fry within two or three days after incubation is completed, since the attempts made to rear them have not given good results. The fry do not take readily to artificial feeding, and when moved from hatching troughs to rearing ponds they usually refuse food entirely for the first several days. However, the outcome of recent experiments along this line gives ground for the belief that with proper facilities this difficulty in rearing may be overcome.

THE LAKE OR MACKINAW TROUT.

RANGE.

The lake trout is found throughout the chain of the Great Lakes and the inland lakes of northern New York, New Hampshire, and

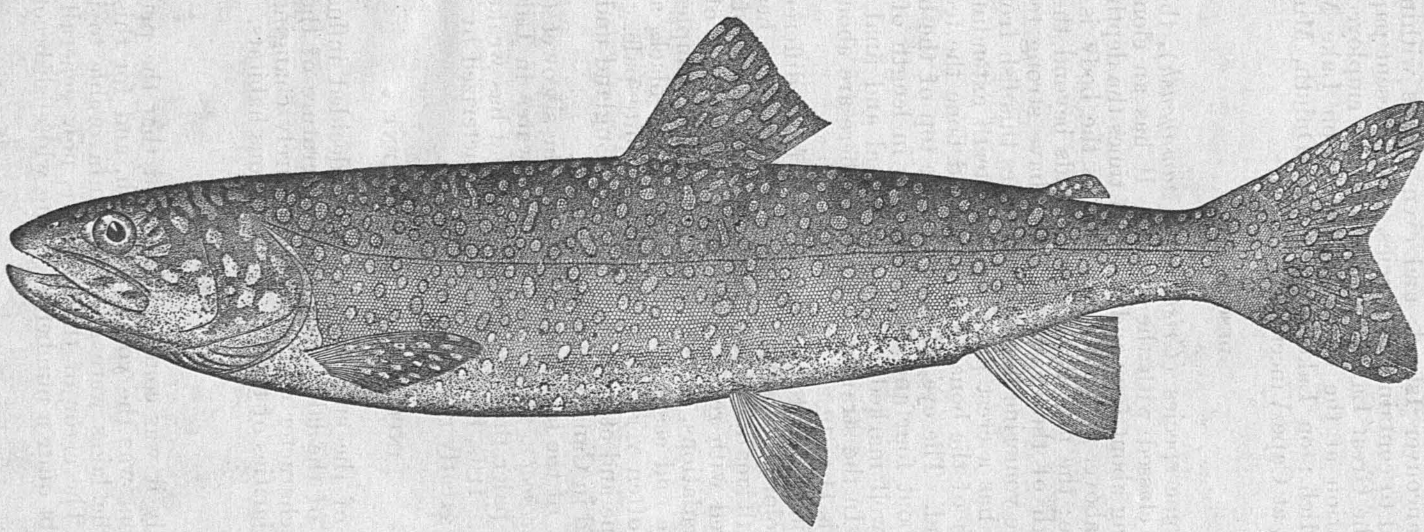

FIG. 35.—Lake trout, *Cristivomer namaycush*.

Maine; the headwaters of the Columbia and Fraser Rivers and streams of Vancouver Island; and even waters within the Arctic Circle are said to contain this species. The present paper discusses the trout of the Great Lakes and the methods employed in its artificial propagation at the bureau's stations on Lake Michigan, at Charlevoix, Mich.; on Lake Superior, at Duluth, Minn.; and on Lake Ontario, at Cape Vincent, N. Y.

DESCRIPTION.

This handsome species (*Cristivomer namaycush*), the largest of the trouts, is classed with the charrs. It has an elongated body, the length being about four and one-half times the depth. The head is large, flat above, and about as long as the body is deep. The mouth is large; the maxillary bone extends beyond the eye and is half the length of the head; the jaws have strong teeth. A peculiarity of the vomerine bone distinguishes this fish from the genus Salvelinus; it has a crest provided with teeth extending backward from the shaft of the bone. On the hyoid bone the teeth are in a cardiform band. The eye, placed near the top of the head, is contained only about four and one-half times in length of head. The caudal fin is well marked. Both the dorsal and anal fins contain 9 to 11 rays. In the straight lateral line there are about 200 scales. Branchiostegals 11 to 12.

The coloration is quite variable in fish from different localities. The general color is usually dark gray. The body, head, and fins are covered with small, discrete rounded spots, usually of a pale color but often tinged with reddish. On the back and top of head there are fine vermiculations, as in the brook trout. Examples from some lakes of Maine and eastern Canada are nearly black, and Alaskan examples are often very dark; others are quite pale. This fish is known in Maine and other sections of New England under the name of "togue," and in Canada as the gray trout.

That variety of the lake trout known as the siscowet (*Cristivomer namaycush siscowet*), found only in deep water in Lake Superior, is shorter and paler than the typical fish and has weaker teeth and a shorter head. It is, however, chiefly characterized by an excessive fatness, which greatly reduces its food value.

INFLUENCE OF ENVIRONMENT.

The nature of the environment has a decided influence on the characteristics of the lake trout, the temperature of the water, the food, and the character of the bottom entirely changing the markings and peculiarities of the fish in its various habitats.

FOOD.

Until recently it was commonly thought that the principal food of the lake trout was the young whitefish, and for this reason the fishermen of the lakes were generally unfavorable to its artificial propagation. The error of that belief is now generally conceded, though no doubt quite a number of young whitefish become food for trout during each season. Inasmuch as the habits of the lake trout take it to deep water immediately after spawning, whereas the young whitefish remain in shallows, the few whitefish that are destroyed in this manner are either stragglers from shoal to deep water or are taken by trout aimlessly wandering from their natural range. The lake trout is an omnivorous feeder and has a ravenous appetite. It greedily devours all fishes possessing fins of flexible character; and jackknives, corncobs, and other articles equally indigestible have been found in its stomach.

ENEMIES.

The spawn and fry of lake trout suffer from the same enemies as the young of all fishes, but the mature fish are too formidable for other species to prey upon. They are troubled with a few parasites. Occasionally individuals very thin in flesh and sickly looking, known to fishermen as "racers," are found swimming near the surface. No sufficient cause has been discovered for this condition, as the racers are no more afflicted with parasites than are healthy fish.

COMMERCIAL VALUE AND ABUNDANCE.

In the early history of the fisheries of the Great Lakes the lake trout was so plentiful that it did not command a price commensurate with its edible qualities. It has since increased in favor and is to-day one of the highly prized and, with the exception of the whitefishes and ciscoes, perhaps the most numerous food fish of the Great Lakes. It is exceeded in weight by the sturgeon only. Instances are cited by fishermen and others of lake trout weighing as high as 125 pounds, and its average weight has been given at from 20 to 30 pounds; but of late examples are rarely found exceeding 10 or 15 pounds. If unmolested by man they might again reach the enormous weight of early citations, their sluggish movements and voracity being conducive to such a result.

In 1917 the catch of lake trout from the five Great Lakes and Lake St. Clair amounted to 13,344,130 pounds, valued at $1,286,704, the catch being exceeded in weight and value only by that of the ciscoes. Very little thought was given to the conservation of the lake trout until 1886, when it became apparent to those interested that decisive steps must be taken to provide against the extermination of a most valuable food fish. Artificial propagation was undertaken at this time and has been continued by the Federal Government and the several States interested. During the fiscal year 1921 the output of lake trout fry and fingerlings from the hatcheries operated by the Bureau of Fisheries amounted to 19,478,500.

Attention was also directed to the desirability of regulating the methods employed in the fishery, and all States have enacted laws specifying the forms of apparatus that may be used and the season of the year when fishing may be legally conducted. Unfortunately such laws are not uniform in their application. However, most of the States require all fishermen to deliver, either to agents of the bureau or the State, all ripe eggs taken in their work or to afford suitable accommodations to spawn takers employed by the bureau or State.

SPAWNING HABITS.

Spawning commences the last of September in Lake Superior and later in the lower lakes, since the water does not become sufficiently cool there as early as in the headwaters. In Lakes Huron and Michigan the height of the season is from November 10 to 20, and spawning continues to the 1st of December. The spawning grounds are on the reefs of "honeycombed" rocks, 10 to 15 miles from shore, and during the reproductive period vast numbers of fish visit these places, spawning in a depth of from 1 to 20 fathoms. Owing to the great depth of water, the shyness of the fish, and the severity of the weather at this time, nothing definite has been determined as to the maneuvers of the fish while spawning. The supposition is that the female lies over an indentation of the rocks and allows her eggs to settle into the "honeycomb" cavities, since fragments of the rock with the cavities filled with eggs have been hauled in by fishermen when lifting their nets. No doubt the general characteristics of the Salmonidæ are carried out by the lake trout so far as is permitted by the conditions in which they exist.

Observers of the spawning habits of the lake trout in Lake George, N. Y., have the following to say on the subject:

> It is the habit of the lake trout to migrate to shallow water for the spawning function, the time varying anywhere from October 25 to November 1, in accordance with the water temperature. During the spawning period fish will be found upon almost every rocky shoal, at the end of an island, or along the main shore line, in from 1 to 4 feet of water, though they sometimes spawn at a much greater depth. Ordinarily spawning occurs in places where there are small bowlders from 1 to 3 feet or more in diameter. Between such bowlders it is possible to see the trout lying side by side in pairs, each heading in an opposite direction, as if to guard against intrusion from all points.

An instance has been known of a Mackinaw trout of 24 pounds weight containing 14,943 eggs; but not over 5,000 or 6,000 eggs are commonly found, and after the trout have attained maturity, at 3 years of age, 1,000 eggs to the pound of fish may be accepted as a general rule.

A much smaller variety, called the shoal trout, is found in Lake Huron in the vicinity of Alpena and in Lake Michigan near Charlevoix and Northport. Its weight compared with its length is greater than that of the true Mackinaw trout. The markings and appearance of the two differ also. The shoal trout spawns in September, about a month earlier than the Mackinaw trout. Its spawning grounds are the cobble, bowlder, or gravel bottoms, in from 2 to 8 feet of water.

ARTIFICIAL PROPAGATION.

COLLECTION AND INCUBATION OF EGGS.

The present methods of fishing for lake trout include gill nets, seines, and pound nets, but most of the eggs taken for artificial propagation are obtained from the gill-net fishermen. The gill nets are operated from steam vessels equipped with the most approved appliances for their trade and with living quarters for a crew of 8 to 10 men.

During the egg-collecting period spawn takers are employed to accompany the fishing boats for the purpose of taking ripe eggs from the fish secured. Where a boat is operating a long string of

FIG. 36.—Tug lifting gill net for lake trout in Lake Michigan.

FIG. 37.—Collecting lake-trout spawn on fishing steamer in Lake Michigan.

nets, or where exceptionally large catches are being made, two spawn takers may be detailed to one boat.

Pans, pails, and dippers are taken on board and made ready by the time the nets are reached. As the net is lifted the men disentangle the trout and throw them on deck, where the spawn takers sort them over, taking the eggs from ripe females and impregnating them with milt from the males. During very severe weather the fish are thrown into the hold instead of on deck, and the work is done there.

On the small gasoline boats operated by two to four men the crew takes the eggs and delivers them to the bureau's agent or to the collecting boat. The eggs are sometimes taken at widely separated points and shipped to the main field station and then to the hatchery.

The manner of taking the eggs is similar to that employed in taking spawn from other trout and salmon. First, a female is taken up and the eggs, if mature, are gently stripped into an ordinary milk pan and then impregnated with milt from a male. This operation is repeated until the pan is half full, when the eggs are "washed up" and poured into a 5-gallon pail. The washing-up process is performed by filling the pans with water and allowing it to run off, repeating the act until the water poured off no longer appears milky. As the specific gravity of the eggs prevents their rising to the surface, this can be done without loss if ordinary care is exercised. The pans are refilled and emptied in this manner until the pail is half or three-fourths full, when it will contain about 75,000 eggs. Other pails or buckets are brought into use as often as may be necessary. To keep the eggs from dying, the water is changed in the large pails every hour until the eggs are taken from the boat and transferred to scrim trays or floating boxes. All pans, pails, and other metallic utensils are coated with asphaltum paint to prevent the appearance of rust, which is fatal to the eggs.

When the weather is so cold that there is any chance of the eggs freezing to the pan, two pans are used. The outside one is partly filled with water, upon which floats the pan that is to receive the eggs as they are stripped. The pan of water protects that part of the inside pan where the eggs rest, and in that way their temperature is kept above the freezing point.

SHIPPING EGGS TO THE HATCHERY.

When spawn takers are operating at a distance, the eggs are held at conveniently located field stations, whence they are sent to the hatchery as soon as possible; but if the stations are at isolated points on the lakes it is often necessary to hold the eggs for several days before means of transportation can be obtained. In such cases the eggs are held in floating boxes, which are made 2½ by 1½ feet by 1 foot, with the ends rounded up about 6 inches. The sides and ends are 1-inch pine and the bottom ⅛-inch mesh iron wire cloth, which is continued over the rounded ends. Cleats are nailed on the sides, one end somewhat lower than the other, to give the box a tilt when placed in water. Each box carries safely about 180,000 eggs, and when filled it is anchored either in running water or in a sheltered cove of the lake. In the former case a current of water is kept passing through the box, while in the latter the eggs are given a slight motion by the action of the waves upon the surface of the water.

When eggs held in floating boxes are to be shipped, they are dipped into pails and carried to a place arranged for packing them, where a table upon which to rest the trays has been improvised from any material on hand.

The egg trays are constructed of three-fourths inch material 16 inches square inside measurement, with cheesecloth or linen scrim tacked on one side. A case large enough to contain 19 of these one over the other and to allow for a surrounding air space of 1 inch is made of seven-eighths inch pine. Cleats of one-half inch material are fastened to the bottom, on which the egg trays rest, and 1-inch strips are attached to the inside corners to hold the stack securely in position. The case is provided with hinged cover and suitable handles. Such a case with 18 egg trays, the top tray being

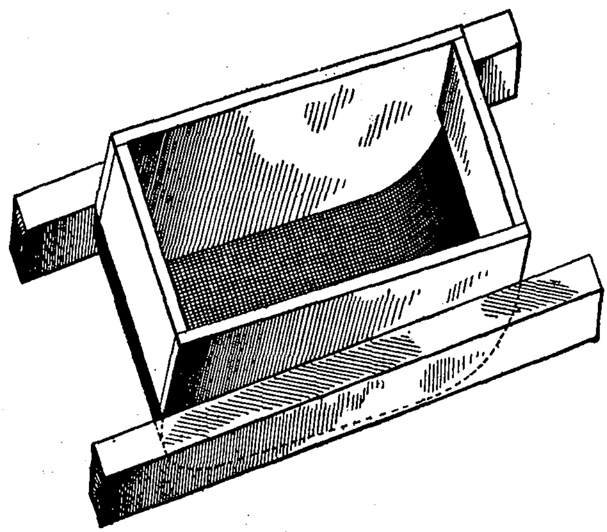

FIG. 38.—Floating box.

filled with moss and serving as a cover for the eggs, has a capacity for approximately 145,000 eggs.

When making up a shipment from a field station, the eggs are transferred from the pails to trays by means of a graduated dipper. About 8,000 are carefully placed on a tray and evenly distributed. This is easily accomplished by a gentle shake of the tray, holding it on a flat, smooth surface. A small amount of water in the measure, added either before or after the eggs are on the tray, will facilitate the work. The use of ice depends upon the outside air temperature and the distance the eggs are to be transported in baggage cars. For short shipments from the field little, if any, is needed. If the case is to pass through a varied air temperature, moss is packed in the space between the trays of eggs and the sides of the shipping case for protection against abrupt changes in the weather.

If it is necessary to hold the eggs on the trays for any length of time, as is often the case, each tray must be taken out and sprinkled with water at least once every 24 hours. If held for a longer period than four or five days, they must be taken from the trays and washed in a tub of water in the manner described in taking spawn. In adding water the dipper is either held down near the eggs or the water is poured against the side of the tub a little above the surface of the spawn in order to guard against its striking them with such force as to cause injury. Poured in this manner the eggs are given a steady whirling motion and are not injured.

The process of transferring eggs from trays to a tub is very simple. After filling a tub with water to about one-third of its capacity a tray of eggs is placed in the water at an angle of about 45° with its surface, causing most of the eggs to slide down the incline into the tub. The few remaining eggs may be washed down by pouring a little water on the uppermost side of the tray. After giving the eggs a good washing they are replaced on the trays and returned to the cases as described above.

The eggs are shipped in charge of a messenger to insure careful handling at transfer points and when being placed in the baggage car. They must be kept in the coolest place in the baggage car, provided its temperature is not below 28° or 30° F.

MORTALITY OF LAKE-TROUT EGGS.

Because of the difficulties encountered in collecting lake-trout eggs from commercial fishermen for artificial propagation it is not surprising that the percentage of fry produced from such eggs falls below the percentage realized in the hatching of other species of trout whose eggs are obtained under more promising conditions.

In common with the eggs of all the trouts and salmons, the eggs of the lake trout display a strong adhesive tendency when first expressed from the fish. This characteristic persists for a longer or shorter period, apparently depending to a considerable extent on the water temperature. The necessity of absolute quiet during this period has long been recognized in fish-cultural practice. The rolling and pitching of the boats upon which the spawn takers operate prevent the eggs from separating naturally. Separation should occur approximately within 30 minutes after the eggs are stripped, but, as the boats are out from 5 to 24 hours or longer, quiet is no longer of value when they reach the shore. Furthermore, the temperature often falls below the freezing point, and despite all precautions considerable numbers of the eggs are frequently chilled, though the ill effects may not become apparent until after they have reached the hatchery. Other losses often occur through accident or the carelessness of those handling the cases of green eggs while en route to the hatchery.

It is very probable that the greatest loss occurs through improper taking of the eggs. The bureau can not place experienced spawn takers on all the boats, and the fishermen of the smaller outfits take the eggs available and are sometimes careless in performing the operation. Frequently eggs and milt are taken from fish that have been dead for some time. After taking the eggs they are not always cleaned and carefully placed in the kegs. The fishermen are naturally more interested in the catch of fish than in the care of the eggs.

HATCHERY EQUIPMENT.

The hatching trough in use at the Charlevoix (Mich.) station embodies the principles of the Williamson hatching apparatus, with the exception that it has deep pockets and trays (fig. 40). Though simple in construction, this trough possesses more advantages than any other device for the development of large numbers of eggs within a limited space. It permits of a thorough circulation of water; the eggs can be readily handled for picking and cleaning, and the fry may be carried on trays until the yolk sac is absorbed, when they are ready to plant. Only the best 1½-inch pine or cypress is used in its construction, all planks containing imperfections being rejected. The sides and ends are each made of a single piece of lumber, the bottom being made first. All strips of different widths used in the construction are tongued and grooved, and all joints are laid in white lead.

Referring to Figure 40, it will be noted that the trough is divided by cross partitions into compartments 16½ by 14½ inches. The stationary wooden partitions are mortised one-fourth inch in the sides of the trough and are raised three-fourths inch from the trough bottom to allow water to pass under them. They extend to within three-fourths inch of the top. The movable partitions are made of 14 or 16 gauge galvanized iron, set 1½ inches from the others in one-fourth inch saw cuts in the sides and bottom of the trough and are readily removable. These movable partitions extend from the bottom of the trough to the level of the top egg tray.

In the bottoms of the compartments thus formed strips one-half inch by seven-eighths inch are nailed at the sides, on which the trays rest. Each compartment holds 13 trays, of which 12 are filled with eggs, the top one serving merely as a cover to prevent the eggs on the twelfth tray from being carried off by the current. About three-fourths inch below the top on either side is a three-eighths-inch groove running the full length of the trough. A cross-bar with a five-eighths-inch block is made to fit into these grooves and hold the trays securely in place, preventing them from rising in the water.

Water enters the head of the trough through a 1-inch pipe, a flow of 5 gallons per minute being the usual volume. By arranging the partition as is indicated in Figure 40, all water must pass from the bottom of the trough upward through each alternate stack of trays containing the eggs or fry, flowing first over an iron partition, under the succeeding wooden one, up through the trays, and so on throughout the length of the trough.

The troughs are set upon iron standards cemented into the floor and are given a pitch of 1 inch to every 8 feet in length. The height from the floor is a matter of convenience to the operator, or it depends upon the fall of water available. The trays are wooden frames 14 by 16 inches, made of seven-eighths-inch strips. They are covered with galvanized wire cloth 14 meshes to the inch for eggs, a smaller mesh being substituted for fry, as is described under care of eggs and fry. The trays will conveniently hold 1 quart of eggs (approximately 6,400) or 3,500 fry to the time they are ready to take food. The troughs and trays are given three coats of asphaltum

FIG. 39.—Interior of a lake-trout hatchery showing manipulation of eggs.

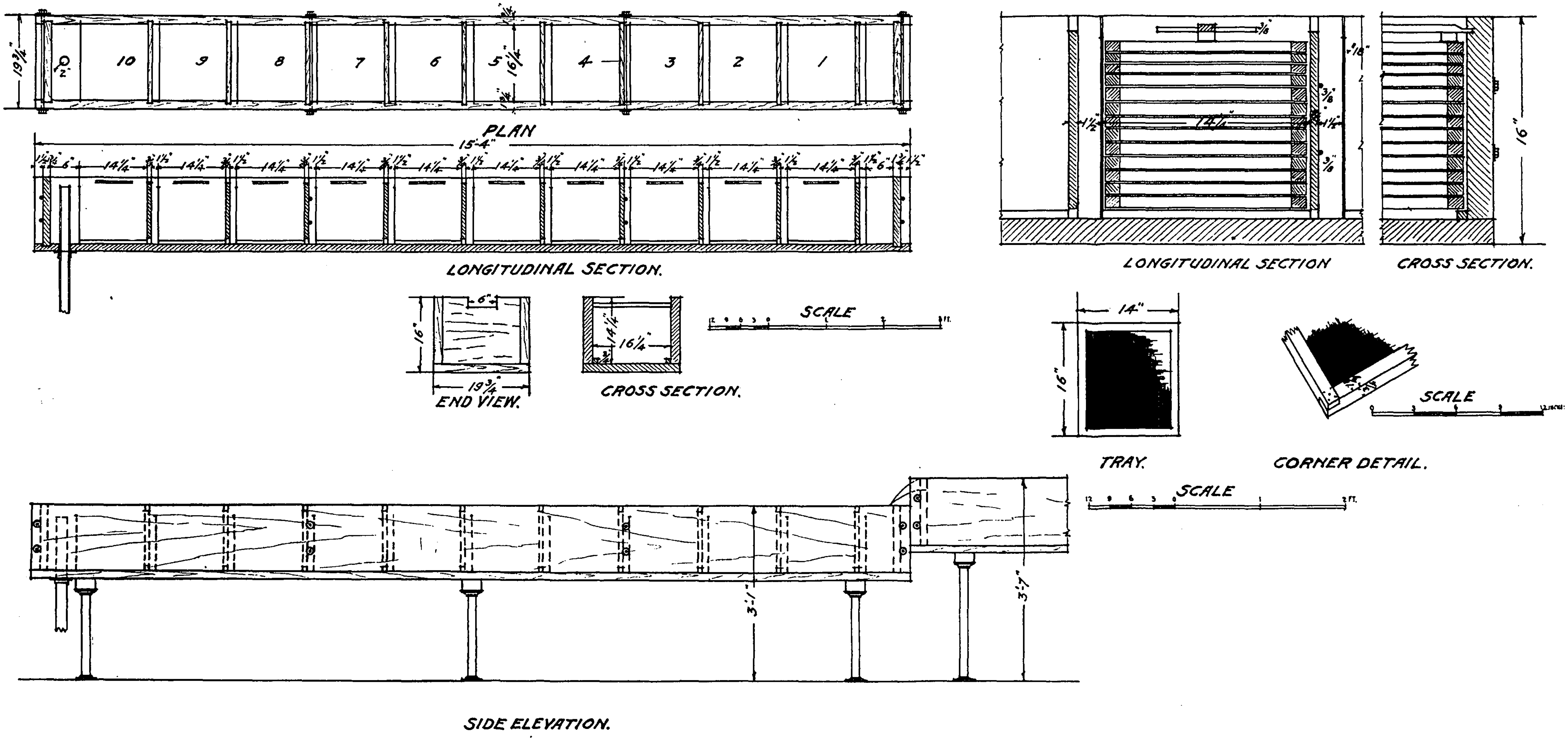

FIG. 40.—Plan of improved Clark-Williamson hatchery tray system.

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paint before using and one additional coat at the beginning of each successive season.

Where there is occasion to economize in the use of water, it may pass through two or more troughs, so placed that the overflow from the first trough is 8 inches higher than the head of the one immediately below. This fall gives some aeration to the water, and the results are usually as satisfactory as where an independent water supply is furnished to each trough. In this manner two double troughs, with 38 compartments, occupying a floor space of about 90 square feet, with the required flow of 10 gallons of well-aerated water per minute, will accommodate very nearly 3,000,000 eggs.

If the water supply carries any considerable amount of sediment, or if it is subject to even occasional periods of turbidity from surface drainage or other causes, it is essential to install a filter, otherwise the eggs soon become coated with sediment, the trays clog, and the water circulation is impaired, a condition which is sure to result in serious loss. The bureau has found that water pumped directly from the lakes is the most satisfactory source of hatchery supply. Spring water, with its usually higher temperature, shortens the natural incubation period and for this reason is objectionable.

A convenience in caring for the eggs is a shallow picking trough of any length, 15 inches wide and 2½ inches deep. A strip one-half by seven-eighths inch is nailed along each side of the bottom, and upon these the trays rest, to give a good circulation while the eggs are being assorted. The trough has a fall of not more than one-half inch throughout a length of 20 feet, and it is fed by a flow of about 2 gallons of water per minute. A dam at its lower end raises the water 1¼ inches, not entirely covering the trays. This is a point that must not be overlooked, for if the water flows over the tops of the trays many of the eggs or fry will be washed away.

CARE OF EGGS AND FRY.

On arrival at the hatchery the eggs are removed from the shipping cases and turned into tubs, whence they are transferred to the hatching troughs. In removing them from the shipping trays to tubs the method followed in washing eggs that have been held in cases for several days is employed, the transfer being made at a temperature not exceeding 50° F.

The eggs are measured in a dipper having a perforated bottom, its capacity first being determined by an actual count of eggs, 1 quart—approximately 6,400 eggs—being placed on each tray. A tray is placed in the water and a dipperful of eggs poured upon it and evenly distributed; then another tray, placed on top of the first, is filled, and the operation repeated until 12 trays have been filled. The thirteenth, or cover tray, is left empty and the whole apparatus is secured in place by the use of the cross bar or binder described on page 24. For the first few weeks after the eggs are installed in the hatchery they must be given close attention to prevent the growth and spread of fungus; all dead eggs must be carefully removed and the trays and troughs kept thoroughly clean.

To remove the egg trays for assorting, the binder is first slipped from the grooves and the trays are taken out separately. Each tray will rise to the surface as the one above it is removed, or they may be taken out as a unit by encircling the stack of trays with a galvanized-iron binder 1½ inches wide. All the trays are taken from one compartment and placed one after the other along the picking trough. The dead eggs, which soon become white and opaque and are easily distinguishable, are then picked out with small metal tweezers. If allowed to remain on the trays, a fungus would soon develop on them and spread its growth until all eggs within a short radius were affected and eventually smothered. When it is necessary to change the position of the eggs, bringing those at the bottom to the surface, it may be accomplished by the use of a soft feather, which, if carefully manipulated, will have no injurious effect. After carefully assorting the eggs the trays are again placed in the hatching trough and are looked over at least every three days during the first five or six weeks.

After the eggs have reached that stage of development where the eye spots are discernible by the unaided eye they are comparatively hardy and less susceptible to injury from handling. At this time it is customary to remove them from the hatching trays and subject them to a thorough washing. This may be accomplished by placing the eggs in pans or buckets and passing a soft feather brush among them; or a stream of water can be introduced into the vessel with sufficient force to agitate the eggs to a considerable extent. This washing not only removes all sediment that may have become attached to the outer covering of the eggs, but it also causes all infertile eggs (ringers), which up to this point have retained the color and appearance of good eggs, to turn white, thus greatly facilitating their removal. If there are only a few infertile or dead eggs, they may be removed by the use of the tweezers mentioned; but if there is a considerable number, their separation can be more readily accomplished by submerging the trays with the eggs in a salt solution. As the specific gravity of dead eggs is slightly less than that of live ones, they rise to the surface of the solution and may be removed with a small net. The salt solution is composed of approximately one part dairy salt to eight or nine parts of water. It is always advisable to test its suitability by introducing into it a small number of both living and dead eggs. Fresh water or salt may be added as required to bring the solution to the proper density.

From this time to the hatching point the eggs will require but little attention, it being necessary to go over them only about once a week for the purpose of removing any accumulation of sediment or an occasional dead egg.

From two to three weeks before the hatching period the eggs are transferred from the trays to tubs of water, carefully washed, and placed on clean trays, after which a careful measurement is made to determine the actual number of eyed eggs remaining in the hatchery. From this time until the fry commence to hatch a careful count is kept of all the dead eggs removed. On the completion of the hatching period this number is deducted from the measurement of the eyed eggs to determine the approximate number of fry. A careful count is also kept of the fry losses up to the time they are ready to plant. In a water temperature of 40° to 45° F. the eye spots are visible in from 20 to 40 days, while the total incubation period is approximately 131 days in a mean temperature of 36°. The fry absorb the yolk sac in 30 days at a mean temperature of 39°. These stages of development are all subject to considerable variation, being shortened or lengthened as the mean water temperature is decreased or increased. As the time of hatching approaches the distinct outline of the fish is plainly visible in the dark hue of the egg, and the convulsive movements of the embryo fish continue to increase until hatching occurs, when the fish breaks forth from the shell with its tail. The bright warm days of spring and the slightly warmer water temperatures usually bring out 50 per cent of the fry between the hours of 6 and 10 p. m.

Just prior to the hatching period the eggs are removed from the trays on which they have been developing and transferred to trays covered with wire cloth of smaller mesh—16 to the inch. The larger mesh cloth gives a freer circulation of water during the development of the eggs, but the smaller mesh is required for the fry, as the yolk sacs of many of them become enmeshed if a more closely woven cloth is not provided.

Considerable attention is required of the fish-culturist at this time to guard against smothering of the fry. The shells from hatching fish must be removed to prevent clogging of the trays and stoppage of the water circulation. To provide against it, when about 50 per cent of the eggs have completed development, one stack of 12 trays is emptied into a pan of water and the eggs and fry stirred with a feather. This causes the shells to rise to the top, and they can be poured off easily by gently tipping the pan. By repeating the operation several times the hatching fish are entirely freed from refuse. In returning the fish and eggs to the trays they should be divided as equally as possible among the 12 trays. To accomplish this the trays are placed in the picking trough and the fish-culturist starts at the upper end, pouring an equal quantity on each of the trays. Since handling the eggs at this time hastens hatching, it is seldom necessary to give this treatment more than two or three times.

From the hatching period until just prior to the complete absorption of the food sac, at which time the fry are usually distributed, the treatment given them is somewhat similar to that prescribed for the eggs. Monstrosities, "blue-sacs", and dead fry are picked out as soon as discovered. The fry grow very fast at this period; therefore it is not advisable to place more than 3,500 on a hatching tray, 14 by 16 inches in dimensions, which number can be held until they are ready to plant.

DISTRIBUTION OF FRY.

In view of all the considerations involved, perhaps the most satisfactory results are to be obtained from planting lake-trout fry just prior to the complete absorption of the yolk sac. Liberated at this stage of development, they are provided with sufficient nourishment to sustain life until they become somewhat acclimated to their new surroundings and the impulse to forage for their natural food has not been lessened by having artificial food placed conveniently before them. At none of its stations where lake trout are propagated is the bureau equipped for rearing to the fingerling size the large numbers of fry produced. In view of the importance of the industry dependent on the lake-trout fishery and the urgent need for exercising the most careful conservation in order to maintain the supply, the bureau has for a number of years found it expedient to distribute the output of its lake-trout hatcheries on the local spawning grounds from which the eggs are obtained. The fry are placed in the ordinary 10-gallon cans used in the distribution work, one tray of fry being carried to each can for medium distances. They are frequently transported in the bureau's distribution cars to a convenient lake port and thence by means of a fishing steamer to the planting areas. However, most of the plants are made by placing the cans of fish on regular commercial vessels employed for the trip. At the Charlevoix (Mich.) station, where the bureau has a boat equipped with two troughs, the trays of fish are carried from the hatchery to the boat, a distance of 100 feet, and placed in troughs, which are supplied with running water by a pump. Since the conditions are the same as in the hatchery, the fry may be carried long distances without loss. Allotments of lake-trout eggs are not infrequently supplied to various State fish commissions, where this course will result in economy in distributing the resulting fry or where possibilities exist for extending the fishery to new and unproductive fields.

PACKING EYED EGGS FOR SHIPMENT.

Just as soon as the eye spots are plainly visible the eggs can be packed and successfully shipped to any part of the United States or to most of the foreign countries, provided they are maintained at a uniform temperature. The shipping trays are usually constructed of material three-fourths inch thick by 1 inch wide, and the bottoms are covered with linen scrim or heavy cheesecloth. The size of the trays depends upon the number of eggs to be shipped. For a 50,000 case of eggs 12 trays 14 inches square are used. After installing the eggs on them the trays are placed one above another in the egg case. The ice hopper is then inserted and the pressure of the lid holds down the entire lot. For shipments to points within the United States where the eggs will not be en route more than four or five days the packing case is insulated with a 1½ or 2 inch thickness of ground cork.

In preparing the shipment the temperature of the room in which the eggs are to be packed should not be higher than 40° or lower than 26° F. The trays are first stacked in order on a table to receive the eggs; then a compartment of eggs that has been previously picked and cleaned is taken from the trough and carried to the packing room in a tub of water. The day before the shipment is to be made up the eggs are usually poured from one pan to another, the slight concussion resulting being sufficient to cause all infertile eggs to turn white. In the packing room most of the water is poured from the tub, and the eggs are removed by the use of a graduated dipper with perforated bottom and placed in a 16-ounce glass graduate. The proper number of ounces is then poured onto each tray, the trays having previously been spread with mosquito bar from 4 to 6 inches wider than their outside dimensions. The eggs are carefully distributed over the surface of the tray, as already described, and the edges of the mosquito bar brought in and lapped

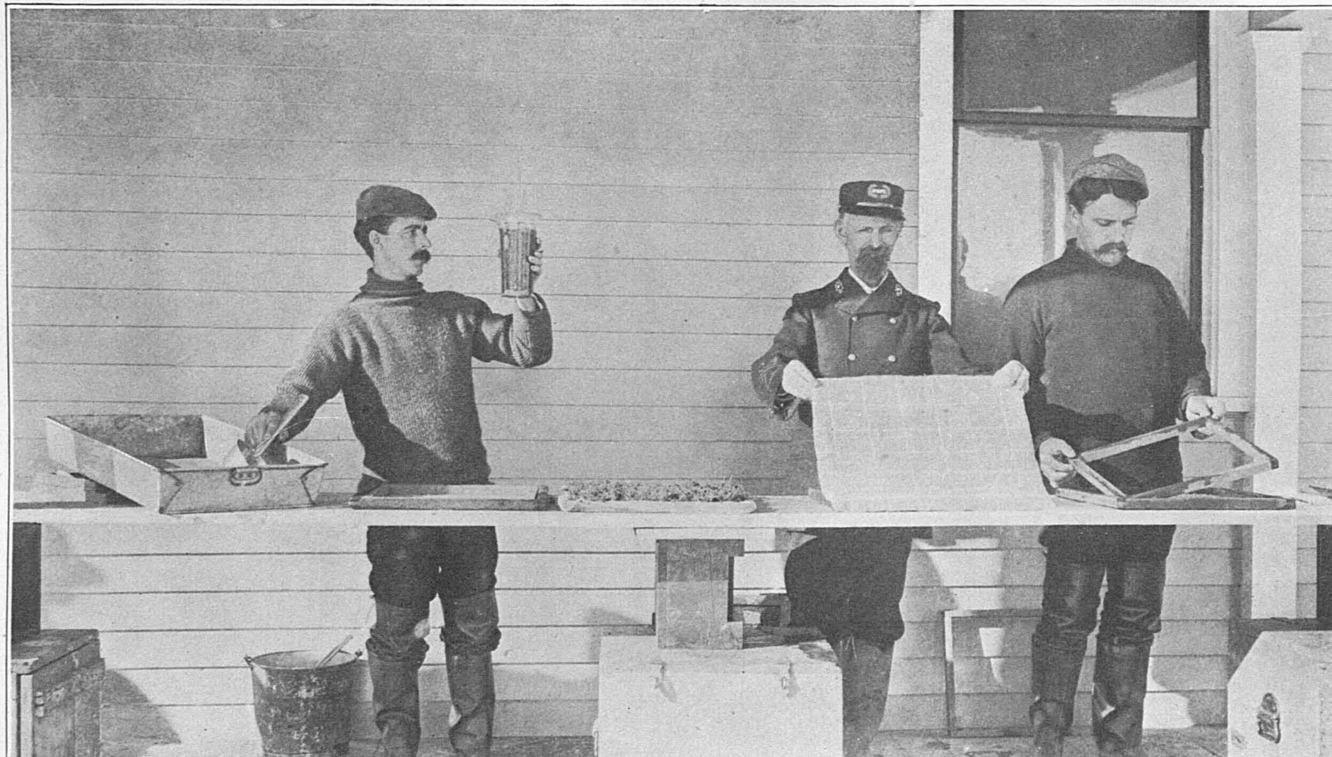

FIG. 41.—Packing eyed eggs for shipment, Northville, Mich.

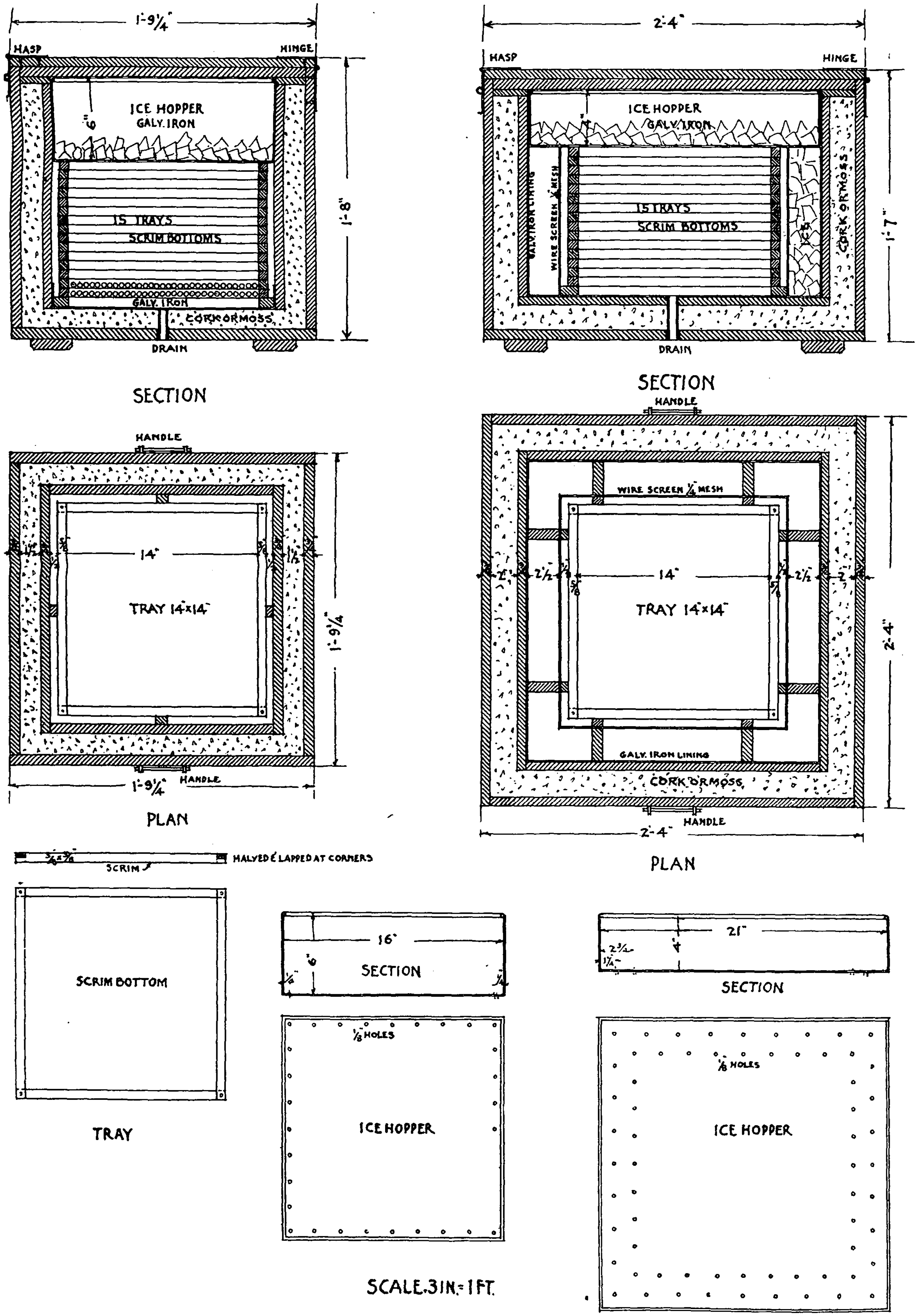

Fig. 42.—Egg-shipping case.

52881°—23. To face p. 30.)

over the top of the eggs. Unless the shipment is to be in transit a number of days it is not necessary to use moss. When moss is used it is placed between the eggs and the wooden frame of the tray, and frequently some of it is scattered over the top of the eggs, the mosquito bar preventing it from coming in direct contact with them. The best moss for the purpose is known as sphagnum, which is found in low, swampy places. It should be gathered in the fall when green and stored in a damp place until required. It is well soaked in water before placing it on the trays and the surplus water removed by squeezing a bunch of it between the hands.

When packed, the egg trays are placed upon an empty tray that has previously been filled with moss, the upper tray of eggs is covered with a tray of moss, and the ice hopper is put in place. Best results will follow if a block of ice is fitted into the ice hopper. In most of the shipments that are destined to points within the United States crushed ice is not used around the egg trays. Shipments intended for foreign countries are prepared in the same manner, except that moss is placed on each of the egg trays and the outside packing case is provided with a 2-inch thickness of cork insulation. The interior of the case is so arranged as to provide a 1½ or 2 inch space all around the egg trays for crushed ice. An ice hopper is also used at the top. These cases are shown in Figure 42.

FEEDING AND REARING.

Lake-trout fry may be held in troughs and fed, as are the fry of other species of trout. Such a procedure is prohibitive at stations of the Bureau of Fisheries that are concerned with the commercial fishery, owing to the impossibility of providing sufficient space and facilities for accommodating the large numbers produced. Moreover, it is the consensus of opinion among scientists and fish-culturists that better results are assured in this field by planting the young fish on the spawning grounds just before the yolk sac is absorbed, at the time when they are known as "free swimmers." At stations of the bureau where small numbers of lake trout are reared for noncommercial purposes the fish are held in troughs 12 to 16 feet long, 14 inches wide, and 8 inches deep, inside measurement. A screen compartment about 6 inches wide at the head of the trough prevents the fish from coming in direct contact with the inflow of water, and about 1 inch below it is a dam board extending within one-half inch of the bottom of the trough. At intervals of 18 inches throughout the remaining length of the trough cleats 1¾ inches high are mortised across the bottom of the trough. In the sides of the trough just above the cleats saw cuts one-fourth inch deep are made for the insertion of screens, their purpose being to distribute the fish evenly in small compartments throughout the length of the trough. After the fish have been fed for two or three weeks they will adjust themselves to the different parts of the trough, when the screens may be removed.

A week or 10 days before the disappearance of the yolk sac the fry intended for rearing should be transferred to troughs. A trough 14 feet long, supplied with 8 to 10 gallons of water per minute, at a temperature ranging from 45 to 50° F., will support 25,000 fry for two or three weeks after the beginning of the feeding period. As the fingerlings increase in size they must be thinned by removing some of them, and by the time they have attained a length of 3 inches not more than 5,000 can be safely carried to a trough.

For the first four weeks the fry are fed from four to six times a day on finely chopped beef liver or beef heart. The food must be carefully trimmed of all fat and gristle, and, after being run through the finest plate of a meat chopper two or three times, it should finally be passed through a tin having perforations one-tenth inch in diameter. This tin is usually placed between the knives and the plate on the meat grinder. Just before giving it to the fish the food is diluted with water and carefully stirred with a spoon. A small amount is then dipped up with a feather and carefully placed in the troughs. For some days the fish will appear not to be taking their food, but with the continuance of the feeding routine the entire lot will soon commence to feed. No prescribed quantity of food can be suggested for a given number of fish. The amount must depend upon the manner in which the fish take it. From 50 to 70 days after hatching the number of feedings per day may be reduced to three.

The troughs must be thoroughly cleaned twice daily, morning and evening, and during the cleaning process it is usually well to double the flow of water. The foul matter in the trough may be gradually worked to the foot screen with a feather, and by reducing the depth of water in the trough the scurrying of the fish will hasten the flow of sediment toward the foot screen.

After the fish reach a length of 2 or 3 inches they may be distributed in outside rearing ponds. At stations of the bureau where lake trout were formerly reared in ponds from 50,000 to 75,000 fish of this size were held in a pond 100 feet long, 5 to 6 feet wide, and provided with a flow of 35 to 50 gallons of water per minute, at a temperature not exceeding 50° F. Ponds for work of this character should have natural earth sides and gravel bottoms.

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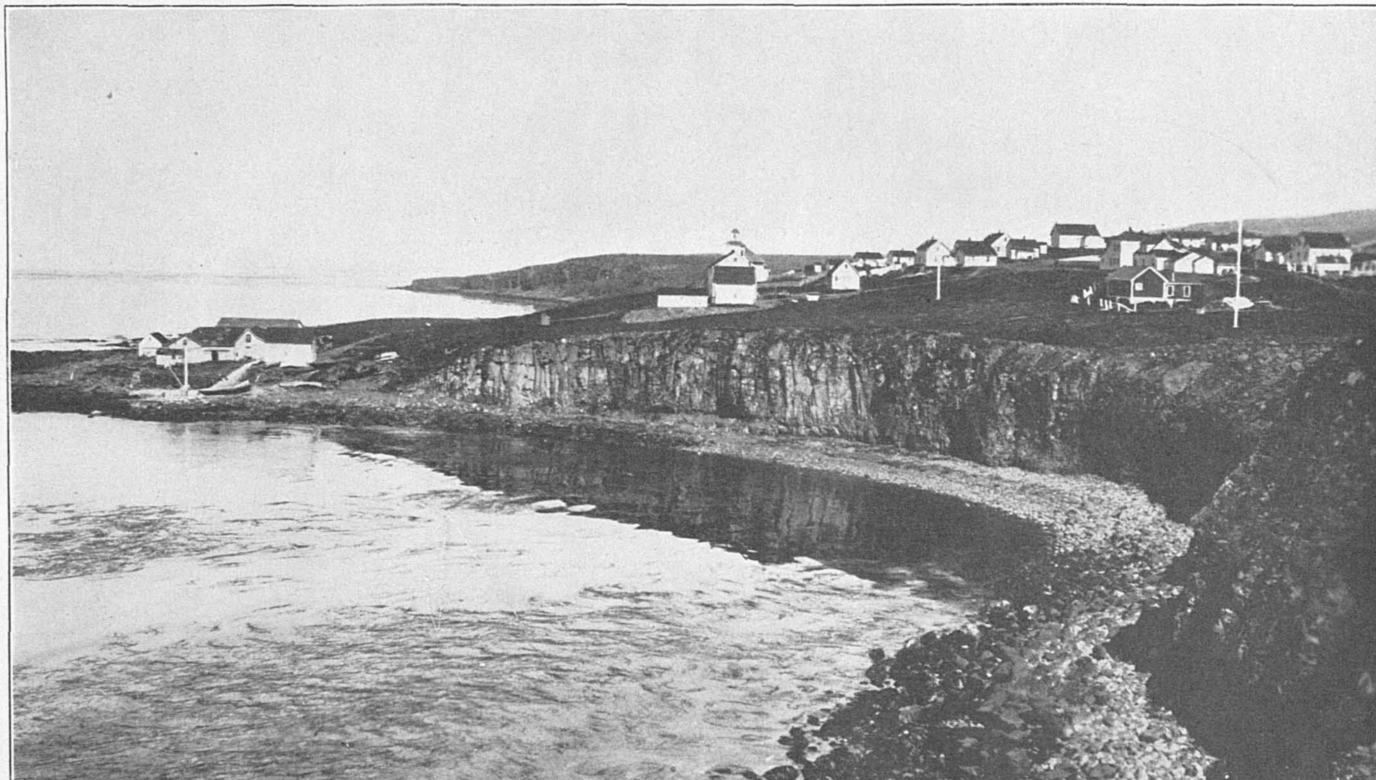

FIG. 1.—St. George landing and village, Pribilof Islands.

ALASKA FISHERY AND FUR-SEAL INDUSTRIES IN 1922.[1]

By WARD T. BOWER, *Field Assistant.*

CONTENTS.

[1] Appendix IV to the Report of the U. S. Commissioner of Fisheries for 1923. B. F. Doc. 951.

INTRODUCTION.

The bureau's work in Alaska was conducted along much the usual lines in the calendar year 1922, the chief change being the adoption of the policy of establishing reservations in districts that were threatened with overfishing and the licensing of operators under restrictions on output and apparatus. Two reservations were created, the Alaska Peninsula Fisheries Reservation by Executive order of February 17, 1922, and the Southwestern Alaska Fisheries Reservation by Executive order of November 3, 1922. Special regulations governing fishing operations in the Alaska Peninsula Fisheries Reservation were in effect during the fishing season of 1922.

A considerably increased force of temporary stream guards worked under the direction of the bureau's permanent employees during the active fishing season. Three patrol boats were added to the bureau's fleet and were made use of for the first time this season. A larger number of small boats was also chartered during the season.

An expedition was again sent into the Bristol Bay region, which during the early part of the season gave attention to the destruction of predatory fishes and birds and during commercial fishing activities maintained a patrol for the enforcement of the fishery laws and regulations. Two members of the party remained in the district during the winter of 1922–23 to make an examination of spawning beds and secure information as to the size of the escapement of spawning salmon.

A count of spawning salmon ascending the Karluk River was again made, and similar operations were undertaken at Chignik River, where a rack was constructed a short distance above Chignik Lagoon. A special study of fishery conditions on the Kuskokwim River was made.

The bureau cooperated with the Federal Power Commission in connection with applications for licenses for power projects in Alaska. Inquiries were made regarding the use of salmon for fox food on the numerous fur farms in Alaska.

In connection with studies by Dr. C. H. Gilbert of the life history of the Pacific salmons, and particularly the determination of migration routes, important work was inaugurated by the tagging of salmon taken from traps along the Alaska Peninsula and at the Shumagin Islands and by the collection of data on the time and place of recapture.

No change was made in the regulations for the protection of walruses and sea lions.

Transportation of Government employees and supplies for the Pribilof Islands was chiefly by commercial vessels, although valuable assistance along these lines was rendered by Coast Guard and naval vessels in a number of instances.

Operations in connection with the fur-seal and blue-fox industries and the administration of the affairs of the natives on the Pribilof Islands were carried on in a manner similar to previous years. The improved methods of taking skins and the removal of blubber at the islands was extended in operations on St. Paul Island. The total take of sealskins in the calendar year 1922 was 31,156; and 888 blue and 29 white fox skins were taken in the trapping season of 1922–23, in addition to which 12 live foxes for breeding purposes were sold to fox farmers in Alaska.

Two sales at public auction of sealskins taken on the Pribilof Islands were held at St. Louis in 1922 by the selling agents of the department. The fox skins taken in the preceding season were also disposed of at one of these sales.

Acknowledgment is made of the assistance rendered by Assistant Agent Edward M. Ball in the compilation of statistics and text in the fisheries section of this report and by H. D. Aller and Edward C. Johnston in the preparation of data regarding the fur-seal and fox industries of the Pribilof Islands.

A special party headed by the Assistant Secretary of Commerce, and of which the author of this report was a member, made an extensive trip for the study of conditions of the fisheries and fur seals of Alaska, also the seal herds of Russia and Japan, and returned by way of Asia and Europe. The latter part of the trip was more particularly devoted to trade promotion and a study of economic conditions in the various countries visited.

SPECIAL INVESTIGATIONS BY ASSISTANT SECRETARY OF COMMERCE AND PARTY.

With a view to making certain essential inquiries regarding the fisheries of Alaska and the fur-seal industry of the north Pacific, also to devote attention to other important governmental matters, a party sailed from Seattle June 20, 1922, on the Coast Guard cutter *Mojave*, which had been specially detailed for this purpose. The party was headed by C. H. Huston, Assistant Secretary of Commerce, other members officially attached being Dr. Leonhard Stejneger, of the United States National Museum; Dr. Alfred H. Brooks, United States Geological Survey; Lieut. Col. H. M. Evans, United States Public Health Service; Lieut. John M. Creighton, United States Navy; Ward T. Bower, Bureau of Fisheries; D. J. Davis, Department of Labor; and J. L. Baker and C. E. Lindquist, special assistants. Col. James G. Steese, president of the Alaska Road Commission, joined the party at Juneau and continued as far as Petropaulski, Siberia. In Alaska the more important places visited were Ketchikan, Yes Bay, Wrangell, Petersburg, Juneau, Cordova, Seward, Karluk, Chignik, False Pass, Akutan, Unalaska, the Pribilof Islands, and Nome. En route from Seattle a brief stop was also made at Prince Rupert, British Columbia. At Cordova the party left the *Mojave* and proceeded by railroad and automobile to Fairbanks, thence by Government railway to Anchorage and Seward, where the *Mojave* was rejoined.

Consideration was given to important fishery questions in the Territory, particularly in regard to measures for perpetuating the supply of salmon so seriously threatened in a number of places. The Government hatchery at Yes Bay was visited, as was also the Territorial hatchery at Juneau. Important conferences were had with the Governor of Alaska and other officials. Note was made of the salmon-counting experiments conducted at Karluk. Important action was taken in regard to administering the fisheries of the Alaska Peninsula Fisheries Reservation.

On July 10 Mr. Huston, accompanied by Dr. Stejneger and Messrs. Bower, Baker, and Lindquist, left the *Mojave* and proceeded to the Pribilof Islands on the Coast Guard cutter *Algonquin*, arriving at St. Paul Island July 12, having stopped for a few hours en route at St. George Island. Doctor Stejneger and Captain Lindquist left the Pribilofs shortly thereafter on that vessel for the Commander Islands via Unalaska for a special investigation of the Russian fur-seal herd. Mr. Huston made a thorough investigation of the condition of the fur-seal herd at the Pribilof Islands and observed administrative methods and various features of the work. Attention was devoted especially to the improved manner of taking sealskins by stripping the pelts from the animals instead of the old laborious skinning by hand. The journey was resumed on the *Mojave* July 19, arriving at Nome July 21.

Thereafter visits were paid to Emma Harbor and Anadir, Siberia, where salmon fishery conditions were noted. Although the river at Anadir is large, it does not carry a particularly heavy run of salmon. No canneries were found in that region, and fishing operations were limited to two salteries, the product being destined for Japanese markets.

The *Mojave* returned from Anadir to Dutch Harbor, Alaska, for fuel, sailing from that place August 2 and arriving at Bering Island of the Commander group on August 8, where a brief visit ashore was made and Doctor Stejneger and Captain Lindquist were taken aboard. The condition of the fur-seal herd of the Commander Islands is not good; the lack of stable government has proved unfortunate in respect to the protection and conservation of the Russian seal herd. Representatives of the Government at Vladivostok were in charge, but their authority was more or less in doubt and they did not know what developments might be brought forth from day to day. Inasmuch as this condition has resulted in lack of supplies for the natives, it is only natural that they should engage in the occasional surreptitious disposal of fur-seal and fox skins. From time to time Japanese cruisers have visited the waters, and it is said that the natives traded skins for supplies. It was understood that in 1922 about 600 fur seals would be taken at the Commander Islands, chiefly for food for the native inhabitants.

There has been some seal poaching by Japanese schooners around the Commander Islands; in fact, the crew of a Japanese vessel was captured by native guards at Copper Island and was confined in jail at the time the *Mojave* was in Petropaulski. Subsequent inquiries at Tokyo developed the fact that officials of the Japanese Government regard this poaching as wholly improper and indefensible.

The Russian fur-seal herd has declined to probably not over 18,000 animals. This matter will be made the subject of a special report by Doctor Stejneger, who had visited the Commander Islands previously in 1882, 1883, 1895, 1896, and 1897. The department considered itself fortunate in securing the services of Doctor Stejneger for this important investigation.

From August 9 to 11 the *Mojave* was at Petropaulski on the Kamchatka Peninsula, where inquiries were made regarding fishery and fur-trade conditions. This is the principal port on the Kamchatkan coast and is the base of salmon fishery operations conducted at four canneries in that region. The Kamchatka River, about 100 miles north of Petropaulski, is the only stream of real importance on the eastern coast of Kamchatka. It has a fairly good run of red salmon.

On the west coast of Kamchatka the Ozernaya River has a good run of red salmon and is fished by several canneries. The lack of harbors makes operations precarious. The products are marketed largely in Japan and England. Fishery operations are chiefly controlled by Japanese capital. Several Japanese cruisers were observed in this region, their presence being primarily to afford protection to Japanese fishing interests.

From Petropaulski the *Mojave* proceeded to Robben Island, arriving August 15. Representatives of the Japanese Government who had been especially sent there for the occasion extended a cordial welcome. A careful examination of the rookeries revealed them to be in splendid condition. The Japanese Government is handling Robben Island very successfully. Doctor Stejneger visited this island in 1896 and was much surprised to note the great increase of the herd in 1922. This island is small, not over one-half mile in length, and the number of fur seals is necessarily correspondingly limited. Doctor Stejneger's preliminary estimate, however, was that the herd now numbers upward of 20,000 animals, a very remarkable increase. The take of skins in 1922 numbered 600. The results of observations here will be covered in a special report.

After leaving Robben Island August 16 the *Mojave* made calls at Otomari, Otaru, and Hakodate and reached Yokohama August 26. Members of the party visited Tokyo for conferences with Japanese officials and went also to the Marine Biological Laboratory at Misaki. Messrs. Stejneger, Brooks, and Lindquist returned to the States by commercial steamer from Yokohama. Dr. James F. Abbott, commercial attaché at Tokyo, joined the party and remained with it until arrival at Shanghai. Some of the members of the party proceeded to Kyoto and Osaka, rejoining the *Mojave* at Kobe. After leaving the latter port a call was made at Itozaki, and Vladivostok was reached September 6, where consideration was given to fishery matters affecting the Siberian coast. The party left Vladivostok September 9 and arrived the following day at Fusan, Korea. From this point Mr. Huston and Doctor Abbott proceeded by train to Seoul, Mukden, Peking, and Shanghai. The *Mojave* reached Shanghai September 14 and remained nine days. The next port of call was Manila, which was reached September 27. Lieutenant Creighton left at this point and returned to the States.

At Manila the *Mojave* was dispensed with. Approximately 103 days were spent aboard the vessel and about 12,000 miles were cruised. This was the first extended voyage of the *Mojave*, one of the new electric-driven Coast Guard cutters built in the fall of 1921. The results speak very highly for the ship and for the efficiency of Lieut. Commander H. G. Hamlet, commanding the vessel, and the officers and crew. Acknowledgment is hereby made of the splendid cooperation and numerous courtesies freely extended by the officers and crew of the *Mojave*.

From Manila the party, which now consisted of Assistant Secretary Huston and Messrs. Evans, Bower, Baker, and Davis, proceeded by commercial steamer to Hongkong. A trip was also made to Canton. October 10 the party left Hongkong for Singapore, which was reached five days later. Other points thereafter visited included Penang, Calcutta, Bombay, Aden, Port Said, and Cairo. Marseilles was reached November 25. From that point visits were made to Monte Carlo, Rome, Milan, Zurich, Vienna, Prague, Berlin, Brussels, Paris, The Hague, and London. Departure from Southampton occurred December 14, and New York was reached December 23.

After leaving Japan attention was chiefly devoted to a study of economic conditions and possibilities of trade promotion through the countries of Asia and Europe. Attention was also given to the activities of representatives of the Department of Commerce stationed in those countries.

In London visits were made to plants where fur-seal skins have been dressed and dyed, and special attention was given to conditions affecting the marketing of fur-seal skins. The conclusion was reached that there was nothing to warrant any change in the method of this Government in disposing of its fur-seal skins in the United States.

REGULAR EMPLOYEES, ALASKA SERVICE.

During the year 1922 the following regular employees were identified with the Alaska service of the bureau:

Regular employees identified with the Alaska service in 1922.

Name.	Position.	Headquarters or chief place of duty.
Ward T. Bower	Field assistant	Washington, D. C.
Dennis Winn	Chief agent	Seattle.
Edward M. Ball	Assistant agent	Juneau.
Harry J. Christoffers	do	Seattle.
Calvin F. Townsend	Inspector	Fairbanks.
Shirley A. Baker	Assistant agent	Cordova.
Lemuel G. Wingard	do	Bethel.
A. H. Proctor	Superintendent	St. Paul Island.
Charles E. Crompton	Agent and caretaker	St. George Island.
Henry D. Aller	do	St. Paul Island.
Edward C. Johnston	Storekeeper	Do.
Henry C. Scudder	do	St. George Island.
George B. Bowlby	Physician	St. Paul Island. (Resigned Oct. 9, 1922.)
William M. Murphy	do	St. George Island. (Resigned Aug. 11, 1922.)
George S. Lesher	do	St. George Island.
Robert E. Davis	do	St. Paul Island. (Appointed Oct. 10, 1922.)
Henry Mygatt	Assistant to agent	St. Paul Island. (Resigned Aug. 9, 1922.)
Paul E. Moran	do	St. Paul Island. (Appointed Aug. 10, 1922.)
Richard Culbertson	School-teacher	St. Paul Island. (Resigned July 31, 1922.)
Harold W. Lashler	do	St. Paul Island. (Appointed Aug. 18, 1922.)
John M. Orchard	do	St. George Island.
Edna C. Mygatt	do	St. Paul Island. (Resigned July 10, 1922.)
Lois L. Proctor	do	St. Paul Island. (Appointed Aug. 14, 1922.)
Michael J. O'Connor	Warden	Juneau.
Fred H. Gray	do	Wrangell.
James K. Nevill	do	Do.
Adolph T. Looff	do	Nushagak.
Joseph N. Braun	do	False Pass. (Resigned Sept. 12, 1922.)
William E. Baumann	do	Afognak.
Chauncey C. Combs	do	Haines. (Resigned Aug. 31, 1922.)
Charles Petry	do	Chignik.
Lawrence K. Smith	do	Seldovia. (Resigned Dec. 31, 1921.)
Arthur H. Mellick	Master power vessel Eider	Unalaska.
Jesse L. Nevill	Master patrol vessel Auklet	Wrangell.
George G. Naud	Master patrol vessel Murre	Juneau. (Resigned Aug. 31, 1922.)
Arthur McLean	do	Juneau. (Appointed Sept. 1, 1922.)
Earle L. Hunter	Master patrol vessel Widgeon	Juneau. (Appointed Aug. 1, 1922.)
C. E. Tibbits	Master patrol vessel Petrel	Do.
Hector McAllister	Master patrol boat Scoter	Nushagak. (Appointed May 1, 1922.)
Albert K. Brown	Clerk	Washington, D. C.
Mary S. Haines	do	Do.
Edna Bishop	do	Do.
E. Elaine Baker	do	Seattle. (Resigned Apr. 15, 1922.)
Gladys M. Gamlen	do	Seattle.
Beverly G. Rupp	do	Seattle. (Appointed Apr. 17, 1922.)

Regular employees at Government hatcheries in Alaska in 1922.

Location and name.	Position.
Afognak:	
Edwin Wentworth	Superintendent. (Resigned Sept. 21, 1922.)
Fred R. Lucas	Superintendent. (Promoted Aug. 21, 1922, from fish-culturist.)
Harry J. Heuver	Foreman. (Transferred Oct. 31, 1922, to Saratoga, Wyo.)
Frank L. Snipes	Foreman. (Transferred Nov. 1, 1922, from fish-culturist, Tupelo, Miss.)
Alfred Nelson	Fish-culturist.
Homer H. Whitford	Fish-culturist. (Transferred Aug. 1, 1922, from apprentice fish-culturist, Puget Sound stations; promoted Oct 16, 1922.)
Nicolai Boskofsky	Apprentice fish-culturist.
Ray S. Wood	Do.
Nicolai W. Anderson	Apprentice fish-culturist. (Appointed Feb. 1, 1922; appointment expired May 4, 1922.)
Carl A. Kjorsvick	Apprentice fish-culturist. (Appointed May 5, 1922; appointment expired Aug. 8, 1922.)
Russell Waterbury	Apprentice fish-culturist. (Appointment expired May 4, 1922.)
Robert E. Forsyth	Apprentice fish-culturist. (Appointed May 5, 1922.)
William Rossing	Cook.
McDonald Lake:	
C. H. Van Atta	Superintendent. (Transferred Sept. 21, 1922, to Leadville, Colo.)
John W. Gardner	Superintendent. (Promoted Sept. 22, 1922, from foreman, Puget Sound stations.)
Calvin D. Ryan	Foreman.
George L. Savage	Fish-culturist. (Dismissed Feb. 28, 1922.)
Melvin L. Soules	Fish-culturist. (Promoted Aug. 1, 1922, from apprentice fish-culturist.)
Arthur P. Swanberg	Fish-culturist. (Resigned Nov. 14, 1922.)
Frank W. Ross	Apprentice fish-culturist. (Resigned July 19, 1922.)
Gustavus W. Benson	Apprentice fish-culturist. (Appointed Aug. 16, 1922.)
Herbert D. Rhodes	Apprentice fish-culturist. (Transferred Aug. 1, 1922, from apprentice fish-culturist, Cape Vincent, N. Y.)
Louis Flagstad	Apprentice fish-culturist. (Appointed Jan. 1, 1922; resigned Sept. 30, 1922.)
Joseph M. Lysnes	Apprentice fish-culturist. (Appointed Oct. 1, 1922.)
Sadie Ross	Cook. (Resigned July 19, 1922.)
Marie Flagstad	Cook. (Appointed Aug. 16, 1922.)

FISHERY INDUSTRIES.

As in corresponding reports for previous years, the Territory of Alaska is here considered in the three coastal geographic sections generally recognized, as follows: Southeast Alaska, embracing all that narrow strip of mainland and the numerous adjacent islands from Portland Canal northwestward to and including Yakutat Bay; central Alaska, the region on the Pacific from Yakutat Bay westward, including Prince William Sound, Cook Inlet, and the southern coast of Alaska Peninsula, to Unimak Pass; and western Alaska, the north shore of the Alaska Peninsula, including the Aleutian Islands westward from Unimak Pass, Bristol Bay, and the Kuskokwim and Yukon Rivers. These divisions are solely for statistical purposes and do not coincide with districts made under reservations created during the calendar year, which include areas from both the central and western statistical divisions.

Detailed reports and statistical tables dealing with the various fishery industries are presented herewith, and there are also given the important features of certain subjects that were the objects of special investigation or inquiry.

WATERS CLOSED TO COMMERCIAL FISHING.

Restrictions and limitations imposed by previous orders of the Department of Commerce prohibited all commercial fishing in the streams and lakes of Alaska and within a zone extending 500 yards off the mouths of all streams, with the exception of the Ugashik and Karluk Rivers, where, owing to peculiar geographic conditions, specified districts remained open to fishing. Executive orders previously issued remain in effect also with regard to the Afognak Reservation, Aleutian Islands Reservation, Yes Bay and Stream, and the Annette Island Fishery Reserve. Executive orders issued in 1922 established two new reservations—the Alaska Peninsula Fisheries Reservation and the Southwestern Alaska Fisheries Reservation.

ALASKA PENINSULA FISHERIES RESERVATION.

By Executive order of February 17, 1922, the Alaska Peninsula Fisheries Reservation was created. It extends eastward from the Aleutian Islands Reservation to a line from Foggy Cape, on the eastern end of Sutwik Island, to Cape Menshikof, on the northern shore of the Alaska Peninsula, and includes the Shumagin Islands and the territorial waters adjacent to these lands and also the lands of the Aleutian Islands Reservation. The text of the order is as follows:

In addition to the islands of the Aleutian Chain, Alaska, withdrawn and made a preserve and breeding ground for native birds, for the propagation of reindeer and fur-bearing animals, and for the encouragement and development of fisheries, by the Executive order of March 3, 1913 (No. 1733), as modified by the Executive order of August 11, 1916 (No. 2442), a reservation comprising the islands, peninsulas, and lands adjoining the eastern end of the reservation established by the said Executive order of March 3, 1913, and extending in an easterly and northerly direction from Isanotski Strait to a line extending from low-water mark at Foggy Cape on the eastern end of Sutwik Island to low-water mark at Cape Menshikof on the northern shore of the Alaska Peninsula, including the Shumagin Islands and all other islands, peninsulas, or parts thereof within the described area, is hereby set apart as a preserve to more effectively insure the protection of the fisheries and for their encouragement and development. This latter reservation is to be known as the Alaska Peninsula Fisheries Reservation.

It is hereby further ordered that all straits, bays, and other waters over which the United States has jurisdiction by reason of their relation and proximity to the islands, peninsulas, and other lands to which this order, as well as the said order of March 3, 1913, applies, be, and the same are hereby, reserved and set apart also as a preserve to more effectively insure the protection of the fisheries and for their encouragement and development.

The Secretary of Commerce shall have power to make regulations for the proper administration of the said Alaska Peninsula Fisheries Reservation and the straits, bays, and other waters reserved by this Executive order.

The establishment of the reservations under this Executive order shall not interfere with the use of the waters, islands, or other lands for lighthouse, military, naval, or other public purposes, nor with the use of any of said islands or other lands under the laws of the United States for town-site purposes, mining purposes, or grazing of animals thereupon, under rules and regulations to be established by the Secretary of the Interior.

Under authority of the above Executive order the department, under date of April 18, 1922, issued the following regulations:

1. For purposes of administration the following six fishing districts are created:

(*a*) *Port Heiden district.*—Extends along the Bering Sea shores of the reservation from its eastern limit to the one hundred and sixtieth meridian of west longitude.

(*b*) *Port Moller district.*—Extends along the Bering Sea shores of the reservation from the one hundred and sixtieth meridian of west longitude to the north entrance of Isanotski Strait (otherwise commonly known as False Pass), which forms its western boundary.

(*c*) *Ikatan district.*—Includes Isanotski Strait south of its northern entrance and extends thence along the Pacific shore of the reservation eastward to the one hundred and sixty-first meridian of west longitude.

(*d*) *Shumagin district.*—Includes the Shumagin Islands and the mainland shores and islands of the Pacific side of the reservation from the one hundred and sixty-first to the one hundred and fifty-ninth meridian of west longitude.

(*e*) *Chignik district.*—Extends from the one hundred and fifty-ninth meridian of west longitude along the Pacific shores of the reservation to its eastern margin.

(*f*) *Aleutian Islands district.*—Waters over which the United States has jurisdiction from Isanotski Strait westward throughout the entire Aleutian Islands reservation.

2. No individual or concern shall engage in the business of catching, canning, or preparing salmon, except for personal or family use and not for sale or barter, within the above-stated districts without first securing a permit from the Secretary of Commerce. Applications for annual permits shall be addressed on or before January 15 of each year to the Secretary of Commerce, Washington, D. C., and shall give full information on the following points: (*a*) Name and permanent address of person or corporation desiring permit; (*b*) character of business proposed, whether fishing, canning, salting, or otherwise curing fish; (*c*) character and extent of plant to be operated and its location; (*d*) method and extent of fishing proposed; (*e*) exact place or places where fishing is to be carried on; (*f*) number and kind of each class of fishing apparatus to be used; (*g*) number of cases of salmon to be packed (based upon 48 one-pound cans per case) or number of barrels of salmon to be salted or tierces of salmon to be mild cured; (*h*) when operations are to begin; (*i*) if application is for continuance of operations formerly conducted, the catch and pack of salmon by species and the amount of each class of gear operated in the next preceding sea-

son must be shown; (*j*) affidavit as to correctness of facts set forth in the application must be made by competent authority.

3. Permits will specify the amount of pack and the character and extent of fishing operations allowed.

4. Permits for the season of 1922 will be issued only to such individuals or concerns as are now operating within the reservation.

5. Permits will be valid only within the district for which issued.

6. Transportation of fresh salmon for canning, salting, or otherwise preserving will not be permitted from one fishing district to another or outside the reservation.

7. These regulations do not apply to persons taking salmon with rod, hand line, or spear for their personal or family use and not for sale or barter.

8. These regulations will be subject to such annual revision by the Secretary of Commerce as may appear advisable in view of the investigation and the experience of the preceding season.

9. These regulations will be in full force and effect immediately from and after date of issue.

Under date of December 14, 1922, revised regulations for the reservation were issued as follows:

1. For the purposes of administration the following six fishing districts are created:

(*a*) *Port Heiden district.*—Extends along the Bering Sea shores of the reservation from its eastern limit to the one hundred and sixtieth meridian of west longitude.

(*b*) *Port Moller district.*—Extends along the Bering Sea shores of the reservation from the one hundred and sixtieth meridian of west longitude to the north entrance of Isanotski Strait (otherwise commonly known as False Pass), which forms its western boundary.

(*c*) *Ikatan district.*—Includes Isanotski Strait south of its northern entrance, the waters surrounding Unimak and the Sanak Islands, and the waters to the eastward along the Pacific shores of the reservation to the one hundred and sixty-first meridian of west longitude.

(*d*) *Shumagin district.*—Includes the Shumagin Islands and the mainland shores and islands of the Pacific side of the reservation from the one hundred and sixty-first to the one hundred and fifty-ninth meridian of west longitude.

(*e*) *Chignik district.*—Extends from the one hundred and fifty-ninth meridian of west longitude along the Pacific shores of the reservation to its eastern margin.

(*f*) *Aleutian Islands district.*—Waters over which the United States has jurisdiction from Unimak Pass westward throughout the entire Aleutian Islands Reservation.

2. No individual shall engage in the business of catching, canning, or preparing salmon, except for personal or family use and not for sale or barter, within the above-stated districts without first securing a permit from the Secretary of Commerce. Applications for annual permits shall be made on or before January 15, 1923, and on or before December 15 of each year thereafter, to the Secretary of Commerce, Washington, D. C., and shall give full information on the following points:

(*a*) Name and permanent address of person or corporation desiring permit. (*b*) Character of business proposed, whether fishing, canning, salting, or otherwise curing fish. (*c*) Location and capacity of plant (number of lines of machinery in cannery and whether for pound or half-pound cans). (*d*) Number and kind of each class of fishing gear desired, and location where same is to be operated. (*e*) Number of cases of salmon to be packed (based upon 48 one-pound cans per case), or number of barrels of salmon to be salted, or tierces of salmon to be mild cured. (*f*) If application is for continuance of operations formerly conducted, the catch and pack of salmon by species and the amount of each class of gear operated in the next preceding season must be shown. (*g*) Affidavit as to correctness of facts set forth in the application must be made by competent authority.

3. Permits shall specify the amount of pack allowed, if that be limited, and the character, extent, and locality of fishing operations to be conducted.

4. Transportation of fresh salmon for canning, salting, or otherwise preserving will not be permitted between any two districts or zones within the

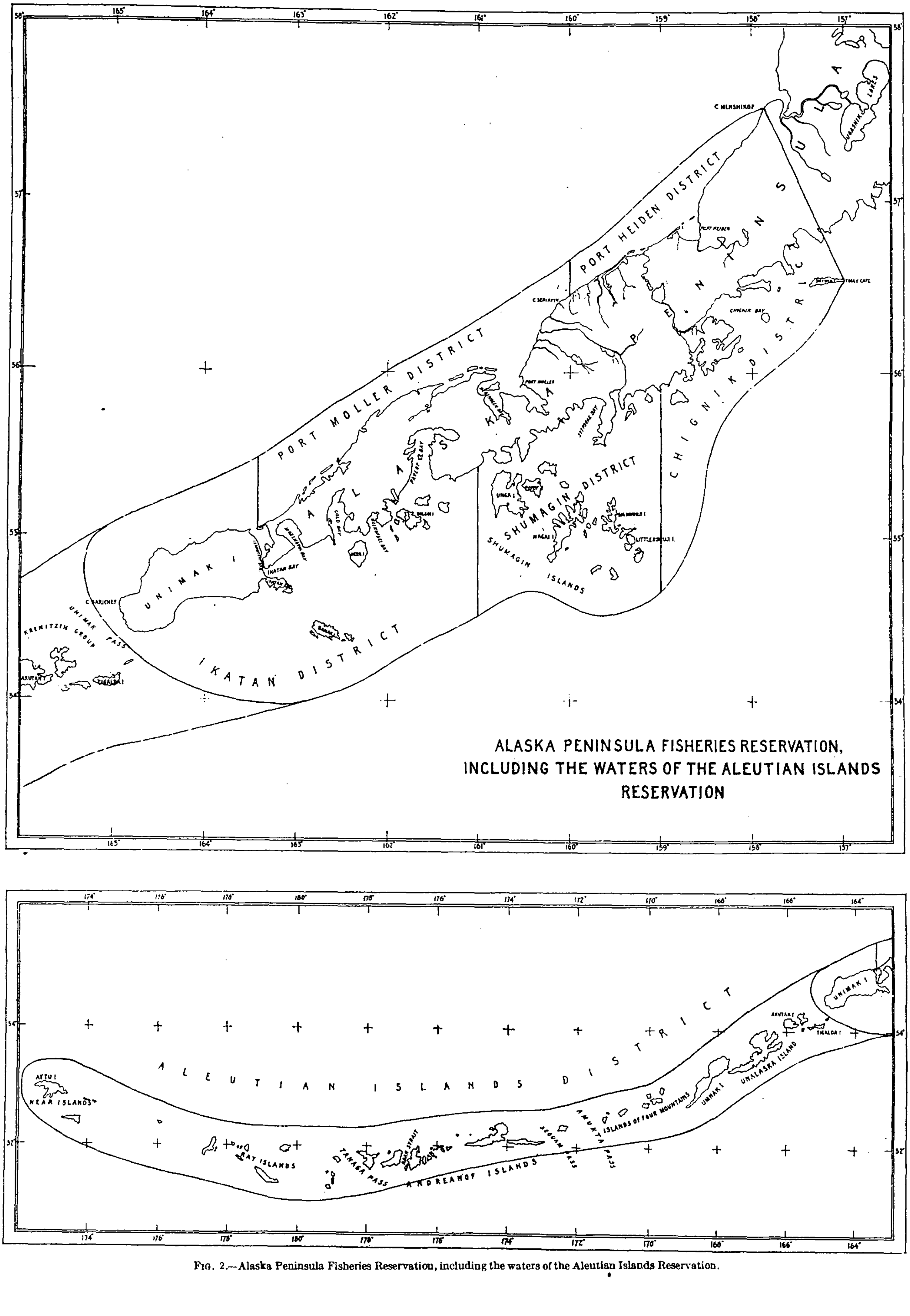

Fig. 2.—Alaska Peninsula Fisheries Reservation, including the waters of the Aleutian Islands Reservation.

reservation or between any district or zone within the reservation and any outside district.

5. The pack of each plant shall be made exclusively from the proceeds of the fishing gear specifically allotted to it. Transfer of salmon from one plant to another will not be permitted; but nothing in these regulations shall prevent the purchase of salmon from natives or local inhabitants who have secured permits to fish.

6. Fox farmers may take and prepare salmon for fox feed in all legal ways but must secure permits from the Secretary of Commerce.

7. These regulations shall be subject to such annual revision by the Secretary of Commerce as may appear advisable in view of the investigation and the experience of the preceding season. They shall be in full force and effect immediately from and after date of issue.

Ten formal permits for commercial salmon-canning operations by established plants within the reservation were granted for the season of 1922, as shown in the table below, which gives also the pack of canned salmon in the reservation. A permit was also granted to George Albert, of Port Heiden, for the salting of not over 700 barrels of all species of salmon, and 30 permits were issued to local residents by Warden J. N. Braun, the bureau's representative in the district, for fishery operations upon a small scale. Approximately 1,570 barrels of salted salmon were prepared under these minor permits.

Pack of canned salmon in the Alaska Peninsula Fisheries Reservation, Alaska, in 1922.

Permit No.	Name of permittee.	Location.	Cohos.	Chums.	Humpbacks.	Kings.	Reds.	Total.
			Cases.	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*
47	P. E. Harris & Co.	False Pass		4,095	1,678	205	58,634	64,612
48	Joint permit to Pacific American Fisheries, Nelson Lagoon Packing Co., Phoenix Packing Co., and Fidalgo Island Packing Co.	Port Moller		4,004		1,729	44,624	50,357
49	Everett Packing Co.	Herendeen Bay		104		97	15,931	[1] 16,132
50	Pacific American Fisheries	Ikatan		8,215	4,723	458	67,043	80,439
51	do	King Cove	261	15,556	11,403	74	73,028	100,322
52	Shumagin Packing Co.	Squaw Harbor		5,946	2,808	63	27,183	36,000
53	Northwestern Fisheries Co.	Chignik	462	7,413	4,431	52	37,677	50,035
54	Columbia River Packers' Association.	do	521	6,409	5,411	40	37,836	50,217
55	Alaska Packers Association	do	632	7,117	4,701	32	37,811	50,293
	Total		1,876	58,859	35,155	2,750	399,767	498,407

[1] Included in this pack were 520 chum, 312 king, and 194,045 red salmon purchased from a cannery at Ugashik River, hence not taken from the waters of the reservation.

SOUTHWESTERN ALASKA FISHERIES RESERVATION.

With the rapid depletion of the salmon fisheries in other parts of Alaska and the realization that an exodus from the less profitable districts would probably soon occur to such districts as still maintained large runs of the valuable red salmon the bureau felt that some definite action should be taken at once to secure broad enough control of these districts to regulate operations properly and conserve the runs in their present value. Efforts had been made for many years to secure the passage of a fishery law that would enable effectual preservation of the fisheries of Alaska, but always without success because of the opposition of certain divergent interests. As a last resort and as a more or less temporary measure pending the passage of adequate laws by Congress the President, under date of November 3, 1922, signed an Executive order creating the Southwestern Alaska Fisheries Reservation, including the waters of Bristol Bay, Cook Inlet, and the Kodiak-Afognak region. The text of the order is as follows:

Whereas it has become apparent that certain valuable fisheries of Alaska have been seriously impaired and are in danger of further depletion, and that it is necessary to establish authority to meet the exigency which has arisen for the protection of these fisheries, and

Whereas by Executive order issued under date of March 3, 1913, modified by an order of August 11, 1916, a reservation known as the Aleutian Islands Reservation was created, and by an Executive order under date of February 17, 1922, a reservation known as the Alaska Peninsula Fisheries Reservation was created, including therein the lands and the territorial waters of the United States contiguous to the lands covered by said Executive order,

Now, therefore, I, Warren G. Harding, President of the United States of America, by virtue of the power in me vested by the laws of the United States, do hereby set apart as a preserve to more effectively insure the protection of the fisheries and for their encouragement and development, in addition to the above reservations, a reserve of lands and waters, which said reservation shall be known as the Southwestern Alaska Fisheries Reservation, which shall include all territorial waters, and the lands within one-half mile of the shores thereof, within the lines defined as follows:

From the northeasterly point of the Alaska Peninsula Fisheries Reservation at Cape Menshikof, Bristol Bay, northwesterly to a point in latitude 58° 32′ north, longitude 162° 12′ west, off Cape Newenham; thence to a point in latitude 59° 15′ north, longitude 162° 0′ west; thence eastward along parallel of latitude 59° 15′ north, to longitude 155° west; thence to a point in latitude 61° 20′ north, longitude 151° 20′ west; thence to a point in latitude 61° 20′ north, longitude 150° 10′ west; thence to a point in latitude 61° 35′ north, longitude 149° 40′ west; thence to a point in latitude 61° 35′ north, longitude 149° 0′ west; thence to a point in latitude 60° 40′ north, longitude 149° 0′ west; thence to a point in latitude 60° 40′ north, longitude 151° 0′ west; thence to a point in latitude 57° 30′ north, longitude 151° west; thence to a point in latitude 55° 0′ north, longitude 157° 0′ west; thence to low-water mark at the eastern extremity of Foggy Cape on Sutwik Island; thence to point of beginning.

Fishery operations within the said Southwestern Alaska Fisheries Reservation shall be subject to such regulations and restrictions as shall be issued by the Secretary of Commerce, in addition to the general fisheries laws and regulations of the United States as administered by the Secretary of Commerce.

The reservation hereby established shall not interfere with the use of the waters, islands, or other lands embraced therein for any purpose not inconsistent therewith, nor with the operation therein of the laws now or hereafter applicable to the public lands in Alaska, nor with the respective jurisdictions of the Secretary of Agriculture and the Secretary of the Interior thereover.

Warning is hereby expressly given to all unauthorized persons not to fish in or use any of the waters herein described or mentioned.

Following the issuance and publication of the order, announcement was made that the Commissioner of Fisheries would hold hearings at Seattle on November 21 and at San Francisco on November 28, at which all interested persons were invited to be present and discuss the conditions and needs of the fishery, in order to establish a basis of information for the issuance of the necessary regulations and the granting of permits for operations to be carried on in 1923. Dr. Charles H. Gilbert, of Stanford University, who conducted extensive investigations in southwestern Alaska during the season of 1922, was present at and assisted in the conduct of the hearings. Dennis Winn, agent, Alaska service, who was in the Bristol Bay region during the fishing season, and Ransom L. Wilkins, who was stationed in Cook Inlet district, were present at the Seattle hearing.

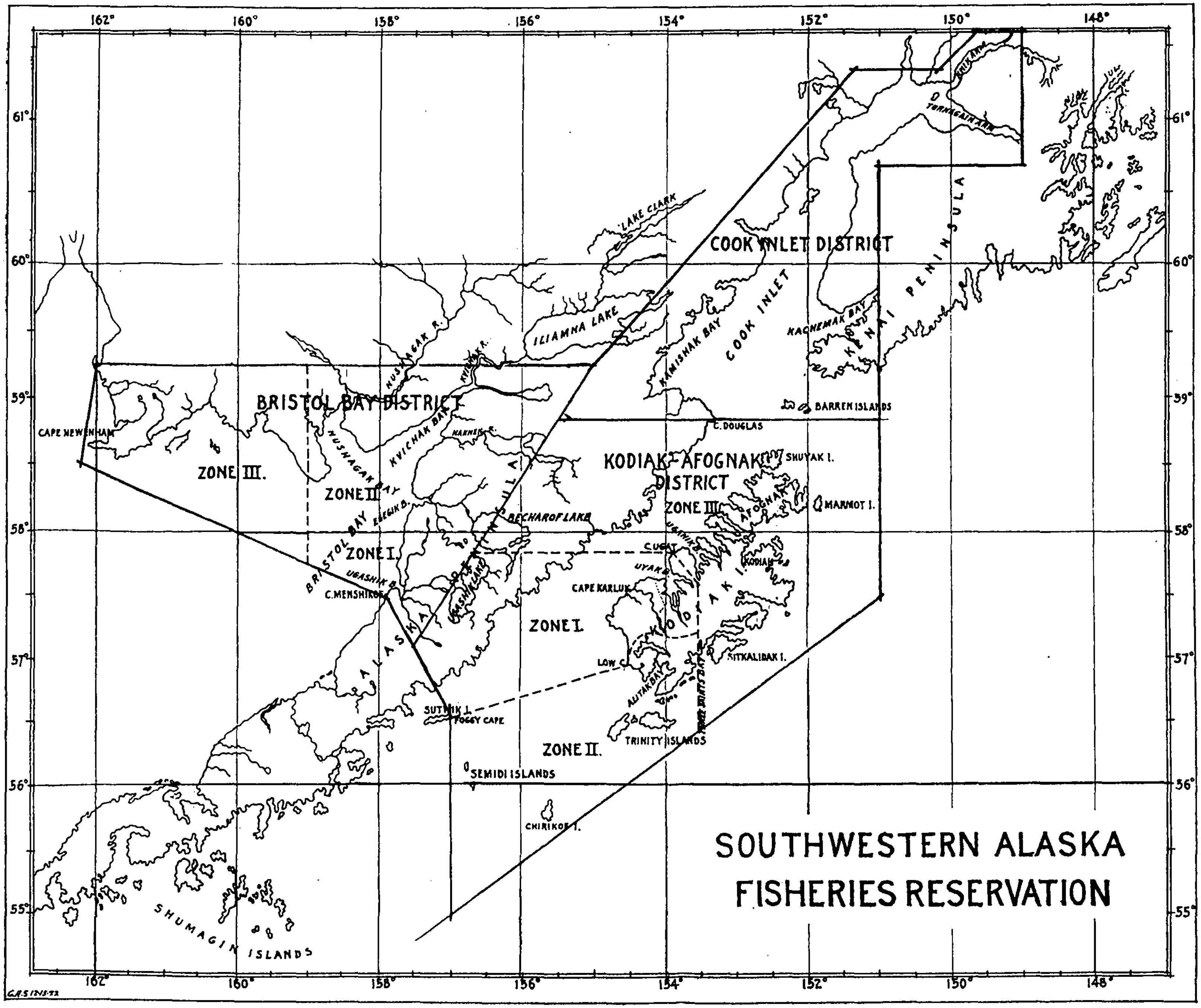

FIG. 3.—Southwestern Alaska Fisheries Reservation.

Regulations for the administration of the reservation were issued by the Secretary of Commerce on December 16, 1922, as follows:

1. For purposes of administration the following districts and zones are established:

(*a*) *Bristol Bay district.*—All that portion of the reservation lying within the Bering Sea, the coast line extending from Cape Menshikof to Cape Newenham and thence northward to 59° 15′ north latitude.

Zone 1. Including all the Ugashik fishing grounds which lie northerly and westerly from Cape Menshikof and are included between the boundary of the reservation and the fifty-eighth parallel of north latitude east of the one hundred and fifty-ninth meridian.

Zone 2. All that portion of Bristol Bay north of the fifty-eighth parallel of north latitude and east of the one hundred and fifty-ninth meridian, including the Egegik, Naknek, Kvichak, and Nushagak fishing areas.

Zone 3. All waters of the Bering Sea included in the reservation, but not included in zones 1 and 2.

(*b*) *Cook Inlet district.*—Embracing all that portion of the reservation east of Bristol Bay and north of the latitude of Cape Douglas (approximately 58° 50′), including the Barren Islands, the shores and outlying islands of the Kenai Peninsula, and all the shores and waters of Cook Inlet.

(*c*) *Kodiak-Afognak district.*—All that portion of the reservation south and east of the Alaska Peninsula and south of the latitude of Cape Douglas, including the Kodiak-Afognak group of islands, the Trinity and the Semidi groups, Chirikof Island, Shelikof Strait, and all the mainland shores from Cape Douglas to the southwestern boundary of the reservation.

Zone 1. Extends on Kodiak Island from Low Cape to Cape Ugat, and on the mainland coast from the latitude of Cape Ugat to the western limit of the reservation. Includes Red and Karluk Rivers and Uyak Bay.

Zone 2. Extends from Low Cape on the western coast of Kodiak Island to but not including Three Saints Bay, on the southeastern coast, and includes Alitak and Olga Bays and Chirikof, Trinity, and Semidi Islands.

Zone 3. Embraces all that portion of the district not included in zones 1 and 2. Includes the western shores of Kodiak and Afognak Islands north of the latitude of Cape Ugat and the northern and eastern shores as far south as Three Saints Bay. It also includes Shelikof Strait and the mainland shores north of the latitude of Cape Ugat.

2. No individual shall engage in the business of catching, canning, or preparing salmon, except for personal or family use and not for sale or barter, within the above-stated districts without first securing a permit from the Secretary of Commerce. Applications for annual permits shall be made on or before January 15, 1923, and on or before December 15 of each year thereafter, to the Secretary of Commerce, Washington, D. C., and shall give full information on the following points: (*a*) Name and permanent address of person or corporation desiring permit. (*b*) Character of business proposed, whether fishing, canning, salting, or otherwise curing fish. (*c*) Location and capacity of plant (number of lines of machinery in cannery and whether for pound or half-pound cans). (*d*) Number and kind of each class of fishing gear desired and location where same is to be operated. (*e*) Number of cases of salmon to be packed (based upon 48 one-pound cans per case) or number of barrels of salmon to be salted, or tierces of salmon to be mild cured. (*f*) If application is for continuance of operations formerly conducted, the catch and pack of salmon by species and the amount of each class of gear operated in the next preceding season must be shown. (*g*) Affidavit as to correctness of facts set forth in the application must be made by competent authority.

3. Permits shall specify the amount of pack allowed, if that be limited, and the character, extent, and locality of fishing operations to be conducted.

4. The use of purse seines in fishing for salmon will not be permitted within the reservation.

5. Fox farmers may take and prepare salmon for fox feed in all legal ways, but must secure permits from the Secretary of Commerce.

6. Transportation of fresh salmon for canning, salting, or otherwise preserving will not be permitted between any two districts or zones within the reservation or between any district or zone within the reservation and any outside district.

7. Throughout the Cook Inlet and the Kodiak-Afognak districts the pack of each plant shall be made exclusively from the proceeds of the fishing gear specifically allotted to it. Transfer of salmon from one plant to another will not be permitted.

8. Nothing in these regulations shall prevent the purchase of salmon from natives, local inhabitants, or other individuals who have secured permits to fish within areas properly tributary to the cannery, but fish so purchased shall not be in excess of the pack limit which may be allotted.

9. No fishing for salmon shall be permitted in Chinik Inlet, Kamishak Bay, within a line which joins the outer headlands of the inlet and passes outside the two small islands which lie near its entrance. Markers shall be placed on the headlands to designate the closed areas.

10. In the Bristol Bay district the following regulations shall be in effect: (*a*) In zone 2 it is permitted that fishing boats discharge their catch wherever convenient, but lighters or other collecting boats shall not transport salmon from the Nushagak fishing grounds to the canneries along the east shore, nor from the Egegik-Naknek-Kvichak fishing grounds to the Nushagak canneries. For the purposes of this regulation the fishing grounds off Cape Etolin shall be considered as belonging to the Nushagak River. (*b*) Fishing for salmon for commercial purposes shall be conducted solely by the use of drift gill nets, except that traps operated in the season of 1922 in the Nushagak region may continue to operate during the season of 1923. In 1924 and in subsequent years no traps shall be driven or operated in the Bristol Bay district. (*c*) King salmon nets shall have a mesh not less than 8½ inches knit measure, and red-salmon nets, after the season of 1923, a mesh not less than 5¾ inches stretched measure between knots. For the season of 1923 only, red-salmon nets will be permitted with mesh as small as 5½ inches, measured as above. (*d*) Companies operating motor gill-net fishing boats during the season of 1922 may continue their use in 1923, but the use of motor fishing boats will not be permitted in the Bristol Bay district after the season of 1923. (*e*) Each fishing boat may be provided with gill nets not to exceed in length 200 fathoms hung measure. (*f*) Fishing for red salmon shall not begin prior to midnight of June 25 and shall close at or before midnight of July 25 of each year; but each cannery may operate one commissary net at any time to supply fresh salmon for the mess. Salmon traps shall not be operated prior to midnight of June 25. (*g*) Fishing for king salmon with drift gill nets having a mesh not less than 8½ inches knit measure is permitted prior to June 26, as well as after that date; but the total length of gill nets employed by any fishing boat at one time shall not exceed 200 fathoms.

11. These regulations shall be subject to such annual revision by the Secretary of Commerce as may appear advisable in view of the investigation and the experience of the preceding season. They shall be in full force and effect immediately from and after date of issue.

AFOGNAK RESERVATION.

During the 1922 salmon-fishing season 60 Afognak and Uzinki (Spruce Island) natives were granted permits to engage in commercial fishing in the Afognak Reservation. These natives operated 19 beach seines, averaging 125 fathoms in length, 5 at Malina, 6 at Paramanoff, 4 at Seal Bay, and 4 at Little Afognak, with 15 natives working at each locality.

On May 25 fishing was begun at Malina and on September 6 ended at Little Afognak. During this period 173,255 salmon of all species were taken within the reservation, of which 84,411 were purchased by the Kadiak Fisheries Co. and 88,844 by the Katmai Packing Co.

At the principal bays closed seasons were imposed, as has been the custom for many years, in order to insure against overfishing and to provide sufficient escapement to the spawning grounds. Warden William E. Baumann, who was in charge of the general enforcement of the fisheries laws and the patrol work of the Afognak Reservation, established these close periods at the height of the red-salmon runs in the various localities.

Fishing periods in principal bays of Afognak Reservation in 1922.

Locality.	Fishing began.	Fishing ended.	Close season.	Number days closed.
Malina	May 25	Aug. 1	July 17-22	6
Paramanoff Bay	June 5	July 25	July 5-8	4
Seal Bay	June 16	...do...	June 12-15	4
Little Afognak	May 24	Sept. 6	June 21-24	4

To secure information as to escapement, Mr. Baumann visited the headwaters of the various streams and found that an adequate number of salmon appeared to have ascended to the spawning grounds and that conditions generally compared favorably with previous seasons.

The total catch of all species of salmon taken in the waters of the Afognak Reservation in 1922 was 173,255, as compared with 192,694 in 1921, a decrease of 10 per cent. This decrease is probably due to the fact that fishing activities were less intensive during the latter part of the season in the Afognak Reservation than during the same period in 1921. When the fishing season was well under way at Karluk, labor troubles arose among the fishermen, who called a general strike, which necessitated the employment of native fishermen. Several Afognak natives were employed at Uyak Bay by the Northwestern Fisheries Co. and several in the Karluk district by the Katmai Packing Co.

Commercial catch of salmon in waters of Afognak Reservation in 1922.

Locality.	Coho.	Chum.	Humpback.	King.	Red.	Total.
Little Afognak	11,609	....	2,141	17	5,241	19,008
Danger Bay	2,777	....	16,680	....	14	19,471
Litnik Bay	17,569	....	....	....	117	17,686
Paramanoff Bay	....	485	9,731	7	14,228	24,451
Malina	2,905	82	65,366	....	17,123	85,476
Seal Bay	....	....	154	6	5,426	5,586
Zelaif [1]	1,112	....	....	....	....	1,112
Marca Bay [2]	465	....	....	....	....	465
Total	36,437	567	94,072	30	42,149	173,255

[1] In Raspberry Strait.
[2] Or Markaway Bay, between Litnik Bay and Danger Bay.

ALEUTIAN ISLANDS RESERVATION.

The waters of Aleutian Islands Reservation were embraced in the Alaska Peninsula Fisheries Reservation created by Executive order of February 17, 1922, and the regulations of April 18, 1922, for that reservation were therefore applicable also to fishing in the Aleutian Islands. Because of the remoteness of the district and the slowness of communication by mail it was deemed desirable to allow operations to continue in the season of 1922 under permits granted to local residents and other operators westward of Unimak Island. Permits for the salmon canneries of the Pacific American Fisheries and P. E. Harris & Co., on the eastern end of Unimak Island, are listed in the table (p. 11) regarding the Alaska Peninsula Fisheries Reservation. No other permits were granted for the Aleutian Islands proper. At the end of the calendar year notice was mailed to all holders of permits that such permits were canceled and if it was desired to operate in the season of 1923 application for new permits should be made under the revised regulations issued December 14, 1922, for the administration of the Alaska Peninsula Fisheries Reservation.

A permit for the grazing of sheep on Amaknak Island was granted to O. K. Quean jointly by the Secretaries of Agriculture and Commerce under date of February 13, 1922.

ANNETTE ISLAND FISHERY RESERVE.

Fishery operations within the Annette Island Fishery Reserve were again conducted in the season of 1922 by the Annette Island Packing Co. under its lease from the Department of the Interior. Data in regard to operations have been furnished by the Bureau of Education, of that department, which administers the affairs of the reserve for the benefit of the Metlakatla Indians residing therein.

In 1922 the total number of fish taken by traps within the reserve was 847,800, on which a royalty of 1 cent per fish was paid, amounting to $8,478. A fee of $100 each for the five traps operated was also charged. In addition 318,553 salmon were taken by natives in purse seines and gill nets and were purchased by the company for $13,351.26. The natives received $25,425.32 for cannery labor, and other payments brought the total amount disbursed to the Indians by the Annette Island Packing Co. to $52,186.94, which was $13,794.87 more than in 1921. In addition the amounts of $500 for trap fees and $2,478.54 for case tax on canned salmon are due but withheld pending a decision on a suit brought by the Territory of Alaska for collection of territorial license taxes for 1922. This suit was decided in favor of the Federal Government on trial in the United States District Court at Juneau, but was taken on appeal by the Territory to the Circuit Court of Appeals in San Francisco.

The six-year lease to the Annette Island Packing Co. expired October 1, 1922. During this period $11,429.72 was paid to the Indians of the reserve for trap fees and per case tax paid to council, $50,261.27 for salmon taken in traps, $172,465.11 for cannery labor, and $68,526.89 for salmon taken by purse seines and gill nets. Other miscellaneous items brought the grand total to $337,556.30, exclusive of approximately $7,547.30 and the territorial income tax, payment of which is withheld pending decision of the territorial case mentioned above.

STREAM MARKERS.

Considerable work was done in marking the mouths of streams in the southeast district of Alaska in the season of 1922 because of the change in the regulations under date of December 30, 1921, which extended the protected zone from 200 yards to 500 yards off the mouths of all streams. Larger notices and more substantial posts and signs were used. Attention was particularly given to the streams heretofore unmarked along the west coast of Baranof Island from Sitka to Cape Ommaney and through Peril Strait.

Work in the central district consisted principally in the replacement, at the mouths of the sloughs of the Copper River, of markers that had been defaced by weather or carried away by winter storms. Markers were also erected by stream guards at Kachemak Bay, Kamishak Bay, Chinik Inlet, and other localities on Cook Inlet, and at Coghill River, Miners River, Cowpen River, and other places on Prince William Sound. Markers were also posted at the various streams in Olga Bay on Kodiak Island.

In western Alaska attention was given to the replacing of markers at the salmon streams in Bristol Bay, and for the first time markers were established at the mouth of the Kuskokwim River on a line extending from Point Popokamute to Beacon Point. Fishermen have urged that fishing should be permitted up that river as far as Helmick Point, which is 8 miles above the upper end of Eek Island, or at least up to the upper end of Eek Island. The bureau has held, however, that it can not change the markers as placed, as a number of years ago the United States Coast and Geodetic Survey designated these points as the mouth of the Kuskokwim.

STREAM GUARDS.

The plan of augmenting the bureau's patrol force by the employment of stream guards for duty during the active fishing season was carried out on a still larger scale in 1922 than ever before. In all 59 persons were thus employed for varying periods in this service, of which 30 were stationed in the southeast district, 16 in central Alaska, and 13 in Bristol Bay.

In southeast Alaska guards were stationed in the following localities: Chilkoot River, Chilkat River, Excursion Inlet and north shore of Icy Strait, Tenakee Inlet, Freshwater Bay and Redoubt Lake, Glacier Bay and Cross Sound, Whitewater Bay to Killisnoo, south shore of Icy Strait, Port Frederick to Point Adolphus, Redoubt Lake and Basket Bay, Redfish and Whale Bays, Pybus Bay to Point Gardiner and Tebenkof Bay, Gut Bay to Cape Ommaney, Wrangell Narrows, Cholmondeley Sound, Kasaan Bay, Karta Bay, Lake Bay, Rocky and Thorne Bays, Kah Sheets Bay and Carroll Inlet, Point Barrie and Steamer Bay, Salmon Bay and McHenry Inlet, Red Bay, Deweyville and Staney Creek, Hanus Bay, Howard Bay, Auke Cove and Pavlof Harbor, Ratz Harbor, Eagle Creek, Mud Bay to Lisianski Strait, and Anan Creek. The agent in charge of the district reported that the presence of the guards was of unquestioned benefit to the fisheries in preventing encroachments on the streams and closed areas at their mouths, thus permitting a larger escapement of salmon than otherwise would have been the case. The men were chosen chiefly for their knowledge of the country and general interest in the fisheries of Alaska.

In the central district two of the guards were detailed to duty in Cook Inlet, five at various points in Prince William Sound, six on the Copper River Delta, and one each at Bering River, Karluk, and Alitak. Some transfers were made to other localities as the centers of activity changed and operations progressed.

In the Bristol Bay districts the 13 temporary employees were engaged in the destruction of predatory trout in the Naknek, Egegik, Ugashik, and Nushagak waters before the beginning of active salmon-fishing operations and later were on guard duty near the mouths of these rivers and also at the Igushik River.

FISHERY PATROL.

In 1922 the bureau maintained eight vessels in Alaska for patrol work in connection with the enforcement of the laws for the protection of the seal and salmon fisheries. Of these the *Murre*, *Auklet*, *Petrel*, *Widgeon*, and *Puffin* were stationed in southeast Alaska; and the *Merganser*, *Scoter*, and *Tern*, at Chignik, Bristol Bay, and the Yukon River, respectively. The *Widgeon* and *Scoter* were additions to the bureau's fleet this year, and the *Merganser* was made use of actively for the first time. In addition six launches owned by the Bristol Bay packers were used both for the destruction of predatory trout and in the bureau's patrol. During the fishing season 18 small boats were chartered in the southeast district, 1 in Cook Inlet, and 3 in the Prince William Sound region for periods ranging from 10 to 75 days during the season from May to September.

During the calendar year it is reported that the *Auklet* cruised 6,300 miles, *Murre* 7,708 miles, *Petrel* 5,478 miles, *Puffin* approximately 1,500 miles, *Widgeon* 3,588 miles, and *Tern* 5,015 miles. The *Auklet* and *Murre* were in continuous commission except during the time required to install in each new 40-horsepower engines and to effect necessary alterations and repairs. These improvements have made both vessels better for the bureau's service, and they are now able to make headway against wind and sea that heretofore would have sent them to shelter. The *Petrel* was redecked and remodeled generally and was in commission four months. The Dusenberg engine was taken out and replaced by the 25-horsepower Standard engine from the *Auklet*. The *Puffin* was used chiefly in the protected waters of the west coast of Prince of Wales Island. The *Widgeon* reached Alaska late in August and was in commission the remainder of the year.

In February the *Merganser* was towed to Seattle by the *Auklet*, where a new 16-horsepower engine was installed and certain repairs and alterations were made. The *Merganser* was loaded on the ship *St. Paul* March 27 for transportation to Chignik, reaching there in April.

The *Scoter*, a vessel about 60 feet long and of the seaworthy purse-seine type, was purchased in April for the Bristol Bay district. It was used throughout the season by the agent in charge of the district and proved of great value in keeping in touch with the different sections and in facilitating action in prosecuting law violators.

The *Tern* was used as usual between Fairbanks and the mouth of the Yukon River and in patrol of the delta. The *Swan* remained at Fairbanks during the year but was not in use.

The Coast Guard cutter *Unalga* was stationed in southeast Alaska and rendered cooperative service in connection with fishery matters.

ALASKA FISHERY INTELLIGENCE SERVICE.

The triweekly dissemination of telegraphic information regarding the price of certain fresh and pickled fish to the important fishery centers of southeast and central Alaska was continued by coopera-

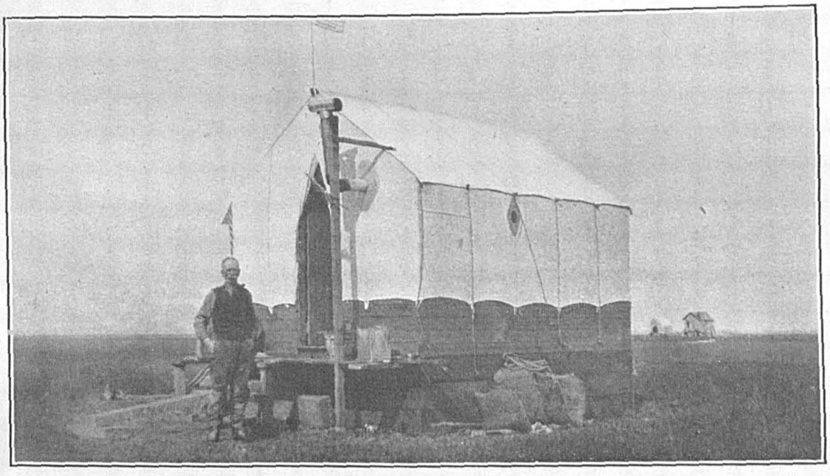

FIG. 4.—Camp for temporary stream guard, Copper River district.

FIG. 5.—Patrol boat *Widgeon*.

tion of the Alaska Military Telegraph & Cable System. The purpose of this service is to make available to the fishermen in the several localities the market quotations on halibut, sablefish, red rockfish, and herring in the important buying centers of Ketchikan and Seattle.

VIOLATIONS OF THE FISHERIES LAWS AND REGULATIONS.

During the season of 1922 there were 17 prosecutions in the Bristol Bay district. In each case the offense consisted in fishing at various distances above the Government markers in the Naknek and Ugashik Rivers. The fines and costs aggregated $2,137.25.

On Saturday, June 17, Stream Guard Neil C. Gallagher apprehended Jack Moore, Peter Kanosh, and Moses Smith while trolling for salmon in Port Frederick during the weekly close season. Each man was using a power boat and fishing with more than one line. They were arraigned before the United States commissioner at Hoonah, pleaded guilty, and each paid a fine of $1 and costs.

On Sunday, June 25, during a patrol off Port Alexander and Cape Ommaney, Earle L. Hunter, master of the *Petrel*, found Charles Olsen, P. Peterson, and L. M. Hair, of Ketchikan, and Edward Thompson and John Thompson, of Seattle, trolling for salmon with power boats, contrary to law and regulations. They were ordered to stop fishing and to go to Port Alexander, where notice was served on each one informing him that he would be reported to the United States attorney for prosecution. In due time this was done, and the attorney advised that he would endeavor to have the *Unalga*, then at Juneau, go to Port Alexander so that he could dispose of the cases, but the commanding officer demurred on the ground that Chatham Strait, in the region of Port Alexander, was unsurveyed and that he could not risk his vessel in those waters. Therefore these cases have not come to trial.

On June 24 Warden O'Connor found Richard T. Marshall trolling for salmon off Point Gardiner at 6.50 p. m. with four lines from a power boat. No action was taken against him as he had but recently returned to Alaska from school in Oregon and probably had not heard that a notice had been issued earlier in the season warning all fishermen that trolling for salmon during the weekly close season, except by line held in the hand, was unlawful.

On July 9 at 1.10 p. m. Warden O'Connor found a trap on Pleasant Island and one on Porpoise Island in Icy Strait, operated by the Thlinket Packing Corporation, with the pot tunnels open. On July 16 he found a trap at Wilson Cove, owned and operated by the Wilson Fisheries Co., with the tunnel but partly closed and the heart walls opened 44 and 23 inches, respectively, at one hour before low water. These matters were laid before the United States attorney, who decided that as they were largely technical offenses it was not worth while to take them up.

On August 9 O. Benjaminson, O. Odsera, and O. E. Fasness made a set with a purse seine within 500 yards of the mouth of a salmon stream 2 miles north of Point Barrie, Kupreanof Island, where Lawrence L. Hick was stationed as stream guard. The case was reported to the commissioner at Wrangell, and warrants were issued and served on Benjaminson and Odsera. They were brought to trial at Petersburg before a jury which, after due deliberation, found them guilty of a violation of the fishery regulations. They were fined $10 each and the costs of the prosecution, amounting to about $70. Fasness had gone to Seattle, so the case against him is still pending.

On October 16 the grand jury at Juneau indicted Chris Wick, Ole Olson, and Magnus Nygard for fishing within 500 yards of the mouth of a stream entering Redfish Bay, on the southwest coast of Baranof Island. They were arraigned October 19 and entered pleas of not guilty. On October 20 pleas were changed to guilty. Judgment and sentence were filed and entered October 21. Wick was fined $50 and costs and sent to jail for 30 days at Petersburg; Olson was fined the costs of the case and sent to jail at Petersburg for 30 days; Nygard was sentenced to jail for 20 days at Juneau.

In a complaint filed before the commissioner at Craig, James Peratovich was charged with unlawful fishing within 500 yards of the mouth of Klawak Creek, and upon conviction was fined $32.15, including costs of the case. At the same time, and before the same court, a complaint was entered against Jim Dick, charging him with setting a seine entirely across the lagoon of Klawak Creek. He was tried, convicted, and fined $17.15, including costs.

On August 23 a complaint was filed before the commissioner at Ketchikan, charging Clyde Cowan with purse-seine fishing in White River on August 22. He pleaded guilty and was fined $10 and costs.

Warden Combs reported that a trap near Craig, operated by the Alaska Consolidated Canneries, did not have the tunnel closed and the heart walls open on Sunday, July 30, in compliance with law. Owing to the resignation of Mr. Combs on August 31 and his departure from Alaska, this case was not presented for trial.

A controversy arose between the Alaska Consolidated Canneries and the A. & P. Products Corporation over the location of two floating traps along the southern shore of Kanaganut Island, the disputed question being the lateral distance interval between the traps. The A. & P. Products Corporation claimed that its trap was the first one put into position and set for fishing, and that later the Alaska Consolidated Canneries set a trap approximately 1,100 feet westward therefrom, making it fast to a rock submerged at high tide, contrary to the regulations of the War Department. Joint investigations were made by representatives of the bureau and of the engineers office of the War Department at Juneau, as a result of which the permit issued to the Alaska Consolidated Canneries was canceled and the removal of the trap was ordered, because the company had misrepresented the facts by stating in its application for the permit that the trap would be tied to a small island. In view of all the circumstances the United States attorney did not think it advisable to accuse either company of a violation of the fisheries law.

On July 12 John Olson was found fishing with a set gill net covering more than one-third the width of a slough of the Stikine River. Complaint was filed with the commissioner at Wrangell and the case was tried by a jury on July 13, resulting in a disagreement. Further disposition of the case has not been made.

The cases against the Kenai Packing Co. for the wanton waste of salmon and against the Copper River Packing Co. for wanton waste of salmon and for not opening the heart walls of its trap located in Prince of Wales Passage on Sunday, August 15, 1920, on which indictments were returned at the Valdez term of the district court in October, 1920, were again continued with the consent of the bureau's representative and probably will be brought to trial at the February, 1923, term of court at Valdez.

TERRITORIAL LICENSE TAX.

Fisheries license taxes were collected by the Territory under the revenue laws of Alaska as revised in 1921. A statement from the treasurer, under date of May 9, 1923, gives the collections made to that date for the fiscal year 1922. It was stated that only a comparatively small amount remained uncollected on that date. The total for the calendar year is apparently about $134,000 greater than in the preceding year.

Fishery license taxes collected by Territory for fiscal year ended December 31, 1922.

Schedule.	Division No. 1.	Division No. 2.	Division No. 3.	Total.
Salmon canneries (pack)	$63,481.32		$152,385.45	$215,866.77
Salmon canneries (net income)	2,797.76		18,183.83	20,981.59
Clam canneries	16.30		436.86	453.16
Salteries	3,012.86	$256.20	7,950.21	11,219.27
Cold-storage plants	950.00		375.00	1,325.00
Fresh-fish dealers	3,018.23		13.11	3,031.34
Fish-oil works and fertilizer and fish-meal plants	3,413.33		897.60	4,310.93
Fish traps	51,800.00		31,300.00	83,100.00
Gill and stake nets	684.00	46.00	6,654.50	7,384.50
Seines	2,885.00		1,925.00	4,810.00
Total	132,058.80	302.20	220,121.56	352,482.56

It is of interest to compare the Alaska territorial revenue from all sources with that derived from the fishery industry. The following tabulation covering the last four years for which complete returns are at present available shows that in this period the fishery industry paid an annual average of 48.7 per cent of all territorial revenue:

Comparison of Alaska territorial revenue from all sources with that from fishery industry, 1918–1921.

Year.	Total territorial revenue.	Fishery license tax.	Percentage of fishery tax.
1918	$475,450.55	$265,082.48	55.7
1919	555,887.43	301,301.59	54.2
1920	571,943.34	271,696.43	47.4
1921	563,474.01	218,268.71	38.7
Total	2,166,755.33	1,056,349.21	48.7

WATER-POWER PROJECTS IN ALASKA.

During 1922 the Federal Power Commission referred to the bureau 10 applications for permits for development of water-power projects in Alaska. The importance of this matter is readily apparent, because of the possibility of hindering or preventing salmon from ascending to their spawning grounds. With respect to the stream covered by each application the commission desired information from the bureau as to whether it was used by spawning salmon, its economic value to the fishery industry, and whether an effective fishway could be constructed over the proposed dam.

The 10 applications referred to the bureau were for Speel River, Cascade Creek, Mill Creek, Aaron Creek, Harding Creek, Grant Creek, Tyee Creek, White River, and Anan Creek, in the southeast district, and Kenai River in central Alaska. Thorough investigation of the streams concerned in southeast Alaska was made during the season by Assistant Agent E. M. Ball, and of the Kenai River by Assistant Agent Shirley A. Baker. Upon the basis of their reports and other information on file in the bureau, the Federal Power Commission was advised that there was no objection to the development of the proposed projects in Speel River, Cascade Creek, Harding Creek, Grant Creek, Tyee Creek, and White River, inasmuch as there were no commercial runs of salmon in them. No objection was made regarding Mill Creek, as the proposed dam would not be too high to prevent the installation of a successful fishway. The contemplated project in Aaron Creek affected only one fork of that stream, and the remaining spawning beds were regarded as ample for the preservation of the run.

In the case of Anan Creek the bureau expressed unqualified opposition to any project that contemplated its use for any purpose other than the propagation of salmon under natural conditions. As bearing upon this stream, the following is quoted from a letter of January 30, 1923, addressed by the Secretary of Commerce to the Federal Power Commission:

> Anan Creek has long been known as one of the most important humpback-salmon streams in southeastern Alaska. It has been a large and steady producer for more than 20 years—in fact, it has yielded about a million salmon in a single season—and it continues to be a salmon producer of the first magnitude. It embraces a spawning area of unequaled excellence approximately 4 miles in length. Its economic importance to the fishery industry is second to none in southeastern Alaska. The erection of a 60-foot dam at the mouth of Anan Creek would practically destroy one of the most valuable salmon fisheries of southeastern Alaska for two reasons: (*a*) That a successful fishway of that height would be impracticable, and (*b*) that the spawning grounds would be flooded with several feet of water, thus greatly lessening their value. In view of these things it is the opinion of this department that Anan Creek should not be used for any other purpose than the production of salmon. Unquestionably there are numerous streams in southeastern Alaska that are better adapted to the development of electric power than Anan Creek and which are inaccessible to salmon by reason of natural insurmountable barriers.

Opposition was also expressed to the development of the project contemplated on Kenai River, which was discussed in the same letter, as follows:

> It is understood that this project involves the construction of a storage dam 6 feet in height at the outlet of Kenai Lake and a diversion dam 120 feet high at a point about 11 miles below the lake. The department has given very careful consideration to this matter, and an extended personal investigation in the region has been made by an agent of the Bureau of Fisheries. As a result two important outstanding facts are developed: (*a*) That the main run of red salmon spawns in the upper Kenai River waters above the proposed diversion dam in Kenai River Canyon; (*b*) that the tributary streams below the proposed diversion dam carry almost negligible runs of red salmon.

These two important facts have most vital bearing on the subject under discussion. The Kenai River is by far the most important salmon stream in Cook Inlet, and it is believed that the salmon industry of that region would be irreparably ruined if the run in the Kenai River were to be destroyed, which would, I believe, be the practical effect of the proposed power projects. If the run on the Kenai River were stopped, it would probably necessitate the closing of several large salmon canneries, including those of Libby, McNeill & Libby, Northwestern Fisheries Co., Alaska Packers Association, and Fidalgo Island Packing Co., and would also limit the operations of various smaller canneries and salting stations perhaps to such an extent that they would eventually be compelled to close.

Flowing into Kenai River and Kenai Lake above the proposed dam site in the canyon are six remarkably fine salmon streams, all of which carry good runs of red salmon. They are as follows: Russian River, Trail Creek, Ptarmigan Creek, Quartz Creek, Chain Lake Creek, and Snow River. Below the proposed project and between Skilak Lake and the mouth of Kenai River there are only three worth-while salmon streams, and they contain mixed runs with few reds, the latter being the most valuable and sought-after species. These streams are Killey River, Funny River, and Moose River. Although Skilak Lake has valuable spawning areas on the north shore, it is, nevertheless, of minor value, as the tributaries which flow into this lake are not red-salmon streams.

Kenai Lake shows that it has remarkable fitness for supporting fish life and is the chief spawning lake of the Kenai River basin, being the lake where the greater portion of the young red salmon spend the first year of their lives before proceeding to salt water.

The agent of the Bureau of Fisheries who investigated the matter states that a 120-foot dam in the Kenai River would flood a tract averaging 1 mile in width and 8 miles in length, and that this flooded area would cover Chain Lake Creek and its first head lake. Thus, a very valuable spawning area would be lost even if the salmon could get over the dam, which seems to be wholly out of the question.

The report in question shows that there are documents on file in the Cordova office of the Forest Service which indicate the intention to utilize Russian River waters in connection with the Kenai River project. Russian River is the chief red salmon tributary of the Kenai River, flowing into the larger stream about 5 miles above the Kenai River Canyon. The construction of a high dam on Russian River would be a most serious blow to the salmon industry.

In the matter of possible hatchery operations above the dam in Kenai River Canyon, the following is extracted from the report of the investigating agent:

"In the letter from the Federal Power Commission, under date of May 22, 1922, the suggestion has been made to put in a hatchery above the dam. It would be absolutely impracticable to put in a hatchery either above the dam or below the dam and to corral the red salmon until they are ripe. As it is now, the mature salmon come into the lake to ripen. The young red salmon must live a year in the lake—sometimes they stay longer—before going to the ocean waters. It is impracticable and impossible to accommodate in a hatchery the spawning adults and the young fry of the great Kenai River red-salmon run. Therefore the project of the establishment of a hatchery either above or below the dam is a forlorn hope and should not be entertained at all."

The matter of the proposed power project on the Kenai River, Alaska, was rather recently referred to Dr. C. H. Gilbert, of Stanford University, who is a noted authority on the salmons of the Pacific coast and Alaska. Dr. Gilbert's reply is as follows:

"I beg to express my conviction that the proposed dams between the Kenai and Skilak Lakes would result in reducing the red-salmon run in the Kenai River to such a point that it would cease to have any commercial significance. I believe it would be wholly impracticable to construct a fishway over a dam of the height proposed, and I regard it as equally impracticable to operate successfully a hatchery below the dam. The red salmon on their ascent of the river are far too green to spawn. It is their habit to remain in the deep waters of the lake for a month or more until their eggs are ripe. To impound them for this purpose in the river below the dam would certainly result in the loss of a large percentage of the spawning fish. The Kenai River is the most important red-salmon stream of Cook Inlet. If the Kenai run is destroyed, the Cook Inlet salmon fisheries will go with it. I recommend that the Bureau of

Fisheries use its influence in opposition to the construction of the proposed dams."

This department desires to express the hope that the proposed power project on Kenai River will not be undertaken, for if it is there is apparently no way of saving the salmon run of the Cook Inlet region.

The Federal Power Commission advised the applicants in the case of Anan Creek and Kenai River that it is doubtful if the commission would feel justified in disregarding the desires of the Department of Commerce and that it would probably refuse to grant a license for the projects under present conditions.

TAGGING OF SALMON.

In the attempt to ascertain what streams form the spawning grounds of the red salmon that constitute important runs along the Alaska Peninsula and the migration routes followed in reaching these streams extensive tagging experiments were carried out by Dr. C. H. Gilbert and W. H. Rich in the Shumagin Islands, in Morzhovoi and Ikatan Bays, and at Port Moller. Consecutively numbered aluminum tags were attached to 4,000 red salmon, which were then released and of which nearly 20 per cent were later recaptured. The most important result of the experiments was the demonstration that a large body of Bering Sea red salmon use as feeding grounds the district south of the Alaska Peninsula and on attaining maturity return to Bering Sea and distribute themselves to the red-salmon streams of the peninsula and Bristol Bay and pass as far north even as the Kuskokwim River. This discovery has an important bearing on the problem of conserving the vastly important red-salmon runs of Bristol Bay. It is planned to continue this work upon a larger scale during the season of 1923.

SALMON FOR FOX FOOD.

The notable expansion of the fox-farming industry in Alaska within the last year or two has correspondingly increased the use of salmon for fox food. This has occurred along with the constantly growing demand upon the runs of salmon for cannery use and during a period when the future of the salmon supply has been viewed with grave apprehension. Consequently, in the season of 1922 representatives of the bureau were instructed to make a careful investigation to determine the extent of the use of salmon for fox food, the places and methods of procurement, and whether other sources of food less esteemed for human consumption than salmon might be available.

In September a complete canvass of southeast Alaska was made under the supervision of Assistant Agent E. M. Ball, which showed 75 fox farms stocked with approximately 4,500 foxes. At the time there was on hand a total of 654,550 pounds of food, about half of which consisted of salmon heads obtained from canneries, while the remainder was whole fish, chiefly chum salmon. It was estimated that to carry these animals through until the following summer approximately 642,000 pounds additional would be required, practically all salmon if obtainable. This means an average daily ration of about three-quarters of a pound of fish for each fox, to which is added about one-quarter of a pound of other food, chiefly cereals. Other species of fish, such as halibut, sablefish, flounders, and herring, are used to some extent in southeast Alaska, but are not regarded as the best fox food. Fish that can be dried are preferable, as the foxes do not relish salted fish. Few of the fox farmers do their own fishing, usually purchasing salmon from packing companies and operators of independent traps, purse seines, and other fishing apparatus.

In the Prince William Sound, Cook Inlet, and Kodiak-Afognak regions of central Alaska a careful survey of the situation was made under the direction of Assistant Agent Shirley A. Baker. In this part of the Territory 87 fox farms were listed, upon 42 of which 1,649 foxes were reported. The reticence of operators made it practically impossible to get an approximation of animals on quite a number of farms. It was computed that in the season of 1922 in this district 270,770 salmon were taken for fox food, of which 26,600 were reds, 191,000 humpbacks, 29,200 chums, and 23,970 cohos. These fox farmers supplement the supply of salmon with other foods, including herring, cod, skates, sharks, hair seals, porcupines, rabbits, and cereals.

Fishing for salmon for use on fox ranches comes strictly under the head of commercial operations and is subject to all restrictions imposed by the laws and regulations. Fishing on the spawning beds and within streams in order to supply fox ranches is as much in violation of the regulations as if salmon so caught were for cannery use. There is no more certain method of depleting the runs of salmon than to take them from the spawning beds. Some fox farmers have seemed concerned lest such full protection of the salmon might work an undue hardship by depriving them of enough food for their foxes. It is not the intention to burden the fox farmers or to prevent in any way the legitimate development of their business, but at the same time care must be taken to preserve the salmon industry by absolute avoidance of commercial fishing within the streams. It is believed that reasonable foresight upon the part of fox farmers in securing the heads of salmon from canneries and in obtaining surplus salmon, particularly of the cheaper grades, from outside waters will fully meet all needs along this line.

BRISTOL BAY DISTRICT.

In 1922 a special force consisting of two regular wardens and a number of other employees under the direction of Agent Dennis Winn was again sent into the Bristol Bay district. As in the previous season, efforts were devoted during the spring to the destruction of predatory fishes, and after the beginning of active salmon-fishing operations a patrol was maintained on Bristol Bay and in all tributary rivers. Very satisfactory work was accomplished. Two employees were detailed to remain over the winter and make a thorough survey of the spawning grounds of the Wood River lake system. The report submitted by Mr. Winn follows:

GENERAL REPORT OF SEASON'S OPERATIONS.

Operations in the season of 1922 were conducted along the line of previous years. The operators necessary to conduct the work of the different sectors were engaged in the States and Alaska, preference being given to suitable help procurable in Alaska. Owing to the scarcity of such help around Bristol Bay it was necessary to send most of the employees from the States.

Transportation for nine men was granted on the Alaska Packers Association ship *Star of Lapland* from Semiahmoo, Wash., to Bristol Bay. The Alaska-Portland Packers' Association ship *Berlin*, Portland, Oreg., transported three men, supplies, and equipment, and two launches and quantities of fuel oil for the summer's work at Naknek. The *Burgess* of the same company transported supplies, equipment, and fuel oil, and the Columbia River Packers' Association ship *St. Nicholas*, Astoria, Oreg., furnished passage for three men and transported one launch for Nushagak operations. Various ships of the Alaska Packers Association transported needed supplies and equipment to the sectors operated at Kvichak, Egegik, and Ugashik, together with necessary fuel oil for the same districts.

On the return passage was furnished for seven men on the Alaska Packers Association ship *Star of Zealand* and for one man on the *Indiana* to San Francisco, for three men on the Alaska-Portland Packers' Association ship *Chillicothe*, for two men on the ship *Burgess* of the same company, and for three men on the Columbia River Packers' Association ship *St. Nicholas* to Astoria.

The writer and an assistant proceeded over the regular transportation route from Seattle to Anchorage, across Cook Inlet via launch to Iliamna Bay, thence over the divide to Iliamna Village by snowshoes, thence after the ice break-up to Bristol Bay, in which section the former supervised the work to the end of the season, after which the return trip was made over the same route to the States.

In compliance with the recommendation of the previous season the bureau purchased in Bristol Bay a cruising boat of the purse-seine type that had been towed up from the States by the Alaska-Portland Packers' Association steamer *Akutan*. This boat, known before the purchase as the *Clatsop*, was rechristened *Scoter* by the bureau. It met every expectation, made it possible to keep in close touch with the different crews, and minimized the difficulties of getting action in prosecuting law violators, which was never successful with the facilities of previous years.

Three small launches of the Columbia River trolling-boat type, purchased by the packers for the bureau's operations, were used for trout work and stream patrol. As some repairs were necessary to two of the launches it was late before they could be placed in commission, but they were all especially useful in patrol work.

Before the arrival of the writer in Bristol Bay Warden A. T. Looff assumed charge and placed the different crews in their allotted districts, using the *Scoter* for transportation. Every courtesy was shown by the cannery superintendents in the different sections visited, and sincere appreciation is expressed for the unselfish assistance given.

Warden A. T. Looff, with an assistant, was detailed by the bureau to remain in the Wood River district for the winter of 1922–23. His duties were to visit the spawning grounds and obtain all information possible regarding the salmon, especially that pertinent to their predatory enemies, and to do whatever was possible to exterminate the latter. A thorough survey of this lake system is contemplated with the hope of obtaining authentic data regarding each tributary stream that will be useful in future work. Such a survey could be accomplished only during the late fall after the departure of the cannery ships.

DESTRUCTION OF PREDATORY FISHES AND BIRDS.

Naknek.—The Naknek crew of three men, in charge of Gus Severson, sailed from Portland on April 21 on the Alaska-Portland Packers' Association bark *Berlin*. Through misfortune the ship ran on Egegik flats, off Egegik River, on May 17. Although no lives were lost and nearly all the supplies and equipment were salvaged, the ship was held fast and broke completely during the summer storms. The evening of May 18 the crew was landed at the Naknek cannery of the Alaska-Portland Packers' Association. Work of preparing equipment, painting dories, etc., was accomplished, and as soon as sufficient mess supplies were available the crew left for Naknek Lake to begin the season's work. Two loaded dories were towed to the foot of the rapids with patrol boat *No. 2*, in charge of Warden A. T. Looff. A few days were spent here fishing the river, using drift nets and gill nets stretched entirely across the stream. The results were good but of short duration. When the catch showed a material reduction camp was moved above the rapids to the outlet of the lake. The loaded dories were lined through the rapids and the Evinrude used for power above that point. Good fishing occurred here. On June 7 the first red salmon made its appearance, but salmon were not numerous before the 12th. Camp was then moved to Kidawik Creek, where good catches of trout occurred up to July 2, when salmon made their appearance in sufficient numbers to compel removal of set nets, and from that time on baited traps and set and hand lines were used.

During the earliest fishing the trout stomachs examined were empty, but from late June to the middle of July practically all contained young salmon. The stomach of one large lake trout contained 40 fingerling migrating salmon. The greater portion of the catch was lake trout (*Cristivomer namaycush*), all extremely large, averaging from 12 to 15 pounds, and one specimen weighing 22 pounds was captured at the mouth of Kidawik Creek. Several specimens weighing 18 pounds were reported.

A trip was attempted up the Savonoski River to the lakes at its head in an endeavor to operate at that point before the advance of the salmon, but water was too low, making it impossible to navigate the river. An investigation was made July 5 in the upper lakes, going there overland from the north shore of Naknek Lake and arriving just below the rapids connecting the two Savonoski lakes. No boats were available on the lakes, so that only limited observations could be made. No salmon or trout were seen in the upper reaches of either lake. However, it was early for salmon in these waters. The water was clear and the shores appeared excellent for spawning. A folding boat that could be carried on the back overland would be useful here, as at several other points that are difficult of access for observations and trout work also. Along the north shore of Naknek Lake a few salmon were observed, but owing to the deposits of ashes their spawning grounds are limited. It was learned without doubt that the islands in this locality are the greatest breeding grounds for terns in the district, and good work was accomplished on this trip in the destruction of their eggs. Several trips were made during the season to all the breeding islands for the purpose of destroying tern eggs.

The crew returned to Kidawik Creek, as the best work could be accomplished there. Many salmon made their appearance in the creek July 11 and the number increased daily, a large portion passing over the falls and into Brooks Lake, of which Kidawik Creek is a tributary. Cohos made their first appearance in the creek July 13, and the main run, which is not large at this point, was entering toward the end of July.

The season's take in this district was 3,436 trout, weighing 41,232 pounds, an average of 12 pounds each. Eighty per cent were lake trout, the remainder being Dolly Vardens, steelhead trout, and pike, in nearly equal proportions. More Dolly Vardens were captured this year than formerly, but the percentage was small. Several fish ducks were taken in the nets each night.

All equipment was overhauled and the boats were painted and stored at the cannery of the Alaska-Portland Packers' Association at Naknek. The crew returned to the States on the *Chillicothe*.

Egegik.—The Egegik party, consisting of H. B. Looff, foreman, and two assistants, left Semiahmoo, Wash., April 16, on the *Star of Lapland*, arrived at Bristol Bay May 16, and transferred as soon as possible to Egegik, establishing base headquarters at the Alaska Packers Association cannery. Supplies being delayed, a sufficient quantity was borrowed from the Libby, McNeill & Libby cannery, which, added to stores from the previous year, enabled the crew to make an early start upriver. Various difficulties and accidents, such as Evinrude trouble, storms, in which one of the loaded dories capsized, and sickness of one of the men, caused some delay. Camp was eventually established at the outlet of the lake on June 1. Fishing with seines and set nets at this point produced fair returns. Great schools of young salmon were noted migrating on June 6, and large numbers of terns were in evidence working on the young salmon and following the schools downstream.

All islands in the vicinity were visited and considerable numbers of tern eggs destroyed. As soon as it became apparent that possibilities at this point were limited camp was moved to the upper end of the lake at Little Becharoff on June 12, where good results were obtained throughout the remainder of the season.

The effects of the fishing of last season were noticeable in the reduced numbers of trout seen at Kanatak Creek and surrounding streams, which are the principal salmon streams in this district and which produced the greater portion of our trout catch last year. Winter men and natives at the village here report that Kanatak Creek was practically clear of trout after our departure last fall.

All creeks in the vicinity were visited with good results, the fishing appliances used being seines, spears, hand and set lines, bait traps, and set nets. Seines were used with considerable success along the lake shore near the mouths of the different streams.

The trout averaged much larger than those taken in previous years and were fat and bright, with every appearance of being sea-run fish. Specimens weighing 8 pounds were common. Those of last year were for the most part thin and emaciated.

The north shore of the main lake was investigated, but conditions were not found to be conducive to extensive spawning. Some salmon were noted near the mouth of several streams, but in much smaller numbers than in the Little Becharoff section. All trout taken were given to the local natives, who dried them for food.

In Salmon Creek 386 trout, all weighing from 6 to 8 pounds, were taken July 3, and red salmon were noted schooling at the creek mouth. The high water of July 7 brought the salmon into many of the creeks in such numbers as to compel the discontinuance of set-net operations in certain streams. Aggressive fishing was conducted in the different streams with movable equipment until the salmon made their appearance in each, after which hand lines, bait traps, and spears were used exclusively.

A most successful method of capture consisted in baiting the lake shores in the vicinity of the streams with trout offal and seining the baited territory. For several successive days an average of 200 trout was taken in this manner, amounting to nearly half a ton, and on July 26, 1,139 Dolly Vardens were caught. Most of this catch were large fish, one specimen weighing 14 pounds, but several were small, measuring from 4 to 8 inches. The total catch for the season aggregated 10,063 fish, all Dolly Vardens, averaging 4 pounds each, or 40,252 pounds weight.

All equipment was overhauled and stored at the Alaska Packers Association cannery, Egegik, and the return trip to the States was made on the Alaska Packers Association ship *Star of Zealand*.

Ugashik.—The Ugashik crew, in charge of William Tanner, were transported on the Alaska Packers Association ship *Star of Lapland* from Semiahmoo, Wash., with the Egegik party. Upon arriving in Bristol Bay there was some delay in starting operations because of engine trouble on the *Sooter*, but the crew was located as soon as possible and base headquarters were established on May 24 at Red Salmon cannery, Ugashik River. A start upstream was made immediately after arrival. Camp was established at the rapids near the foot of the lower lake, where fishing was conducted for several days with meager results.

A barrier with trap was installed across the entire stream to take both ascending and descending fish, in the belief that some migration of trout was possible either way. The results being unsatisfactory, camp was moved to last year's location on the stream between the two lakes. Here the barrier was installed across the stream with trap on one end, where the fish were in the habit of passing, and expectations were more than justified, as trout were intercepted passing up and down stream. Those passing up were bright, having the appearance of sea-run fish, and those caught from the other direction were thin, evidently "spawnouts."

Observations proved that it was late for the early ingress of sea-run trout at the first location, as they had passed into the first lake. They were the fish taken in the trap while attempting to ascend to the second lake, and those captured descending were possibly en route to salt water. At the beginning of operations very large trout were taken, but toward the end their size kept decreasing to very small fish, making the average weight 2½ pounds.

Migrating salmon passed out of the lake in enormous numbers en route to the ocean from June 5 to 14, but small schools were noted at times before and after those dates. Terns were in attendance in great numbers.

Catches were light until July 1, when the trout became active, continuing so until early August. The trap did excellent service, although the heavy rains of early July interfered materially with fishing, as refuse drifted against the wire netting, making it impossible at times to hold the netting across the stream at the bottom. Fair success was experienced with drift nets in the evenings during darkness. Trips were made also to all tributary streams and fish were driven down into fyke or gill nets near the stream mouths. These results were satisfactory.

The first red salmon reached the camp June 30, but they did not interfere with operations before July 13, although they were in the lower lake in enormous schools. On their arrival in numbers sufficient to offer interference barrier and trap were removed and fishing was conducted exclusively with bait trap and set and hand lines.

At the season's close the equipment was overhauled and stored at the cannery of the Red Salmon Canning Co., Ugashik, and the patrol launch at the Alaska Packers Association cannery at the same point. The crew proceeded to the States on the Alaska Packers Association ship *Star of Zealand*, after being transferred to that vessel by the *Margaret* of the Naknek Packing Co.

The number of fish taken aggregated 8,946 and weighed 22,365 pounds, an average of 2½ pounds each. About 80 per cent were Dolly Vardens and the remainder lake and rainbow trouts. Some whitefish and grayling were taken, but in negligible numbers.

Nushagak.—This crew was in charge of Eric Fenno and embarked on the Columbia River Packers' Association ship *St. Nicholas*, from Astoria, Oreg., April 19, arriving at Nushagak May 18. A small launch, which was transported on the *St. Nicholas*, was used by the crew to make the trip to Snag Point.

Until supplies were unloaded from the *Burgess*, the crew busied themselves in overhauling equipment and boats. The latter were placed in the water so that seams could be properly swollen to stop leakage. When this work was completed and supplies were available, the crew started up river with two loaded dories in tow by patrol boat *No. 3*.

Camp was established June 3 at the head of the first lake, and fishing progressed with but meager results to June 12, when catches began to improve. The greatest success was experienced with set nets, which were transferred from place to place, those on the side of the river toward the lake outlet making the best catches. No large schools of trout were noted at any time. Numbers were observed passing up stream with the salmon, however, and it was concluded that they were going up immediately on arrival from salt water.

About the time it became necessary to break camp trout were arriving in greater numbers than at any other period. A run arrived from salt water August 1, and several successful hauls were made with the seine. The sizes show a decided decrease each year, from an average of 4 pounds in 1920 and 3½ pounds in 1921 to 2½ pounds the current year. A few specimens weighing 7 pounds were taken through the season. In former years this size was common.

Schools of migrating salmon were seen passing down at intervals but never in large numbers. The action of the terns gave positive evidence when a school was passing. An intermission in the tern depredations was noticeable from June 18 to 23, and no migrations were reported during that period. The last migrations reported were on July 27, and all the terns disappeared from the lake on July 29. Several trips were made to all islands in the lake for the purpose of destroying tern eggs. On trips of observation to the second lake, terns were seen working the entire river.

Incoming salmon made their appearance at the operating point near the river's outlet on July 2, necessitating the removal of nets at that point, after which set and hand lines were used here. At other points the nets were fished with success to July 9, when the salmon began scattering over the entire territory. For a few days during the early part of the run the salmon passed up in continuous schools, which soon declined to small numbers of from 20 to 30 passing at intervals with long periods between.

Gill-net marked fish, although noticeable all through the run, were not seen in large numbers before the middle of July, when the ratio of fish badly injured reached about 10 per cent, and a few days later, as the run slackened, 25 per cent. July 21 most of the salmon noted ascending and endeavoring to ascend were injured and sick. Many of these, however, were fish that for some time had endeavored to ascend, but without success, and would perish in any case before spawning.

Humpback-salmon spawning was in progress near the outlet of the lower lake when the crew departed on August 9, but not in large numbers.

The total take of trout for the season was 7,410 fish, weighing 18,525 pounds, an average of 2½ pounds each. Ninety-five per cent were Dolly Vardens, the remainder being pike with a few rainbow trout.

Equipment with one small launch was stored at the Alaska-Portland Packers' Association cannery at Snag Point, and the launch *Scoter* and patrol boat *No. 3* were placed on the ways of the Alaska Packers Association cannery at the same place. The return trip was made on the Columbia River Packers' Association ship *St. Nicholas*.

Iliamna.—The writer and an assistant left Seattle April 15 by regular passenger vessel for Anchorage and proceeded thence down Cook Inlet by launch to Iliamna Bay, and from that point over the divide to Iliamna Village on snowshoes, arriving May 2.

Ice still covered the lake, but was not safe for travel. Many of the streams, however, were entirely free of ice. On May 6 a trip was made up Iliamna River about 6 miles. The water was clear, and not over a dozen trout were noted in the entire stream. At this time the young salmon were emerging from the gravel, and small schools were seen at certain points along the stream descending slowly to the lake. No trout have gathered in any numbers in this river since 1920.

A trip was made to Pile Bay on May 8. Five native women were fishing through holes in the ice in about 4 feet of water, using black thread for line and preserved fish eggs for bait. One woman caught 21 fish and the others from 8 to 16 each, all Dolly Vardens, weighing a pound apiece. It is the practice of natives to fish in this manner through the late winter and spring, when weather and ice conditions permit, and the women's catch on this date was a fair average of their usual take.

On the occasion of this visit of the crew the ice on the lake was so dangerous that no work could be attempted. Another trip was made up the Iliamna River and several nets set at advantageous points to determine whether trout were moving. The nets were fished with negligible results for a few days, when the ice broke sufficiently to permit passage across the lake.

On May 18 the crew proceeded down river with a load of equipment and met O. B. Millett with his launch at Fish Village, where they were forced to seek shelter with the smaller boat. They were taken in tow and arrived at Goose Bay in the evening. The bureau's launch had been on the ways here through the winter in care of Mr. Millett and was overhauled, painted, and ready to be placed in the water before the crew's arrival.

After the launch was sufficiently long in the water to stop leakage equipment was taken aboard and the season's work was begun. Nets were placed across the mouth of Goose Bay, and although some miscellaneous species of fish were taken, among which were Dolly Vardens, rainbow trout, whitefish, and grayling, the catches were very small. Trips were made to the surrounding creeks. At each point, the spawning grounds, where young salmon were emerging from the gravel, were visited. Large schools of fry were noted in all the tributary creeks and spring ponds, but few had as yet reached the main creek in their descent to the lake. When inspecting this section last fall during the spawning period a fair run was noted in the spring ponds, and the crew were advised that the run continued very late and that live spawning fish were seen January 6.

Fishbones piled at different points along the shore—the work of bears—testified to a good run. The natives' popular method of hunting bears is to have roosts in the tree tops along the shore line, where they lie in wait for the bears, the fish being the bait to attract them. Several were killed from these roosts last year.

The entire section was prospected for trout, but very few were caught. It became evident that they were not in the streams or in that vicinity, so equipment was transferred to Woody Island, at the upper end of Iliamna Lake, the object being to locate trout in connection with the salmon spawning grounds and the presence of salmon fry. Very little is known of this island, but upon investigation it was found to contain several series of connecting lakes, with the entrance to each series from the main lake and deep enough to accommodate patrol boat *No. 1*. Young salmon were noticed in considerable schools feeding along the shores. Nets were set around some of the schools, and an excellent catch of trout during the night was the result.

Most of the catch during the season was made in this district. When fishing became unprofitable in one series of lakes, camp was changed to another. The employees lived aboard the launch, which facilitated their movements. The first salmon made their appearance on July 3, and at this time trout were becoming scarce, so operations were transferred to the southeastern part of the lake in the vicinity of Intricate Bay. This was an excellent place for the work, but the salmon appeared in such numbers as to make extensive fishing impossible. Enough information was gathered, however, to show the necessity of a season's aggressive operations in that locality. Another year it is the intention to place a crew of residents on patrol boat *No. 1*, which was left on the ways at the head of the lake, and proceed immediately after the break-up to Intricate Bay, where operations will be begun.

Sufficient equipment and mess supplies were stored at Iliamna for work next year in this sector. One of the smaller patrol boats is to be dispatched with a crew from Naknek to undertake operations at the lake outlet.

Considerable work was accomplished on the fishway at Kokhonak Falls. The grade was made easier, the passage wider, and a new resting pool added to the lower end of the passage, which now enables the salmon to get over the falls without obstruction. To complete these improvements several tons of rock were removed by blasting.

The total catch in this sector for the season was 3,697 fish weighing 9,242 pounds, an average of 2½ pounds each. Ninety per cent were Dolly Vardens, the remainder being lake and rainbow trouts and pike.

Upon completion of the work the launch and equipment were overhauled and the former was placed on the ways at Goose Bay, the latter stored at the home of O. B. Millett.

Predatory trout taken in 1922.

Location operated.	Fish taken.	Average weight.	Total weight.	Dolly Vardens.	Lake trout.	All others, steelhead, rainbow trout, and pike.
	Number.	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Per cent.*
Naknek	3,426	12	41,112	10	80	10
Egegik	10,063	4	40,252	100	....	....
Ugashik	8,946	2½	22,365	80	10	10
Nushagak	7,410	2½	18,525	95	....	5
Iliamna	3,697	2½	9,242	90	5	5
Total	33,542	....	131,496	....	....	....

Recapitulation.—It is felt that the work of destroying predatory fish is showing results, as reduced numbers are encountered in streams that have been aggressively fished. This is very noticeable in Iliamna River and the upper portion of Iliamna Lake, also in certain creeks in Little Becharoff Lake, notably Kanatak Creek and vicinity. The work in this section proves also that a continuous war must be waged against the marauders.

Practically all the trout captured this year were large, fat, and sea-run. The majority taken in previous years had the appearance of being lake fish. Most of the fish captured through the entire season's operations were Dolly Varden trout.

The small trap installed this year at Ugashik as an experiment can be utilized with profit at Wood River and possibly other points where sea-run trout may be intercepted. It is cheap, efficient, easy to install, and, with slight changes as to leads and pots, can be made to fish both incoming and outgoing trout, the incoming feature to be removed as the salmon appear and the outgoing portion to remain efficiently operating for the migrations that occur through July at Ugashik. It is assumed that a like migration occurs at other lakes. The bureau is furnishing web for this purpose, and measurements of the width of the river at the lake outlet, together with water depths, are at hand.

Experiments were made with small-caliber shotguns (36 gauge) in making war on terns. Excellent execution was possible from the stern of the boat, as there are usually several birds following in the wake of each boat, picking up small fish that are worked to the water's edge by action of the propeller. The cost of the gun and ammunition is nominal, and the guns can be profitably utilized on all boats.

EXTENT OF SALMON RUNS.

There were approximately 1,500,000 cases of fish packed in Bristol Bay during the current year, of which about 70 per cent was reported for the east shore, including Kvichak, Naknek, Egegik, and Ugashik, and 30 per cent for the west shore, including all of Nushagak. It is estimated that about 10 per cent of the Nushagak pack consisted of fish transferred from the east shore.

Along the east shore of Bristol Bay the red salmon made their appearance June 26, when small numbers were taken in the vicinity of Egegik. Fishing improved gradually to July 1, when the heavy rush set in. Purse seiners operating through this period made excellent catches about 25 miles offshore from Egegik. The number of fish increased so rapidly that practically all canneries in this section were compelled to raise their limit flags simultaneously. In the Naknek and Kvichak districts the run held from July 2 to 11, when a falling off was noticed and some limit flags were taken down. All flags were removed a few days later. After July 13 the run declined rapidly with occasional flashes to the 20th, after which fishermen for the most part lost interest. The Ugashik run held steadiest and continued strong to July 22. Fair numbers were entering to the end of July.

At Nushagak the main run of red salmon began July 3 and held steady until July 17, when it fell off to almost nothing. The run, however, was never heavy, and no cannery was driven to its limit, although operating on 80 per cent capacity. A small run of humpback salmon was reported July 20. At Igushik red salmon made their appearance July 5, the run reaching its crest the 8th, after which it tapered off rapidly, and after July 15 very few fish were noted. The run was never large even at its height.

In checking the salmon run at the outlet of the stream between Alegnagik and Nerka Lakes an estimate was made of about 500,000 salmon passing upstream. Some spawning is accomplished in Alegnagik, but it is negligible in comparison with the connecting series of lakes above.

No estimate was possible at the operating points along the east shore and none is necessary. The escapement was ample to meet every requirement for the perpetuity of the cycle. In many cases the fish were too numerous in the spawning beds for any results above normal seeding, especially in certain streams tributary to Iliamna Lake.

PATROL.

The patrol of the entire district was especially efficient. Six power boats and the vessel *Scoter* were used. Three 30-foot Columbia River type boats, each fitted with living accommodations for three men, were on hand from 1921, and three 28-foot boats of the Columbia River trolling type, powered with 5 and 6 horsepower engines, each fitted with living accommodations for two men, were available for this year's operations. These boats were used in connection with the predatory trout work and were placed on patrol when the fishing season began. It was thus possible to cover the entire field with suitable power boats to insure proper law enforcement. One boat with warden and assistant was assigned each to Wood, Nushagak, Igushik, Kvichak, Naknek, and Ugashik Rivers. Egegik was handled as previously, using an Evinrude motor and dory with perfect success. One of the boats was used the entire season for operations in Iliamna Lake.

The *Scoter* proved a welcome addition, making it possible to keep in touch with the different phases of the work at all times and to prosecute those on boats taken for violating fishery laws by transporting the commissioner and marshal to the points where the violations occurred.

The situation at Ugashik is bad. The fishermen refuse to remain below the markers unless absolutely compelled to. There are 15 miles of river above the markers to the Red Salmon Canning Co.'s cannery, and at times fishing boats were anchored at intervals along the entire distance. Although it is certain they were fishing and the method employed is known, positive evidence could not be procured, as the bureau's boat could be seen at a distance when it was impossible to see their nets in the water. A small piece of net is so drawn across the channel that it can easily be removed. In making the rounds with the warden the writer noted a fisherman 6 to 8 miles above the marker who supposedly had a net in the water, but just before his action could be seen he raised his sail. One boat after another followed his example until from 8 to 10 boats were sailing down the river ahead. The situation can be controlled by two boats, one to operate in the vicinity of the ships just above the markers and the other in the vicinity of the "chutes" and above, and this arrangement will be in force another year. Every effort was made to enforce the laws with the single patrol boat available, and as a result eight boats were apprehended. Fines were imposed in each case.

SPAWNING GROUNDS.

When work was completed in Bristol Bay and arrangements made for the return of the different crews to the States the writer proceeded to Iliamna Lake to view the spawning grounds in this section before departure for the States, in accordance with the custom of the two preceding years. All the spawning territory was visited and observations indicated a sufficient escapement to seed all available grounds. The tributary streams along the southeast, east, and north shore of Iliamna Lake contained surplus spawners to the extent, in many cases, of being wasteful from an economic standpoint. On the trip to and through the Lake Clark section great numbers of salmon, either spawning or spent, were noted along the entire Newhalen River, and extensive spawning was in progress along the shore of Lake Clark to Tarnalia. Fish seemed to be everywhere, and in localities where none were seen the two preceding years.

Visits were made in turn to Tarnalia River, Current Creek, and Big River; thence to the head of Little Lake Clark. Return was made along the opposite lake shore to Kegik Creek. Tazimina River was visited last. Trips were made upstream at each creek and river visited, but the discoloration of the streams caused by glacial water and floods precluded all possibility of intelligent observation, with the exception of Kegik Lake and Tazimina River. The trip was somewhat early for the run in the upper reaches of the lake, but red salmon were observed jumping at the entrance to Little Lake Clark.

From information obtained from reliable residents relative to last year's run in this section it was learned that "very few fish reached the upper portion of Little Lake Clark, and the only fish of consequence were noted in Kegik Lake, where fair numbers were seen earlier in the season. Signs of a few thousand fish were seen in the sloughs of Current Creek about 10 miles upriver, but the brown bears had cleared off every fish from their spawning beds," and it is felt that the results from spawning here were negligible. At Tarnalia, where great numbers were noted the present season and are numerous in all good years, "there were no dead fish found along the lake shore, where previously many were picked up for garden fertilizer." On arrival at Kegik on August 23 a trip was made to the lake, where several thousand red salmon were noted milling along the upper shores near the mouths of several small streams. All fish noted were silvery and fresh, as though they had just arrived, and no spawning was in progress. The same resident observers will report next spring on the extent of this year's run in Upper Lake Clark.

A survey was made of Tazimina River to the falls, and salmon were found in its entire length of about 8 miles. This fall is impassable, has a perpendicular drop of about 75 feet, and is about 50 feet wide. And on the date visited the stream was low, about 2 feet of water passing over. The rush upstream was under way in the river, and some spawning at various points was in progress. An unbroken line of fish from 1 to 3 feet wide was passing near the river mouth, with seemingly no limit to the numbers.

The natives had their winter's supply cured, and it is estimated that about 60,000 fish, divided between 30 families, was their Lake Clark quota. About 50,000 fish would be required for the local families around Iliamna Lake.

On the return to Iliamna on August 28 supplies were taken aboard preparatory to an inspection around the lake. Each stream of consequence was visited and examined upriver several miles. The Upper Tularic was visited late in the season, but is not considered of importance as a salmon-spawning stream, although it had the appearance of being thoroughly suitable for the purpose. It was estimated that not over 10,000 fish spawned in its waters. An abundance of spawners was noted along the lake shore in every direction, and the lake surface was generously dotted with the dead fish after spawning.

Visits were made to Chekok Creek and tributaries, and many thousand salmon were seen on the spawning beds and schooling preparatory to spawning. In one spring pond, 350 feet long by 40 feet wide and 6 to 8 inches deep, it was estimated that there were about 5,600 fish in course of spawning and fully as many more in pools outside in the creek schooling and ready to enter. This pool is fed by springs and never freezes. The bottom was pure, coarse, clear gravel down as far as dug. The fish were not working as actively as in a flowing stream. In the course of digging it was noted that about 25 per cent of the eggs among the gravel were dead, due to the activities of the late arrivals. No trout or birds were in evidence. The tenure of life of spawning fish seemed to be prolonged in this water, and the dead were not decaying as rapidly as those in the creek beds. Other spring ponds not as suitable were supplied to capacity with spawners and many far beyond that point. In one pond, 150 feet long by 50 feet wide and 18 inches deep, there were estimated to be about 2,000 fish either dead or spawning. The bottom was literally covered with dead eggs; but few live ones were noted, and they would all eventually be picked up by the numerous gulls. Many more fish were schooling in the creek outside destined to the spring ponds.

At Copper River, August 29, it was estimated that there were about three times as many fish in the stream as were observed last year, possibly at least 1,000,000 fish in this river. The entire river bottom was dug over, and from the number of dead noticed it was concluded that one run had spawned. Another run was then on the beds, and sufficient numbers to cover this spawning territory a third time to capacity were yet in large schools, finning and milling in every eddy and deep pool.

Many sloughs in which extensive spawning was accomplished before the lowering of the stream were dry or nearly dry, and many that were separated from the main stream in which spawning was yet in force would be dry eventually. These formed serious losses, as the river was due to drop considably and continue extremely low throughout the winter months. Many nests in sloughs, entirely separated from the river, were dug up and both live and dead eggs found in about equal proportion.

Large losses of eggs have also occurred from rotational spawning on the same grounds, one set of spawners beginning after the first set is through. While watching the spawning riffles in the main river white eggs were seen at times drifting in a steady flow with the current. These were eggs dug up by the latest spawners and were a total loss. It was judged that about one-third of the number of spawners in this stream would bring maximum efficiency.

The number of fish at Kokhonak River was slightly larger than last year; possibly 2,000 were seen below the falls. The salmon were not active in the fishway on August 31 at the date of the inspection. With the improvements made to the fishway no trouble is experienced in their ascent over the falls.

The party followed the river to Kokhonak Lake, a very extensive body of water that has the appearance of being ideal for salmon and is connected with numerous smaller lakes and ponds of more or less value to salmon. The river is about 8 miles long and has four series of falls, each, with the exception of the falls near the river mouth, followed by rapids several hundred yards in length. No. 1 series of falls at the river mouth is about 20 feet high, over which the fishway is blasted, and is the most severe. No. 2 series, about 5 miles above that point, passes through three openings between high rock bluffs and is about 5 feet high. No. 3, a quarter of a mile above, passes through two openings between rock bowlders. No trouble is anticipated for the fish negotiating these natural obstacles. No. 4 is a serious obstruction for salmon. These falls are about 1 mile below the lake. The river passes through two entrances between rock ledges, and the fall is about 15 feet. There are three shelves over which the water flows, and it is doubtful if any salmon are able to pass over. Attention will be centered on this barrier another year.

The conditions at Kokhonak Creek were very similar to those experienced in Copper River, with an equal surplus of spawners and a like loss of eggs from overseeding.

The numbers of salmon entering Belinda Creek were about equal to those entering in 1921, and very few were taken by the natives at that point for home consumption. Early in the season great numbers were seen schooling near the creek mouth, but evidently the main body passed up the lake to other streams or scattered along the lake shore to deposit their eggs.

The fact is emphasized that this season was exceptional, and although it is felt that the corresponding cycle will bring results fully on a par with this year, no absolute reliance can be placed on the return of the next two years. Following that period a substantial improvement may be looked for all along the line. It is felt that the extermination of the predatory enemies of salmon is the most important work that can be accomplished toward salmon conservation and that the results much more than warrant the expenditures made.

WOOD RIVER LAKE SYSTEM.

Warden A. T. Looff and one assistant remained in the district during the winter of 1922–23 to make a survey of the spawning grounds of the Wood River lake system. The following report was submitted by Mr. Looff as a result of observations before the freeze up in the fall.

GENERAL REPORT OF SEASON'S OPERATIONS.

During the fall of 1922 an examination was made of the Wood River system to determine the extent of its fishery waters. All of the spawning areas were inspected and the number of salmon on the beds estimated. All tributaries were examined for obstructions to the ascent of salmon. The principal breeding grounds of the predatory tern were located, and a study was made of the spawning habits of Dolly Varden trout in this district.

The Wood River watershed consists of the 5 Wood River lakes, namely Aleknagik, Nerka, Beverly, Fourth, and Kulik, together with their connecting rivers, 5 small tributary lakes, and 55 tributary streams. The whole is drained by Wood River into Bristol Bay.

Leaving Snag Point August 23 the party proceeded up Wood River to Aleknagik Lake, thence to Nerka, Beverly, Fourth, and Kulik Lakes. Patrol boat *No. 4* was used for the run up Wood River and the work on Aleknagik Lake. An 18-foot codfish dory was used on the upper lakes. No difficulty was experienced in ascending and descending the connecting rivers. Each lake was circled and the entire shore line examined. All tributary lakes and streams were studied, and those frequented by salmon or other fish were explored. Work was completed and return made to winter quarters at Snag Point on October 9, camp having been established 19 times, and about 525 miles, 400 of which were rowed in a dory, having been covered.

Aleknagik Lake.—Aleknagik Lake is about 16 miles in length, has an average width of about 3½ miles, and lies southeast and northwest. In the lake are 15 islands, 4 of which are important breeding grounds of gull and tern. Besides the connecting river coming down from Lake Nerka, nine tributary streams enter the lake, one of which drains a small tributary lake. Five of the tributaries are entered by salmon.

Creek No. 1 enters the lake on the southeast shore about 3 miles above the outlet of the lake. It is 2 miles in length and heads in a small lake one-half mile long and one-third mile wide. About 5,000 red salmon spawned in the stream and lake. It was examined July 28 and September 25 and 29. Later, while working on this stream in connection with Dolly Varden trout operations, a number of coho salmon were seen ascending.

Creek No. 2 enters the lake one-half mile northwest of creek No. 1. It is small, 1 mile in length, and heads in the tundra. However, 50 red salmon spawned in the stream, and one nest in only 2 inches of water was marked for winter examination.

Creek No. 3 enters the lake on the northeast shore behind the large island near the lake outlet. Its length is 1 mile, and it heads in the tundra. A native reported that red salmon enter this stream, but no salmon were found there.

Bear Creek enters Bear Bay on the southwest shore about 6 miles above the outlet of the lake. It is a fair-sized stream 5 miles in length and heads in the mountains to the southwest. The stream was examined on July 28 and September 27 throughout its entire length for obstructions and Dolly Varden trout. Salmon were found 3 miles above the mouth, and it was estimated that 5,000 red salmon spawned in its waters.

Creek No. 4 is a branch of Bear Creek. It is one-half mile in length and heads in the tundra to the west. Twenty red salmon spawned in this little stream.

Creek No. 5 enters the lake on the southwest shore about halfway up the lake. It is the largest tributary and should really be classed as a mountain river. It is 8 miles in length and rises in the mountains to the south. It was examined July 28 and October 5. Salmon spawned 3 miles above the mouth, and it was estimated that the stream contained 4,000 red salmon.

Stormy Creek enters the lake on the southwest shore near the head of the lake. It is a mountain stream 2 miles in length and has no salmon.

Creek No. 6 enters the head of the lake. It is 4 miles in length and has its source in the marshy country to the northwest. Natives stated that salmon spawn in this stream, but none was found.

Of the shore line of Aleknagik Lake proper about 10 miles is suitable for spawning. It was estimated that 18,000 red salmon spawned along the lake shore in areas the total length of which is 5½ miles.

The river connecting Nerka and Aleknagik Lakes is 4½ miles in length and flows generally south. It was examined August 25 and September 16. Salmon were spawning in the river throughout its entire length, and it was estimated that it contained 5,000 red salmon.

Nerka Lake.—Nerka Lake is the largest of the Wood River lakes. It lies like a great horseshoe with the opening toward the east. The shortest route from outlet to head is fully 45 miles. In circling this lake the distance traveled is estimated at 160 miles, not counting side trips up tributaries. In the lake are 26 islands, of which three are grass islands and showed evidence of being vast breeding grounds of gull and tern. Twenty-three tributaries enter the lake, four of which have their origin in tributary lakes. Eight tributaries are entered by salmon.

Creek No. 7 enters the lake on the southeast shore about one-half mile above the outlet. It is a mountain stream 2 miles in length and contained no salmon.

Creek No. 8 enters the lake on the southeast shore about 1 mile above the outlet. Length 2 miles, source mountain, no salmon.

Creek No. 9 enters the southeast shore about 5 miles above the lake outlet. Length 3 miles, source low hills, no salmon.

Creek No. 10 enters the lake on the east shore about 15 miles above the lake outlet. This stream is 3 miles in length. At its head is a small lake 1 mile long and one-half mile wide. The lake and stream have good gravel. The estimate for both was 5,000 red salmon. Examined August 26 and September 15.

Creek No. 11 enters the lake on the east shore 18 miles below the head of the lake. Length 1 mile, source mountain, no salmon.

Creek No. 12 enters the west arm of the big bay on the east shore of the lake, is 1 mile long, and heads on the mountain side. Over 50 red salmon were spawning in this little creek. Examined August 28.

Creek No. 13 enters the east arm of the big bay on the east shore of the lake. Length 1 mile, source low hills, no salmon.

Creek No. 14 enters on the northwest shore 3 miles below the head of the lake. Length 1½ miles, source low hills, no salmon.

Creek No. 15 enters on the northwest shore 9 miles below the head of the lake. Length 3 miles, source mountain, no salmon. This stream has good gravel for a distance of one-half mile above the mouth.

Creek No. 16 enters on the northwest shore 13 miles below the head of the lake. Length 3 miles, source mountain valley, no salmon.

Creek No. 17 enters the bay formed by the long peninsula on the northwest shore of the lake. This stream is 3½ miles in length and drains a small mountain valley, is 8 to 10 feet in width, and has an average depth of 2 feet. For a distance of 2 miles above the mouth the bottom is thoroughly suitable for spawning. Here over 50 red salmon were counted. The season was well advanced. Examined September 11.

Creek No. 18 enters the same bay one-fourth mile southwest of Creek No. 17. The stream is 4 miles in length and drains a mountain valley. Its bottom is suitable for spawning for a distance of 1 mile above the mouth. One hundred and fifty red salmon were counted here. Examined September 11.

Creeks Nos. 19 and 20 are short mountain creeks that enter the arm on its north shore. They are each one-half mile long and have no salmon.

Creek No. 21 enters the head of the northwest arm of the lake. This is Nerka's largest tributary. Length 8 miles, average width 20 feet, depth 3 feet. Origin is in the mountains to the northwest. There is good gravel for a distance of 5 miles up this stream. It was estimated that not less than 8,000 red salmon were spawning in this stream. Examined September 12.

Creek No. 22 enters near the entrance of the arm on the south side. This is Nerka's third largest tributary. Length 4 miles, origin in the mountain valley leading to the west. This stream contains good gravel. Estimate for the stream was 1,000 red salmon. Examined September 12 and 13.

Little Togiak River connects Little Togiak Lake with Nerka Lake. The river is only 500 yards long, and it was an easy matter to pole a boat up into Little Togiak Lake. The lake is 8 miles in length and 1½ miles in width. The shore line is not attractive as a spawning area, the water being shallow and the bottom covered largely with rocks. At the head of the lake, however, is a small area with good gravel, and here were 2,500 red salmon. In Little Togiak River were about 500 spawning red salmon. Examined September 14.

Creek No. 23 is a small mountain stream entering the head of Little Togiak Lake. Its length is 2 miles, and salmon do not ascend.

Creek No. 24 enters on the southwest shore of the lake 1 mile southeast of the outlet of Little Togiak River, is one-third mile in length, and drains a small lake 1 mile long and one-fourth mile wide. The creek is small and the lake shallow. Salmon do not enter.

Creek No. 25 enters on the southwest shore of the lake 1½ miles southeast of the outlet of Little Togiak River, is 2 miles long, and drains a small lake one-half mile in diameter. Stream and lake have good gravel, and salmon were spawning in both. Estimated to contain 1,000 red salmon. Examined September 13.

Creeks Nos. 26, 27, and 28 enter along the southwest shore of the lake. They are short, draining mountain ravines, and are entirely unsuitable for spawning.

Of the 160 miles of shore line of Lake Nerka proper, 90 miles is suitable for spawning. Salmon were spawning in 20 distinct areas with a total length of 22 miles. The areas are well distributed around the lake, most of them centering at the mouths of tributary streams. Salmon were most abundant in two areas, one on each side of the long peninsula on the northwest shore of the lake, but were certainly not crowded. It was estimated that the lake-shore spawning areas totaled 31,000 red salmon.

The river connecting Beverly Lake with Nerka Lake is 2 miles long and flows south. This was found to be the most difficult of ascent of the four connecting rivers. The water is swift and the channel strewn with large bowlders, which makes the river unsuitable for spawning. While ascending the river August 29 thousands of salmon were seen in the eddies. They seemed weak, and upon examination were found to have spawned. While descending the river September 8 fully 30,000 dead and dying salmon were found along the shores and in the eddies. Several hundred of the dead fish were examined. All were spawned out. They did not spawn in the river, but must have spawned along the shores of Lake Beverly above, and upon becoming weak dropped back into the river, where the swift rapids made short work of them.

Beverly Lake.—Beverly Lake is the second largest of the Wood River lakes, with a length of about 20 miles and an average width of 4 miles. From the outlet to inlet the direction is west-northwest. In the lake are four islands. All are rocky, and gulls and terns do not nest on them. Twelve tributary streams enter the lake, of which three are ascended by salmon. A brief description of the tributaries follows:

Creeks Nos. 29, 30, 31, 32, and 33 are small streams that enter the lake along the north shore. Salmon do not ascend any of them, although Nos. 30 and 31 have small patches of good gravel. The creeks all head in the low timbered country to the north of the lake.

Creek No. 34 enters the head of the bay on the north shore of the lake about 7 miles below the mouth of the river coming down from Fourth Lake. Length, 1 mile; source, tundra; no salmon.

Creek No. 35 enters on the north shore of the lake about 4 miles below the outlet of the river coming down from Fourth Lake. Its length is 1½ miles. The stream has good gravel bottom and drains a small mountain valley, but salmon do not enter.

Creek No. 36 enters on the north shore of the lake about 2 miles below the outlet of the river coming down from Fourth Lake. This stream drains a small mountain valley and is 2 miles long. It has good gravel bottom for a distance of one-half mile above the mouth, and 500 red salmon were spawning here. Examined August 30 and 31.

Creek No. 37 enters the lake one-half mile south of the outlet of the river coming down from Fourth Lake, is 1 mile long, and has its source at the base of a large mountain to the west. It has good gravel, but salmon do not ascend.

Creek No. 38 enters the head of the north arm on the upper end of the lake. This is Beverly's largest tributary with a length of 4 miles and an average width of 15 feet. The stream drains a mountain valley. The water in the lower 2 miles flows slowly with an average depth of 3 feet. Five thousand red salmon spawned here. Examined September 5.

Creek No. 39 enters the head of the south arm on the upper end of the lake. This is a small mountain stream 1 mile long and has no salmon.

Creek No. 40 is a small mountain creek, one-half mile long, that enters the bay on the south shore of the lake. Twenty red salmon were counted. Examined September 7.

Creek No. 41 is a small stream that enters on the south shore near the outlet of the lake. Length 2 miles, source low hills, no salmon.

Beverly Lake has a total shore line of 45 miles, of which 12 miles is thoroughly suitable for spawning purposes. Salmon were spawning in four distinct areas having a total length of 7 miles. Estimates of salmon spawning in lake-shore areas total 34,000. If to this be added the 30,000 dead and dying salmon seen in the river below, which it is believed spawned in the lake, more than twice as many red salmon spawned in Beverly Lake as in any one of the four other lakes. In the lower end of the lake and along most of the north shore the water is shallow and the bottom covered with grass and mud, altogether unsuitable for spawning. Along most of the south shore is good gravel, but large sections of it are covered with a brown slime. Examined August 29, 30, and 31, and September 5, 6, 7, and 8.

The river connecting Fourth Lake with Beverly Lake is 2½ miles long and averages 200 feet in width. Leaving Fourth Lake the river flows southeast. Just before entering Beverly Lake it swings southwest and then back to southeast. It was easy to pole a boat up. The entire length offers splendid spawning gravel, and salmon were spawning all along. It was estimated that 15,000 red salmon were spawning in the river. Examined September 1 and 5.

Fourth Lake.—Fourth Lake is 2 miles long and 1 mile wide. Excepting for the deep narrow gorge at the head where the river enters and the gorge at the outlet where the river flows out, this tiny lake is entirely surrounded by steep and high mountains rising from the very water's edge. The lake has no other tributaries and no islands. Along the shore line of the left limit is no spawning area, the water being extremely deep close up to the shore. Along the right limit the water is also very deep, but in places there is a narrow shelf of gravel where 1,000 red salmon were found spawning. At the upper end of the lake the river coming down from Kulik Lake has formed a gravel delta one-fourth mile in diameter. This was almost one continuous spawning nest, and it was estimated that 10,000 red salmon were spawning here. Contrary to findings in the three lower lakes the spawning period was apparently just beginning. The salmon were in fine condition. Examined September 1, 4, and 5.

The river connecting Kulik Lake with Fourth Lake is 3½ miles long and flows south-southeast. There are several rapids in the river and in places the stream breaks up into separate channels. The boat was lined up in five hours. Parts of the river have good gravel, but the water is mostly too swift for spawning. Very few salmon were seen in the river, and such as were seen were ascending, judging from their fresh color. Examined September 1 and 5.

Kulik Lake.—Kulik Lake is the last of the Wood River lakes, or the first as the water flows, and is 18 miles long with an average width of 4 miles. From the outlet the lake leads northeast for the first 6 miles, then curves to the southeast for 10 miles, narrowing down at the head to a small arm 2 miles wide and 2 miles long leading east. In the lake is one large island covered with timber and unfit for breeding grounds of gull or tern. Ten tributary streams enter the lake, only one of which is ascended by salmon. A brief description of the tributaries follows:

Five small creeks enter along the south shore east of the outlet. All of them emerge from narrow mountain ravines and are altogether unfit for spawning. Another small creek enters the head of the lake coming out of the low timbered country to the east. This creek is 2 miles long and has some good gravel, but salmon do not enter.

Creek No. 42 is a large stream that enters on the north shore about 5 miles below the head of the lake. It is about 4 miles long and 10 feet wide, with a depth of 1½ feet. The bottom is good gravel for a distance of 2 miles above the mouth. Here were 5,000 red salmon in the height of their spawning period on September 2 and 3.

Creek No. 43 is a large stream on the north shore about 8 miles below the head of the lake. It is 4 miles long and has good gravel for a distance of 2 miles above the mouth, but salmon do not enter.

Creek No. 44 is a small creek that enters on the north shore 6 miles northeast of the lower end of the lake; length 2 miles; drains small mountain valley; unfit for spawning.

Creek No. 45 enters the west end of the lake, is 3 miles long, and has as its origin a small glacier. The bottom is good gravel, but salmon do not ascend.

Kulik Lake has a total shore line of 40 miles, of which 25 miles is suitable for spawning purposes. The east end and the west end of the lake are rocky, but along the north and south shores are fine areas of gravel. Salmon were spawning sparsely on nearly all suitable territory. Estimates for the lake shores total 21,000 red salmon, spawning over areas totaling 20 miles in length.

Summary.—All references herein are to red salmon unless otherwise specified, as very few of the other species enter the lakes in this district, and although they were found occasionally they have not been included in the estimates. During the late summer several thousand humpback salmon spawned in the upper part of Wood River and around the outlet of Aleknagik Lake. About 50 king salmon were spawning here during the same period. An occasional chum salmon was found—about 25 in all—along with the red salmon in Aleknagik, Nerka, and Beverly Lakes, but none was found in the two upper lakes. Several hundred coho salmon were spawning in Aleknagik Lake and its tributaries during the latter part of September and as late as October 9.

Throughout the work on the spawning areas careful check was made to determine the ratio of male salmon to female. The rich red color of the male makes it easy to distinguish him from the female. That this might work to the male's favor was realized, and tests were limited to conditions where there could be no mistake. As a result of these observations, dealing with thousands of salmon on many spawning areas in each of the lakes, it is believed that fully as many male red salmon were on the spawning grounds of the Wood River lakes as female red salmon.

The four rivers that connect the Wood River lakes with a total length of 12½ miles, although more or less difficult to ascend with a boat, offer no serious obstruction to the ascending salmon, unless they are badly fungused. Throughout the investigation wherever opportunity offered, which was often, dead salmon were examined. The number of dead salmon found that had not spawned was almost negligible. Such as were found were mostly fungused. That the fungus caused their premature end is certain, as the only places where they were found in any numbers was at the outlet of the rivers entering Aleknagik and Nerka Lakes. No fungused salmon were found in the three upper lakes.

The 17 tributaries frequented by salmon, although small, with a total spawning area insignificant as compared with the main lake areas, are all clear of obstructions and easily ascended by the salmon. All other tributaries that were at all suitable for spawning were examined for obstructions. In two fairly good streams log jams were removed, but as no salmon were at the base the work was of no benefit for this season at least.

On lake-shore areas the salmon were distributed over such a vast territory that the areas appeared almost deserted. Only in a few cases were salmon spawning in groups of any size. It was not an uncommon experience to row for 5 miles along a lake shore with splendid spawning gravel and not see a salmon. In two places where this condition prevailed the ruins of native villages were seen, both in Lake Beverly. As native villages in this section are always located with regard to the fish supply, thousands of salmon must have spawned there when the villages were populated—evidently not many years ago.

In arriving at an estimate of the number of salmon that spawned in the Wood River lake system each area was treated as a separate unit. In many cases figures represent actual count, particularly in tributary-stream and small lake-shore areas. In all cases careful count was kept of dead fish and backbones of dead fish scattered along the shores and on the lower lakes, where the spawning period was much further advanced than on the upper lakes. Where it was impossible to count the fish the number was estimated. Although the weather was exceptionally favorable during the examination it is realized that some fish may have been missed. Gulls surely consumed many and dragged the remains of others out of sight. The following facts seem certain: (1) Not less than 213,600 red salmon spawned in the Wood River lakes and their tributaries; and (2) whether 50,000 more than 213,600, or twice 213,600 spawned, there was room for 10 times the number that actually spawned.

PREDATORY FISH AND BIRDS.

Several agencies detrimental to salmon production in the district are of more or less importance. These are depredations by fish and birds on the salmon spawn and young, fishing for salmon on the spawning grounds by natives, and possibly the action of ice on the spawn. The predatory fish of this district are lake trout, pike, and Dolly Varden trout, the last being by far the most abundant and therefore the worst.

Lake trout were found in small numbers with the salmon on the spawning beds in Fourth Lake and in the river connecting Fourth Lake with Beverly Lake, also around the outlet of Little Togiak River. The depredations of these trout on young salmon in several of the salmon streams of Bristol Bay are well known. Examination of the stomachs of several caught proved that they are also egg eaters of no mean ability. However, their number is very small here.

Pike are not plentiful, but a few were found in each of the lakes. They do not feed upon spawn, their food consisting of live fish. It is certain that they consume a large number of young salmon.

Of the depredations of Dolly Varden trout on both the salmon spawn and young the bureau has ample evidence. An effor was made to determine something as to their number, their activities in connection with the ascent and spawning of the salmon, where they congregate, and their spawning habits. While inspecting the spawning areas in the various lakes and their tributaries, a trout gill net was used in places where it could be done without injury to the salmon. Being egg eaters most of the trout would be found on the salmon spawning grounds during the spawning period. As all of the salmon spawning areas were examined, it is believed that a large part of the Dolly Varden trout of this district were seen. During the latter part of September and the first part of October, when the red-salmon spawning period was over, attention was given almost entirely to work on trout. During this time six trout gill nets, one fyke net, and one seine were operated. Young Dolly Varden trout between 4 and 6 inches in length were found during early October coming out of the small tributary lake that enters on the southwest shore of Aleknagik Lake. A fyke net was set in the stream below so as to catch all of them, but was only partly successful on account of drifting leaves, with which the streams are choked during this season of the year.

A fence of spruce trees constructed above the net was not effective, due to the great quantities of leaves. About 200 young trout were caught. During the red-salmon spawning period and after, thousands of Dolly Varden trout were found in the upper part of Wood River and in Aleknagik Lake. Ascending the system from Aleknagik Lake they were less and less numerous, until in Kulik Lake they were so scarce that only three or four were seen in the entire lake. Two places were found in the upper lakes that might be profitably fished—namely, at the outlet of Nerka Lake and at the outlet of Little Togiak River—where there were trout by hundreds but not by thousands as in the lower lake. Altogether 1,018 trout were caught and destroyed, all of which were examined. The following conclusions were noted in regard to trout:

There are more Dolly Varden trout in the upper part of Wood River and in Aleknagik Lake than in all the other lakes combined. During the salmon-spawning period the trout congregate on the salmon-spawning beds and feed on the spawn. After the salmon-spawning period is over the trout gather around the outlets of tributary streams where they feed on the bodies of spent salmon. Until October 9 about 5 per cent of the trout were ripe and spawning around the outlets of tributary streams, none of them having ascended the streams. All tributaries of Aleknagik Lake were examined in October, and it is certain that no trout had ascended any of them prior to October 9. The condition of the others would indicate their spawning period as ranging from probably November to some time in the spring, with the bulk of them to spawn during the winter months. From the presence of young trout in the tributary lakes it would seem that at least part of the trout ascend tributaries to spawn. An attempt will be made during the winter to determine whether trout ascend the tributaries later.

In this district there are many gulls and terns. Although all terns had left before the 1st of September great flocks of gulls remained around the spawning areas throughout the spawning period and after, until the "freeze up." That the gulls were feeding on spawn, where the salmon were spawning in shallow water, during the early part of the spawning period was plain. As the season advanced, however, it was noticed that they were feeding for the most part on the bodies of spent salmon. Of the menace of terns to young salmon nothing need be said in this report. Their favorite nesting grounds, if not their only ones, are grass-covered islands. All of the 52 islands in the Wood River lakes were examined for breeding grounds of gulls and terns. Besides four islands in Aleknagik Lake already known, three islands in Nerka Lake showed evidence of having vast breeding grounds of both these predatory birds, and it is believed that a large part of the great flocks of terns that frequent this district during the spring and summer nest on these three islands, which are close together, and could be kept clear of eggs by two men during the nesting period.

FISHING ON SPAWNING GROUNDS.

Five native families fished for salmon on the spawning beds of Aleknagik Lake during the spawning period. There was no fishing on any of the other lakes. About 3,000 salmon were caught and dried, of which some were spent red salmon and some cohos. Three native families continued fishing in the lake after the red-salmon spawning period was past and until the first part of October, the last family leaving the lake on October 7. They operated a total of nine nets most of the time, which it was estimated caught over 1,000 Dolly Varden trout besides other fresh-water fish, all for food for themselves and their dogs.

ACTION OF ICE ON SALMON EGGS.

To determine the action of the winter ice on salmon eggs, several nests in shallow water near the lake shores were marked with poles for winter examination. During the fall water gages were placed in several of the lakes to register the rise or fall of the water. From August 23 to September 5, when it reached its lowest level, the water of the lakes fell 2 inches. From that date on the water rose steadily, until by October 21 it had reached a level 18 inches higher than on September 5. The shallowest spawning nest found on lake-shore areas was covered with 12 inches of water on August 26. As the height of the spawning period was during the lowest stages of the water, few of the spawning beds were covered with less than 2½ feet of water when the "freeze up" came on November 4. It is reported that the past fall has not been wet. The condition of eggs in tributary streams is not certain. The streams, being for the most part small and very short, reach a flood stage on rainy days, but fall again to a low level in a few hours. Several nests in 2 inches of water were marked and will be examined during the coming winter.

CONCLUSION.

In conclusion it may be stated that throughout the examination of the district natural conditions were found to be almost ideal for salmon production. All of the great spawning areas are easily accessible to the salmon. Although thousands of trout and terns still remain to menace the young, much benefit has resulted from the past three seasons of work toward their extermination. In the season just passed (1922) the spawning areas were almost destitute of breeding salmon. With continued work on predatory fish and birds, and an ample escapement of brood salmon, it would seem that the Wood River lake system should produce many times the number of red salmon it has in the past.

LAKE ALEKNAGIK INVESTIGATIONS.

In connection with recent studies of the Wood River region, it is believed that it will be of interest and value to publish a report of examinations of Lake Aleknagik and its tributaries that were made in 1908 and 1909 by Millard C. Marsh, then chief agent in the bureau's Alaska service. In 1908 Mr. Marsh was accompanied by Claudius Wallich, field superintendent, specially detailed for the trip, and the period from May 31 to August 9 of that year was spent on the lake. The following year, accompanied by J. A. Legge, of the Afognak hatchery, Mr. Marsh was on Lake Aleknagik from June 7 until August 8. The report on these explorations, which has recently been revised by Mr. Marsh, is as follows:

NOTES ON EXPLORATIONS OF LAKE ALEKNAGIK, ALASKA, ITS TRIBUTARIES, AND THE SALMON SPAWNING GROUNDS, IN 1908 AND 1909.

In 1908 the Bureau of Fisheries, jointly with two of the salmon-packing companies, began the series of annual counts of red salmon escaping up Wood River into Lake Aleknagik, in the Bristol Bay region of Alaska.[1] Incidental to this project the lake shores and the tributary streams were examined in some detail in relation to the spawning migration of the salmon and possible future salmon-hatching operations in the region. Many of the observations concern the physical conditions only, and the rather desultory notes are chiefly of local value, to be interpreted on the ground covered. The lake is the first of a chain comprising a spawning basin of great extent and carrying a large quota of spawning salmon, and itself receives, besides its main inlet, nearly 40 large and small creeks, most of which are typical spawning grounds, some of them suitable for hatchery sites. It is the nearest large field to the Nushagak region for the study of the spawning grounds and the spawning fish upon them. Since it is accessible to small craft from tidewater, it is the more available as a resource for hatchery operations. For prospectors in either field these notes are likely to be of some assistance. Claudius Wallich, at that time field superintendent, participated in 1908 in some of the trips up the lake and rendered valuable assistance.

The foot of Lake Aleknagik consists of a nearly circular body of water about a mile in diameter. This is referred to throughout the text as the "lagoon." On its north shore is a native village. Its junction with the main body of the lake is marked by two distinct gravel spits making out from shore on either side. The distance between their tips was rather more than 200 yards, and it was here that the tally rack, through which the fish were made to pass for counting, was stretched in 1908 and 1909. This place was the base for the expeditions up the lake and the point of departure for the enumeration of the streams and all the observations.

There is, of course, great variation from year to year in the correlation of the calendar with the water temperature, the lake level, the disappearance of ice, the seasonal run-off, etc. Besides the observations recorded for particular creeks the following few notes and readings were made for the lake itself: Temperature at surface—June 7, 1909, 1 mile above lagoon, 9.30 a. m., 38° F. (head of Nushagak Bay, 44.5° F.); June 16, 1909, head of lagoon, 39.5° F. Lake level, 1909—highest seasonal level at lagoon June 19, when it was 20 inches above the level of June 7. The fall, beginning June 21, was about 41 inches during the next 49 days, when observations ceased. The tidal influence affected the lagoon level (June 7) not more than 1 to 3 inches. The current at the site of the rack at this date was 1.6 miles per hour. Several soundings were made in the lake, the deepest of which was 57 fathoms.

The earliest record is of May 31, 1908. Ice was encountered about 1 mile above the lagoon. As far as could be seen it covered the whole of the rest of the lake as a continuous sheet only a few inches thick and much honeycombed. It would bear no one's weight and was easily broken up, but only a large vessel could have made way through it. Many wet places could be seen indicating cracks through which water welled up on the ice. On June 12 of the same year the lake was open to the main inlet and carried a small amount of drift ice. From the inlet to the head of the lake the thin sheet of honeycomb ice still persisted.

Only a few tributaries to the lake can be recognized from craft traversing the lake without following closely the shore. Thus, the map of the lake appearing on page 200 in Bulletin of the United States Fish Commission for 1901[2] showed but 9 of the 36 streams here recorded as flowing into the lake, the majority of which carry at least some salmon and constitute spawning grounds. There are many tributaries unsuspected until the observer approaches within a few yards of their mouths. Probably there remain a few still unnoticed.

As most of the creeks are not named and as any value of the observations depends on identifying them they have been numbered. A few have been named. The exact dates are usually given as of use in comparing the two

[1] Excepting the interruption of one season (1914), these yearly tallies were continued for 11 consecutive years.

[2] Alaska Salmon Investigations in 1900 and 1901, by Jefferson F. Moser. Bulletin U. S. Fish Commission, Vol. XXI, for 1901 (1902), pp. 173-398. Washington.

years and in correlating the spawning advance with the season. The consecutive series begins with the Village Creek at the Indian village. It proceeds thence westward along the north shore and continues completely around the lake.

Creek 1. Village Creek.—August 4, 1908. At the extreme foot of the lake, emptying at the native village. Examined for about 1 mile of meander without seeing a single salmon. About one-half mile from the village the creek has a considerable hill on the right bank, while the other side is low. About 100 yards above the hill the stream becomes wider (7 feet) and shallower. It has a good coarse gravel bottom, with larger stones and rocks and much moss. Many deadfalls and overhanging branches obstruct passage along the creek bed. Farther up are two low hills one on each side, where the creek could be dammed, though the valley between is 75 feet or more wide. This flat

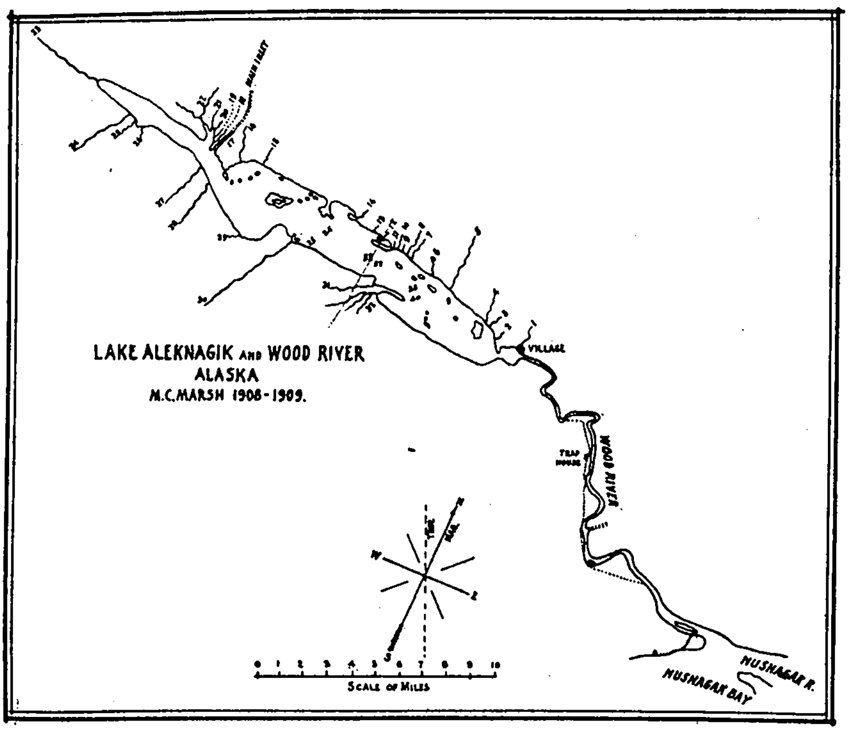

FIG. 6.—Lake Aleknagik and Wood River, Alaska.

is boggy and has a high, thick growth of grass. In and about this bog four-fifths of the volume of water originates. Several distinct channels rising in this soft mossy ground make into the main creek, which was followed up until it became scarcely a foot wide and was almost hidden by overhanging grass and vegetation. Here it ran between rather high banks. From the spring flats above mentioned the village was reached in a half hour of steady traveling.

The water of this creek is clear and cold, the bottom is favorable, its size is sufficient, and the gradient is easy, yet salmon do not enter it. There is a bar opposite its mouth and the water is shallow, but fish would have little trouble getting over it. The influence of the current of the creek is little felt where the salmon are passing up the lake, and they may not readily find it. Nevertheless, it is difficult to understand why it is entirely avoided. At this date, August 4, the salmon had been for some time entering the small streams. Its condition in winter is a question. A man who had wintered on the lake said it does not freeze and that the natives get water from it in the winter. Probably at least a trickle of water remains, but it should not be regarded as a hatchery creek for several reasons.

Hundreds of redfish fry of the most recent hatch were seen opposite the village August 4. As they did not come from the village creek they may represent some lake spawning in the lagoon or possibly they had migrated from some distance.

Creek 2.—August 7, 1908. Around the first point from the lagoon, on the north shore. Small creek of brown water, too small for any use. Its course lies through a considerable low growth of willows. The bay off its mouth is at this date too shallow for the draft of a small launch.

Creek 3.—August 7, 1908. Opposite inner end of a small island. A small, unimportant creek of brown water. Temperature of the strait separating the island from mainland at this point, at 9.15 a. m., 52° F.

Creek 4.—August 7, 1908. A little west of No. 2. Temperature 45° F. About 1,000 spawning salmon were seen in less than a half mile of the meander. Many eggs were seen, and on a shallow riffle 22 fish were counted drifting by downstream during 10 minutes. The water was of a brownish color and considerably roiled, probably by salmon above. The gradient is very gradual, and there is no place for a dam, nor is it a good hatchery stream. Fifty salmon were seen crowded into one small hole, and many were schooling at the mouth.

Creek 5, North Shore Creek.—Opposite a point a little east of the tip of the high peninsula of the south shore. August 7, 1908, 12.30 p. m., temperature 52° F. It is 6 to 16 feet wide, with plenty of water, and carried some sediment, probably not produced by the salmon on the beds above. Near the mouth the stakes of a native barricade were seen. There were not many salmon off the mouth, and only 200 to 300 were seen in from 200 to 300 yards of stream. The bottom is of good gravel. A few redfish fry, the young of the season, and many small sculpins were seen. The banks are flat, and there is no place to dam. The creek comes from a valley between high mountains and may be many miles long, with possibly many salmon above. The estuary is broad and very shallow, and there is much uneven boggy ground around its mouth. The creek has seen very much higher water than the present stage. It is not a hatchery creek. Apparently there are fewer salmon in it than in much smaller creeks even 10 days earlier.

Creek 6, Spring Creek.—August 7, 1908. On the north shore about opposite the high peninsula of the south shore. The approaches were rather shallow, but a launch could get within 50 yards. The stream is about 1 mile long, with its source in a beautiful spring emerging from elevated mossy rocks, making immediately a gravelly pool about 60 feet in diameter. The temperature of the spring was 38° F. and of the outlet to the pool 45° F. The upper reaches to the creek are 20 feet or more wide and are very shallow, with blackish stones and gravel. Near the pool the gravel had a white tinge. The creek receives some small spring tributaries, including one spring pool large enough for salmon; but the large spring mentioned is the main source, and the volume of water is well maintained to this source. The rise is rapid enough for a gravity storage of water, but there is no very good place for a dam. It runs close to a hill at one point, but the banks are mostly low.

On August 7, 1908, there were many finely colored salmon in and off the very shallow mouth. All the salmon in the stream itself and in the two pools were counted:

Total dead	1,610
Total alive	2,800
Total entered creek to August 7	4,410

Shortly below the head spring a considerable reach of the stream had dead fish only.

The whole stream being accessible a complete census of spawners is possible. Two visits to this stream in 1909 enabled some comparisons. On August 1 of that year only 370 salmon had entered, of which 65 per cent were dead. The spring pool contained 46, all alive. An excess of males appeared, and nearly all fish were highly colored. The gulls had eaten the eyes and most of the flesh of the dead salmon. One week later (August 8) the total tally of salmon was 555, of which 71 per cent were dead. This is but 12½ per cent of the total that had entered the stream during the 1908 season up to August 7. In comparing these figures the great escapement for 1908, as shown at the tally rack, should be recalled.

Creeks 7 and 8.—On the north shore about 1 mile west of Creek 6. These are streams of size, the easternmost the larger, with their mouths only 200 yards apart. The two are of the same general character, with fine bottom for spawning beds and moderately rapid rise but no good places to dam nor good hatchery sites near the lake. They are probably long streams, with perhaps a common source farther inland. Heavy underbrush occurs all along the lake and the creeks in this region. Spawning salmon are apparently as abundant in proportion to size as in Creek 6, which is somewhat smaller.

Creeks 9 and 10.—These small creeks are a few hundred yards west of the preceding and one must steer close inshore to discover their existence. They are near the base of one of the several long, narrow crooked peninsulas that make out from the north shore and then bend and run parallel with the shore, inclosing long, narrow bays. The region about Creeks 9 and 10 is in a considerable bight. A few hundred salmon were seen in the larger of the two.

Creeks 11 and 12.—Creek 11 is a very small one on the neck of the peninsula referred to above and discharges into the bight. There may be another little creek on this neck nearer its base. In the bight is a secondary peninsula of the same shape as and lying similarly to the first, inclosing a secondary bight navigable for a small launch. Creek 12 discharges into this on the neck of the little peninsula. No live salmon were seen, but there were several dead stranded at its mouth. The neck of the larger peninsula is but a very few hundred yards wide. The lake could be seen across it from a boat at anchor in the head of the bight.

Creek 13.—A small stream about one-third of a mile west of Creek 12. It was not examined. A few salmon were seen near its mouth.

Creek 14.—August 8, 1908. This is at the head of a bight made by another small peninsula like those described above. It is small, with a mouth so shallow that salmon enter with difficulty. Fifty to one hundred had already entered and about a dozen were dead at the mouth, but no dead were seen in the creek. Only two or three live salmon were seen off the mouth. The stream has good bottom. It bifurcates a short distance up and can not be very large.

West of Creek 14 is another peninsula of irregular shape somewhat like a T. It has several small bays, which deliver no creeks. Several considerable schools of salmon turning red were seen hereabouts. From this peninsula westward for several miles there is fine gravel along the lake shore, but no creeks. A launch can skirt the shore very closely. Many large schools were seen, in total many thousands of salmon, and some of them miles from the nearest creek. They were not all in spawning color. The deep water in many places along here comes close to shore, which shelves off abruptly into 15 or 20 feet of water, in some places at an angle of nearly 45°. Often the bottom could not be seen at 30 feet from shore. Dead salmon were only occasional. Native drying racks were seen on shore, and the shelving bank and shore appeared good spawning ground. The salmon seen had mostly turned red, and it seems probable some may spawn here. Great schools, startled by the launch, would be seen for an instant as they shot away from shore into deeper water.

Creek 15.—This is a little creek on a gravel point that was covered with willow and alder. It has two mouths but is too small to carry salmon. There are four small islands near. Opposite the easternmost of these soundings showed 5¼ fathoms at 30 feet from shore and 15 fathoms at 100 feet.

At places between the mouths of Creeks 15 and 16 strands of long grass on the bottom of the lake showed the current was making gently toward the head instead of the foot of the lake.

Creek 16, Steep Creek.—August 8, 1908. It comes down from the west side of the highest and westernmost of the flat top range of mountains and is marked by the steepest gradient of all the tributaries of the lake. It affords favorable places for a dam, but the volume of water is too small to maintain a hatchery. Many salmon were present for so small a stream, and many eggs were seen in the water. Some distance up its temperature was 42° F. The shore region adjoining might furnish many spawning salmon. Between Creek 16 and the main inlet a sounding of 27 fathoms was made about 100 yards off the point making out from the north shore.

Creek 17, main inlet.—This stream drains the lakes above Aleknagik and is by far the largest of all the tributaries of the latter. On June 12, 1908, while ice still covered the lake west of the inlet, the flow in the latter was at a high stage, the current swift, and the water very clear. Only with difficulty could a boat have been pushed up the heavy riffles, which in places become rapids. Some drift ice was constantly passing. Two hours' walk up the trail along its west side disclosed no falls nor cascades nor rise sufficient for a gravity supply of water. The lake near the inlet mouth had an excellent gravel shore with deep water. Many salmon bones lay in a windrow on the bottom 10 or 12 feet from shore. Many thousands of redfish fry, the young of the season with sacs but recently absorbed, were schooling along the beach close inshore. On July 27 of the same season these young fish were no longer to be seen.

The inshore gravel was bare from the fall of the lake level, and the bottom was algæ-covered. In the shore eddies of the inlet stream many ragged and tattered salmon were resting. Farther up a straggling procession, most of the fish still uncolored, was ascending. No ripe salmon were seen, and it seemed evident these fish were bound for the upper lakes and not to spawn in the inlet. On August 8 at the same point a similar procession, nearly all in red color, was still slowly passing at the rate of about 300 an hour. These were close inshore, and although the depth prevented seeing any fish beyond a few feet from shore they probably represented most of the run on the west side of the inlet at this date. They kept close in to avoid the current, like the ascending columns in Wood River. Certainly many of these migrating fish were bound for the upper lakes. There was no good evidence of spawning in the inlet.

In 1909 a few observations were repeated. July 1 there were no fry on the gravel beach where on June 12, 1908, they were in force. On July 23, however, they were again seen in numbers along the beach below the inlet. Some young of the season were seen July 1 up the inlet but no adults. July 23 the usual thin procession, with many gaps, was passing, and very few fish had turned red. The native drying racks had only green fish. Information from a native indicated that the inlet does not freeze over in winter, that considerable drift ice comes down, and that there are "plenty lakes" above. The lake surface July 1 registered a temperature of 42° F. at 7 p. m. A bench mark placed at this date showed on August 2 a fall of 21 inches for the lake level.

Padden Bay and its streams.—August 8, 1908. West of the inlet is a considerable indentation known locally as Padden Bay. The trend of its upper portion is NW. by W., of its lower or main portion about N. Five creeks (18–22) empty into it, only one of which is of importance.

Creek 18.—This is a small brown creek just inside the bay. There were about 100 salmon in its sluggish muddy estuary.

Creek 19.—A short distance beyond Creek 18 and of the same type. Many live salmon and many eggs on good gravel were seen in its mouth.

Creek 20.—Like the preceding. Fifty salmon were schooling off its mouth. Heavy underbrush impedes progress along the stream, which is close to the peninsula on which is located the cabin of the prospector whose name is given to the bay.

Creek 21.—A small brown creek, corresponding in position to Creek 22, each emptying on opposite sides of a little peninsula. There were many salmon about its mouth. Near by, among moss and plants, a lot of young pike (Esox) were seined. A small bight opposite the cabin may possibly contain another small creek.

Creek 22, Padden Creek.—July 27, 1908. This is the main stream of the bay and is indicated on Rodman's sketch map of 1900. No observations were made August 8. Above its long narrow estuary it meanders through tundra and is bordered by black birch and alder. Its width varies greatly, not exceeding 8 or 10 feet. It is shallow, reaching a depth of 2 feet where its coarse gravel is hollowed out by salmon. It has a moderate current with occasional riffles. It soon bifurcates, and the eastern branch trends toward the second lake. The salmon present were nearly all in deep red color, and many were spawning. The fish were evidently the first comers, marking the beginning of the spawning season here at a date when practically none of the salmon ascending the main inlet had turned in color. Mr. Wallich estimated the stream as capable of furnishing 12,000,000 to 15,000,000 eggs.

The courting fish, in fine spawning color, were here and there fluttering and fanning over the gravel. A pair seen at Chilkoot Lake in 1907 brought the actual spawning under better observation. The female had been fanning with her tail fin over a definite nest. The two fish approached each other and heading in the same direction lay parallel at the bottom of the nest with their sides in contact. At the same moment, while a convulsive fluttering shudder shook their whole bodies and the mouth of each fish distended widely, eggs and milt were ejected, slightly clouding the water. The pair soon repeated this performance. The nest was then examined, and at first no eggs were seen. After picking away the stones at the bottom about two dozen eggs were found, presumably just extruded. Accompanying them were several large nematode worms which had been voided by the salmon. It appears that, at least on occasion, only a few eggs are spawned at the mating juncture, which must be frequently repeated.

Lake next above Aleknagik.—July 27. A mere view of a portion of this lake was obtained. From the mouth of Creek 22 it was reached after an hour's walk over a fairly good old native trail. From the point where the trail meets the shore the lake is somewhat more than a mile wide and the trend of the 10 or 12 miles of water visible is apparently like that of Aleknagik. Opposite this shore of large uniform pebbles the water was very clear. A few salmon were obscurely seen near shore. The vicinity did not appear to be good spawning ground. Heavy shore growths came down close to the water. From Padden Bay to the head of the lake there are no streams.

Creek 23.—July 28, 1908. At the extreme head of Lake Aleknagik. This is one of its largest tributaries, though much smaller than the main inlet. Opposite its mouth a gravel bar rises abruptly from deep water and should be cautiously approached in power boats. The creek empties in two channels over shallow flats and wide reaching bars of gravel, sandy mud, or quicksand. Above the delta the mouth was about 75 feet wide. Its water was very clean and clear, with a temperature of 41° F. at 9 a. m., warming rapidly to 51° F. at noon of a hot day. The shallows near the mouth contained small schools of 2 to 15 red salmon fry.

A mile and a half of the creek showed an ordinary meander with swift current and excellent spawning bottom, the gravel getting coarser upstream. There were many willows and alders about the mouth and bordering the banks farther up. Pools and holes four to six feet deep occur. Salmon by hundreds in spawning color were seen migrating upstream, while few were making beds. In a small slough over a mile above the mouth a male humpback salmon was seen at the head of a school of 50 Dolly Varden trout and 2 red salmon. The stream is doubtless many miles long. It carries considerable drift timber, of which a large accumulation was cast up on the lake beach south of the mouth.

Creek 24, Wallich Creek.—This is the first stream on the south shore, about 2 miles below the head of the lake. It was first examined on July 28 by Mr. Wallich with a view to its value as a location for a hatchery. It is nearly as large as No. 23 and offers perhaps more advantages for the establishment and maintenance of a hatchery than any of the other streams. The estuary is long and shallow, with gravel bars. Along the lake shore on both sides of the mouth deep water comes within a few feet of shore, and a steamer could dock at a short wharf. A few hundred yards to the west of the mouth at 30 feet from shore the water was 6 feet deep. It is moreover convenient to the head of the lake and to Creeks 22 and 23 for supplementary egg supplies. On the lake front west of the stream is a tundra-covered plateau, with thin spruce woods, rising quite abruptly from the flats of the creek and bordering these upstream.

In the first half mile the stream is from 15 to 60 feet wide and has excellent gravel beds. About 300 or 400 yards above the mouth there is an island between 500 and 600 feet long. From the upper end of this island to the mouth of the creek the levelings made indicated a fall of at least 16 feet. Several feet of this fall occur in the reach along the island. The plateau passes along the lesser channel opposite the island, standing 10 or 12 feet above the creek bed. This high ground slopes down somewhat at each end of the island to the creek flats, maintaining itself at the lower end as a low, abrupt ridge 4 or 5 feet above the flats. The upper end of the island is apparently the best place to dam the stream. From here a flume could be buried by grading along the face of the bluff on the west shore and led to the lake front not far from the creek mouth. Here a hatchery could be placed above the highest lake level and low enough to receive water taken from the creek at the upper end of the island.

On August 8, 1908, and August 2 and 8, 1909, the salmon in the stream below the first bend above the island were counted and estimated. The result indicated at least 500 to 600 on each date, besides a few dead. Thermometer readings showed water temperatures between 45° and 52° F. Observations of the water level in the creek at the upper end of the island showed in 1909 a fall of 4¼ inches between July 23 and August 2. On August 8, 1½ inches had been recovered from the heavy rains of the day. July 1, 1909, it had fallen at least 2 feet from the high of the season.

Immediately east of Creek 24 are two indentations. The one visited proved to be a lagoon, its water scarcely flowing out of it into the lake. Salmon bones of the preceding season were seen on the gravel beach outside of it. The other indentation is probably of a similar nature, perhaps with an unimportant creek.

Creek 25.—August 8, 1909. Farther eastward of Creek 24 a long, shallow bight receives Creeks 25 and 26. Its western portion has shallow flats. Creek 25 has a very narrow mouth overgrown by bushes and is of the swift-current type, carrying no salmon. None was seen in the creek, either living or dead, nor any close to the mouth. Nevertheless, on the flats there were many. At the eastern end of the bight a rounded gravel point makes almost perpendicularly down into the lake. Here a large vessel could almost dock against the shore. Many salmon were schooling along this shore.

Creek 26.—August 8, 1909. No salmon were seen in this small creek. It has a little lagoon mouth a short distance east of Creek 25. Between Creeks 25 and 26 the beach is terraced with small gravel as left by the fall of the lake level. Many old salmon bones were confined mainly to the gravel, which was not continuous between the two creeks.

For some miles eastward of Creek 26 along the south shore of the lake there are no streams. At this date the fall of the lake level had exposed a border of fine gravel just above the water's edge along this region.

Somewhere between Creeks 26 and 27 there is a bay, which was entered July 28, 1908, but no creek could be found. A considerable school of red salmon in spawning color was working on a bottom of large stones and some seemed to be spawning. Red-salmon fry were seen here. Eggs were not certainly identified. For a long distance salmon were seen broaching off shore, and it seems probable there is some shore spawning here.

Creek 27.—August 8, 1908. This stream is opposite the main inlet across the lake and is an interesting example of the streams carrying few or no salmon. It has a steep grade, good bottom, strong current, and water enough to maintain a hatchery. The temperature was 42° F. There were many salmon off its mouth, but only two alive and one dead were seen in the stream. One only of the two was in spawning color. The very narrow mouth had a number of dead salmon around it. Much underbrush and deadfalls made it difficult to ascend the creek bed.

Why do the salmon refuse this stream? Many smaller ones with no better gravel beds had many spawning fish at this date and earlier. The answer may be that it is too swift and torrential for proper spawning, though salmon are able to stem its current, and its mouth, though narrow, is sufficiently accessible. One may compare certain creeks flowing into Chilkoot Lake in southeast Alaska, which appear admirable in all conditions except an abundance of quiet places but which take no salmon whatever; but compare also Creek 16, which also has a steep grade, but has many salmon. It, however, contains more resting places and quiet spawning pools. The temperature of the lake water at the surface 100 yards off-shore, beyond Creek 27, at 8 p. m., was 54°F.

Creek 28.—August 8, 1908. It is about 1 mile east of Creek 27 and of about the same size and type. Temperature at mouth 43½° F. The mouth was narrow, discharging over the beach gravel without a channel. A former channel at the mouth was nearly obliterated, and the creek made a right angle turn just before debouching. The wash of a storm, or perhaps ice, may have blocked the former mouth, which had become a seepage through gravel and larger stones. The current was swift, and the bed rose rapidly. No fish were seen in the hundred feet examined. Entrance without the channel would be difficult.

Creek 29.—August 8, 1908. Farther east of Creek 28 there is a lagoon inside the shore line. At this date after a seasonal fall of at least 40 inches it was barely above the lake level and delivering only a trickle of water. The land about was very low. It has been claimed there is a connection between Lake Aleknagik and Snake River Basin, and these conditions gave some hint of this. At this time on account of darkness no stream was identified, but the trickle of one could be heard flowing into the lagoon. However, on July 1, 1909, the place was again visited. The lagoon mouth was then 3 feet deep and three small creeks were delivering into it, while the lake level was only 6 inches below the high water for the season. It is therefore highly improbable that there is any seasonal overflow from this point to another basin. Two of the three creeks are very small. All have brown water. Redfish fry were playing in all of them.

Creek 30.—August 9, 1909. It is of the same type and about the same size as Creek 24, running through very low land. Its estuary has low islands, gravel bars, and little sloughs. The rise of the lake would put the mouth back hundreds of yards. The creek is 40 to 50 feet wide, narrowing at the mouth. Temperature 44° F. There are many big rocks and bowlders upstream. Several hundred salmon were seen in a half-mile reach.

Creek 31.—August 9, 1908. East of Creek 30 there are no creeks for a few miles. Just before reaching the high and prominent peninsula a good-sized bight occurs, making a small peninsula on its western end. A small brown creek empties into the eastern portion of this bight, cutting a rather wide mouth through the beach gravel. Temperature at mouth 44° F. It carried many salmon for so small a stream. Many eggs and spawning fish were seen. It differs markedly in type from those carrying no salmon. It is heavily overgrown with bushes, runs through tundra-like country between mountains, and the grade rises rapidly but leaves plenty of pools and easy currents for fish. It is an excellent supplementary stream as a source of eggs.

Creek 32.—July 28, 1908. At the head of a large bay about 1 mile long behind the high peninsula. The entrance is foul with rock shoals on each side, and caution must be used in approaching. The stream is a large one, exceeded in size by not more than four or five of the lake tributaries, and drains low swampy ground with many stagnant sloughs. There is no favorable place for a dam. It very soon bifurcates, and one branch bifurcates again. It is probably made up of several or many branches. The main stream is about 20 feet wide. The ground about the mouth was at this date swampy and cut up by dry sloughs. The water was very clear and cold, with the finest kind of gravelly spawning grounds, pools, and riffles. Many highly colored redfish in spawning condition and many nests and eggs were seen. Some thousands of salmon must already have entered at this date.

Creek 33.—July 30, 1909. An insignificant stream, heavily overgrown with bushes, about a half mile east of the island at the mouth of the bay at whose head is Creek 32. There was a school of salmon and some redfish fry near the almost stagnant mouth of brown water, but there were no salmon in the few yards of the stream inspected. A few trout were seen.

Creek 34.—June 30, 1909. This important creek is about a mile west of Creek 35 and similar in size to the latter. There were some native drying racks near by. Though the stream did not appear promising at the mouth, which is less extensive than that of Creek 35 and debouches more abruptly, it contained an abundance of salmon. Besides hundreds in the mouth, 500 were tallied in less than a half mile, all in fine color and none dead. Nine days later the same reach contained not fewer than 765 living and 34 dead. Nearly all were highly colored and many making nests. This is evidently one of the best streams of the lake. The grade rises rapidly, the bed is ideal spawning ground of heavy gravel, and the water is very clear and cold. It probably does not come from a lake as does Creek 35.

A female redfish with a remarkable gill-net twine wound was seen here. The fish, which was not in full color, had an immense deep sore along the usual site of twine scars. The sore was deepest in the muscles of the back, making a gaping red wound so deeply eroded that, with the more superficial erosion extending around the belly, the two halves of the body vibrated on this wound as a hinge. The fish seemed about to break in two parts whenever it swam rapidly. It had a much fungused head and was rather feeble.

Having in mind the possibility that the salmon may acquire a terminal infection during the latter stages of life or when spent, two highly colored examples were taken from this creek and bacteriological cultures made from them. One was a dead and spent male 26 inches long, the other a dying spent female 23 inches long. Blood from the heart of each was planted in agar plates. The result was negative.

Creek 35.—July 30, 1909. In the bight south of the point which is opposite the island nearest the location of the tally rack. It is a creek of some importance, with a conspicuous estuary. The water was warmer than most of the other creeks, indicating its source in a lake that is about a half mile long and less than an hour's travel above the mouth. The grade rises rapidly, making cascades in its upper reaches. About 50 adult salmon were seen, all living. There were many fry where the stream leaves the lake, and four adults were seen entering the latter. Algæ covered the foot of the lake and the origin of the stream. Just inside the lake, to the right, a small stream enters, coming from a spring pool 100 yards away. This cold pool contained many fry but no adults. In some seasons Creek 35 probably receives many salmon.

Creek 36.—July 27, 1909. This is a little stream 2 feet wide at its mouth emptying into the south side of the lagoon at the foot of the lake. It was not seen in 1908 and carried no salmon in 1909. It bifurcates soon and branches again, having various sources in boggy seepage in and about the sparse woods near the lagoon. It evidently does not drain any of the small lagoon-like waters lying south of the foot of the lake which were seen on July 21 from the top of the mountain near the village. One of the branches of this creek rises in an irregular seepage pool in which a number of young trout 7 or 8 inches long were seen. These were probably Dolly Vardens. A number of adults of this species were seen in the creek itself. Not a single salmon was seen in the creek, though the bottom is favorable and many pass near its mouth.

THE LARGE ESCAPEMENT OF 1908.

Certain comparable observations in 1908 and 1909 tend to throw light on the size of the escapement of 1908 as related to the preceding and succeeding years.

In 1909 the abundance of redfish fry about the shores of the lagoon and in the small shore pockets of the upper river was frequently noted and appeared to be greatly in excess of that seen in 1908. The escapement for 1907 is of course unknown, but this confirms the presumption arising on other grounds that it was a small one. In Creek 6, the whole of which was explored in both seasons, there had entered in 1908 on and before August 7 eight times as many salmon as had entered in 1909 on and before August 8. This is consonant with the records for the escapement of 1908 and 1909, which were roundly 2,600,000 and 890,000, respectively. There is thus, outside the actual figures from the tally rack, some confirmation of 1908 as a year with a very much higher escapement than that which preceded and followed it.

Unlike lakes in Alaska on which hatcheries have been established, in Lake Aleknagik the salmon do not all resort for spawning to one or two, or at most very few creeks, but spread through a wide territory represented by many creeks. Moreover, a large number of the salmon entering the lake proceed through it to the upper lakes, of which there are said to be three. What the proportion is between the numbers spawning about Lake Aleknagik and in the basins of the upper lakes is unknown but it is certain that many salmon ascend the main inlet of Aleknagik apparently bound for the upper series of lakes. There is little evidence that any great amount of spawning takes place in the inlet.

From the numbers of salmon seen in the different creeks of Aleknagik during the seasons of 1908 and 1909 up to August 9 it does not appear certain that any one creek contained enough salmon to supply a large hatchery with eggs. However, as many fish may have already passed to the upper portions of the streams, and as more were to enter before the end of the season, it is not improbable that a barricade would show from any one of several streams a quota large enough to fill a hatchery. If the supply were short, it would not be difficult to take eggs from streams at a distance from the hatchery.

Since red salmon have been successfully impounded at the Baker Lake station in Washington, the question arises whether this method can be applied to Lake Aleknagik. The temperature of the water is favorable to holding the salmon in this way. It is not likely that this method will be found expedient in this region. If gravity water supply is to be depended upon, this will control the location of the hatchery and probably place it so far up the lake that the eggs may be taken from the streams. Reports should be obtained on the condition of streams in the winter with respect to freezing and volume of flow.

KUSKOKWIM RIVER.

As conditions seemed to warrant a special investigation of the fishing and salmon-run conditions on the Kuskokwim River, Bering Sea district, Alaska, Assistant Agent L. G. Wingard was sent to the region in 1922, leaving Seattle for those waters May 30 on the steamer

Admiral Goodrich and arriving at Bethel June 13. Mr. Wingard made a careful study of conditions, his findings indicating the extent of the run of salmon and the need of conservation to prevent depletion by the influx of fishing concerns from other districts where the industry has declined. His report is as follows:

On arriving at Bethel a good, sturdy gas boat was engaged, as work in the country was to consist wholly of operations along the Kuskokwim River. The first work was the placing of markers at the mouth of the river, which is discussed in detail on page 53. Following that, all fishermen and packers on what is termed the lower river were visited and given notification of the location of the markers and the nature of the regulation governing fishing. After this the writer patrolled the river for 32 days. As every evidence during this time showed that both packers and fishermen intended in entire good faith to obey the regulation, and the run being over except for the silvers, a general trip of observation was made up the river. This trip lasted 18 days and extended as far as the Eskimo village of Tuliviksak, approximately 400 miles up the Kuskokwim River. Here high water, great quantities of drift, consisting of stumps, uprooted trees, etc., together with an unpopulated country ahead, and consequently nothing to be gained by a farther advance except the town of McGrath, which was over 100 miles farther, caused the agent to turn back to the lower river. On this trip stops were made not only at every village but at every habitation, interviewing residents, taking notes, and getting as nearly as possible all the information obtainable relative to salmon runs and fishing conditions.

As there are no canneries located on the Kuskokwim, the packing operations on the river resolve themselves into the activities of salteries and drying stations. Four salteries—Knaflich station, Jessland station, Walsh-Joaquim station, and Lundstrum-Garthy station—operated there this season. The Knaflich station, located at Apokak, 5 miles from Beacon Point, is owned and operated by Louis Knaflich and employed but three fishermen. The season's pack amounted to thirty-one 800-pound tierces of king salmon and forty-seven 200-pound barrels of red salmon. The silver pack at the time of departure was not complete. The Jessland station, located at Quigiung, 20 miles above Beaçon Point, had packed 11 tierces of kings and 35 barrels of reds and had dried 3,000 chum salmon. The Walsh-Joaquim station, located 45 miles up river from Beacon Point, packed 88 tierces of kings and 24 barrels of reds and dried 5,000 chums. The Lundstrom-Garthy station, on the Kuskokwak creek, 5 miles below Beacon Point, packed 8 tierces of kings and 30 barrels of reds and dried 2,000 chums. The output of these four concerns comprises the entire commercial pack of the river that goes outside and is the total pack put up on the river by white men between Bethel and the sea. The total number of fish caught was only 35,000. In explanation of this small number it should be stated that none of the packers are large operators. Two or three natives were the most employed at any one time by them during the summer.

There are a number of small operators drying fish whose output is consumed locally or sold to persons traveling in the region. On the river above Bethel, at Steamboat Slough, Neal Corrigan dried 1,500 fish for his own dogs. Farther up the river at Ohogamute a white trader named Morgan caught 1,500 small fish and 100 kings, drying them for his own use and for barter with the natives. Five miles above Ohogamute Charley Swanson dried 1,500 small fish and 50 kings. A man named Walters, a mile below the native village of Aniak, dried 1,800 small fish and 50 kings. At Aniak a man named Johnson dried 1,650 small fish and 47 kings. At Napamute George Hoffman dried 2,000 small fish and 30 kings for his dogs and for barter. Sam Voich, 32 miles above Napamute, dried 3,500 small fish and 50 kings. At Crooked Creek a man named Dennis Perrin dried 6,000 small fish and 200 kings. At Georgetown, something like 300 miles up the Kuskokwim, George Fredericks dried 5,500 small fish and 50 kings. A short distance above Georgetown at what its known as Lousetown J. Young dried 2,500 small fish and 200 kings. Eight miles above Georgetown George Woods dried 2,200 small fish and 400 kings. Thirteen miles below Sleitmute, a native village 350 miles from the sea, two partners, Nick Millet and J. Johnson, dried 3,000 small fish and 150 kings. At Sleitmute a white trader, George Bishop, employed a native fisherman, and after drying 250 small fish, desisted on account of high water. Fifty miles above Sleitmute, at the native village Tuliviksak, a trader, Ora Barnhardt, also had a native fishing for him but was in turn discouraged by the high water after he had dried more than 100 small fish.

The term "small fish" is used on the Kuskokwim to indicate red salmon and chum salmon, no distinction being made between these two varieties by driers. At the salteries, however, they split the reds for salting and dry the chums for winter use locally.

From observations and from reports of the white traders and trappers it seems that the natives of the Kuskokwim do not depend upon dried salmon for their winter food supply in by any means as large a ratio as do the natives of the Copper River region, or of the Kvichak district, one reason being that about only one-half of the native families have dog teams, and those consist of but two to five dogs.

On the lower river—that is to say, between Bethel and the sea—the native makes his living by trapping and fishing, deriving the larger part of his livelihood by shooting muskrats and trapping foxes. The natives are seminomadic, each family apparently having three or four homes. One of these is a summer salmon camp, where a tent is pitched or where there is an old barabara built in previous years. There the family lives through the fishing season on salmon and dries a few for winter use. After the salmon run the family will move to some permanent camping grounds, usually a village, which is its winter headquarters. There the native trades, bartering a portion of his dried fish for food or other articles he needs, and fishes for the ever abundant whitefish and smelt in the sloughs and for blackfish, called by the natives Chinagik, in the lakes. All of these fish are easily taken and furnish a constant source of fresh food supply during the winter in noteworthy contrast with the very large amount of dried fish eaten by natives farther south in the Bering Sea region. For these reasons and the further fact that he is an active hair-seal hunter in the early spring, the Kuskokwim native is not dependent upon dried salmon to the extent that natives in other sections are.

There were roughly 150,000 small fish dried in the 15 native villages between Bethel and the sea. This allowed 1,000 fish for each family, which is the number the consensus of opinion on the river credited the average native family with putting up and the average of the agent's counts tallied with this number. One-half of these and sometimes more are sold or bartered, leaving the rest for home consumption.

In 50 native villages and camps above Bethel 150 families were found, each one of which averaged the usual 1,000 dried fish, or 150,000 in all. These upriver natives impressed one as being more energetic and thrifty than the lower Kuskokwim or tundra natives. With the conditions for fishing not as good as on the lower river, they nevertheless made fair catches under adverse circumstances. Driftwood, consisting of huge logs and roots of trees, together with swift and high water throughout the entire fishing season, resulted in the ruin of nearly all their fish wheels.

As one of the matters to be investigated was the amount of salmon available for the use of the natives, it can be reported, after traveling 300 miles upstream from Bethel and visiting more than 50 villages, that the natives have sufficient dried salmon for both themselves and their dog teams.

Whitefish, before referred to, are caught throughout the winter by natives, giving them fresh fish, which are relished more than dried fish. The natives also subsist largely on game in the winter, such as ptarmigan, Arctic hares, and snowshoe rabbits. These, with an occasional moose and caribou, together with smelt taken during the run of this small fish in the winter, and with provisions secured from the white traders, such as flour, rice, tea, and sugar, make ample provision for these people. Berries are an important article of diet among families with a semblance of thrift.

The Kuskokwim native is quiet and peaceable, possibly a little less advanced in civilization than are the natives of the Kvichak River region. In all about 65 villages and camps were visited, and some of these contained as many as 30 families.

There are tabulated below a few of the villages visited, with the number of families in each and the amount of fish dried. The number of fish in the shed were determined by entering the smokehouse or drying rack where the fish were curing. Because the natives were late in beginning fishing, as mentioned before, they caught very few king salmon, many of the families drying none at all. Many camps that had no name were visited. These have been designated as camps and placed in the order in which they came, traveling from Bethel up river.

Native villages on the Kuskokwim River and approximate number of salmon dried in each.

BELOW BETHEL.

Name of village.	Number of families.	Number of fish.	Name of village.	Number of families.	Number of fish.
Apokak	17	8,700	Napagahogamute	14	15,000
Davis Pt	3	1,500	Napaiskak	9	5,500
Quickchogamute	12	7,500	Kalagamute (Lower)	7	7,500
Kiktok	5	2,200	Kalagamute (Upper)	5	5,500
Quigiung	2	1,750	Kokokamute	22	20,000
Quigiugh	7	7,000	Popokamute	31	30,000
Ichikslikomute	19	20,000	Four camps	11	12,000
Lomavik	11	9,000			
Moravian Mission	1	2,200	Total	176	155,350

BETHEL AND ABOVE.

Name of village.	Number of families.	Number of fish.	Apparatus.		Name of village.	Number of families.	Number of fish.	Apparatus.	
			Set nets.	Fish wheels.				Set nets.	Fish wheels.
Bethel	7	5,500	1	....	Napamute	1	400	......	1
Five camps	14	15,000	1	....	Martin Village	6	7,000	1	3
Akiachuk	23	18,000	1	....	*Three camps*	3	3,500	......	3
One camp	3	3,200	1	....	Canoe Village	3	10,000	......	2
Tulaksak (Main)	6	4,500	1	....	Two camps	3	4,100	......	3
Tulaksak (Lower)	2	1,500	1	....	Georgetown	1	700	......	1
Tulaksak (Upper)	3	2,000	1	....	Lousetown	1	1,200	......	1
Koskogamute	14	16,000	......	1	Two camps	4	3,300	......	4
Ohogamute	7	9,000	1	3	Sleitmute	5	1,200	......	5
Two camps	5	11,000	1	4	Tuliksak	2	400	......	2
Crow Village	2	5,500	......	2					
Aniak	1	1,100	......	1	Total	117	125,800	10	37
Russian Mission	1	1,700	......	1					

MARKERS.

The location of the markers at the mouth of the Kuskokwim River did not prove satisfactory to the fishermen and packers on the lower river, as markers had never before been placed on the Kuskokwim, the regulations being promulgated only at the close of last season.

Upon arriving on the Kuskokwim the markers were placed immediately at points directed by the bureau, the one at Popokamute Point being fixed June 15 and the one at Beacon Point June 16. Following this all the operators were visited and informed of the ruling of the bureau and also of the further fact that the markers were already in position. In conversation with them it became apparent that they all were of the opinion that the markers were too far down the river. They felt it was imposing a needless hardship upon fishermen to ask them to go outside the line drawn across the river by the markers, it being practically a big bay, wide open to the sea, with rough weather nearly all the time and generally a sea running. The present fishing operations, they felt, were of such small volume, and the methods and gear employed in the catch would be considered so ineffective where large operations are under way in other portions of Alaska that it was needless to go so far down the stream.

The writer agreed with them in the matter of the small demand made upon the river at this stage of the fishing and packing operations, but informed them at the same time that the prohibitive locations were made as a matter of stream protection in case other and larger operators came in; that the bureau had in view such efficient protection of the Kuskokwim as would keep the river runs of salmon up to their present level throughout perpetuity. The conversations ended by all admitting that as the regulation was made and in force they would have to abide by it for the present, but nearly all of them expressed the hope that the matter would be reconsidered and the markers placed farther upstream so that they would have at least some sheltered water to fish in.

Going farther into the discussion of the locations of these markers, which may in the wisdom of the bureau require further consideration, it may be said that the Kuskokwim is about 14 miles wide at the point where the prohibitive line from marker to marker crosses the river. The river at this point is rapidly widening into the ocean, and as the stream opens to the south, from which prevailing storms blow, it reduces the matter of fishing to open-sea operations, with a high sea, due to storms, generally running. The Kuskokwim fishermen and operators nearly all asked that fishing should be permitted upriver as far as Helmick Point, which is 8 miles above the upper end of Eek Island. At the very least they requested that the markers be placed not higher than Quigiung and West Point, which would bring the prohibitive line across the river just at the upper end or head of Eek Island. Notwithstanding the discussions that arose over the locations and the objections to the sites of the markers, as far as observed or ascertained, there was no infraction of the regulations.

RUNS OF SALMON.

Four salmon runs seasonally enter the Kuskokwim River, consisting of the king, red, silver, and chum salmon runs. There is no humpback-salmon run. It is commonly reported that the run of silvers is the largest and the chum salmon next, with the red salmon a close third. The run of kings is the smallest in point of numbers, yet, owing to the size of the fish this run, weight for weight, will likely equal the red-salmon run.

The first run of the season is that of the kings, which commences about June 10 and lasts hardly a month. While the kings are still in the river, along about June 25, red salmon are found in scattering numbers and by July 1 the run is good. Two or three days after the first red salmon appear in the river chum salmon commence showing up, these two species running almost simultaneously. Both runs last about three weeks, with the peaks of the runs passing between July 1 and 10, storms out on the ocean often either retarding or accelerating the action of the runs. By the 1st of August silvers are running and continue almost until the time of the freeze-up.

Owing to the severe storms this season all the salmon runs were about 10 days ahead of time. This advance in time was not known along the river, and by catching the fishermen unawares a third of the run got up river before gear was in the water. The natives were particularly tardy in opening fishing. It was the first open season on beaver and marten trapping in several years, and they were still occupied with dressing and bartering their furs.

By comparing and sifting information obtained from interviews with hundreds of native fishermen and with every one of the white fishermen and checking them with the writer's own observations a fair estimate of the volume of the different salmon runs in the Kuskokwim River was arrived at. The red-salmon run is about one-half of the red-salmon run in the Egegik River. The run of chums is fully as large as the run of chums in the Egegik. As for the silver run it is doubtless as large as the run of silvers in any of the other rivers flowing into Bering Sea. The general comment everywhere along the Kuskokwim was that the silver run was always heavy, and many stories and statements were constantly forthcoming as to the strength of the run of this fish. The king salmon run also would stand on about the same level as the run of kings in the Egegik.

As for good and poor years, considered from the standpoint of the salmon run, not a great deal of information could be obtained. The general opinion among the fishermen, both white and native, seemed to be that there were two good years with large runs and two poor years with lean runs.

Fishing on the Kuskokwim is carried on by fish wheels and set nets. The fish wheel is not used at all on either the Nushagak or the Kvichak, which are sister rivers in the Bering Sea country. Set-net operators, taking advantage of the tides, can utilize nets of from 25 to 30 fathoms in length on all the lower river where the tidal ebb and flow offers the advantage of rising and falling waters. Above the tides eddies in the stream are utilized and fair fishing locations found. Wheels are placed on exposed points where the salmon crowd the meandering line of the stream in rounding the curve.

NATURAL ENEMIES.

As for natural enemies there are not as many gulls and terns in Kuskokwim waters as on other salmon streams of Alaska. There are more seals and belugas there ordinarily, if reports given by many different fishermen are correct, but as yet this season both of these pests were very scarce on the river. In this connection Al Walsh, of the Walsh-Joaquim saltery, has for several years been keeping a systematic tab on the salmon taken that have seal marks on them. Last season he found that "seal marked" king salmon averaged 1 in every 30 fish taken. This season there was but 1 so marked in every 72 caught. Natives also caught very few seals the past spring. In consequence of this there will be a shortage the coming winter of the seal muckluck which is so dear to the comfort of the average native.

GENERAL DESCRIPTION OF THE KUSKOKWIM.

In topography and physical conditions the Kuskokwim district is very similar to the Kvichak River. The volume of water flowing out of the river is much larger, however. In addition to being one of the largest rivers of Alaska, the Kuskokwim is also distinguished by the fact that it is the only Alaskan stream of any consequence that has not had salmon canneries operating upon it. Flowing out of the mountains of the interior the upper river is a swiftly running stream with many large tributaries feeding it. One hundred and twenty-five miles from its mouth the river leaves a rolling country covered with clumps of spruce, willow, and birch, and from that point onward traverses a tundra plain to the sea. Shallow waters, bars, sloughs, and a tendency of the stream to shift channels are the features of this portion of the river. The freeze-up in the fall and the break-up in the spring occur at approximately the same time as in the Naknek and the Kvichak Rivers in Bristol Bay. When the spring break-up takes place the river rises with the melting snow and ice, then as the season advances gradually falls, and by midsummer is very low. This season the water was from 5 to 7 feet above the normal summer level and higher than the average rise during break-up. The river, as is usual with tundra streams, has a wide bed and plenty of room for surplus water, but, owing to continued rains in July, the water, which had started to fall, suddenly commenced rising again. The old timers said over and over that it had been many and many a year since there was such high water during the summer as during this second rise.

The damage done was large, considering the small number of people living in the immediate valley of the stream. On the trip up the river at least four out of every five fish wheels encountered were damaged in varying extent, only those on sheltered sloughs escaping damage. Some of them were entirely swept away, others being jammed, splintered, and portions of them carried downstream. The greatest loss was caused by logs and stumps drifting against the wheels.

The Kuskokwim River country naturally divides itself into upper and lower river regions. The line of division crosses the valley of the river at Bethel, where, as stated, the country breaks from a region of rolling landscape into a low-lying tundra country, which reaches away to Bering Sea. Much of this lower river country has water upon it when there are extreme high tides and storms driving inland. Small lakes everywhere dot these thousands of square miles of monotonous tundra, which is treeless. Just above Bethel scattering, stunted spruce, birch, and willow begin showing, and about 30 or 40 miles farther up the river timber is scattered profusely over a rolling country.

The tidal flow on the Kuskokwim is noticeable 75 miles from the mouth, but the current of the river shows the retarding effects of the tide as far up as Akiak, over 100 miles from the sea. The height of the tides is not so great on the Kuskokwim as on the Kvichak and the Nushagak.

In an endeavor to give the bureau an accurate "close-up" of the general conditions of life in the Kuskokwim district it may be stated that in the whole district, from the Tuliviksak tributary to the sea, approximately 400 miles, there are 300 native families and about 75 white people. They all live along the river, either on the banks of the river proper or on sloughs paralleling the river and forming part of it. The natives of the lower river live in an igloo form of structure, as do many of the natives in the Kvichak region, more energetic families sometimes having log cabins. The home life, as is usual in the isolation of the Northland, is somewhat barren. Hunting, fishing, trapping, prospecting, and trading form the occupations of the whites. The natives live by trapping, fishing, and hunting. Although the region is sparsely settled, yet mile for mile there are more families on its banks than on the Kvichak River.

Communication is carried on up and down the river by three small river steamers, which operate from Bethel. These steamers are the *Tana*, owned and operated by Captain Langley; the *Quickstep*, operated by Captain Green; and the *Tacotna*, operated by Captain Buggy. They carry freight, mail, and passengers and serve the little trading posts and native villages, and through their offices the necessities, many of the comforts, and a few of the luxuries of life reach the modest huts of the natives and whites scattered up and down the river.

The trading center of the Kuskokwim region is the little town of Bethel. It is situated on the northwest bank of the river, 80 miles from its mouth, at the head of sea navigation. It is also the judicial center of the region, United States Marshal J. L. Heron and also United States Commissioner Bohnam being located there, and has the Government school for the natives. The Moravian Mission has a church, sawmill, and large launch there and makes Bethel the general headquarters for their mission operations in the Kuskokwim region. There are two stores and several independent traders. A native village of 15 or 20 families forms part of the community. There are several white families and five or six white men with native wives.

Situated 40 miles upriver from Bethel is Akiak, a native village, where a hospital, school, and the office of the superintendent of schools are located. Going on up the river white men are found about every 50 miles operating trading posts or roadhouses. Most of them have native wives.

On the lower river—that is, below Bethel—there are a few scattering whites, who trade with the natives, bartering provisions and various articles for fur. In the summer they fish; in the winter they do a little trapping. Their life is an easy, indolent, and, it might be said, shiftless existence. Of course, there is thrift showing here and there.

The spirit with which the people along the river accepted the entrance of the bureau into the fishing operations of the district was gratifying. Both fishermen and packers seemed much pleased to have their corner of the world officially recognized by a department of the Government, and during the writer's entire stay he was cordially received and on no occasion was aware of any resentment because of the efforts of the bureau to regulate fishing. While some were visibly disappointed, as noted elsewhere in this report, with the point of location of the prohibitive markers, the spirit seemed to be to accept the regulation and abide by it. The inference given everywhere in conversations with these men was that they were interested in the conservation of the fish runs and stood ready to cooperate, a feeling very different from the attitude taken elsewhere on occasions by many fishermen and even packers. The impression given on the writer's departure was that the entire fishing interests of the Kuskokwim would welcome a return of bureau representatives year by year. In the case of the Walsh-Joaquim and Jessland stations fishing was begun before the writer's arrival and consequently before any markers were set, so that they had been fishing above the limits as prescribed by the bureau. After placing the markers and giving notice of the same to the operators concerned, there was no evidence of any attempt to evade the law.

If the salmon runs of the Kuskokwim are carefully conserved, the time may come when, due to depletion of runs in other streams of Alaska, the modest-sized runs of this river will measure up to the size of the receding runs of other salmon rivers of Alaska, and the Kuskokwim will then take an important place in the fisheries of the North. Certainly the runs should be carefully protected to start with.

CHIGNIK SALMON COUNTS.

Arrangements were made in the spring of 1922 for the counting of salmon ascending Chignik River to spawn, and a crew consisting of John W. Gardner, Charles Petry, warden, and three others left Seattle April 5 to install a rack through which the fish should pass to enable counting. All necessary supplies and the small patrol boat *Merganser* were transported on the *St. Paul*, of the Northwestern Fisheries Co., from Seattle to Chignik, reaching there on April 25.

Construction of the rack was begun at once at a point several miles up the Chignik River, where it is 464 feet wide and from 2 to

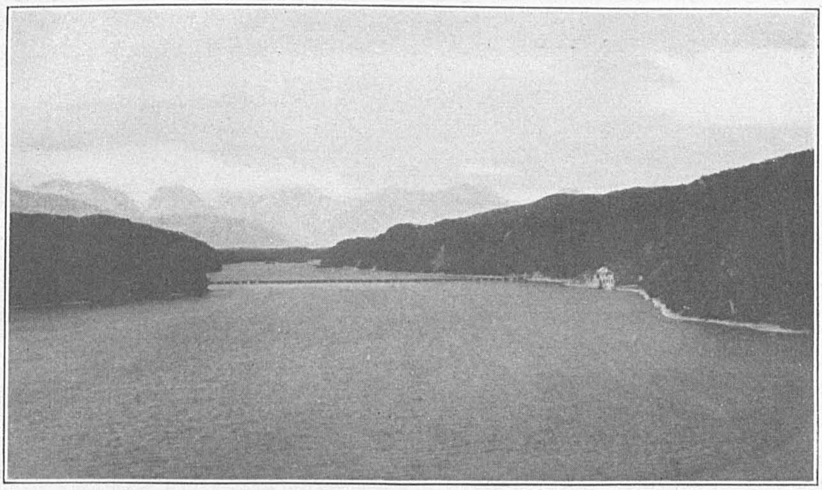

FIG. 7.—Salmon counting rack in Chignik River.

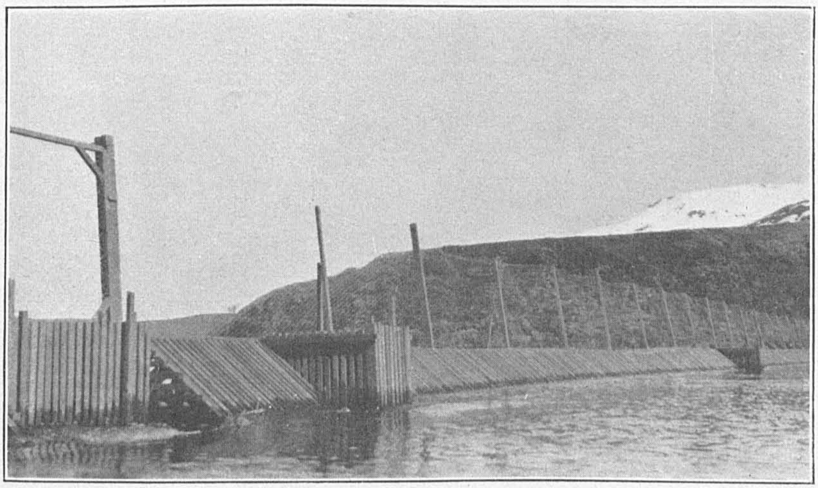

FIG. 8.—Upstream side of rack in Chignik River.

4 feet deep. The rack was of tripod and picket construction, standing 4 feet above low water, but because of high tides it was found necessary to raise its height 5 feet by means of wire netting. A plank walk extended along the top of the pickets, and four openings were built in the rack for passage of fish, the counter to stand directly over an opening. A gate 6 feet wide was constructed for the passage of small boats.

The rack was practically completed by June 2, and on June 9 the first salmon was seen below it. Counting was continued until fish ceased running October 20. A total of 428,976 red, 58,300 coho, and 241 king salmon were counted during this period. Humpback and chum salmon were not counted, but it was estimated that probably 15,000 humpback and 1,200 chum salmon ascended the river. These two species spawn chiefly in the creeks that empty into Chignik Bay and Lagoon. Reports of the three companies operating at Chignik show a catch of 1,403,701 red salmon, indicating that the escapement in the season of 1922 was only 23.4 per cent, or less than one-fourth of the total run. The counting experiment will be continued over a series of years with a view to determining a basis for commercial operations in this district.

KARLUK SALMON COUNTS.

Red salmon ascending the Karluk River for spawning purposes were counted in 1922 as they passed through a rack 360 feet long placed across the river about half a mile above the lagoon. Everything was in readiness at the rack by May 12, and the first salmon were counted on May 20. Considerable numbers of Dolly Varden trout were captured by means of trap and seine, and large numbers also were destroyed by dynamite before the appearance of salmon necessitated stopping its use. Counting was in charge of Fred R. Lucas, who was detailed from the bureau's hatchery at Afognak. It was reported that considerable difficulty was experienced with humpback salmon, which spawned in large numbers above and below the rack and in some instances undermined sections of it. Thousands of the dead fish were carried down in a slight rise of water, and it was necessary to open a section of the rack to let them pass through in order to prevent the water damming up and carrying out the rack.

The ascent of salmon continued until October 22, a total of 384,683 reds and 9,752 kings passing through the rack during the season. No count of other species was made. Upon the basis of reports of the various companies securing salmon from Karluk it is computed that approximately 700,000 red salmon were captured. The escapement for spawning purposes was thus slightly over 35 per cent of the total run.

YUKON RIVER FISHERY.

The general prohibition on commercial fishing for salmon on the Yukon River for export from Alaska was in force in the season of 1922. The floating cannery of the Carlisle Packing Co., which was operated at Kwiguk Slough in 1921, was towed out at the end of that season and found a new location on Bristol Bay, where it was operated in 1922.

The mild-curing plant of Waechter Bros., which was located on Leslies Island, outside of the protected zone, continued operations in

1922, all of its fishing being carried on in the shallow waters of Bering Sea, extending several miles off the delta. The season was successful, fishing operations beginning June 10 and ending July 11, when it was necessary to close the plant in order to make connections at St. Michaels with the steamship *Victoria*, which took the pack to Seattle. The total catch was 16,825 kings, from which 277 tierces were mild cured and 26 tons frozen. The 2,787 chum salmon taken were turned over to the natives camped around the saltery. Rates paid for king salmon ranged from 25 to 35 cents each to fishermen who were furnished gear by the company, and 40 to 60 cents to independent fishermen. Chum salmon were not purchased by the company.

The bureau's representative reported that the catch by natives along the river was probably the smallest in its history, which was probably due to the extreme high water, the river being bank full all summer, the longest stage of high water ever known. At a number of places good catches were made, which indicated that there was a normal run. It was reported also that the natives fished less diligently than usual, as in many places they were still supplied with money from the sale of their large catch of furs the previous winter. All occupied camps from the delta to Rampart Rapids were visited, the catch being estimated at approximately 15,000 kings and 215 tons of dried dog salmon. In addition, W. F. O'Connor, at Andreafsky, and Charles Homeier, at Mountain Village, put up small packs of canned salmon, 448 cases and 43 cases, respectively, for local use.

HATCHERIES.

EXTENT OF OPERATIONS.

Four hatcheries, exclusive of Territorial plants, were again operated in Alaska in 1922. Two belong to the United States and are located at Afognak Lake on Afognak Island and at McDonald Lake near Yes Bay in southeast Alaska. A third is maintained by the Alaska Packers Association at Loring, and the fourth by the Northwestern Fisheries Co. at Quadra. The total number of red-salmon eggs collected at these four hatcheries in 1922 was 110,745,000, which is a decrease of 17,455,000 from the collections of 1921. The largest decrease occurred at McDonald Lake, where the take of eggs in 1922 was 26,000,000 less than in 1921.

Operations of Federal and private hatcheries in Alaska in 1922.

Location of hatchery	Red or sockeye salmon.		
	Eggs taken in 1921.	Salmon liberated in 1921-22.	Eggs taken in 1922.
McDonald Lake	[1] 51,000,000	47,640,000	25,000,000
Afognak Lake	[2] 53,835,000	32,580,000	[3] 61,790,000
Fortmann	13,380,000	12,885,000	17,760,000
Quadra	9,985,000	9,647,000	6,195,000
Total	128,200,000	102,752,000	110,745,000

[1] 150,000 eyed eggs planted in two lakes adjacent to the hatchery.
[2] Shipped 5,200,000 red salmon eggs to State hatchery at Bonneville, Oreg.
[3] Shipped to Territorial Fish Commission 5,098,936 red-salmon eggs; to State hatchery at Bonneville, Oreg., 5,045,000 red-salmon eggs; to the Washington State Fish Commission 534,464 red-salmon eggs.

HATCHERY REBATES.

The Federal fishery law of Alaska, approved June 26, 1906, provides that the owners of privately operated hatcheries shall be exempt from the payment of all taxes and license fees on their catch and pack of salmon at the rate of 40 cents per 1,000 red or king-salmon fry liberated.

Rebates credited to private salmon hatcheries, fiscal year ended June 30, 1922.

Owner.	Location.	Red-salmon fry liberated.	Rebate due.
Alaska Packers Association	Naha Stream	12,885,000	$5,154.00
Northwestern Fisheries Co	Hugh Smith Lake	9,647,000	3,858.80
Total		22,532,000	9,012.80

HATCHERY OPERATIONS.

M'DONALD LAKE.

In 1921 the collection of red-salmon eggs aggregated 51,000,000, from which 47,640,000 fry and fingerlings were liberated. In addition 150,000 eyed eggs were planted in two lakes adjacent to the hatchery. The loss of eggs and fry together was 6.6 per cent. In 1922, 210,000 humpback-salmon fingerlings were liberated. In the season of 1922 egg taking began on September 7 and was completed on September 22, between which dates 25,000,000 red-salmon eggs and 499,200 humpback-salmon eggs were taken.

AFOGNAK.

From the collection of 53,835,000 red-salmon eggs taken at Afognak in 1921 there were shipped to the State hatchery at Bonneville, Oreg., 5,200,000 eggs. Out of the remaining 48,635,000 there were lost 2,614,000 eggs, and 46,021,000 fry were hatched. The loss of fry aggregated 13,441,000, the plantings of red-salmon fry being 32,580,000. An epidemic in May and June, 1921, occasioned a very heavy loss of fry. Its cause is thought to have been due in part at least to low vitality of the parent fish occasioned by exceedingly low water that occurred the latter part of the previous August and early September when the take of eggs was heavy. No doubt such reduced vitality might have been transmitted from the parent fish to the eggs and fry.

In the season of 1922, in the period from August 1 to September 14, the take of red-salmon eggs was 61,790,000. Of these 10,678,400 were shipped in September, 5,098,936 going to the Alaska Territorial Fish Commission at Juneau, 5,045,000 to the Oregon Fish Commission at Bonneville, and 534,464 to the State Fish Commission at Seattle, Wash. In addition, 600,000 humpback-salmon eggs were taken, of which 278,616 were shipped to the bureau's hatchery at Birdsview, Wash.

FORTMANN.

The Fortmann hatchery of the Alaska Packers Association on Heckman Lake, Revillagigedo Island, liberated 12,885,000 young red salmon in Naha stream and lakes out of 13,380,000 eggs collected in 1921. The loss of eggs was 3.7 per cent. In addition 830,000 humpback-salmon fry were hatched from 900,000 eggs collected in 1921 and liberated in the same water system. Egg taking in 1922 began August 28 and ended November 4 after 17,760,000 red and 240,000 humpback-salmon eggs were collected.

QUADRA.

The hatchery of the Northwestern Fisheries Co. on Hugh Smith Lake produced and released 9,647,000 red-salmon fry out of a total collection of 9,985,000 eggs in 1921. The loss was 3.4 per cent. Spawn taking began in 1922 on August 11 and ended November 21, after 6,195,000 red-salmon eggs had been taken.

TERRITORIAL HATCHERIES.

The Alaska Territorial Fish Commission carried on salmon culture at Eyak Lake near Cordova and at Auk Lake and Anan Creek in southeast Alaska. At Eyak Lake 3,134,000 red-salmon eggs were taken, from which 3,078,000 were eyed and planted in the gravel of streams tributary to that lake, there being a loss of 56,000 eggs during the period of incubation. Spawn taking began in this field on July 6 and was discontinued August 1. At Auk Lake 945,000 red-salmon eggs were collected and transferred to the hatchery at Juneau, from which 779,000 fry were produced and distributed in streams of the Juneau district. In addition a shipment of 5,098,936 red-salmon eggs was received from the Federal Bureau of Fisheries station at Afognak, from which 4,933,000 fry were hatched. Of this number 2,600,000 were planted in Auk Lake and 400,000 on Mendenhall Bar.

The commission operated a humpback-salmon collecting station on Anan Creek during July and August and secured a total of 250,000 eggs. These were transferred to Juneau in a green state with a loss of approximately 50 per cent. The 121,000 fry that resulted were distributed in the Juneau district.

At the beginning of the year 100,000 coho fingerlings were being held in the Juneau hatchery. These were planted during the summer in streams and lakes tributary to Gastineau Channel and Lynn Canal.

In addition to its fish-cultural operations the commission continued the work of removing obstructions from salmon streams, thus opening larger areas to the spawning fish. Several streams in the Seward and Ketchikan districts were cleared during the year, $3,659.04 being expended in this work.

EGG COLLECTIONS BY WASHINGTON STATE FISHERY AUTHORITIES.

Early in the season the Washington State Fish Commission applied for permission to make collections of humpback-salmon eggs in southeast and central Alaska, stating that approximately half of them would be planted in the waters of the State of Washington and the remainder returned to the streams from which they were secured. The bureau took the position that it could not recommend the granting of the desired permission even could it be lawfully done, for the reason that the fisheries of the Territory were in a precarious state and the export of eggs would add to the already existing danger of serious depletion of the streams.

The bureau's representative in charge of the southeast district reported by telegraph August 14 that a barricade had been placed in Anan Creek that was causing the death of thousands of salmon and also that preparations were being made to collect 20,000,000 humpback-salmon eggs for shipment to Puget Sound, with apparently no preparation to stock Alaskan streams with salmon equaling the number of eyed eggs to be exported. Instructions were at once issued to remove the barricade in Anan Creek, which was accordingly done on August 25 without any eggs having been taken.

On August 15 the bureau's agent at Cordova reported that over 10,000,000 humpback-salmon eggs had been collected by representatives of the Washington State Fish Commission at Irish Cove, on Fidalgo Bay, Prince William Sound, which probably would be a total loss. This was due to the use of water from the vicinity of an abandoned copper mine. Instructions were at once issued that the eggs on hand be planted and all operations cease. In the meantime the operations of the commission had been moved to the head of Whalen Bay, where the water proved to be more suitable for development of the eggs and further large collections had been made.

An agreement was reached with the Washington State Fish Commission on August 24 (1) that the operations at Anan Creek should cease entirely, (2) that the healthy eggs already secured on Prince William Sound should be eyed for shipment but no further collections made, and (3) that the expedition would withdraw entirely from Alaska. Final reports from the bureau's representative at Cordova, who inspected the shipments, indicated that the total sent out in October was 14,571,708 eyed humpback-salmon eggs.

GENERAL STATISTICS OF THE FISHERIES.

In 1922 the total investment in the fisheries of Alaska was $54,590,-302, or $15,589,206 more than in 1921. The investment in the herring industry more than doubled that of 1921, and the salmon industry investment increased more than 25 per cent. Of the total investment, $47,509,138, or approximately 87 per cent, was in the salmon industry alone. Employment was given to 21,974 persons, or 6,904 more than in 1921. The total value of the products in 1922 was $36,170,948, or $12,084,081 more than in 1921.

Summary of investments in the Alaska fisheries in 1922.

Industries.	Southeast Alaska.	Central Alaska.	Western Alaska.	Total.
Salmon canning	$17,032,035	$10,373,814	$17,801,708	$45,207,557
Salmon mild curing	1,572,025			1,572,025
Salmon pickling		123,779	387,219	510,998
Salmon, fresh	35,541			35,541
Salmon by-products	183,017			183,017
Halibut fishery	1,839,910			1,839,910
Herring fishery	872,550	2,471,088	24,203	3,367,841
Cod fishery		778,376		778,376
Shrimp fishery	163,111			163,111
Crab fishery	129,976			129,976
Whale fishery		374,057	427,893	801,950
Total	21,828,165	14,121,114	18,641,023	54,590,302

Summary of persons engaged in the Alaska fisheries in 1922.

Races.	Southeast Alaska.	Central Alaska.	Western Alaska.	Total.
Whites	4,620	3,423	4,386	12,429
Natives	2,675	1,147	370	4,192
Chinese	383	313	526	1,222
Japanese	482	346	96	924
Filipinos	649	300	575	1,524
Mexicans	70	92	1,216	1,378
Negroes	6	20	126	152
Miscellaneous	48	28	77	153
Total	8,933	5,669	7,372	21,974

Summary of products of the Alaska fisheries in 1922.

Products.		Quantity.	Value.
Salmon:			
Canned	cases	4,501,652	$29,787,193
Mild cured	pounds	4,266,050	821,169
Pickled	do	3,585,100	248,015
Frozen	do	3,849,153	261,094
Fresh	do	3,802,729	271,869
Dried and smoked	do	906,550	148,464
Fertilizer	do	774,000	23,438
Oil	gallons	12,989	5,015
Herring:			
Fresh for bait	pounds	824,600	8,246
Frozen for bait	do	2,664,015	23,340
Pickled, Scotch cure	do	35,905,450	2,030,975
Pickled, Norwegian cure	do	237,850	14,009
Dry salted for food	do	240,000	9,600
Fertilizer	do	3,292,000	98,528
Oil	gallons	425,241	144,418
Halibut:			
Fresh	pounds	7,886,764	772,610
Frozen	do	3,188,473	262,357
Cod:			
Dry salted	do	6,085,989	458,958
Pickled	do	16,800	925
Stockfish	do	20,000	3,000
Tongues	do	11,860	1,186
Oil	gallons	100	100
Whale:			
Oil	do	904,359	328,944
Fertilizer	pounds	3,092,480	78,974
Whalebone	do	14,000	1,400
Ivory (teeth)	do	500	200
Clams	do	32,290	185,007
Shrimps	do	336,380	126,690
Crabs:			
Canned	cases	4,619	46,231
Fresh meat	pounds	120	48
Whole in shell	dozen	383	1,100
Trout:			
Fresh	pounds	64,727	5,266
Canned	cases	134	648
Sablefish	pounds	49,167	1,538
Flatfish	do	12,255	367
Ling cod	do	1,327	26
Total		....	[1] 36,170,948

[1] These figures represent the value of the manufactured product. It is estimated that the value of the catch to the fishermen was approximately $10,000,000.

SALMON INDUSTRY.

Among the notable developments of the salmon industry in 1922 may be mentioned the increased production of canned salmon in western Alaska and the surprisingly large run of humpback salmon in the Ketchikan district of southeast Alaska. The pack in both of these districts again reached normal proportions, and that in central Alaska was not far below the average for several years.

The condition of the salmon fisheries in the northern section of southeast Alaska was unsatisfactory, and concern is felt over the very evident decline of the salmon runs in that region. Several canneries in the affected district were idle during the year, and at most of those that did operate much smaller packs were made, showing unmistakably that the supply of salmon is depleted.

SALMON CATCH AND APPARATUS.

In 1922 there were used in the salmon fisheries of Alaska 160 beach seines, aggregating 21,905 fathoms, and 289 purse seines, aggregating 48,600 fathoms, a total of 449 seines or 70,505 fathoms, an increase over 1921 of 236 seines or 35,442 fathoms. Southeast Alaska is credited with 308 seines, having a total length of 48,380 fathoms; central Alaska, with 119 seines, having a total length of 17,525 fathoms; and western Alaska, with 22 seines, having a total length of 4,600 fathoms.

The gill nets operated in the salmon industry in 1922 total 3,335, aggregating 378,440 fathoms of webbing, an increase over 1921 of 100 nets and 3,120 fathoms. Operators in southeast Alaska used 270 gill nets, with 28,775 fathoms of webbing; in central Alaska, 1,010 gill nets, with 71,930 fathoms; and in western Alaska 2,055 gill nets, with 277,735 fathoms.

The total number of traps used in the salmon industry in 1922 was 111 floating and 265 driven, a total of 376, an increase of 196 traps over the number in 1921. Southeast Alaska is credited with 138 driven and 109 floating traps; central Alaska with 118 driven and 2 floating; and western Alaska with 9 driven. Southeast Alaska is credited with 5,790 lines used in taking salmon and western Alaska with 7 salmon wheels. Of the total catch of salmon approximately 23 per cent were taken in seines, 35 per cent in gill nets, and 41 per cent in traps. Less than 1 per cent was taken by all other methods combined.

Percentage of salmon caught in each Alaska district, by principal forms of apparatus.

Apparatus.	Southeast Alaska.		Central Alaska.		Western Alaska.	
	1921	1922	1921	1922	1921	1922
Seines	32	36	25	28	6	4
Gill nets	5	2	10	7	90	93
Traps	56	60	63	65	3	2

In 1922 the total take of salmon was 72,370,400, as compared with 37,905,591 in 1921, an increase of 34,464,809, or approximately 91 per cent. The increase occurred in all three districts of Alaska, that of southeast Alaska being 19,202,791, central Alaska 7,683,497, and western Alaska 7,578,521. As compared with 1921 the catch in Alaska shows that cohos increased 655,889, chums 2,636,982, humpbacks 23,432,524, and reds 7,795,481. Kings decreased 56,067. The number of humpbacks taken in 1922 was an increase of approximately 327 per cent over the take of 1921.

Salmon taken in 1922, by apparatus and species, for each geographic section of Alaska.

Apparatus and species.	Southeast Alaska.	Central Alaska.	Western Alaska.	Total.
Seines:				
Coho, or silver	336,201	91,348		427,549
Chum, or keta	2,278,660	164,831	5,166	2,448,657
Humpback, or pink	7,835,208	2,880,490		10,715,698
King, or spring	2,705	2,963	2,386	8,054
Red, or sockeye	614,478	1,286,944	1,029,674	2,931,096
Total	11,067,252	4,426,576	1,037,226	16,531,054
Gill nets:				
Coho, or silver	122,870	6,303	163,131	292,304
Chum, or keta	49,169	3,357	614,882	667,408
Humpback, or pink	38,972	148,250	220,288	407,510
King, or spring	73,884	23,151	89,863	186,898
Red, or sockeye	316,109	826,198	22,918,065	24,060,372
Total	601,004	1,007,259	24,006,229	25,614,492
Traps:				
Coho, or silver	679,586	269,075		948,661
Chum, or keta	1,398,044	700,641	39,040	2,137,725
Humpback, or pink	15,649,373	3,747,254	69,507	19,466,134
King, or spring	32,223	26,522	9,160	67,905
Red, or sockeye	952,205	5,435,516	519,493	6,907,304
Total	18,711,521	10,179,008	637,200	29,527,729
Lines:				
Coho, or silver	168,580			168,580
Chum, or keta	93			93
King, or spring	506,852			506,852
Total	675,525			675,525
Wheels:				
Coho, or silver			1,000	1,000
Chum, or keta			20,000	20,000
King, or spring			600	600
Total			21,600	21,600
Total:				
Coho, or silver	1,307,237	366,726	164,131	1,838,094
Chum, or keta	3,725,966	868,829	670,088	5,273,883
Humpback, or pink	23,523,553	6,775,994	289,795	30,589,342
King, or spring	615,664	52,636	102,009	770,309
Red, or sockeye	1,882,882	7,548,658	24,467,232	33,898,772
Grand total	31,055,302	15,612,843	25,702,255	72,370,400

SALMON CANNING.

CHANGES IN CANNERIES.

The year was marked by a number of changes in the ownership and operation of canneries and also by the opening of new plants. In southeast Alaska a company, known as the Alaska Consolidated Canneries, was organized to operate the Tee Harbor, Chomley, and Yes Bay canneries of the Alaska Pacific Fisheries, the Quadra and Rose Inlet canneries of the Southern Alaska Canning Co., and the Tenakee cannery of the Columbia Salmon Co. The A. & P. Products Corporation leased the Ford Arm cannery of the Deep Sea Salmon Co. and the Heceta Island cannery of Swift-Arthur-Crosby

Co. The J. D. Roop Co. operated the plant of the Standard Salmon Packers (Inc.) at Tenakee; A. P. Wolf & Co. leased the plant of the Sitka Packing Co. at Sitka; and the Mitkof Island Packing Co. continued to operate the Petersburg cannery of the Petersburg Packing Corporation. The Noyes Island Packing Co. was reorganized as the Steamboat Bay Packing Co. The Stuart Packing Corporation became the owner of the floating cannery of the Mutual Packing Co. The Sea-Coast Packing Co. purchased the Craig cannery of the Columbia Salmon Co.

In central Alaska the Emel Packing Co. operated the Valdez Packing Co.'s cannery at Valdez, the Star Canning Co. took over the floating cannery of the Hayes-Graham Fish Co., the cannery of the Hillery-Scott Co. at Cordova was transferred to the Cordova Packing Co., and the Snug Harbor cannery of the Surf Packing Co. was operated by the Polar Fisheries Co. The Cordova cannery of the Pioneer Packing Co. is now listed under the name of the Pioneer Sea Foods Co., and the Seldovia Canning Co. was succeeded by the Seldovia Packing Co. For operating purposes the Carlisle Packing Co. and the Canoe Pass Packing Co. consolidated and used the Cordova plant of the former.

In western Alaska the floating plant of the Carlisle Packing Co., previously operated at Kwiguk Slough at the mouth of the Yukon River, was moved to Koggiung River, on Bristol Bay.

NEW CANNERIES.

Fifteen new or heretofore unlisted canneries were operated in Alaska in 1922. Of these six were located in southeast Alaska, as follows: A. & P. Products Corporation, at Hidden Inlet on the site formerly occupied by the cannery of the Hidden Inlet Canning Co.; Big Harbor Packing Co., at Craig; Ness Fish Co., at Petersburg; Red Salmon Packers Association, floating cannery *Retriever*, at Dry Bay and later at Ketchikan; R. J. Peratovich, at Bay View; and the Dobbins Packing Co., a floating plant at Petersburg for salmon and crabs.

Central Alaska is credited with six new canneries, located as follows: Anchorage Packing Co., at Anchorage; Kamishak Canning Co., at Kamishak Bay; Kodiak Island Fishing and Packing Co., at Seward; North Coast Packing Co., at Ninilchik; Robinson Packing Corporation, floating cannery *Azalea*, at Zachar Bay; and Hopp & Danielsen, at Uganik Bay.

One new cannery was opened in western Alaska at Ugashik River by the International Packing Co., which operated the motor ship *Santa Flavia* as a floating plant. After the close of the season on Bristol Bay this cannery was moved to Uyak to pack humpback salmon. W. F. O'Connor and Charles Homeier put up small packs of canned salmon on the Yukon River for local use; their plants have not been listed heretofore.

CANNERIES NOT OPERATED.

Forty-six canneries were closed during the season, of which three are probably permanently out of business—the F. H. Madden cannery at Abercrombie abandoned by reason of the enforcement of regulations for the protection of the Copper River salmon run, the Ketchikan Packing Company's cannery sold under bankruptcy proceedings, and the small plant of E. R. Strand, near Petersburg. Including these three, the list is as follows:

Admiralty Packing Co	Pybus Bay.
Alaska Sanitary Packing Co	Cape Fanshaw.
Alaska Salmon & Herring Packers	Tyee.
Alaska Union Fisheries (Inc.)	Port Conclusion.
American Packing Co	Juneau.
Astoria & Puget Sound Canning Co	Excursion Inlet.
Baranof Packing Co	Red Bluff Bay.
Cape Fanshaw Fish & Packing Co	Cape Fanshaw.
John L. Carlson & Co	Auk Bay.
Chilkat Packing Co	Haines.
Canoe Pass Packing Co	Shepard Point.
Central Alaska Fisheries	Drier Bay.
Fidalgo Island Packing Co	Bay of Pillars. Herendeen Bay.
Hood Bay Packing Co	Hood Bay.
Hoonah Packing Co	Gambier Bay.
Karheen Packing Co	Karheen.
Ketchikan Packing Co	Ketchikan.
Kenai Packing Co	Drier Bay.
King Salmon Fisheries Co	Unakwik Inlet.
Libby, McNeill & Libby	Lockanok.
F. H. Madden	Abercrombie.
Marathon Fishing & Packing Co	Cape Fanshaw.
Midnight Sun Packing Co	Kotzebue Sound.
Nelson Lagoon Packing Co	Nelson Lagoon.
Northern Packing Co	Juneau.
Northwestern Fisheries Co	Dundas Bay. Hunter Bay. Kenai. Orca. Quadra. Roe Point. Santa Ana. Seldovia. Shakan.
Pacific American Fisheries	Excursion Inlet.
Pavlof Harbor Packing Co	Pavlof Harbor.
Petersburg Packing Corporation	Washington Bay.
Phoenix Packing Co	Herendeen Bay.
Point Warde Packing Co	Point Warde.
Revilla Packing Co	Ketchikan.
San Juan Fishing & Packing Co	Seward.
Southern Alaska Canning Co	Big Port Walter.
E. R. Strand	Wrangell Narrows.
Todd Packing Co	Todd.
G. W. Hume Co	Union Bay.

TOTAL CANNERIES OPERATED.

In 1922 there were 123 canneries operated in Alaska, of which 57 were located in southeast Alaska, 36 in central Alaska, and 30 in western Alaska. This is an increase of 40 over the number operated in 1921.

Companies canning salmon in Alaska, number and location of canneries operated, and number of pound nets owned by each, 1922.

[New canneries indicated by (*).]

Company.	Canneries.		Pound nets.		
	Number.	Location.	Driven.	Floating.	Total.
Southeast Alaska:					
Alaska Consolidated Canneries	6	Chomley	3	4	7
		Tenakee	2	2	4
		Roso Inlet	1	3	4
		Boca de Quadra	4	2	6
		Tee Harbor	2	4	6
		Yes Bay	3	4	7
Alaska Fish Co	1	Waterfall	1	1	2
Alaska Herring & Sardine Co	1	Port Walter	2	9	11
Alaska Packers Association	2	Loring	5	3	8
		Wrangell	1	5	6
A. & P. Products Corporation	3	Ford Arm	...	5	5
		Heceta Island	...	5	5
		Hidden Inlet*	2	2	4
Alaska Sanitary Packing Co	1	Wrangell	2	...	2
Annette Island Packing Co	1	Metlakatla	...	...	...
Auk Bay Salmon Canning Co	1	Auk Bay	1	2	3
F. C. Barnes Co	1	Lake Bay	1	...	1
Beauclaire Packing Co	1	Port Beauclerc	...	...	...
Beegle Packing Co	1	Ketchikan	2	...	2
Big Harbor Packing Co	1	Craig*	...	...	...
Burnett Inlet Packing Co	1	Burnett Inlet	...	3	3
Deep Sea Salmon Co	1	Port Althorp	...	13	13
Dobbins Packing Co	1	Petersburg (floating)*	...	...	...
Douglas Island Packing Co	1	Douglas	...	...	...
Fidalgo Island Packing Co	1	Ketchikan	8	...	8
George Inlet Packing Co	1	George Inlet	2	...	2
Haines Packing Co	1	Letnikof Cove	...	...	...
P. E. Harris & Co	1	Hawk Inlet	3	6	9
Hetta Packing Co	1	Coppermount	...	...	...
Hidden Inlet Canning Co	1	Hood bay	...	...	...
Hoonah Packing Co	1	Hoonah	21	4	25
G. W. Hume Co	1	Scow Bay	2	...	2
Libby, McNeill & Libby	2	Taku Harbor	12	...	12
		Yakutat	...	...	...
Mitkof Island Packing Co	1	Petersburg	6	4	10
Mount Baker Packing Co	1	Red Bluff Bay	...	...	...
Mountain Point Packing Co	1	Wrangell Narrows	1	...	1
George T. Myers & Co	1	Chatham	4	4	8
Ness Fish Co	1	Petersburg*	...	...	...
North Pacific Trading & Packing Co.	1	Klawak	1	2	3
Northwestern Fisheries Co	1	Kasaan	8	2	10
Red Salmon Packers Association	1	(Floating)*	...	...	...
Pure Food Fish Co	1	Ketchikan	2	...	2
Pyramid Packing Co	1	Sitka	...	2	2
R. J. Peratovich	1	Bay View*	...	...	...
J. D. Reop Co	1	Tenakee	2	2	4
Sea-Coast Packing Co	1	Craig	1	1	2
Sanborn Cutting Co	1	Kake	...	4	4
J. L. Smiley & Co	1	Ketchikan	3	2	5
Starr-Collinson Packing Co	1	Moira Sound	...	2	2
Stuart Packing Corporation	1	Ketchikan (floating)	...	...	...
Steamboat Bay Packing Co	1	Noyes Island	...	...	...
Sunny Point Packing Co	1	Ketchikan	5	...	5
Thlinket Packing Corporation	1	Funter Bay	4	6	10
The Trading Union, Inc.	1	Petersburg	...	...	...
Ward's Cove Packing Co	1	Ward Cove	2	...	2
A. P. Wolf & Co	1	Sitka	...	...	...
Central Alaska:					
Alaska Packers Association	4	Alitak	6	1	7
		Chignik	3	...	3
		Larsen Bay	...	...	...
		Kasilof	16	...	16
Alaska Sea Food Co	1	Point Whitshed	...	...	...
Alitak Packing Co	1	Lazy Bay	4	...	4
Anchorage Packing Co	1	Anchorage*	5	...	5
Arctic Packing Co	1	English Bay	...	...	...
Bainbridge Fisheries Co	1	Evans Island	...	...	...
Carlisle-Canoe Pass Packing Co	1	Cordova	...	1	1
Columbia River Packers' Association	1	Chignik	3	...	3
Cordova Packing Co	1	Cordova	...	...	...
Copper River Packing Co	1	McClure Bay	2	...	2
Emel Packing Co	1	Valdez	1	...	1
Eyak River Packing Co	1	Eyak River	...	...	...
Fidalgo Island Packing Co	1	Port Graham	12	...	12

Companies canning salmon in Alaska, number and location of canneries operated, and number of pound nets owned by each, 1922—Continued.

Company	Canneries.		Pound nets.		
	Number.	Location.	Driven.	Floating.	Total.
Central Alaska—Continued.					
P. E. Harris & Co.	1	Isanotski Strait	4		4
Hoonah Packing Co.	1	Bering River			
Hopp and Danielsen	1	Uganik Bay *			
Kadiak Fisheries Co.	1	Kodiak	1		1
Kamishak Canning Co.	1	Kamishak Bay *			
Katmai Packing Co.	1	Uzinki			
Kodiak Island Fishing and Packing Co.	1	Seward *			
Libby, McNeill & Libby	1	Kenai River	16		16
Moore Packing Co.	1	Orca Inlet	1		1
Northwestern Fisheries Co.	2	Chignik	3		3
		Uyak			
North Coast Packing Co.	1	Ninilchik *	2		2
Pacific American Fisheries	2	Ikatan	8		8
		King Cove	9		9
Pioneer Sea Foods Co.	1	Cordova	2		2
Polar Fisheries Co.	1	Snug Harbor	4		4
Robinson Packing Corporation	1	(Floating) *			
Seldovia Packing Co.	1	Seldovia	2		2
Shumagin Packing Co.	1	Squaw Harbor	4		4
Star Canning Co.	1	(Floating)			
Western Alaska:					
Alaska Packers Association	9	Kvichak River (2)			
		Naknek River (3)			
		Nushagak River (2)			
		Egegik River			
		Ugashik River			
Alaska-Portland Packers' Association	2	Naknek			
		Nushagak	3		3
Alaska Salmon Co.	1	Wood River			
Bristol Bay Packing Co.	1	Koggiung			
Carlisle Packing Co.	1	Koggiung River			
Columbia River Packers' Association	1	Nushagak Bay			
Everett Packing Co.	1	Herendeen Bay			
Charles Homeier	1	Mountain Village *			
International Packing Co.	1	Ugashik (floating) *			
Libby, McNeill & Libby	5	Ekuk			
		Koggiung			
		Libbyville			
		Nushagak			
		Egegik River			
Naknek Packing Co.	1	Naknek River			
Northwestern Fisheries Co.	2	Naknek River			
		Nushagak			
W. F. O'Connor	1	Andreafsky *			
Pacific American Fisheries	1	Port Moller	6		6
Red Salmon Canning Co.	2	Naknek River			
		Ugashik River			

LOSSES AND DISASTERS.

The loss of property and apparatus in the salmon industry in 1922 totaled $253,470, the most important item being the Alaska-Portland Packers' Association's bark *Berlin* (1,416 tons), valued at $114,768, which went ashore at Egegik Flats May 17. There were no lives lost. In the whole of Alaska 10 people were killed in this industry, 4 of whom were drowned. Of the total number 4 were fishermen, 1 was a transporter, and 5 were shoresmen.

STATISTICS.

In 1922, 123 canneries were operated in Alaska, as compared with 83 in 1921. These represented an active investment of $45,207,557, or $11,961,265 more than in 1921. The increase by districts was: Southeast Alaska, $8,394,097; central Alaska, $2,766,989; and western Alaska, $800,179. Employment was given to 17,697 persons, or

4,711 more than in 1921. The increase in numbers was: Whites 2,234, natives 1,174, Chinese 332, Japanese 275, Filipinos 563, Mexicans 5, Negroes 44, and miscellaneous 84.

A total of 4,501,652 cases of salmon was packed in 1922, valued at $29,787,193. This is an increase over the 1921 pack of 1,904,826 cases, or approximately 73 per cent, and of $10,154,449, or approximately 52 per cent. This increase was largely due to the increased run of humpbacks, which produced 1,658,423 cases, having a value of $7,189,494, as compared with 423,984 cases in 1921, valued at $1,788,778. Other species increased as follows: Cohos from 106,555 to 175,993 cases, chums from 255,495 to 565,918 cases, and reds from 1,765,798 to 2,070,658 cases. Kings decreased from 44,994 to 30,660 cases. By districts, southeast Alaska increased from 803,071 to 2,018,743 cases, central Alaska from 643,099 to 988,143 cases, and western Alaska from 1,150,656 to 1,494,766 cases. In southeast Alaska the increase was 1,215,672 cases, or approximately 151 per cent.

Investment in the Alaska salmon-canning industry in 1922.

Items.	Southeast Alaska.		Central Alaska.		Western Alaska.		Total.	
	Number.	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
Canneries operated	57	$5,183,390	36	$2,815,986	30	$5,335,954	123	$13,335,330
Working capital		5,680,677		3,148,248		4,252,163		13,081,088
Wages paid		2,319,459		1,866,584		3,849,181		8,035,224
Vessels:								
Power, over 5 tons	202	1,457,616	88	799,385	79	1,526,263	369	3,783,264
Net tonnage	4,108		2,279		9,590		15,977	
Sailing	1	45,000	7	360,000	31	1,148,740	39	1,553,740
Net tonnage	1,974		10,900		48,561		61,435	
Barges	3	71,871					3	71,871
Net tonnage	2,770						2,770	
Launches, under tonnage	66	68,063	145	179,169	57	143,189	268	390,421
Boats, row and sail	778	188,077	709	102,415	1,265	505,108	2,752	795,600
Lighters, scows and houseboats	320	307,834	168	188,181	186	477,874	674	973,889
Pile drivers and pile pullers	49	336,236	34	157,835	23	51,765	106	545,836
Apparatus:								
Beach seines	52	37,210	97	38,226	4	1,500	153	76,936
Fathoms	6,845		14,250		400		21,495	
Purse seines	255	154,580	16	13,250	17	27,700	288	195,530
Fathoms	41,450		2,915		4,150		48,515	
Gill nets	263	24,493	989	93,418	1,937	446,871	3,189	564,782
Fathoms	27,325		69,380		267,335		364,040	
Pound nets, driven	137	855,556	113	608,317	9	35,000	259	1,498,873
Pound nets, floating	109	301,973	2	2,800			111	304,773
Wheels					2	400	2	400
Total		17,032,035		10,373,814		17,801,708		45,207,557

Persons engaged in the Alaska salmon-canning industry in 1922.

Occupation and race.	Southeast Alaska.	Central Alaska.	Western Alaska.	Total.
Fishermen:				
Whites	930	994	2,365	4,289
Natives	1,044	401	66	1,511
Japanese	....	1	....	1
Miscellaneous [1]	18	8	....	26
Total	1,992	1,404	2,431	5,827
Shoresmen:				
Whites	1,232	912	1,511	3,655
Natives	1,260	639	219	2,118
Chinese	380	313	526	1,219
Japanese	444	345	96	885
Filipinos	645	300	575	1,520
Mexicans	67	92	1,203	1,362
Negroes	6	20	121	147
Miscellaneous [1]	5	19	77	101
Total	4,039	2,640	4,328	11,007
Transporters:				
Whites	356	215	229	800
Natives	17	24	1	42
Negroes	....	....	5	5
Miscellaneous [1]	15	1	....	16
Total	388	240	235	863
Total:				
Whites	2,518	2,121	4,105	8,744
Natives	2,321	1,064	286	3,671
Chinese	380	313	526	1,219
Japanese	444	346	96	886
Filipinos	645	300	575	1,520
Mexicans	67	92	1,203	1,362
Negroes	6	20	126	152
Miscellaneous [1]	38	28	77	143
Grand total	6,419	4,284	6,994	17,697

[1] Koreans, Porto Ricans, Kanakas, etc.

Output and value of canned salmon in Alaska in 1922.[1]

Product.	Southeast Alaska.		Central Alaska.		Western Alaska.		Total.	
	Cases.	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*
Coho, or silver:								
½-pound flat	20,013	$151,666	2,224	$17,039	....	....	22,237	$168,705
1-pound flat	10,773	63,515	1,291	8,005	35	$166	12,099	71,686
1-pound tall	91,861	462,365	36,919	192,234	12,877	67,800	141,657	722,399
Total	122,647	677,546	40,434	217,278	12,912	67,966	175,993	962,790
Chum, or keta:								
½-pound flat	3,698	21,228	....	....	....	....	3,698	21,228
1-pound flat	6,185	25,693	....	....	....	....	6,185	25,693
1-pound tall	414,383	1,640,135	91,239	362,440	50,413	202,044	556,035	2,204,619
Total	424,266	1,687,056	91,239	362,440	50,413	202,044	565,918	2,251,540
Humpback, or pink:								
½-pound flat	30,725	197,953	12,011	75,745	....	....	42,736	273,698
1-pound flat	28,148	134,268	2,731	13,655	....	....	30,879	147,923
1-pound tall	1,273,679	5,461,536	298,226	1,251,399	12,903	54,938	1,584,808	6,767,873
Total	1,332,552	5,793,757	312,968	1,340,799	12,903	54,938	1,658,423	7,189,494
King, or spring:								
½-pound flat	2,695	30,640	1,022	13,341	53	742	3,770	44,723
1-pound flat	1,735	15,209	2,067	20,538	165	2,002	3,967	37,749
1-pound tall	1,703	11,448	7,076	53,168	14,144	100,585	22,923	165,201
Total	6,133	57,297	10,165	87,047	14,362	103,329	30,660	247,673
Red, or sockeye:								
½-pound flat	57,783	779,582	89,603	1,257,544	24,510	384,901	171,896	2,422,027
1-pound flat	17,579	171,509	59,799	614,403	44,071	437,530	121,449	1,223,442
1-pound tall	57,783	530,278	383,935	3,447,679	1,335,595	11,512,270	1,777,313	15,490,227
Total	133,145	1,481,369	533,337	5,319,626	1,404,176	12,334,701	2,070,658	19,135,696
Grand total	2,018,743	9,697,025	988,143	7,327,190	1,494,766	12,762,978	4,501,652	29,787,193

[1] Cases containing one-half-pound cans have been reduced one-half in number, and thus, for the purpose of affording fair comparison, all are put upon the basis of 48 one-pound cans per case.

Output of canned salmon in Alaska, 1916 to 1922.[1]

Product.	1916	1917	1918	1919	1920	1921	1922	Total.
	Cases.	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*
Coho, or silver:								
½-pound flat	13,145	30,412	26,238	9,719	8,915	4,084	22,237	114,750
1-pound flat	8,191	362	12,788	10,438	10,746	7,918	12,099	62,540
1-pound tall	240,573	162,457	179,934	212,713	172,424	94,553	141,657	1,204,311
Total	261,909	193,231	218,958	232,870	192,085	106,555	175,993	1,381,601
Chum, or keta:								
½-pound flat	1,423	26,760	3,559	3,981	53	608	3,698	40,082
1-pound flat	....	2,530	2,996	....	46,167	....	6,185	57,878
1-pound tall	722,692	877,457	1,358,405	1,361,582	987,297	254,887	556,035	6,118,365
Total	724,115	906,747	1,364,960	1,365,563	1,033,517	255,495	565,918	6,216,315
Humpback, or pink:								
½-pound flat	41,491	91,403	63,557	28,185	18,970	1,292	42,736	287,634
1-pound flat	14,796	6,014	20,215	7,553	76,017	....	30,879	155,474
1-pound tall	1,681,506	2,199,559	2,355,182	1,575,870	1,498,133	422,692	1,581,808	11,317,750
Total	1,737,793	2,296,976	2,438,954	1,611,608	1,593,120	423,984	1,658,423	11,760,858
King, or spring:								
½-pound flat	2,617	12,793	6,000	7,584	10,196	4,061	3,770	47,201
1-pound flat	3,804	5,133	5,267	11,532	18,319	19,192	3,967	67,214
1-pound tall	59,452	43,845	37,959	76,870	81,488	21,741	22,923	344,278
Total	65,873	61,951	49,226	95,986	110,003	44,994	30,660	458,693
Red, or sockeye:								
½-pound flat	81,565	124,309	137,008	122,236	101,716	60,831	171,896	799,561
1-pound flat	86,395	89,612	151,864	110,491	120,147	71,108	121,449	751,066
1-pound tall	1,936,971	2,274,460	2,244,865	1,044,934	1,278,875	1,633,859	1,777,313	12,191,277
2-pound nominals	6,006	....	....	....	....	....	....	6,006
Total	2,110,937	2,488,381	2,533,737	1,277,661	1,500,738	1,765,798	2,070,658	13,747,910
Grand total	4,900,627	5,947,286	6,605,835	4,583,688	4,429,463	2,596,826	4,501,652	33,565,377

[1] The number of cases shown has been put upon the common basis of 48 one-pound cans per case.

Average annual price per case of 48 one-pound cans of salmon, 1912 to 1922.

Product.	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922
Coho, or silver	$4.44	$3.45	$4.39	$4.31	$5.34	$8.76	$9.15	$11.27	$9.13	$5.63	$5.47
Chum, or keta	2.37	2.21	3.37	2.59	3.34	6.14	6.27	6.82	4.19	3.68	3.98
Humpback, or pink	2.55	2.58	3.50	2.78	3.64	6.44	6.58	8.35	5.47	4.21	4.34
King, or spring	5.37	4.04	5.01	4.63	5.36	10.40	9.85	13.13	10.97	10.22	8.08
Red, or sockeye	5.45	4.54	5.58	5.82	6.04	9.48	9.44	12.98	13.05	8.96	9.24

MILD CURING OF SALMON.

In 1922 there were employed in this industry 1,243 whites and 61 natives, exclusive of the independent trollers of southeast Alaska. This is an increase of 855 persons. The southeastern district, because of its nearness to market, produced the bulk of mild-cured salmon. The industry in 1922 showed an investment of $1,572,025, as compared with $613,516 in 1921, an increase of $958,509, and produced a total of 5,283 tierces of mild-cured salmon, valued at $821,169, of which 5,200 tierces were kings and 83 cohos. Corresponding figures for 1921 were 3,556 tierces, valued at $608,218, of which 3,530 tierces were kings and 26 cohos.

Investment, persons engaged, and products of Alaska salmon mild-curing industry in 1922.

Items.	Number.	Value.
INVESTMENT.		
Plants	6	$6,600
Operating capital		403,020
Vessels:		
Power, over 5 tons	18	75,900
Net tonnage	263	
Barges	2	17,000
Launches, under 5 tons [1]	1,013	1,014,800
Other boats and skiffs	33	8,455
Lighters	6	9,000
Apparatus:		
Gill nets (5,250 fathoms)	35	7,750
Lines	5,790	29,500
Total		1,572,025
PERSONS ENGAGED.		
Fishermen:		
Whites	1,068	
Natives	50	
Total	1,118	
PERSONS ENGAGED—con.		
Shoresmen:		
Whites	144	
Natives	9	
Total	153	
Transporters:		
Whites	31	
Natives	2	
Total	33	
Grand total	1,304	
PRODUCTS (POUNDS).		
Coho, or silver [2]	66,400	$6,548
King, or spring [3]	4,199,650	814,621
Total	4,266,050	821,169

[1] Includes 1,000 trolling launches, valued at $1,000,000. [2] 83 tierces. [3] 5,200 tierces.

SALMON PICKLING.

In 1922 the investment in salmon pickling was $510,998, a gain of $77,003 over 1921, when the investment was $433,995, the greater part being in western Alaska. The investment in 1922 was confined to central Alaska, $123,779, and western Alaska, $387,219. In 1922 there were employed 250 persons as compared with 195 in 1921. The production increased from 10,082 barrels in 1921, with a value of $179,414, to 17,925½ barrels in 1922, with a value of $284,015, an increase of approximately 77 per cent in quantity and 58 per cent in value.

Investment, persons engaged, and products of Alaska salmon-pickling industry in 1922, by districts.

Items.	Southeast Alaska.		Central Alaska.		Western Alaska.		Total.	
INVESTMENT.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
Salteries			7	$88,600	8	$76,500	15	$165,100
Operating capital				19,609		159,627		179,236
Vessels:								
Power, over 5 tons			1	4,500	8	38,491	9	42,991
Net tonnage			15		116		131	
Sailing					3	60,000	3	60,000
Net tonnage					1,412		1,412	
Launches			6	3,800	5	9,900	11	13,700
Boats, gill net and row			18	1,090	71	21,225	89	22,315
Lighters and pile drivers			4	2,050	10	9,525	14	11,575
Apparatus:								
Haul seines			6	1,170	1	50	7	1,220
Fathoms			360		50		410	
Gill nets			8	460	103	11,271	111	11,731
Fathoms			250		8,900		9,150	
Pound nets, driven			5	2,500			5	2,500
Wheels					5	630	5	630
Total				123,779		387,219		510,998
PERSONS ENGAGED.								
Fishermen:								
Whites			23		85		108	
Natives			5		27		32	
Total			28		112		140	
Shoresmen:								
Whites			12		65		77	
Natives			3		16		19	
Mexicans					13		13	
Total			15		94		109	
Transporters: White					1		1	
Grand total			43		207		250	
PRODUCTS (BARRELS).[1]								
Coho, or silver	749	$10,915	21	285	67	914	837	12,114
Chum, or keta			31	600	55	901	86	1,501
Humpback, or pink			165½	1,660			165½	1,660
King, or spring	1	10	35½	748	319½	5,754	356	6,512
Red, or sockeye			1,458	27,753	15,023	234,475	16,481	262,228
Total	750	10,925	1,711	31,046	15,404½	242,044	17,925½	284,015

[1] Each barrel holds 200 pounds of fish.

SALMON FREEZING.

In 1922 the four companies reporting the preparation of frozen salmon in southeast Alaska produced 3,791,634 pounds, valued at $255,343, and one in western Alaska produced 57,519 pounds, valued at $5,751, a total production of 3,849,153 pounds, valued at $261,094. There were no operators in central Alaska. The total production for 1921 was 1,506,074 pounds, valued at $127,442, making an increase for 1922 of 2,343,079 pounds, or approximately 156 per cent in quantity, and of $133,652, or approximately 105 per cent in value.

Quantity and value of salmon frozen in Alaska in 1922, by species.

Species.	Pounds.	Value.
Coho, or silver	839,640	$48,137
Chum, or keta	236,679	9,467
Humpback, or pink	1,023,707	20,474
King, or spring	1,548,474	162,951
Red, or sockeye	200,653	20,065
Total	3,849,153	261,094

FRESH SALMON.

There was a material decrease in the fresh-salmon trade in 1922 as compared with 1921. The number of persons engaged dropped from 20 to 7 and the production from 9,103,104 pounds, with a value of $418,265, to 3,802,729 pounds, with a value of $271,869. This is a decrease of approximately 58 per cent in the number of pounds and 35 per cent in value. The investment was $35,541 in 1922 as compared with $55,027 in 1921, a decrease of $19,486.

Investment, persons engaged, and products of the Alaska fresh-salmon industry in 1922.

Items.	Number.	Value.
INVESTMENT		
Operating capital		$19,316
Floating equipment		12,525
Apparatus:		
Purse seines	1	200
Fathoms	85	
Traps, pile	1	3,500
Total		35,541
PERSONS ENGAGED.		
Fishermen	2	
Transporters	5	
Total	7	
PRODUCTS (POUNDS).		
Coho, or silver	619,930	25,740
Chum, or keta	126,847	4,011
Humpback, or pink	637,338	7,085
King, or spring	2,072,774	202,279
Red, or sockeye	345,840	32,754
Total	3,802,729	271,869

DRYING AND SMOKING OF SALMON.

In 1922 nine firms reported a production of 815,550 pounds of dried salmon, valued at $145,544, as compared with 8,533 pounds in 1921, valued at $979. The Juneau Cold Storage Co. reported a production of 10,000 pounds of kippered salmon, with a value of $1,500, and two operators produced 1,600 pounds of beleke, valued at $480. Two firms dry-salted 79,400 pounds, with a value of $940. The total quantity of dried, kippered, and dry-salted salmon and beleke was 906,550 pounds, with a value of $148,464.

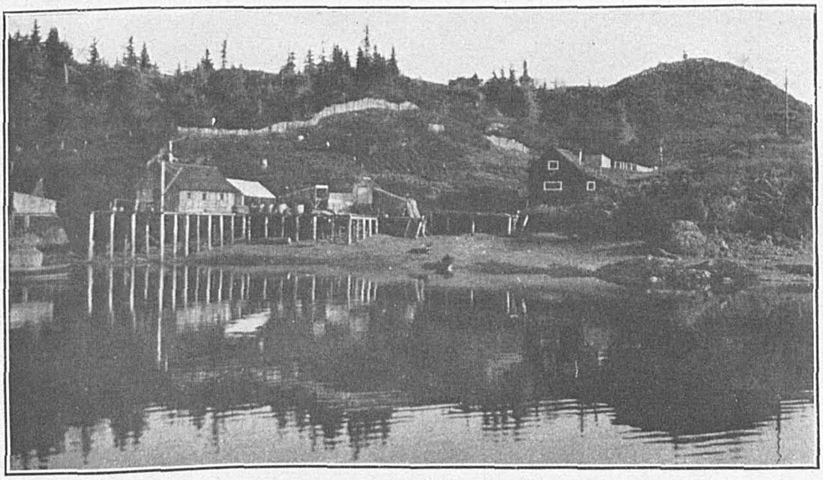

FIG. 9.—Herring station and homestead, Halibut Cove, Cook Inlet.

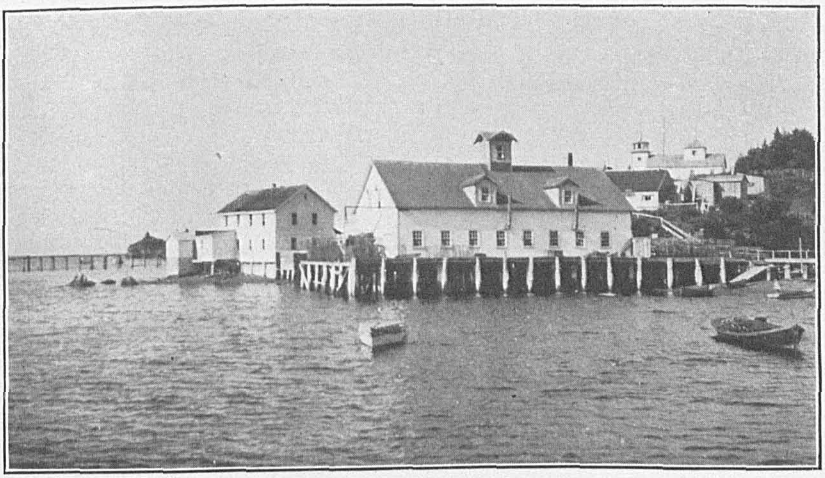

FIG. 10.—Cannery in Cook Inlet district.

Quantity and value of dried, kippered, and dry-salted salmon in Alaska in 1922, by species.

Species.	Dried.		Kippered.		Dry salted.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Coho, or silver	11,750	$620				
Chum, or keta	546,250	105,275				
Humpback, or pink	40,600	1,624	[1] 600	$180	75,000	$500
King, or spring	7,950	865	[2] 11,000	1,800	4,400	440
Red, or sockeye	209,000	37,160				
Total	815,550	145,544	11,600	1,980	79,400	940

[1] Beloke. [2] Includes 1,000 pounds beloke, valued at $300.

SALMON BY-PRODUCTS.

The two firms producing oil and fertilizer from salmon offal and scrap fish in 1921 continued their activities in 1922 with an increased investment and output. They are the Alaska Reduction Co., at Hawk Inlet, and the Petersburg By-Products Co., at Scow Bay. The total investment in 1922 was $183,017, and 29 persons were employed. The products were 387 tons of fertilizer, valued at $23,438, and 12,989 gallons of oil, valued at $5,015. The investment in 1921 was $141,319, with 27 persons employed, and the products were 232 tons of fertilizer, valued at $13,920, and 15,010 gallons of oil, valued at $4,102. The value of the products in 1922 was $10,431 more than the value in 1921.

HERRING FISHERY.

This industry shows a further expansion in 1922 as compared with 1921, not only in number of operators but in volume of products. Practically all the pickled herring was Scotch cured, the pack was of better quality, and sales were better and more promptly made than in past seasons. There is still room for improvement along this line, and the market will be better as the products meet the requirements of the trade.

The tendency of the present packers engaged in this business has been to locate in proved localities, which has, in most instances, resulted in congestion. Scarcely anything in the way of prospecting for new fishing grounds has been done.

STATISTICAL SUMMARY.

In 1922 the herring industry of Alaska showed an investment of $3,367,841, as compared with $1,512,029 in 1921, an increase of $1,855,812. Nine plants were operated in addition to those in operation in 1921, making a total of 22. Employment was given to 1,280 persons, while in 1921 only 445 were employed. The total value of the output in 1922 was $2,329,116, as against $934,044 in 1921, an increase of $1,395,072, or approximately 149 per cent. Scotch-cured herring increased from 14,523,441 pounds in 1921 to 35,995,450 pounds in 1922. Losses in this industry aggregated $25,000, of which $10,000 was a vessel owned by the Alaska Sea Food Products Co., and $10,000 the saltery of the Nildenrich Packing Co., which was destroyed by fire.

sels making deliveries to Alaskan ports and their crews and property must be estimated in compiling these figures. The products of the halibut fishery entered through the ports of Alaska in 1922 were 11,075,237 pounds, valued at $1,034,967, as compared with 17,176,274 pounds in 1921, valued at $1,476,450.

Investment, persons engaged, and products of Alaska halibut fishery in 1922.

Items.	Number.	Value.	Items.	Number.	Value.
INVESTMENT.			PERSONS ENGAGED.		
Vessels:			Whites	455	
Steam and gas	106	$1,114,000	Natives	112	
Net tonnage	2,383		Miscellaneous	2	
Launches	9	8,800	Total	569	
Scows	1	4,000	PRODUCTS (POUNDS).		
Apparatus		21,725			
Shore property		393,935	Fresh (including local)	7,886,764	$772,610
Cash capital		297,450	Frozen	3,188,473	262,357
Total		1,839,910	Total	11,075,237	1,034,967

COD FISHERY.

The cod industry of Alaska in 1922 partially recovered from the shrinkage in 1921. In the vessel fishery the Robinson Fisheries Co. restored the *Wawona* to the cod fleet and the Pacific Coast Codfish Co. put into service the *Charles R. Wilson*, but withdrew the *Maid of Orleans*. The North Star Fish Packing Co. used the power schooner *Northern King*. The Union Fish Co. withdrew the *Sequoia* from the fleet.

The only important shore stations operated in Alaska in 1922 were those of the Union Fish Co. and the Alaska Codfish Co. in the Shumagin Islands.

Alaska cod fleet in 1922.

Name.	Rig.	Net tonnage.	Operators.
City of Papeete	Schooner	370	Alaska Codfish Co., San Francisco, Calif.
Glendale	do	281	Do.
Maweema	do	392	Do.
S. N. Castle	do	464	Do.
Alasco	Power schooner	23	Do.
Alasco II	do	5	Do.
Alasco III	do	8	Do.
Alasco IV	do	14	Do.
Golden State	do	223	Union Fish Co., San Francisco, Calif.
Pirate	do	30	Do.
Progress	Schooner	115	Do.
Mary G	do	21	Do.
Louise	do	323	Do.
Martha	do	14	Do.
Union Flag	do	7	Do.
John A	do	235	Pacific Coast Codfish Co., Seattle, Wash.
Charles R. Wilson	do	328	Do.
Wawona	do	413	Robinson Fisheries Co., Anacortes, Wash.
Fanny Dutard	do	252	J. A. Matheson, Anacortes, Wash.
Northern King	Power schooner	7	North Star Fish Packing Co., Tacoma, Wash.

STATISTICAL SUMMARY.

The cod industry in 1922 showed an investment of $778,376, as compared with $781,665 in 1921. The number of persons employed was 357, or 25 more than in 1921. The production of cod was

6,134,649 pounds and 100 gallons of oil, all valued at $464,169, an increase over 1921 of 1,346,818 pounds in quantity and $6,849 in value.

Investments, persons engaged, and products of Alaska cod fishery in 1922.

Item.	Number.	Value.
INVESTMENT.		
Value of shore stations		$150,930
Cost of operations		133,817
Wages paid		136,316
Vessels:		
Power, over 5 tons	7	102,134
Net tonnage	310	
Sailing	13	194,357
Net tonnage	3,120	
Launches	91	12,161
Dories	306	9,350
Pile drivers	2	250
Apparatus:		
Seines (75 fathoms)	1	250
Gill nets (75 fathoms)	1	195
Lines	1,420	8,616
Total		778,376
PERSONS ENGAGED.		
Fishermen: White	313	
Shoresmen: White	19	
Transporters: White	25	
Total	357	

Item.	Number.	Value.
PRODUCTS (POUNDS).		
Vessel catch:		
Dry-salted cod	3,719,145	$243,601
Pickled cod	16,800	925
Tongues	11,860	1,186
Oil	[1] 100	100
Total		245,812
Shore station catch:		
Dry-salted cod	2,366,844	215,357
Stockfish	20,000	3,000
Total	2,386,844	218,357
Recapitulation:		
Dry-salted cod	6,085,989	458,958
Pickled cod	16,800	925
Stockfish	20,000	3,000
Tongues	11,860	1,186
Oil	[1] 100	100
Grand total		464,169

[1] Gallons.

WHALE FISHERY.

Whaling in Alaska in 1922 was carried on by two companies, the United States Whaling Co., at Port Armstrong, and the North Pacific Sea Products Co., at Akutan. The industry gave employment to 166 whites, 24 natives, 27 Japanese, and 3 Filipinos. The investment, consisting of plants, vessels, wages, and other operating costs, was $801,950. The number of whales captured was 445, of which 204 were finbacks, 95 humpbacks, 77 sulphur bottoms, and 69 sperm. The products were 904,359 gallons of oil, valued at $328,944; 3,092,480 pounds of fertilizer, valued at $78,974; 14,000 pounds of whalebone, valued at $1,400; and 500 pounds of ivory, valued at $200. The total value of all whale products was $409,618.

CLAMS.

In 1922 the production of clam products was 32,290 cases, valued at $185,007, as compared with 1,420 cases, valued at $9,940, in 1921, an increase of 30,870 cases in quantity and $175,067 in value.

Products of the Alaska clam industry in Alaska in 1922.

Item.	Cases.	Value.
Minced:		
½-pound cans	18,078	$74,520
10-ounce cans	11,732	89,634
1-pound cans	1,046	9,249
Whole:		
1-pound cans	1,434	11,604
Total	32,290	185,007

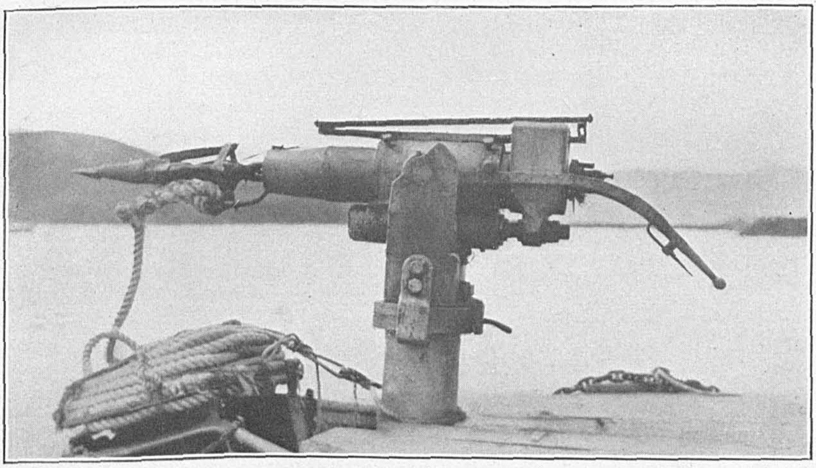

FIG. 11.—Whaling gun mounted at bow of vessel.

FIG. 12.—Hauling out whale at shore station, western Alaska.

SHRIMPS.

Three companies, the Alaskan Glacier Sea Food Co., Olympic Fisheries Co., and Ness Fish Co., located at Petersburg, were engaged in the preparation of shrimps. The entire product consisted of fresh shrimp meat packed in 5-pound tin containers, which are filled by hand, sealed in a hand machine, and shipped in cold storage to Seattle. Immediately upon delivery at the packing houses the shrimps are immersed in hot water for a few minutes, thus cooking them slightly and facilitating removal of shells. The shelling is done by hand by Japanese and natives, who are paid by the pound for the meat prepared.

Employment was given to 16 whites, 79 natives, 3 Chinese, 11 Japanese, 3 Mexicans, and 1 Filipino, a total of 113, as compared with 111 in 1921. Wages aggregated $59,689, and other costs of operation totaled $53,902. The value of plants, vessels, and fishing apparatus was $49,520. The total investment in the industry in 1922 was $163,111, as compared with $147,814 in 1921. The output was 336,380 pounds of meat, valued at $126,690, as compared with 344,986 pounds in 1921, valued at $132,077. Losses in this industry in 1922 amounted to $7,648, of which $7,348 represents the value of products that spoiled for lack of cold-storage shipping facilities.

CRABS.

Three canneries handling crabs exclusively were operated in Alaska in 1922 and four other operators handled crabs incidental to other activities. The reported investment in the industry in 1922 was $129,976, as compared with $43,848 in 1921. Employment was given to 152 persons, as against 44 in 1921. The products consisted of 4,619 cases canned, valued at $46,231; 120 pounds fresh, valued at $48; and 383 dozen whole crabs in shell, valued at $1,100; a total of $47,379. The value of products in 1921 was $33,180.

TROUT.

Although there was no separate investment in the trout industry in 1922 there was reported a production of 64,727 pounds of fresh trout, valued at $5,266, and of 134 cases of preserved trout, valued at $648. Dolly Varden and steelhead were the only species taken. The total production in 1922 was 133,504 pounds, valued at $18,925.

Products of Alaska trout fishery in 1922.

Species.	Fresh.		Canned.	
	Pounds.	*Value.*	*Cases.*	*Value.*
Dolly Varden	49,483	$4,275		
Steelhead	15,244	991	134	$648
Total	64,727	5,266	134	648

MISCELLANEOUS FISHERY PRODUCTS.

Several products, incidental to other fishing operations, deserve mention. These include sablefish, flatfish, and ling-cod. In 1922 the total catch of sablefish was 49,167 pounds, valued at $1,538; of flatfish 12,255 pounds, valued at $367; and of ling-cod 1,327 pounds, valued at $26.

FUR-SEAL INDUSTRY.

PRIBILOF ISLANDS.

GENERAL ADMINISTRATIVE WORK.

In the calendar year 1922, 31,156 sealskins were taken on the Pribilof Islands. With the exception of the year 1918, when 34,890 skins were secured, the take was the largest since 1889. The washing and blubbering of sealskins on St. Paul Island, which was first undertaken on a commercial scale in 1921, was continued more extensively in 1922, when nearly 16,000 were so treated. Extensions were made to the washing and blubbering plant and to the St. Paul salt houses. Work on the new water system for St. Paul village was continued, and the building of a road suitable for motor trucks from that village to Northeast Point was undertaken. On St. George Island improvements were made to the village landings, new building construction was undertaken, and the electric lighting system was extended to include the entire village. The practice of feeding foxes on St. George Island was continued, and steps were taken to secure the services of an experienced man to develop the fox herds on both islands. The regular annual supplies were transported to the islands by a commercial vessel instead of by a Navy vessel. The Coast Guard maintained a patrol of the waters of the North Pacific Ocean and Bering Sea and in addition rendered the fur-seal service valuable aid by transporting passengers, miscellaneous freight, and mail. The bureau's vessel *Eider* made a number of trips from Unalaska to the Pribilofs in the winter and was kept steadily employed throughout the regular sealing season. The usual seal census was taken and included this season a count of all the pups on both islands.

OFFICIAL VISIT BY ASSISTANT SECRETARY OF COMMERCE.

In connection with a general trip to Alaska, an official party headed by Hon. C. H. Huston, Assistant Secretary of Commerce, visited the Pribilof Islands in July. Mr. Huston, accompanied by Ward T. Bower, field assistant, Bureau of Fisheries, Dr. Leonhard Stejneger, United States National Museum, Lieut. Ellis Reed-Hill, engineer officer, United States Coast Guard cutter *Mojave*, Joe L. Baker, special assistant, and Capt. C. E. Lindquist, arrived at St. George on the United States Coast Guard cutter *Algonquin* July 11 and after making an inspection of the station and seal life, proceeded to St. Paul Island where they arrived July 12. Dr. Stejneger and Captain Lindquist left on the *Algonquin* the same day. The others remained at St. Paul Island until July 19 when they took passage on the U. S. Coast Guard cutter *Mojave*. During the week at St. Paul Island close attention was given to all the details of the station's work, particularly to sealing operations, which were at their height. A number of other members of Mr. Huston's party who did not go with him to the Pribilofs on the *Algonquin* arrived on the *Mojave* and were ashore at St. Paul for a brief period July 19.

PERSONNEL.

Superintendent A. H. Proctor, who had been detailed to the Washington office for a part of the winter of 1921–22, returned to the Pribilofs early in the spring by the Coast Guard cutter *Haida*, arriving at St. Paul Island April 25. Accompanying him were E. C. Johnston, storekeeper; A. Christoffersen, by-products expert; William A. Carter and Theodore C. Vick, sealing assistants; Charles Roof, Albert Harland, Joseph Movilla, Benjamin P. Gale, and Andrew Pearson, carpenters; and two Chinese cooks.

W. C. Allis, sealing assistant, left in May. Dr. Daniel L. Roland, who had been employed as dentist on St. Paul Island through the winter of 1921–22, went to St. George Island on duty in May and in June left for the States. Henry Mygatt, assistant to agent, and Edna C. Mygatt, school-teacher, left St. Paul Island for the States also in June.

William P. Zschorna, of the Fouke Fur Co., which dresses and dyes the Government's sealskins, and 12 assistants were detailed to St. Paul Island during the active sealing season to assist with the washing and blubbering of sealskins. G. Donald Gibbins, vice president of the Fouke Fur Co., was also at St. Paul Island for a few weeks in June and July.

In September the steamship *Brookdale* landed Lois L. Proctor and Harold W. Lashier, school-teachers, and Paul E. Moran, assistant to agent, at St. Paul Island, and Dr. George S. Lesher, physician, at St. George Island. Mr. Moran was later detailed to St. George Island for duty during the winter of 1922–23.

Leaving on the steamship *Brookdale* for the States in September were Henry D. Aller, agent and caretaker, E. C. Johnston, storekeeper, and two Chinese cooks, from St. Paul Island, and H. C. Scudder, storekeeper, and Dr. Wm. M. Murphy, physician, from St. George Island. A. Christoffersen left on the U. S. Coast Guard Cutter *Haida* in October. Four of the five carpenters left at various times during the season. Richard Culbertson was transferred from the position of school-teacher to that of sealing assistant. In December Dr. George B. Bowlby, who had tendered his resignation, was relieved by Dr. Robert E. Davis, who arrived on the *Eider*. Mrs. Catherine Davis was appointed nurse. Dr. Bowlby left St. Paul on the *Eider*.

PURCHASE AND TRANSPORTATION OF SUPPLIES.

The method of securing competitive bids for the general annual supplies required for the Pribilof Islands through the use of printed schedules, which has been followed uniformly for a number of years, was again employed in 1922. The supplies were shipped to the islands by the commercial steamer *Brookdale*, the vessel leaving Seattle August 21. The annual supplies for the bureau's vessel *Eider* were shipped at the same time and were delivered at Unalaska.

Unloading was accomplished speedily and the vessel left the Pribilofs September 24. It is estimated that the cargo consisted of approximately 2,500 tons.

Early in the year the bureau contracted with the Alaska Commercial Co. for delivery from the States to the Pribilof Islands of approximately 325 tons of salt, 600,000 feet of lumber, 310,000 shingles, 5,200 sacks of cement, 5 tons of bricks, and 20 tons of miscellaneous supplies. The salt was transported from San Francisco to the Pribilofs by the *Apollo*. The balance of the materials was shipped from Seattle on the steamship *Brookdale* to the Unalaska station of the Alaska Commercial Co., whence it was taken to the Pribilofs by the *Apollo*.

Other miscellaneous supplies were transported from Seattle on Coast Guard cutters through the courtesy of the U. S. Coast Guard and landed either at the islands or at Unalaska for transportation to the islands by the *Eider*.

POWER SCHOONER "EIDER."

The *Eider* has rendered very useful service in connection with activities at the Pribilof Islands, and during the calendar year 1922 made 13 trips to the Pribilofs, 1 to King Cove, 1 to Umnak, 2 to Belkofsky, and 2 to Akutan. The total number of miles cruised was 8,749 in 96 days. The actual running time was 1,228½ hours. Two hundred and three passengers, 320 tons of freight besides mail, 14 cases of fox skins, 50 barrels of sealskins, and 12 live foxes were carried.

CONSTRUCTION WORK.

St. Paul Island.—Construction was continued on the new water-tank house, and the four 40,000-gallon water tanks were set up. The roofing laid in 1921 was damaged in a gale in the fall of that year, and as the building is in a very exposed place it was deemed best to lay shingles over the original roof rather than to attempt repairs.

The roadway from the village to Northeast Point has never been in condition to permit more than lightly loaded wagons to make the trip. The distance between the places is about 12 miles, about 4 of which are over sand dunes. In bringing to the village sealskins taken at Northeast Point it is necessary to transport them by boats on the open sea, a hazardous undertaking, practicable only when the weather conditions are favorable, and subject to frequent delays. In order that these sealskins may be washed and blubbered at the village, as is now being done with the skins taken elsewhere on the island, they must receive attention within a few hours after removal from the seals. Material to lay wooden tracks for automobile trucks and tractors over the worst stretches of sand was shipped to St. Paul in 1922, and the work of grading and laying out those portions of the roadway that could be made usable without tracks was begun in the spring of that year and pushed vigorously until sealing operations demanded all the energies of the working force. It was decided to abandon the old bridge, now in a state of collapse, across

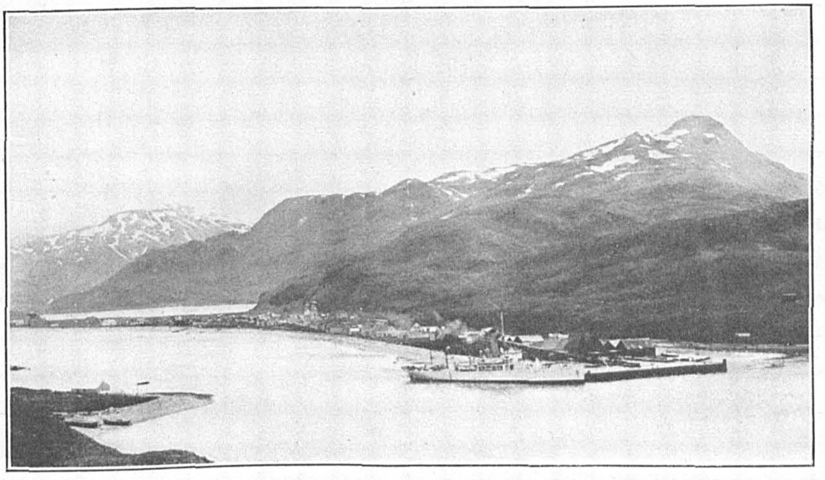

FIG. 13.—Unalaska, nearest port to Pribilof Islands.

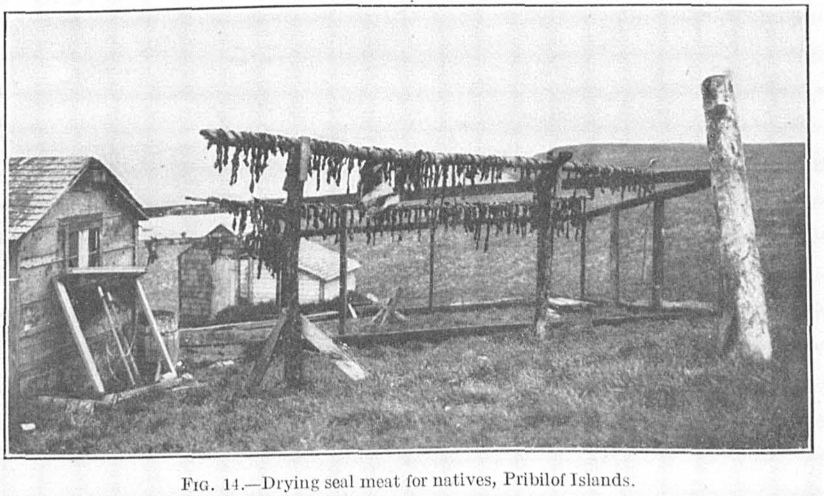

FIG. 14.—Drying seal meat for natives, Pribilof Islands.

the slough near Halfway Point and to carry the new road far enough inland to avoid the slough.

A building in which to wash and blubber sealskins was begun in 1921 and completed with two extensions in 1922. Work was continued on the new village salt house, which was used in its entirety in the sealing season, and on the addition to the old village salt house. The old salt house itself was torn down, and a more modern structure was begun on its site. There will thus be two large salt houses at the village. Work was begun on enlarging the "company" house, which is used as a mess house and living quarters for a part of the station employees.

A new boatway was begun at the warehouse at the village landing preparatory to replacing that warehouse with a building more suitable for the requirements. The work of building 20 privies for the use of the natives was carried to a point where all were available for use.

St. George Island.—A number of improvements were made to the landing facilities at the village on St. George Island. The solid rock floor of the slip was deepened about 18 inches for a distance of approximately 30 feet. A large amount of blasting was done to deepen the channel leading to the slip. Since the work was done under water it is difficult to determine accurately how much was accomplished, but it is known that boats can be operated at lower stages of the tide than formerly. About 1,000 pounds of 40 per cent dynamite were used. A concrete bulkhead was built across the inner end of the landing slip and provides valuable space for temporary storage of cargo and for the placing of boats. In December, 1921, the tramway leading from the wharf was destroyed by heavy seas. It was rebuilt in 1922, concrete replacing the previous frame and stone construction.

A dispensary and physician's quarters was built. The building has ground dimensions of 24 by 32 feet and provides an office, living room, bedroom, bath, and a large surgery on the lower floor and space for two small bedrooms on the upper floor. A building formerly used as a gun house was moved to a position adjoining the new dispensary, with which it will be connected by a vestibule and used as a hospital. A 20-foot addition was made to the schoolhouse.

The first concrete native dwelling was completed and occupied this year and a second building of this type was erected. Each of these contains a roomy vestibule, kitchen, living room, and three bedrooms on the first floor and space for two small bedrooms on the second floor. The work of installing a permanent water-supply system for the village was continued. The source of water will be Upper Lake.

WELL DRILLING.

The bureau cooperated in 1922, as in 1921, with the Navy Department in an effort to secure on St. Paul Island a supply of fresh water from a drilled well. Drilling was begun August 8 at a point between the radio-station buildings and the village cove and was continued until October 10. A depth of 415 feet was attained, but a supply of water was not located.

BY-PRODUCTS PLANT.

Early in the season the by-products plant was placed in readiness for active operations, and some improvements were made. The machinery was tested out the latter part of May, and oil remaining from 1921 was stored in barrels.

Actual operation of the plant was begun July 5 and continued every day until August 10, primarily for the production of oil from blubber to be used in preparing sealskins for the market. Fifteen cookings of seal blubber and two of seal carcasses were made, the latter for the purpose of securing required data.

In the season of 1922, 8,546 gallons of oil—consisting of 7,078 gallons blubber oil, 1,368 gallons press oil, and 100 gallons oil foots—and 1,935 pounds of seal meal were manufactured. The following shipments of fur-seal oil were made:

Shipments of fur-seal oil to Fouke Fur Co., 1922.

Kind of oil.	Year manufactured.	Date of shipment.	Vessel on which shipped.	Number of barrels.	Number of gallons.
Blubber	1921	July 31	U. S. S. Gold Star	11	493
Do	1922	...do	...do	19	905
Do	1921	Sept. 24	Steamship Brookdale	24	1,084
Press	1921	...do	...do	18	920
Blubber	1922	...do	...do	125	6,173
Press	1922	...do	...do	27	1,368
Total				224	10,943

NATIVES.

CENSUS.

An annual census is taken of the natives of the Pribilof Islands, including such details as are deemed of value for purposes of record. For several years the census has been taken as of March 31. This date has now been changed to December 31. The total number of natives actually residing on St. Paul Island on December 31, 1922, was 193, on St. George Island, 127, a total for both islands of 320.

Recapitulation of census of natives, Pribilof Islands, December 31, 1922.

St. Paul Island:	
Resident population on Mar. 31, 1921	188
Births, Apr. 1, 1921, to Dec. 31, 1922	9
	197
Deaths, Apr. 1, 1921, to Dec. 31, 1922	9
	188
Arrivals, Apr. 1, 1921, to Dec. 31, 1922	19
	207
Departures, Apr. 1, 1921, to Dec. 31, 1922	14
Resident population on Dec. 31, 1922	193
Other natives away from St. Paul Island but considered residents	11
Total natives accredited to St. Paul Island	204

Recapitulation of census of natives, Pribilof Islands—Continued.

St. George Island:	
Resident population on Mar. 31, 1921	122
Births, Apr. 1, 1921, to Dec. 31, 1922	11
	133
Deaths, Apr. 1, 1921, to Dec. 31, 1922	2
	131
Arrivals, Apr. 1, 1921, to Dec. 31, 1922	2
	133
Departures, Apr. 1, 1921, to Dec. 31, 1922	6
Resident population on Dec. 31, 1922	127
Other natives away from St. George Island but considered residents	6
Total natives accredited to St. George Island	133
Both islands:	
Total resident population on Dec. 31, 1922	320
Other natives away from islands but considered residents	17
Grand total natives accredited to Pribilof Islands	337

HEALTH CONDITIONS.

There were no features of special importance in respect to the health conditions of the natives. Numerous cases of impetigo occurred on St. Paul Island, and late in the summer and through the fall months there were many cases on St. George Island. There were no other epidemics and no serious accidents. Taking their race into consideration, the health of the Pribilof natives during 1922 may be considered to have been normal. A Unalaska native temporarily employed on St. Paul Island died there in the summer of 1922.

DENTAL WORK.

Dr. D. L. Roland, employed by the bureau as dentist for the natives, arrived at St. Paul Island August 4, 1921, and was continuously engaged in professional work there until May 13, 1922, when he left for St. George Island, arriving there May 14. He left the latter station for the States June 18. A large amount of the more necessary work was accomplished, but much remained to be done. It is hoped that in the future the bureau will be able to send a dentist to the islands for temporary duty on alternate years at least.

SCHOOLS.

St. Paul Island.—The school term of 1921–22 opened September 12 and closed about May 1. The senior school began with an enrollment of 13 boys and 13 girls. The pupils were divided into six classes, and individual instruction was given as far as possible. The course of instruction was similar to that of previous years. Particular emphasis was placed on the use of English. Attention was given to the subject of personal hygiene, and the dentist temporarily at the station through the winter gave weekly instruction in the care of the teeth and inaugurated tooth-brush drills. At the junior school 30 pupils were in attendance, their ages ranging from 5 to 10 years.

Special emphasis was placed on conversations in English, simple arithmetic, and writing. For the youngest pupils modified kindergarten methods were followed. Fair progress was reported for both schools.

St. George Island.—The senior school opened September 6, 1921, and closed April 10, 1922, having been in session 122½ days. The enrollment consisted of 16 boys and 22 girls, a total of 38. The average daily attendance was 37.5 and percentage of attendance about 99. The subjects taught were reading, arithmetic, spelling, writing, history, and geography. The junior school opened September 6, 1921, and closed May 15, 1922. The session opened with an enrollment of 6; 2 were dropped subsequently on account of their youth, and 1 was added from the senior school. Kindergarten methods were followed. A sewing class attended by 22 girls, divided into three classes, was conducted by the teacher of the junior school.

ATTENDANCE AT SALEM INDIAN TRAINING SCHOOL, CHEMAWA, OREG.

All the Pribilof Islands natives who were reported employed at the Salem Indian Training School or in attendance there on December 31, 1921, including Mrs. Akalina Fratis, Iuliania Fratis, Nicolai Stepetin, and Vasilii Stepetin, of St. Paul Island, and George Lekanof and Laurence Merculief, of St. George Island, left during 1922. Mrs. Akalina Fratis and Iuliania Fratis were at Marshfield, Oreg., according to last reports. Nicolai Stepetin returned to his home on St. Paul Island. George Lekanof, who it has developed was dropped from the school in 1921, returned to his home on St. George Island. Laurence Merculief left the school but did not return to his home. Vasilii Stepetin returned to St. Paul Island, where he was given employment as a temporary laborer. Inasmuch as his father has permanently given up his residence on the Pribilofs it is probable that he will not regard the islands as his home in the future. The only person to enter the school from the Pribilofs in 1922 was Serge Shaisnikoff, a 16-year-old boy of St. Paul Island, who entered the school on November 7.

SAVINGS ACCOUNTS.

Certain of the Pribilof Island natives have personal funds in the custody of the United States Commissioner of Fisheries. Through the year 1922 these funds were kept on deposit with the Washington Loan and Trust Co., Washington, D. C., and interest was paid at the rate of 3 per cent per annum, calculated on monthly balances. New accounts for two natives were opened during the year. A summary of the accounts as a whole for the year 1922 is shown in the statement that follows:

Balance on hand, Jan. 1, 1922	$2,726.23
Interest earned from Jan. 1 to Dec. 31, 1922	303.23
Deposited by natives in 1922	8,910.48
	11,939.94
Withdrawn by natives in 1922	106.00
Balance on hand, Dec. 31, 1922	11,833.94

An itemized statement of the account showing the individual balances of the natives follows:

Pribilof Islands natives' savings accounts in custody of U. S. Commissioner of Fisheries, as trustee, December 31, 1922.

St. Paul Island:	
Bourdukofsky, Appollon [1]	$95.92
Bourdukofsky, Peter	.90
Fratis, Agrippina [2]	98.57
Fratis, Akalina [2]	477.58
Fratis, Martha [2]	98.55
Fratis, Iuliania [2]	98.55
Gromoff, Iuliania	370.21
Kochutin, Alexandra [3]	4,516.02
Krukoff, Ekaterina	209.98
Krukoff, Iuleta	9.43
Mandregan, Alexandra M	10.83
Melovidov, Alfey	45.73
Melovidov, Anton	3.89
Melovidov, Iosef	45.73
Merculieff, Agafia	40.99
Merculieff, Dosofey	40.99
Merculieff, Makary	40.99
Merculieff, Mariamna	68.31
St. Paul Island—Continued.	
Merculieff, Paul A. [1]	$16.07
Pankoff, Agrippina	250.10
Pankoff, Maria M	45.74
Sedick, Feofania [1]	14.26
Sedick, Lavrenty	14.26
Sedick, Leonty	14.26
Sedick, Marina	.38
Tetoff, Vikenty M	45.73
St. George Island:	
Borenien, Zoya [1]	250.47
Galanin, Mary	35.53
Lestenkof, Michael	138.67
Merculief, Agrippina	19.40
Merculief, Joseph	35.78
Merculief, Polyxenia	19.70
Merculief, Stefanida [2]	4,618.52
Shane, Michael	41.45
Zacharof, Emanuel	.45
Total	11,833.94

PAYMENTS FOR TAKING SEALSKINS.

Continuing the practice of preceding years payments to certain persons engaged in the taking of sealskins in 1922 were made from funds advanced by the department's selling agents, the Fouke Fur Co., who were reimbursed subsequently from proceeds of sales of skins. The funds were deposited in a bank in Seattle and made payable to the order of the bureau's authorized and bonded agent at the Pribilofs. From these funds the natives of the Pribilofs were paid at the rate of 50 cents for each sealskin taken, four native foremen were given $200 for additional services, and the salaries of a number of sealing assistants and the wages of some natives from Unalaska and elsewhere temporarily employed at the islands were paid, the amounts earned by these persons being as follows:

Salaries of sealing assistants	$13,364.15
Wages of temporary native workmen	19,729.80
Amount earned by St. Paul natives	13,117.50
Amount earned by St. George natives	2,660.50
Total	48,871.95

St. Paul Island.—For the 26,035 sealskins taken on St. Paul Island in the calender year 1922 the resident natives received 50 cents per skin and in addition two foremen received $50 each for special

[1] Deceased.
[2] Not living on island in 1922.
[3] New account.

services. The natives were divided into classes according to their ability and work, and payments were made as follows:

Payments to St. Paul natives for sealing operations, calendar year 1922.

Classification.	Number of men.	Share of each.	Total.	Classification.	Number of men.	Share of each.	Total.
First class	27	$343.50	$9,274.50	Special class	1	$25.00	$25.00
Second class	5	274.00	1,370.00	Two foremen (additional compensation)			100.00
Third class	5	222.50	1,112.50	Total	47		13,117.50
Fourth class	3	171.50	514.50				
Fifth class	4	137.50	550.00				
Sixth class	2	85.50	171.00				

St. George Island.—For the 5,121 skins taken on St. George Island in the calendar year 1922 the resident natives received 50 cents per skin, and in addition two foremen received an aggregate of $100 for special services. As on St. Paul Island payments were made in accordance with rated ability and work.

Payments to St. George natives for sealing operations, calendar year 1922.

Classification.	Number of men.	Share of each.	Total.	Classification.	Number of men.	Share of each.	Total.
First class	18	$93.00	$1,674.00	Boy's class	1	$10.00	$10.00
Second class	4	75.00	300.00	Two foremen (additional compensation)			100.00
Third class	6	65.00	390.00	Total	33		2,660.50
Fourth class	3	55.00	165.00				
Fifth class	1	21.50	21.50				

PAYMENTS FOR TAKING FOX SKINS.

The natives of the Pribilof Islands are paid $5 for each fox skin taken. The take in the trapping season of 1921-22 was 159 on St. Paul Island and 574 on St. George Island, a total of 733, which accordingly yielded the St. Paul natives $795 and the St. George natives $2,870, a total of $3,665. On St. Paul Island the foxes are caught in steel traps, set at various places. Each native who participates in the trapping looks after a definite number of traps and receives $5 for each skin that he secures. On St. George Island no steel traps are used, and since almost all the fox skins taken are secured from foxes that enter the corral at the village trapping-house the work is necessarily a joint operation on the part of those participating. Consequently, the total payment for skins taken on St. George Island is divided among the workmen in accordance with what is considered the proper share of each. The funds for making the payments are advanced by the Fouke Fur Co., which recovers the outlay from the proceeds of sales of skins.

FUR-SEAL HERD.

QUOTA FOR KILLING.

On May 25, 1922, the Assistant Secretary of Commerce approved the bureau's recommendation that the quota of seals to be killed in the calendar year 1922 should be 25,000 three-year-old males. Of this number 21,500 were assigned as the St. Paul Island quota and

3,500 as the St. George Island quota. It was provided that the inter-island quota might be modified and that an increase or change in the aggregate total might be made if circumstances during the progress of the season should indicate such changes desirable.

On July 17 the Assistant Secretary of Commerce, who was then at the islands, increased the year's quota to 30,000 three-year-old males. This change was made after personal observation of conditions and after taking into account the increasing number of seals appearing on the hauling grounds. It was felt that the action in question was entirely compatible with the future welfare of the herd. For determination of the comparative market values of skins from 2-year-old and 3-year-old seals the Assistant Secretary also directed the killing of 200 two-year-old males, as far as practicable the larger animals of this class—that is to say, seals whose lengths are from 39 to 40¾ inches.

KILLINGS OF SEALS.

The total number of seals killed on both islands in 1922 was 31,156, of which 30,002 were 3-year-old males. The other 1,154 consisted in part of the 200 large 2-year-olds taken by direction of the Assistant Secretary and the balance almost altogether of 2 and 4 year-old males taken incidentally with the killing of the 3-year-olds. The 3-year-old class of males varies only 5 inches in length from the smallest to the largest, and as the length of the seal has to be judged by the eye before it is killed it is impossible to avoid killing a few that measure slightly under or over the desired size. Details regarding the killings are shown in the table below.

St. Paul Island.—In the calendar year 97 drives were made and 26,035 skins, including 1 from a seal found dead and 4 from seals killed at odd times, were secured.

St. George Island.—In the calendar year 33 drives were made and 5,121 skins, including 1 from a seal found dead and 2 from seals killed for fox food, were secured.

Seal killings on Pribilof Islands in 1922.

ST. PAUL ISLAND.

Date.	Serial No. of drive.	Hauling ground.	Skins secured.	Date.	Serial No. of drive.	Hauling ground.	Skins secured.
Feb. 4	1	Sea Lion Rock (Sivutch)	31	June 26	16	Vostochni (vicinities of rocks 64 and 70)	312
Apr. 28	......	.....do	1	June 27	17	Tolstoi	171
May 22	2	.....do	75	Do...	18	Gorbatch and Reef	483
May 27	......	Vostochni	2	June 28	19	Zapadni	202
May 29	3	Sea Lion Rock	100	June 29	20	Vostochni (vicinities of rocks 43, 49, and 53) and Morjovi (vicinity of rock 40)	433
June 9	......	Vostochni	1	Do...	21	Little Polovina	46
June 15	4	Sea Lion Rock (Sivutch)	124	Do...	22	Polovina	282
June 20	5	Polovina and Polovina Cliffs	70	June 30	23	Tolstoi	157
Do...	6	Vostochni (vicinities of rocks 49 and 53)	304	Do...	24	Lukanin	48
June 21	7	Lukanin	17	July 1	25	Vostochni (vicinities of rocks 64 and 70)	583
Do...	8	Tolstoi	143	July 2	26	Reef	1,700
Do...	9	Vostochni (vicinities of rocks 64 and 70)	185	July 3	27	Vostochni (vicinities of rocks 49 and 53) and Morjovi (vicinity of rock 40)	160
June 22	10	Gorbatch	105	Do...	28	Little Zapadni	64
Do...	11	Reef	16	Do...	29	Zapadni	221
June 23	12	Zapadni	81	July 5	30	Lukanin	63
June 24	13	Tolstoi	72	Do...	31	Tolstoi	307
Do...	14	Lukanin	95				
Do...	15	Vostochni (vicinities of rocks 49 and 53) and Morjovi (vicinity of rock 40)	269				

Seal killings on Pribilof Islands in 1922—Continued.

ST. PAUL ISLAND—Continued.

Date.	Serial No. of drive.	Hauling ground.	Skins secured.
July 6	32	Vostochni (vicinities of rocks 64 and 70)	554
Do.	33	Little Polovina	16
Do.	34	Polovina	541
July 7	35	Reef and Gorbatch	893
July 8	36	Vostochni (vicinities of rocks 49 and 53) and Morjovi (vicinity of rock 40)	251
Do.	37	Little Zapadni	13
Do.	38	Zapadni	241
Do.	39	Tolstoi	249
Do.	40	Lukanin	24
July 10	41	Little Polovina	44
Do.	42	Polovina	289
July 11	43	Vostochni (vicinity of rock 64)	692
Do.	44	Gorbatch	372
Do.	45	Reef	558
July 12	......	From seal found dead on Gorbatch	1
July 13	46	Vostochni (vicinity of rock 49) and Morjovi (vicinity of rock 36)	555
Do.	47	Tolstoi	230
Do.	48	Lukanin	138
July 14	49	Polovina, Little Polovina and Polovina Cliffs	141
July 15	50	Vostochni (vicinities of rocks 64 and 70)	506
Do.	51	Gorbatch	512
Do.	52	Reef	477
July 16	53	Zapadni	227
July 18	54	Reef	313
Do.	55	Gorbatch	163
Do.	56	Vostochni (vicinities of rocks 43, 49, 53) and Morjovi (vicinity of rock 36)	225
Do.	57	Lukanin	122
Do.	58	Tolstoi	230
July 20	59	Vostochni (vicinities of rocks 64 and 70)	587
Do.	60	Polovina Cliffs	50
Do.	61	Polovina and Little Polovina	205
July 21	62	Reef	142
Do.	63	Gorbatch	412
July 22	64	Vostochni (vicinities of rocks 43, 49, 53) and Morjovi (vicinity of rock 36)	335
Do.	65	Zapadni and Little Zapadni	497
July 23	66	Tolstoi	229
July 23	67	Lukanin and Kitovi	423
July 24	68	Polovina and Polovina Cliffs	320
Do.	69	Vostochni (vicinities of rocks 64 and 70)	463
July 25	70	Vostochni (vicinities of rocks 43, 49, 53) and Morjovi (vicinity of rock 36)	170
Do.	71	Gorbatch	631
Do.	72	Reef	435
July 26	73	Zapadni and Little Zapadni	222
July 27	74	Vostochni (vicinities of rocks 64 and 70)	440
Do.	75	Tolstoi	242
Do.	76	Lukanin	82
July 28	77	Vostochni (vicinities of rocks 43, 49, 53) and Morjovi (vicinity of rock 36)	127
Do.	78	Polovina Cliffs	19
Do.	79	Polovina and Little Polovina	149
July 29	80	Gorbatch	471
Do.	81	Reef	230
July 30	82	Vostochni (vicinities of rocks 64 and 70)	244
Do.	83	Zapadni and Little Zapadni	406
July 31	84	Vostochni (vicinities of rocks 43, 49, 53) and Morjovi (vicinity of rock 36)	239
Aug. 1	85	Tolstoi	103
Do.	86	Lukanin	22
Aug. 2	87	Vostochni (vicinities of rocks 64 and 70)	357
Do.	88	Reef and Gorbatch	544
Aug. 3	89	Vostochni (vicinity of rock 49) and Morjovi (vicinity of rock 36)	137
Do.	90	Zapadni	382
Aug. 4	91	Lukanin	59
Do.	92	Tolstoi	38
Aug. 5	93	Vostochni (vicinities of rocks 49, 53, 64, 70) and Morjovi (vicinity of rock 36)	170
Do.	94	Reef and Gorbatch	329
Oct. 21	95	Gorbatch	201
Oct. 26	96	Reef	215
Nov. 1	97	Vostochni	208
		Total	26,035

ST. GEORGE ISLAND.

Date.	Serial No. of drive.	Hauling ground.	Skins secured.
June 8	1	North, Staraya Artil and East Cliffs	28
June 13	2	North and Staraya Artil	21
June 16	3	Staraya Artil	14
June 17	4	North	17
June 20	5	East Cliffs	42
June 21	6	Zapadni	8
June 23	7	North and Staraya Artil	73
June 26	8	East Cliffs	81
June 28	9	North and Staraya Artil	86
June 29	10	Zapadni	28
June 30	11	East Cliffs	103
July 3	12	North and Staraya Artil	118
July 5	......	From seal found dead	1
July 6	13	East Cliffs	294
July 7	14	Zapadni	63
July 8	15	North and Staraya Artil	132
July 10	16	East Cliffs	135
July 12	17	North and Staraya Artil	284
July 13	18	Zapadni	35
July 15	19	East Cliffs	596
July 17	20	Staraya Artil	144
July 19	21	North and East Cliffs	606
July 20	22	Zapadni	40
July 22	23	North, East Cliffs, and Staraya Artil	586
July 26	24	North	185
July 27	25	Zapadni	50
July 28	26	Staraya Artil	217
July 29	27	North, East Reef, and East Cliffs	303
Aug. 2	28	North, Staraya Artil, and East Reef	498
Aug. 5	29	East Reef	61
Sept. 11	......	North	[1] 2
Oct. 20	30	North	18
Oct. 21	31	East Cliffs and East Reef	119
Oct. 26	32	North and Staraya Artil	180
Nov. 9	33	Zapadni	3
		Total	5,121

[1] Seals killed for food for foxes awaiting shipment.

AGE CLASSES OF SEALS.

The method by which the sizes of male seals of the various age classes have been determined has been described in previous reports. For convenience the limits of these age classes are shown in the following table:

Age standards of body lengths of male seals, Pribilof Islands.

Age.	Lengths of summer seals.	Lengths of fall seals.	Age.	Lengths of summer seals.	Lengths of fall seals.
	Inches.	*Inches.*		*Inches.*	*Inches.*
Yearlings	Up to 36.75	Up to 38.75	4-year-olds	46 to 51.75	48 to 53.75
2-year-olds	37 to 40.75	39 to 42.75	5-year-olds	52 to 57.75	54 to 59.75
3-year-olds	41 to 45.75	43 to 47.75	6-year-olds	58 to 63.75	60 to 65.75

Ages of seals killed on Pribilof Islands, calendar year 1922.

Age.	Summer (Jan. 1 to Aug. 5).			Fall (Aug. 6 to Dec. 31)			Total for year.		
	St. Paul.	St. George.	Total.	St. Paul.	St. George.	Total.	St. Paul.	St. George.	Both Islands.
Yearlings	8		8				8		8
2-year-olds	510	26	536	17	13	30	527	39	566
3-year-olds	24,398	4,755	29,153	602	247	849	25,000	5,002	30,002
4-year-olds	416	45	461		10	10	416	55	471
5-year-olds	8	1	9				8	1	9
6-year-olds	4		4				4		4
7-year-olds and over		2	2		1	1		3	3
Cows [1]	67	20	87	5	1	6	72	21	93
Total	*25,411*	*4,849*	*30,260*	*624*	*272*	*896*	*26,035*	*5,121*	*31,156*

[1] The few cows reported above, less than one-third of 1 per cent of the total taken, were accidentally and unavoidably killed. Every possible effort is made to avoid the killing of cows, but persons familiar with conditions at the islands will readily appreciate that in handling such a large number of seals a small number of cows will be killed.

BRANDED SEALS.

Only one of the seals branded when pups in 1912 was secured in 1922. The animal was taken on St. George Island at North rookery, October 20, 1922. Data were secured as follows: Length, 76¾ inches; total weight after bleeding, 283 pounds; dimensions of green skin, 80 by 51 inches; weight of skin, 41 pounds.

WASHING AND BLUBBERING SEALSKINS.

In 1922 the Fouke Fur Co. carried on its work of washing and blubbering sealskins on St. Paul Island on a more extended scale than in previous years. A permanent building, 70 by 42 feet, constructed for this work, was used. It is known as the washhouse and contains five large wooden tanks, in which the skins to be blubbered are first washed and cooled in salt water pumped from the beach near by, facilities for 10 men to work at blubbering, and a power wringer to extract surplus water from blubbered skins.

The freshly taken sealskins are brought to the washhouse, where they are placed in the tanks and quickly chilled by running sea water to below 40° F. All dirt and other foreign matter are removed by the free use of a pressure hose. The blubber is removed from the pelts by dull, curved knives, the operation being called blubbering. The skins are then run through a large wringer to extract surplus water and are then packed in salt for curing.

The blubbering of the skins before they are salted makes it possible to skin the seals in a more expeditious manner. Formerly the skins had to be removed by cutting away every portion with a knife. They could not be pulled off without leaving too much blubber on the pelts to permit their being cured in salt. When the pelts are blubbered before they are salted, however, the amount of blubber adhering to the skins at the time of removal from the animals is immaterial. Skins that are to be blubbered before salting are now removed by pulling them off the carcasses after a few cuts have been made along the lines that become the edges of the pelt, thus eliminating the former more or less frequent and practically unavoidable cutting of pelts. Another advantage claimed for the blubbering of skins before salting is that the time required for curing is greatly reduced, thus insuring complete curing before any decay starts.

In 1922 there were washed on St. Paul Island 15,752 skins. Of these 15,748 were blubbered and 4 were placed in salt without blubbering for experimental purposes. The washing and blubbering of sealskins was not undertaken on St. George Island in 1922. It was thought best to develop the work thoroughly on St. Paul Island first.

CENSUS.

The census of the Pribilof fur-seal herd was again taken by Edward C. Johnston in 1922. His report is printed in full on pages 111 to 118. The two counting towers used on Reef rookery in 1921 and nine more erected in the spring of 1922—two on Little Zapadni (St. Paul), three on Zapadni (St. Paul), three on Vostochni (St. Paul), and one on Staraya Artil (St. George)—were used. For the first time in a number of years the pups were counted on all the rookeries. Conditions made it impossible to enumerate every pup, but at least 95 per cent of all were actually counted.

The following is a comparative statement of the numerical strength of the various elements of the herd in the years 1912 to 1922, inclusive:

General comparison of recent censuses of the seal herd on Pribilof Islands.

Classes.	1912	1913	1914	1915	1916
Harem bulls	1,358	1,403	1,559	2,151	3,500
Breeding cows	81,984	92,269	93,250	103,527	116,977
Idle bulls	113	105	172	673	2,632
Young bulls (chiefly 5-year-olds)	199	259	1,658	....	....
6-year-old males	....	....	....	....	11,167
5-year-old males	....	....	....	11,271	15,494
4-year-old males	100	2,000	9,939	15,848	16,427
3-year-old males	2,000	10,000	13,880	18,282	19,402
2-year-old males	11,000	15,000	17,422	23,990	24,169
Yearling males	13,000	20,000	23,068	30,307	33,645
2-year-old cows	11,000	15,000	17,422	23,990	24,245
Yearling cows	13,000	20,000	23,067	30,306	33,646
Pups	81,984	92,269	93,250	103,527	116,977
Total	215,738	268,305	294,687	363,872	417,281

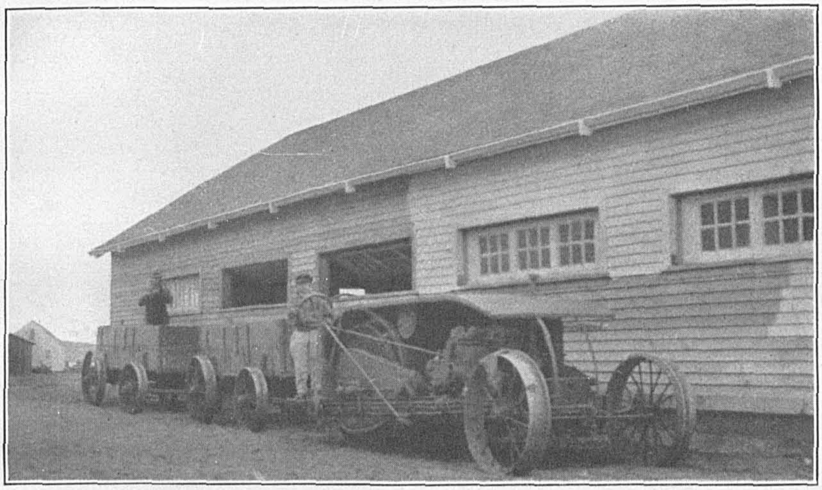

FIG. 15.—Delivering sealskins at washhouse, St. Paul Island.

FIG. 16.—Blubbering sealskins, St. Paul Island.

General comparison of recent censuses of the seal herd, etc.—Continued.

Classes.	1917	1918	1919	1920	1921	1922
Harem bulls	4,850	5,344	5,158	4,066	3,909	3,562
Breeding cows	128,024	142,915	157,172	167,527	176,655	185,914
Surplus bulls	8,977	17,110	9,619	6,115	3,301	2,346
Idle bulls	2,706	2,444	2,239	1,161	747	508
6-year-old males	15,397	13,755	8,901	4,153	3,991	3,771
5-year-old males	14,813	11,941	5,282	5,007	4,729	6,060
4-year-old males	16,631	7,114	5,747	5,667	6,780	11,807
3-year-old males	19,507	9,117	13,596	10,749	14,668	7,459
2-year-old males	26,815	30,159	33,081	39,111	41,893	40,920
Yearling males	38,013	41,595	46,444	51,074	50,249	52,988
2-year-old cows	26,917	30,415	33,287	39,480	43,419	46,280
Yearling cows	38,018	41,608	46,447	51,081	54,447	57,413
Pups	*128,024*	*142,915*	*157,172*	*167,527*	*176,655*	*185,914*
Total	468,692	496,432	524,235	552,718	581,443	604,962

CHARTING OF HAREM AREAS.

In connection with the census the harem areas were platted on the Coast and Geodetic Survey charts of the rookeries. This was done at the time the harem counts were made, which was at the height of the breeding season. A comparison of the extent of these areas with that of the corresponding areas platted in 1916 shows no great change in size. It is not the total number of seals on the breeding grounds that determines the area occupied but the positions taken up by the harem bulls at the beginning of the breeding season. The number of harem bulls 1922 was practically the same as in 1916, and it is entirely consistent that the breeding areas should be about the same in the two years regardless of the fact that the number of breeding cows increased from 116,977 in 1916 to 185,914 in 1922. The increased number of cows simply increased the number of breeding animals per unit of breeding area.

PHOTOGRAPHS OF SEAL ROOKERIES.

The stations used in taking photographs in 1917 were reoccupied and a comparable set of views was obtained. Unfavorable landing conditions made necessary the omission of Sea Lion Rock (Sivutch rookery) from the series in 1922. Although satisfactory views as a whole were obtained, the maximum results were not possible because of rain and fog just at the time when the photographs had to be taken if the views were to be comparable with previous ones.

To serve as an index to the location and direction from which these photographs were taken these data were platted on photographic reductions of the rookery charts. No chart is available for South Rookery on St. George, as it has originated since the series of charts was made.

It is expected that from the counting towers already erected for the census work and from additional ones to be erected a comprehensive series of panoramic views of the herd may be secured, which will better serve the purpose of photographic records of these rookeries.

SPECIMEN SEALS.

In 1922 from among seals found dead 16 were selected and preserved as specimens, including 2 bulls, 2 five-year-old males, 2 three-year-old males, 2 two-year-old males, 2 yearling males, 2 black pups, 2 gray pups, and 2 three-year-old females. The specimens were sold to the Fouke Fur Co., St. Louis, for $56.

FOXES.

FOX-TRAPPING SEASON OF 1922–23.

The season's take of fox pelts on both islands consisted of 888 blue and 29 white pelts, a total of 917.

On St. Paul Island trapping began December 18 and ended December 30, 1922. Forty-four native men engaged in the work, and 532 traps were used. In all 233 pelts were secured, of which 205 were blue and 28 white.

On St. George Island trapping began in December, 1922, and continued until March 8, 1923. Trapping to secure pelts ceased, however, on February 18 when signs of mating were observed, trapping thereafter being solely for the purpose of securing additional data in regard to the breeding reserves. Including 2 blue-fox pelts secured in November, 1922, from animals found dead, the take of pelts for the season consisted of 683 blue and 1 white, a total of 684 pelts. The total number of foxes marked and released as breeders was 304, of which 147 were males and 157 females. The actual breeding reserve was considerably more than 304, since many animals did not enter the traps at all.

Trapping on St. George Island was again very much handicapped by the prevailing warm and wet weather. Foxes will enter the trapping corral at the village only under the urge of hunger. Snow and ice cut off the natural sources of food to a large extent, and under those conditions the foxes enter the corral much more readily than when open weather makes available considerable food at other places on the island.

SALE OF BLUE FOXES.

To assist private enterprise in blue-fox farming the bureau sold 12 live animals from the Pribilof herds in 1922. They were secured on St. George Island and delivered at Unalaska by the fisheries vessel *Eider* in September. The price was $175 per animal, which was somewhat above the current market for pelts. The animals were sold to the following persons: John Mattick, Seward, Alaska, 4 pairs; H. Whittlesey, Seward, Alaska, 1 pair; and Charles Williamson, Unalaska, Alaska, 2 females. From the $2,100 received in payment $60 ($5 per fox) was divided among the St. George natives employed in capturing and shipping the animals. The balance, $2,040, was available for the United States Treasury.

REINDEER.

The reindeer herds on St. Paul and St. George Islands are a valuable source of fresh meat for both the bureau's personnel and the natives. The herds are being drawn upon for food purposes to an increasing extent, but the number remaining at the end of each year, with the exception, for reasons unknown, of St. Paul Island in 1922, has increased. The forage is ample to support herds much larger than those existing at present. The animals run at large and are very wild, the native men of the islands not having much aptitude for handling them. In 1922 on St. Paul Island 38 reindeer were killed for food and on St. George Island 22, a total of 60.

Reindeer herd on the Pribilof Islands, 1911–1922.

Year.	St. Paul Island.				St. George Island.				Grand total.	
	Adults.	Fawns.	Total, end of year.	Killed in year.	Adults.	Fawns.	Total, end of year.	Killed in year.	End of year.	Killed in year.
1911	[1] 25	....	25	....	[3] 15	....	15	....	40	....
1912	[2] 23	17	40	....	[2] 14	11	25	....	65	....
1913	[4] 34	18	52	....	[5] 25	13	38	....	90	....
1914	[6] 51	24	75	....	[7] 37	21	58	....	133	....
1915	65	27	92	....	44	18	62	....	154	....
1916	....	....	111	....	54	31	85	2	196	2
1917	105	39	144	....	70	26	96	3	240	3
1918	120	40	160	2	....	....	114	18	274	20
1919	....	....	164	14	....	....	123	22	287	36
1920	....	....	192	22	....	....	125	31	317	53
1921	....	....	250	34	....	....	160	19	410	53
1922	....	....	190	38	....	....	200	22	390	60

[1] 21 females.
[2] 12 females.
[3] 20 females.
[4] 25 females.
[5] 21 females.
[6] 36 females.
[7] 26 females.

PRIBILOF FUR-SEAL SKINS.

SHIPMENTS AND SALES.

In the calendar year 1922 three shipments of sealskins, consisting of 31,381 commercial skins, and 16 specimen skins, were made from the Pribilof Islands. On July 31 there were placed aboard the U. S. S. *Gold Star* at St. Paul Island 48 barrels, containing 2,358 sealskins, of which 718 were of the 1921 take and 1,640 of the 1922. They arrived at Seattle August 11 and were at once forwarded by freight to the Fouke Fur Co., St. Louis, arriving there September 9.

On August 12 there were placed aboard the fisheries vessel *Eider* at St. Paul Island 50 barrels, containing 2,601 sealskins, which were taken to Akutan and placed aboard the steamship *Cordova*. This vessel left Akutan August 22, and the skins were received at St. Louis September 19.

A third shipment, made on the steamship *Brookdale*, consisted of 334 barrels containing 21,170 commercial sealskins and 2 barrels containing specimen sealskins from St. Paul Island, and 103 barrels containing 5,252 skins from St. George Island. The St. George shipment consisted of 403 skins taken in 1921 and the 4,849 taken in 1922 through August 5. The *Brookdale* left the Pribilofs September 24 and landed the skins at Seattle October 26. They were immediately forwarded by freight to the Fouke Fur Co., arriving at St. Louis November 9.

Two sales of fur-seal skins from the Pribilof Islands—some dressed, dyed, and machined, and others that had not been passed through the full process of dressing, dyeing, and machining—were held in St. Louis, Mo., during the calendar year 1922. In all 30,172 skins were sold at auction for $924,343.05. The table below gives the details regarding the prices secured for each lot of skins at each of the sales, and the table on page 99 is a summary showing the prices obtained for the skins in the various trade classes and the percentages that the number of skins in these several classes bore to the totals in each sale.

April 3, 1922.—At the sale on this date 12,198 dressed, dyed, and machined Pribilof skins were sold for $388,069.75, an average price per skin of $31.81, a decrease of 3.6 per cent as compared with corresponding skins sold at the last previous sale September 28, 1921. There were also sold 579 culls and rejects, consisting of 249 dressed and dyed, 117 dressed, 121 washed and dried, and 92 raw skins, which brought $218.25.

October 9, 1922.—At the sale on this date 17,194 dressed, dyed, and machined Pribilof skins were sold for $535,967.50, an average price per skin of $31.17, a decrease of 2 per cent as compared with corresponding skins sold at the last previous sale April 3, 1922. There were also sold 164 raw, washed, and dried skins and 37 raw salted skins, which brought $87.55.

Sales of Pribilof fur-seal skins at St. Louis, Mo., 1922.

SALE OF 12,198 DRESSED, DYED, AND MACHINED SKINS, APRIL 3, 1922.

Lot No.	Number of skins.	Trade classification.	Price per skin.	Total for lot.	Lot No.	Number of skins.	Trade classification.	Price per skin.	Total for lot.
1	50	Wigs	$46.00	$2,300.00	46	90	Medium	$37.00	$3,330.00
2	40	....do	47.00	1,880.00	47	90	....do	36.00	3,240.00
3	50	Wigs; cut, scarred, etc	29.00	1,450.00	48	90	....do	36.50	3,285.00
					49	90	....do	36.50	3,285.00
4	50	....do	29.50	1,475.00	50	90	....do	38.00	3,420.00
5	60	Extra extra large	63.00	3,780.00	51	90	....do	37.00	3,330.00
6	60	....do	63.00	3,780.00	52	90	....do	38.00	3,420.00
7	50	Extra extra large; cut, scarred, etc	42.50	2,125.00	53	90	....do	37.00	3,330.00
					54	90	....do	37.00	3,330.00
8	70	Extra large	52.00	3,640.00	55	90	....do	36.00	3,240.00
9	70	....do	54.00	3,780.00	56	90	....do	38.50	3,465.00
10	70	....do	55.50	3,885.00	57	90	....do	39.00	3,510.00
11	70	....do	55.00	3,850.00	58	90	....do	37.50	3,375.00
12	70	....do	55.00	3,850.00	59	90	....do	37.50	3,375.00
13	70	....do	59.00	4,130.00	60	90	....do	37.00	3,330.00
14	70	....do	60.00	4,200.00	61	90	....do	37.00	3,330.00
15	70	....do	60.00	4,200.00	62	90	....do	37.50	3,375.00
16	70	Extra large; cut, scarred, etc	43.00	3,010.00	63	90	....do	37.00	3,330.00
					64	90	....do	38.00	3,420.00
17	70	....do	43.00	3,010.00	65	90	....do	37.00	3,330.00
18	70	....do	44.00	3,080.00	66	90	....do	37.00	3,330.00
19	80	Large	50.00	4,000.00	67	90	....do	36.00	3,240.00
20	80	....do	50.00	4,000.00	68	90	....do	37.50	3,375.00
21	80	....do	51.50	4,120.00	69	90	....do	37.00	3,330.00
22	80	....do	47.00	3,760.00	70	90	Medium; cut, scarred, etc	30.00	2,700.00
23	80	....do	49.00	3,920.00					
24	80	....do	50.00	4,000.00	71	90	....do	26.00	2,340.00
25	80	....do	50.50	4,040.00	72	90	....do	26.00	2,340.00
26	80	....do	50.50	4,040.00	73	90	....do	26.50	2,385.00
27	80	....do	50.00	4,000.00	74	90	....do	26.00	2,340.00
28	80	....do	54.00	4,320.00	75	90	....do	26.00	2,340.00
29	80	....do	53.00	4,240.00	76	90	....do	26.00	2,340.00
30	80	....do	51.00	4,080.00	77	90	....do	26.00	2,340.00
31	80	....do	55.00	4,400.00	78	90	....do	26.50	2,385.00
32	80	Large; cut, scarred, etc	39.00	3,120.00	79	90	....do	26.00	2,340.00
					80	90	....do	26.50	2,385.00
33	80	....do	41.00	3,280.00	81	90	....do	26.50	2,385.00
34	80	....do	41.50	3,320.00	82	90	....do	26.50	2,385.00
35	90	Medium	41.00	3,690.00	83	90	....do	26.00	2,340.00
36	90	....do	39.50	3,555.00	84	90	....do	26.50	2,385.00
37	90	....do	37.50	3,375.00	85	90	....do	26.50	2,385.00
38	90	....do	37.50	3,375.00	86	90	....do	26.50	2,385.00
39	90	....do	36.00	3,240.00	87	90	....do	26.50	2,385.00
40	90	....do	36.50	3,285.00	88	90	Small medium	28.50	2,565.00
41	90	....do	36.50	3,285.00	89	90	....do	27.50	2,475.00
42	90	....do	37.50	3,375.00	90	90	....do	28.50	2,565.00
43	90	....do	36.50	3,285.00	91	90	....do	28.50	2,565.00
44	90	....do	37.00	3,330.00	92	90	....do	28.50	2,565.00
45	90	....do	38.00	3,420.00	93	90	....do	28.50	2,565.00

Sales of Pribilof fur-seal skins at St. Louis, Mo., 1922—Continued.

SALE OF 12,198 DRESSED, DYED, AND MACHINED SKINS, APRIL 3, 1922—Contd.

Lot No.	Number of skins.	Trade classification.	Price per skin.	Total for lot.
94	90	Small medium	$28.50	$2,565.00
95	90	.....do	29.00	2,610.00
96	70	.....do	28.00	1,960.00
97	90	Small medium; cut, scarred, etc	23.50	2,115.00
98	90	.....do	22.50	2,025.00
99	90	.....do	22.50	2,025.00
100	90	.....do	22.50	2,025.00
101	90	.....do	22.00	1,980.00
102	90	.....do	22.50	2,025.00
103	90	.....do	23.00	2,070.00
104	90	.....do	22.50	2,025.00
105	90	.....do	22.50	2,025.00
106	90	.....do	22.00	1,980.00
107	90	.....do	22.00	1,980.00
108	50	III Wigs	10.50	525.00
109	50	.....do	10.00	500.00
110	30	.....do	10.00	300.00
111	50	III, 31 extra large, 19 large	15.50	775.00
112	80	III, 37 medium, 43 small medium	11.00	880.00
113	20	IV Wigs	5.00	100.00
114	50	Wigs	60.00	3,000.00
115	50	.....do	58.00	2,900.00
116	50	.....do	58.00	2,900.00
117	58	.....do	53.00	3,074.00
118	50	Wigs; cut, scarred, etc	29.50	1,475.00
119	50	.....do	28.50	1,425.00
120	50	.....do	28.50	1,425.00
121	50	.....do	29.00	1,450.00
122	50	.....do	28.00	1,400.00
123	50	.....do	28.00	1,400.00
124	50	.....do	28.50	1,425.00
125	50	.....do	29.00	1,450.00
126	50	.....do	30.00	1,500.00
127	50	.....do	29.00	1,450.00
128	50	.....do	29.50	1,475.00
129	22	.....do	31.50	693.00
130	33	Extra extra large	62.00	2,046.00
131	50	Extra extra large; cut, scarred, etc	44.00	2,200.00
132	27	.....do	43.50	1,174.50
133	44	Extra large	57.00	2,508.00
134	50	Extra large; cut, scarred etc	41.00	2,050.00
135	23	.....do	40.00	920.00
136	50	Large	48.00	2,400.00
137	25	.....do	53.50	1,337.50
138	50	Large; cut, scarred, etc	35.00	1,750.00

Lot No.	Number of skins.	Trade classification.	Price per skin.	Total for lot.
139	37	Large; cut, scarred, etc.	$37.50	$1,387.50
140	80	Medium	35.00	2,800.00
141	80	Medium; cut, scarred, etc	26.50	2,120.00
142	37	22 medium, 15 small medium	26.50	980.50
143	28	16 medium; cut, scarred, etc., 12 small medium; cut, scarred, etc	21.00	588.00
144	50	III Wigs	6.50	325.00
145	50	.....do	6.00	300.00
146	50	.....do	5.50	275.00
147	50	.....do	5.50	275.00
148	50	.....do	5.50	275.00
149	50	.....do	5.50	275.00
150	50	.....do	5.50	275.00
151	50	.....do	6.00	300.00
152	50	.....do	6.00	300.00
153	50	.....do	6.50	325.00
154	50	.....do	6.00	300.00
155	50	.....do	6.50	325.00
156	50	.....do	6.50	325.00
157	50	.....do	6.50	325.00
158	50	.....do	7.00	350.00
159	42	.....do	6.50	273.00
160	55	III, 14 extra extra large, 4 extra large, 7 large, 5 medium, 25 small medium	13.50	742.50
161	50	IV Wigs	1.50	75.00
162	50	.....do	2.00	100.00
163	50	.....do	2.00	100.00
164	50	.....do	1.50	75.00
165	50	.....do	2.25	112.50
166	50	.....do	3.00	150.00
167	50	.....do	2.25	112.50
168	50	.....do	2.25	112.50
169	50	.....do	1.50	75.00
170	50	.....do	1.50	75.00
171	50	.....do	1.75	87.50
172	50	.....do	1.50	75.00
173	50	.....do	1.75	87.50
174	40	IV, 28 wigs, 8 extra extra large, 2 extra large, 2 large	1.50	60.00
175	27	Skins, damaged	8.25	222.75
	12,198			388,069.75

SALE OF 579 MISCELLANEOUS SKINS, APRIL 3, 1922.

Lot No.	Number of skins.	Trade classification.	Price per skin.	Total for lot.
176	72	Dressed and dyed	$0.50	$36.00
177	177	.....do	.50	88.50
178	117	Dressed	.50	58.50
179	121	Washed and dried	$0.25	$30.25
180	92	Raw	.054	5.00
	579			218.25

SALE OF 17,194 DRESSED, DYED, AND MACHINED SKINS, OCTOBER 9, 1922.

Lot No.	Number of skins.	Trade classification.	Price per skin.	Total for lot.
1	50	Wigs	$51.00	$2,550.00
2	50	.....do	51.00	2,550.00
3	50	Wigs; cut, scarred, etc	32.00	1,600.00
4	50	.....do	32.50	1,625.00
5	39	.....do	34.50	1,345.50
6	60	Extra extra large	59.00	3,540.00
7	60	.....do	60.00	3,600.00
8	68	.....do	62.00	4,216.00
9	60	Extra extra large; cut, scarred, etc	39.00	2,340.00
10	50	.....do	41.00	2,050.00
11	22	.....do	43.00	946.00
12	70	Extra large	$59.00	$4,130.00
13	70	.....do	56.00	3,920.00
14	70	.....do	56.00	3,920.00
15	70	.....do	56.00	3,920.00
16	70	.....do	59.50	4,165.00
17	70	.....do	60.00	4,200.00
18	44	.....do	61.00	2,684.00
19	44	.....do	59.00	2,596.00
20	70	Extra large; cut, scarred, etc	39.00	2,7 0.00
21	70	.....do	37.00	2,590.00
22	70	.....do	36.00	2,520.00
23	70	.....do	40.00	2,800.00

Sales of Pribilof fur-seal skins at St. Louis, Mo., 1922—Continued.

SALE OF 17,194 DRESSED, DYED, AND MACHINED SKINS, OCTOBER 9, 1922—Contd.

Lot No.	Number of skins.	Trade classification.	Price per skin.	Total for lot.
24	70	Extra large; cut, scarred, etc.	$30.00	$2,730.00
25	62	....do	28.00	2,356.00
26	80	Large	48.00	3,840.00
27	80	....do	47.00	3,760.00
28	80	....do	48.00	3,840.00
29	80	....do	48.50	3,880.00
30	80	....do	50.50	4,040.00
31	80	....do	47.00	3,760.00
32	80	....do	46.00	3,680.00
33	80	....do	50.00	4,000.00
34	80	....do	48.50	3,880.00
35	80	....do	46.00	3,680.00
36	80	....do	48.00	3,840.00
37	80	....do	47.00	3,760.00
38	80	....do	46.00	3,680.00
39	80	....do	48.00	3,840.00
40	80	....do	49.50	3,960.00
41	80	....do	45.00	3,600.00
42	80	....do	48.00	3,840.00
43	80	....do	45.50	3,640.00
44	80	....do	46.50	3,720.00
45	80	....do	46.00	3,680.00
46	80	....do	45.00	3,600.00
47	80	....do	47.00	3,760.00
48	80	....do	46.00	3,680.00
49	80	....do	47.00	3,760.00
50	80	....do	47.50	3,800.00
51	80	....do	49.00	3,920.00
52	80	....do	48.00	3,840.00
53	80	....do	46.00	3,680.00
54	80	....do	48.50	3,880.00
55	80	....do	47.50	3,800.00
56	80	....do	46.00	3,080.00
57	80	....do	47.50	3,800.00
58	80	....do	57.00	4,560.00
59	73	....do	48.00	3,504.00
60	80	Large; cut	36.00	2,880.00
61	80	....do	36.50	2,920.00
62	80	....do	35.00	2,800.00
63	80	....do	34.00	2,720.00
64	80	....do	34.00	2,720.00
65	80	....do	32.50	2,600.00
66	80	....do	33.00	2,640.00
67	80	....do	32.50	2,600.00
68	80	....do	32.00	2,560.00
69	80	....do	33.50	2,680.00
70	80	....do	33.00	2,640.00
71	80	....ho	32.50	2,600.00
72	80	....do	32.50	2,600.00
73	80	....do	32.50	2,600.00
74	80	....do	32.50	2,600.00
75	80	....do	33.00	2,640.00
76	80	....do	34.50	2,760.00
77	80	....do	33.00	2,640.00
78	80	....do	35.00	2,800.00
79	80	....do	34.50	2,760.00
80	80	....do	33.50	2,680.00
81	80	....do	33.00	2,640.00
82	80	....do	33.00	2,640.00
83	48	....do	32.50	1,560.00
84	47	....do	34.50	1,621.50
85	90	Medium	35.00	3,150.00
86	90	....do	34.50	3,105.00
87	90	....do	36.00	3,240.00
88	90	....do	34.00	3,060.00
89	90	....do	35.00	3,150.00
90	90	....do	34.00	3,060.00
91	90	....do	33.50	3,015.00
92	90	....do	34.00	3,060.00
93	90	....do	33.50	3,015.00
94	90	....do	33.00	2,970.00
95	90	....do	32.50	2,925.00
96	90	....do	34.00	3,060.00
97	90	....do	32.50	2,925.00
98	90	....do	34.00	3,060.00
99	90	....do	34.00	3,060.00
100	90	Medium	$34.50	$3,105.00
101	90	....do	33.00	2,970.00
102	90	....do	33.00	2,970.00
103	90	....do	33.50	3,015.00
104	90	....do	33.00	2,970.00
105	90	....do	32.50	2,925.00
106	90	....do	32.00	2,880.00
107	90	....do	32.50	2,925.00
108	90	....do	31.50	2,835.00
109	90	....do	31.50	2,835.00
110	90	....do	30.50	2,745.00
111	90	....do	30.50	2,745.00
112	90	....do	30.50	2,745.00
113	90	....do	30.50	2,745.00
114	90	....do	30.50	2,745.00
115	90	....do	35.00	3,150.00
116	90	....do	32.50	2,925.00
117	90	....do	31.50	2,835.00
118	90	....do	31.50	2,835.00
119	90	....do	30.50	2,745.00
120	90	....do	31.50	2,835.00
121	90	....do	31.00	2,790.00
122	90	....do	30.50	2,745.00
123	90	....do	30.50	2,745.00
124	90	....do	30.00	2,700.00
125	90	....do	31.00	2,790.00
126	90	....do	31.50	2,835.00
127	90	....do	30.00	2,700.00
128	90	....do	41.50	3,735.00
129	50	....do	33.50	1,675.00
130	50	....do	33.50	1,675.00
131	90	Medium; cut, scarred, etc.	20.00	1,800.00
132	90	....do	21.00	1,890.00
133	90	....do	21.00	1,890.00
134	90	....do	21.50	1,935.00
135	90	....do	20.50	1,845.00
136	90	....do	20.50	1,845.00
137	90	....do	20.50	1,845.00
138	90	....do	19.00	1,710.00
139	90	....do	22.00	1,980.00
140	90	....do	20.00	1,800.00
141	90	....do	20.00	1,800.00
142	90	....do	21.50	1,935.00
143	90	....do	21.00	1,890.00
144	90	....do	21.50	1,935.00
145	90	....do	21.00	1,890.00
146	90	....do	19.50	1,755.00
147	90	....do	22.00	1,980.00
148	90	....do	20.00	1,800.00
149	90	....do	19.50	1,755.00
150	90	....do	19.50	1,755.00
151	90	....do	19.50	1,755.00
152	90	....do	19.50	1,755.00
153	90	....do	21.50	1,935.00
154	90	....do	20.00	1,800.00
155	90	....do	21.50	1,935.00
156	90	....do	19.50	1,755.00
157	90	....do	20.50	1,845.00
158	90	....do	19.00	1,710.00
159	90	....do	19.50	1,755.00
160	90	....do	20.00	1,800.00
161	90	....do	21.00	1,890.00
162	90	....do	20.00	1,800.00
163	90	....do	20.00	1,800.00
164	90	....do	20.00	1,800.00
165	90	....do	20.00	1,800.00
166	90	....do	20.00	1,800.00
167	90	....do	20.50	1,845.00
168	90	....do	20.50	1,845.00
169	90	....do	20.50	1,845.00
170	90	....do	21.00	1,890.00
171	90	....do	21.00	1,890.00
172	90	....do	21.50	1,935.00
173	90	....do	20.50	1,845.00
174	90	....do	20.25	1,822.50
175	90	....do	20.50	1,845.00
176	53	....do	21.00	1,113.00

Sales of Pribilof fur-seal skins at St. Louis, Mo., 1922—Continued.

SALE OF 17,194 DRESSED, DYED, AND MACHINED SKINS, OCTOBER 9, 1922—Contd.

Lot No.	Number of skins.	Trade classification.	Price per skin.	Total for lot.	Lot No.	Number of skins.	Trade classification.	Price per skin.	Total for lot.
177	90	Small medium	$21.00	$1,890.00	199	90	Small medium; cut, scarred, etc	$17.00	$1,530.00
178	90	do	21.00	1,890.00					
179	90	do	23.50	2,115.00	200	90	do	15.50	1,305.00
180	90	do	24.00	2,160.00	201	90	do	17.00	1,530.00
181	90	do	25.00	2,250.00	202	90	do	16.50	1,485.00
182	90	do	24.50	2,205.00	203	90	do	16.50	1,485.00
183	90	do	25.00	2,250.00	204	53	do	16.25	861.25
184	90	do	26.00	2,340.00	205	53	do	16.75	887.75
185	90	do	27.50	2,475.00	206	50	III wigs	10.50	525.00
186	90	do	27.00	2,430.00	207	39	do	14.50	565.50
187	41	do	27.00	1,107.00	208	52	III, 16 extra extra large, 36 extra large	16.50	858.00
188	90	Small medium; cut, scarred, etc	16.00	1,440.00	209	63	III large	12.50	787.50
189	90	do	15.00	1,350.00	210	60	III medium	13.00	780.00
190	90	do	16.00	1,440.00	211	57	do	11.50	655.50
191	90	do	17.25	1,552.50	212	63	III small medium	8.50	535.50
192	90	do	17.50	1,575.00	213	33	IV, 22 wigs, 1 extra extra large, 2 extra large, 5 large, 1 medium, 2 small medium	7.50	247.50
193	90	do	16.50	1,485.00					
194	90	do	16.00	1,440.00					
195	90	do	17.75	1,597.50					
196	90	do	16.50	1,485.00					
197	90	do	17.00	1,530.00					
198	90	do	17.25	1,552.50		17,194			535,967.50

SALE OF 201 MISCELLANEOUS SKINS, OCTOBER 9, 1922.

Lot No.	Number of skins.	Description.	Price per skin.	Total for lot.	Lot No.	Number of skins.	Description.	Price per skin.	Total for lot.
215	164	Raw; washed and dried	$0.50	$82.00	216	37	Raw; salted	$0.15	$5.55
						201			87.55

Comparative values by sizes and grades, with percentages each size, of Pribilof sealskins sold in 1922.

Classes and sales.	Grade.	Number.	High.	Low.	Average.	Total.	Total number.	Average.	Total price.	Percentage.
Wigs:										
Apr. 3	I and II	298	$60.00	$46.00	$53.81	$16,054.00	2,590	$16.63	$43,074.50	20.27
	Cut, etc	672	31.50	28.00	29.01	19,493.00				
	III	922	10.50	6.50	6.67	6,148.00				
	IV	698	5.00	1.50	1.98	1,379.50				
Oct. 9	I and II	100	51.00	51.00	51.00	5,100.00	350	31.22	10,926.00	2.01
	Cut, etc	139	34.50	32.00	32.88	4,570.50				
	III	89	14.50	10.50	12.25	1,090.50				
	IV	22	7.50	7.50	7.50	165.00				
Extra extra large:										
Apr. 3	I and II	153	63.00	62.00	62.78	9,606.00	302	50.68	15,306.50	2.36
	Cut, etc	127	44.00	42.50	43.30	5,499.50				
	III	14	13.50	13.50	13.50	189.00				
	IV	8	1.50	1.50	1.50	12.00				
Oct. 9	I and II	188	62.00	50.00	60.40	11,356.00	337	50.34	16,963.50	1.94
	Cut, etc	132	43.00	39.00	40.42	5,336.00				
	III	16	16.50	16.50	16.50	264.00				
	IV	1	7.50	7.50	7.50	7.50				
Extra large:										
Apr. 3	I and II	604	60.00	52.00	56.36	34,043.00	924	50.49	46,650.50	7.23
	Cut, etc	283	44.00	40.00	42.65	12,070.00				
	III	35	15.50	13.50	15.27	534.50				
	IV	2	1.50	1.50	1.50	3.00				
Oct. 9	I and II	508	61.00	56.00	58.14	29,535.00	958	47.88	45,870.00	5.51
	Cut, etc	412	40.00	36.00	38.17	15,726.00				
	III	36	16.50	16.50	16.50	594.00				
	IV	2	7.50	7.50	7.50	15.00				

Comparative values by sizes and grades, with percentages each size, of Pribilof sealskins sold in 1922—Continued.

Classes and sales.	Grade.	Number.	High.	Low.	Average.	Total.	Total number.	Average.	Total price.	Percentage.
Large:										
Apr. 3	I and II	1,115	$55.00	$47.00	$50.81	$56,657.50	1,470	$47.56	$69,907.00	11.51
	Cut, etc	327	41.50	35.00	39.32	12,857.50				
	III	26	15.50	13.50	14.95	389.00				
	IV	2	1.50	1.50	1.50	3.00				
Oct. 9	I and II	2,713	57.00	45.00	47.62	129,184.00	4,716	41.33	194,910.50	27.11
	Cut	1,935	36.50	32.00	33.54	64,901.50				
	III	63	12.50	12.50	12.50	787.50				
	IV	5	7.50	7.50	7.50	37.50				
Medium:										
Apr. 3	I and II	3,252	41.00	26.50	37.18	120,923.00	5,010	33.28	166,738.50	39.21
	Cut, etc	1,716	30.00	21.00	26.42	45,341.00				
	III	42	13.50	11.00	11.30	474.50				
Oct. 9	I and II	4,060	41.50	30.00	32.69	132,725.00	8,281	26.33	218,013.50	47.61
	Cut, etc	4,103	22.00	19.00	20.44	83,845.50				
	III	117	13.00	11.50	12.27	1,435.50				
	IV	1	7.50	7.50	7.50	7.50				
Small medium:										
Apr. 3	I and II	805	29.00	26.50	28.36	22,832.50	1,875	24.62	46,170.00	14.68
	Cut, etc	1,002	23.50	21.00	22.48	22,527.00				
	III	68	13.50	11.00	11.92	810.50				
Oct. 9	I and II	941	27.50	21.00	24.56	23,112.00	2,552	19.31	49,284.00	14.67
	Cut, etc	1,546	17.75	15.00	16.57	25,621.50				
	III	63	8.50	8.50	8.50	535.50				
	IV	2	7.50	7.50	7.50	15.00				
Skins damaged:										
Apr. 3		27	8.25	8.25	8.25	222.75	27	8.25	222.75	.21
	Description.									
Culls and rejects:										
Apr. 3	Dressed and dyed	249	.50	.50	.50	124.50	579	.38	218.25	4.53
	Dressed	117	.50	.50	.50	58.50				
	Washed and dried	121	.25	.25	.25	30.25				
	Raw	92	.054	.054	.054	5.00				
Oct. 9	Raw, washed and dried	164	.50	.50	.50	82.00	201	44	87.55	1.15
	Raw, salted	37	.15	.15	.15	5.55				
All classes:										
Apr. 3							12,777	30.39	388,288.00	100.00
Oct. 9							17,395	30.82	536,055.05	100.00

DISPOSITION OF SEALSKINS.

The grand total of all fur-seal skins on hand at the Pribilof Islands and at St. Louis on January 1, 1921, was 53,878. In 1922 a total of 31,156 skins was secured and 30,172 were sold, leaving a balance on hand on December 31, 1922, of 54,862. The following two tables show the skins on hand both at the beginning and end of 1922 at the Pribilofs and at St. Louis, the numbers taken and shipped from the Pribilofs, and the numbers received and sold at St. Louis.

Summary of all fur-seal skins handled on Pribilof Islands, calendar year 1922.

	Balance on hand Jan. 1.	Number taken.	Total handled.	Number shipped.	Balance on hand Dec. 31.
St. Paul Island	[1] 718	26,035	26,753	26,129	624
St. George Island	403	5,121	5,524	5,252	272
Total	1,121	31,156	32,277	31,381	896

[1] The preceding report for 1921 gave the number on hand as 717, but when the skins were packed for shipment in 1922 one more skin was found, thereby increasing the number to 718.

Summary of receipts and sales of Pribilof fur-seal skins by Fouke Fur Co., St. Louis, Mo., and balance in firm's custody, calendar year 1922.

Date of shipment from Pribilofs.	Receipts.		Sales.		Balance on hand.
	Date.	Number of skins.	Date.	Number of skins.	
	Jan. 1				52,757
			Apr. 3	12,777	39,980
July 31	Sept. 9	2,358			42,338
Aug. 12	Sept. 19	2,601			44,939
Sept. 24	Nov. 9	26,422			71,361
			Oct. 9	17,395	[1] 53,966
Total		31,381		30,172	

[1] Includes 7 at Washington.

PRIBILOF FOX SKINS.

SHIPMENTS AND SALES.

The fox skins, 138 blues and 21 whites, taken on St. Paul Island in the season of 1921–22 were shipped on the U. S. S. *Gold Star* July 31, 1922, and reached Seattle August 11. The skins were then forwarded by express to the Fouke Fur Co., St. Louis. The fox skins, 574 blues, taken on St. George Island in the season of 1921–22, were transferred by the fisheries schooner *Eider* in August to the steamship *Cordova* at Akutan for transportation to the States. The skins were consigned to the Fouke Fur Co. and were received at St. Louis on September 19. All were sold there at public auction October 9, 1922. The total amount bid for the 712 blue fox skins was $66,344, the maximum bid being $165 each for a lot of four and the average bid $93.18 per skin. The 21 white fox skins brought $966, an average of $46 per skin. The average price at the last preceding sale, September 28, 1921, was $96.83 for blue and $33 for white fox skins.

Sale of 712 blue and 21 white fox skins at St. Louis, October 9, 1922.

Lot number.	Number of skins.	Trade classification.	Price per skin.	Total for lot.
		Blue fox skins.		
220	4	Extra extra fine	$165.00	$660.00
221	4	Extra fine, extra large	135.00	540.00
222	6	Fine dark	136.00	816.00
223	6	I fine dark silvery	136.00	816.00
224	10	I silvery	134.00	1,340.00
225	10	I blue	98.00	980.00
226	10	I dark	102.00	1,020.00
227	8	.....do	120.00	960.00
228	6	II dark	84.00	504.00
229	10	I and II blue	96.00	960.00
230	4	Extra extra fine	162.00	648.00
231	4	Extra fine, extra large	124.00	496.00
232	6	Fine dark	130.00	780.00
233	6	Dark silvery	141.00	846.00
234	10	Dark	116.00	1,160.00
235	5	Fine dark silvery	137.00	685.00
236	10	I, pt. II, dark	105.00	1,050.00
237	5	Dark	128.00	640.00
238	14	I, pt. II, blue	110.00	1,540.00
239	4	Extra extra fine	145.00	580.00
240	4	Extra extra fine, extra large	130.00	520.00
241	4	Extra fine	127.00	508.00
242	8	I fine dark	115.00	920.00
243	6	Extra dark	112.00	672.00
244	8	I dark	108.00	864.00
245	10	II dark	77.00	770.00
246	10	I blue	95.00	950.00
247	12	II blue	78.00	936.00
248	12	II low blue	62.00	744.00
249	8	II	67.00	536.00
250	20	III	30.00	600.00
251	9	Skins	7.00	63.00
252	10	I dark	100.00	1,000.00
253	12	II dark	88.00	1,056.00
254	8	I blue	100.00	800.00
255	8	II blue	76.00	608.00
256	12	II low blue	67.00	804.00
257	4	Extra extra fine	145.00	580.00
258	6	Extra fine	129.00	774.00
259	8	I fine dark	125.00	1,000.00
260	10	I and II dark	110.00	1,100.00
261	12	II dark	78.00	936.00
262	10	I blue	100.00	1,000.00
		Blue fox skins—Con.		
263	12	II blue	$82.00	$984.00
264	10	I dark	96.00	960.00
265	12	II dark	80.00	960.00
266	8	I blue	100.00	800.00
267	12	Blue	86.00	1,032.00
268	12	II low	45.00	540.00
269	11	Skins	38.00	418.00
270	4	Extra extra fine	164.00	656.00
271	4	Extra extra fine, extra large	122.00	488.00
272	4	Extra fine	145.00	580.00
273	4	Extra fine, extra large	114.00	456.00
274	6	Fine, extra large	114.00	684.00
275	8	I dark	96.00	768.00
276	14	II dark	97.00	1,[illegible]
277	10	I blue	100.00	1,000.00
278	12	II blue	80.00	9[illegible]
279	10	.....do	80.00	800.00
280	16	II low blue	58.00	928.00
281	14	I dark	111.00	1,554.00
282	12	II dark	79.00	948.00
283	14	I and II	65.00	910.00
284	4	Extra extra fine	146.00	584.00
285	4	Extra fine	120.00	480.00
286	10	I dark	114.00	1,140.00
287	16	II dark	89.00	1,424.00
288	10	I blue	103.00	1,030.00
289	12	Blue	86.00	1,032.00
290	8	Silvery	116.00	928.00
291	4	.....do	80.00	320.00
292	8	I and II dark	90.00	720.00
293	14	II dark	80.00	1,120.00
294	8	II extra large	74.00	592.00
295	6	I silvery	106.00	636.00
296	12	II dark	80.00	960.00
297	16	Dark	70.00	1,120.00
298	8	I silvery	104.00	832.00
299	10	I and II	88.00	880.00
	712		....	66,344.00
		White fox skins.		
339	21	I and II, white fox	46.00	966.00
	733		....	67,310.00

FUR-SEAL PATROL BY UNITED STATES COAST GUARD.

An active patrol for the protection of fur seals was maintained by the Coast Guard in 1922. The cutters engaged were the *Haida*, *Algonquin*, *Mojave*, *Snohomish*, *Unalga*, and *Bear*. The *Haida* and *Algonquin* patrolled both in the North Pacific Ocean and Bering Sea. The *Algonquin* also made a trip to Asiatic waters frequented by fur seals. The *Mojave* was used chiefly in transporting an official party headed by the Assistant Secretary of Commerce. The *Snohomish* patrolled the waters between the Columbia River and Dixon Entrance, southeast Alaska. The *Unalga* paid particular attention to southeast Alaska between Dixon Entrance and Yakutat Bay. The *Bear* made its usual cruise northward to the Arctic Ocean. The bureau is under many obligations to the Coast Guard for assistance furnished incidentally to the patrol work in the transportation of passengers, mail, and freight to and from the Pribilof Islands.

The following extracts are taken from information furnished by the Coast Guard in regard to the season's work. In connection with the patrol the cutters perform a great many duties of a public nature aside from those concerned with fur seals and the fisheries. The extracts have been selected only as they relate to fur-seal matters and occasionally to the fisheries industry.

Bear.—Preparatory to proceeding on her annual Alaskan cruise, the Coast Guard cutter *Bear* left Oakland, Calif., May 2, 1922. * * *. Having received on board mail and certain supplies, the vessel sailed from Seattle at 7 p. m. May 16, stopping at Port Townsend and in the Straits of Juan de Fuca, and arrived at Unalaska at 7.40 p. m. May 27. Throughout the voyage from Seattle a close observation was kept for fur seals, but none was sighted. * * *. En route from Nome to Unalaska the *Bear* stopped at St. Paul Island on September 18. * * *. Having completed her duties in Alaskan waters, the vessel sailed from Unalaska October 5 and arrived at Seattle, Wash., October 17.

Haida.—On April 15, 1922, at 10 a. m., the *Haida* left Seattle, Wash., on her Alaskan cruise. On board the cutter were 13 persons from the Bureau of Fisheries desiring passage to the Pribilof Islands and a native student for passage to Unalaska. Stores for the radio station at St. Paul Island and for the Attu schoolhouse were packed on board. All holds and storerooms were filled from the keel to the lower deck. The trip from Seattle to Unalaska was made in less than seven days, the cutter arriving at Unalaska at 8.30 p. m. April 21. * * *. Having received on board mail for points to be visited and several passengers, the *Haida* cast off from the dock at Unalaska at 8.30 a. m. April 24, proceeded to St. Paul Island, anchoring in Village Cove at 5.45 a. m. April 25. Landing at Village Cove being unfavorable, the cutter got under way, stood around Reef Point, and at 9.35 a. m. anchored in Lukanin Bay, St. Paul Island, where mail, 13 passengers, and freight were landed. After receiving on board mail for St. George Island and Unalaska at 4.15 p. m. April 25, got under way and at 7.15 anchored off St. George Island, where freight for the Bureau of Fisheries, mail, passengers, and baggage were landed. After receiving on board mail for St. Paul and Unalaska got under way at 8.40 p. m. April 25, and at 8 a. m. April 27 anchored off Sarichef Lighthouse. During the trip encountered thick mist, heavy snowfall, and rough sea. There being no assistance needed at this point, got under way and arrived at Unalaska at 4.30 p. m. * * *.

On May 3, at 7 a. m., got under way and continued patrolling. At 2.05 p. m. anchored in Ugamak Bay, under the lee of Ugamak Island on account of heavy weather. No vessels passed through nor were any vessels sighted. A large herd of sea lions, about 400 in number, was observed on Round Island. * * *.

On May 27, at 4.35 p. m., cast off from dock at Dutch Harbor and stood over for Unalaska, making fast to the dock at 5.55 p. m. Having taken on board mail and stores and 24 passengers, got under way at 9.15 a. m. June 1 for St. George and St. Paul and came to anchor off St. George village at 9.30 a. m. June 2. Delivered the mail for this point and took on mail for other points and at 9.50 a. m. got under way for St. Paul Island. Stood various courses around Reef Point into Village Cove, where anchored at 2.15 p. m. Delivered mail and stores and landed passengers. On June 3, at 11 a. m., stood out of Village Cove to take up the patrol within a radius of 100 miles around the Pribilof Islands. On June 7, at 12.40 a. m., anchored off St. George Island, and at 7.50 a. m. stood for St. George Village. Took on board six passengers for transportation to St. Paul Island and mail for that point and Unalaska. At 8.55 a. m. stood for St. Paul Island, anchoring off Village Cove at 12.30 p. m., where the six passengers left the vessel. Patrol of the islands was continued from June 7 until the 15th, on which date stood in for St. George Island, anchoring off the village at 3 p. m. At 7.50 p. m. stood offshore and continued the patrol of the island. Boarded the schooner *Fox*, inspected the vessel, and sent message for master. On June 17, at 7.15 p. m., anchored in Village Cove, St. Paul Island. Received on board three persons for transportation to Akutan. After taking on board mail got under way at 8.30 a. m. June 18 for St. George Island; at 12.25 p. m. anchored off North Anchorage and took aboard mail and six persons for transportation to Akutan. At 1 p. m. got under way for Akutan and moored at the dock of the Akutan whaling station at 11.20 a. m. June 19; discharged passengers, delivered the mail, and at 2 p. m. cast off and proceeded to Unalaska, arriving there at 7.25 p. m. While on this cruise sighted 23 fur seals, boarded two vessels, and afforded medical treatment to eight persons. * * *.

On June 20, 21, and 22 remained at Unalaska, cleaning boiler and performing various other duties. On June 23, 24, 26, and 27 executed certain other duties in connection with the command of the *Haida*. On June 28, at 8.50 a. m., having received on board mail for the fishing fleet in Bristol Bay and for other places, got under way and at 9.15 a. m. made fast to the dock of the Alaska Commercial Co. at Dutch Harbor. At 8.05 a. m. June 29 cast off from the dock and stood to eastward and along the north side of Unimak Island and at 9.10 p. m. anchored off Cape Lapin, Unimak Island. On June 30, at 4.35 a. m., stood various courses in the vicinity of Amak Island, then stood to the eastward along Unimak Island and the Alaskan Penisusula. At 5.35 p. m. anchored off Cape Lieskof, the dense fog making further cruising unsafe. On July 1, at 7.30 a. m. got under way and stood various courses to rendezvous with *Algonquin*. At 2.30 p. m. proceeded toward the cannery at Nelson's Lagoon. At 6.10 p. m. boarded the American schooner *Wawona*, of Anacortes, delivered mail to her, and received mail for the schooners *John A* and *Fanny Dutard*. At 7.45 p. m. boarded the Japanese schooner *Bering Maru*, of Tokyo. At 8.45 p. m. stood for Port Moller and anchored off that place at 10.20 p. m. On July 2, at 8.15 a. m., got under way and stood various courses into Port Moller and at 12.05 p. m. anchored off Entrance Point. The medical officer vaccinated 40 natives and gathered statistical information, and the dental surgeon gave treatment to 13 natives. On July 3, at 11.15 a. m., got under way and stood various courses. Boarded schooner *Fanny Dutard*, delivered mail, and gave medical and dental treatment to two members of her crew. At 6.20 p. m. boarded schooner *Charles R. Wilson*, of Seattle, afforded medical treatment to two men, delivered mail, and examined vessel. Took on board a sick seaman for transportation to Unalaska. At 8.50 p. m. anchored near schooner *John A*. boarded her, and delivered mail. Got under way and at 9.55 p. m., anchored off Cape Seniavin. On July 4, at 4.15 a. m., got under way and stood various courses to Port Heiden. Anchored off Christakof Island at 8.55 a. m. The medical officer vaccinated 30 natives and rendered aid to 2 others. Collected statistics at this point. On July 5 the medical officer went ashore and treated 12 more natives at Port Heiden. At 2.55 p. m. got under way and stood various courses to westward. On July 6 continued cruising and at 1.05 p. m., anchored in the lee of Operl Island on account of stress of weather.

On July 7, at 6.10 a. m., got under way and set course for Pribilof Islands. On July 8, at 9.15 a. m., anchored off the village, St. George Island. Received mail for Unalaska and delivered mail for this place. Vessel remained at anchor owing to inclement weather. On July 9, at 8.35 a. m., proceeded for St. Matthew Island. * * *. At 8.35 a. m. got under way and set course for point on the one hundred and seventieth meridian, 150 miles north of St. Paul Island, to take up the patrol. Continued the patrol above mentioned throughout July 15. Continued patrol on July 16 and sighted 21 seals during the day. On July 17 continued patrolling. Upon receipt of a message that a native was in a critical condition and needed medical assistance got under way at 10 a. m. and proceeded to St. Paul Island. At 6.35 p. m. anchored off the village, St. Paul Island, where medical officer went ashore to treat the above-mentioned native. Landed mail and took on mail for Unalaska. Sighted 36 seals. On July 18, at 3.15 p. m., got under way and stood to the westward to continue the patrol. Sighted 32 seals this day. On July 19 continued the patrol. On July 20 proceeded to westward of the Pribilof Islands. On July 21 stood for Unalaska. While on this cruise boarded five vessels, sighted 111 seals, and the medical officer rendered treatment to 14 persons and vaccinated 70. On July 22 delivered mail to postmaster at Unalaska.

Up to July 30 the *Haida* lay in harbor undergoing inspection by a board. On July 30 proceeded to Dutch Harbor and filled fresh-water tank. At 8 p. m. cast off, and on July 31, at 7.50 p. m., anchored in Delarof Harbor, Unga Island. On August 1 shifted to dock at the Pacific American Fisheries cannery in Baralof Bay. * * *. Proceeded to Anchorage Bay, Chignik Bay, and on the morning of August 5 proceeded to Lazy Bay, Alitak Bay, Kodiak Island, arriving there at 7.50 p. m., to investigate a report of illegal possession of sealskin. Boarded the vessel *Lina K*, which was anchored in Lazy Bay, but found no evidence. On August 6 a searching party proceeded to Aiktalik Village to make an investigation; meantime the commanding officer with party made search of the village of Akhiok for evidence of poaching fur-bearing animals; also of stolen articles from Perryville; no evidence was obtained. * * *. On August 9, at 10 a. m., arrived at Unga and delivered prisoner to United States Commissioner. At 2 p. m. got under way for Unalaska and at 3.15 p. m. August 10 made fast to dock at Dutch Harbor. While on this cruise boarded four vessels, sighted three seals, and afforded medical aid to seven persons. On the morning of August 11 moved to the dock at Unalaska.

On August 12, at 1.50 p. m., cast off from the dock and proceeded to the eastward and patrolled the fishing banks. On August 13 remained at anchor from 1.34 p. m. to 3.05 p. m. in order to repair machinery. The Japanese fishing schooners *Okhotsk Maru* and *Bering Maru*, found at anchor off Port Moller, were boarded, but no evidence of illegal operations was found. On August 14, at 7.55 p. m., arrived at Naknek anchorage, notified all cannery superintendents of the vessel's arrival, and offered assistance. On August 15, upon request of the superintendent of the Red Salmon Canning Co., settled a dispute between five Mexican laborers and the cannery officials, with the result that the offending persons resumed their work. On August 16, at 8.30 a. m., got under way for Sarichef, fell in with the tender *Curlew*, of the Alaska Packers Association, and took off that vessel an insane man who, having attempted suicide, was in need of immediate medical attention. On August 18, at 6 a. m., anchored off Sarichef. It being deemed necessary to operate on the man taken aboard from the tender *Curlew*, the *Haida* got under way and anchored in Dutch Harbor at 5.39 p. m. August 18. While on this cruise boarded 30 vessels, sighted two seals, and rendered medical assistance to one person.

On August 19, at 4.25 p. m., having sent patient ashore, cast off from dock at Dutch Harbor and proceeded to Akutan Harbor; anchored off the native village at 4.40 p. m. Party went ashore and searched the entire village for sealskins, but found none. After completing search the *Haida* shifted to berth at dock of Akutan whaling station. Thoroughly searched whaling station, but found no sealskins. Questioned several prominent persons under testimony, but gained no information of value as to illegal sealing. * * *.

On August 29, at 11.30 a. m., left Attu, standing for vicinity of Pribilof Islands to take up patrol, and arrived in patrol limits on September 1. On September 2 patrolled around islands. On September 3 patrolled area about Pribilof Islands. Stood in, and at 1.40 p. m. anchored close to steamship *Brookdale*, off Tolstoi Point, St. George Island. At 3.15 p. m. got under way and resumed patrol. On September 4, 5, and 6 patrolled about islands. On September 7 set course for Unalaska, and at 7.20 p. m. September 8 secured to dock at Unalaska. While on this cruise sighted 90 seals.

The *Haida* remained in the vicinity of Unalaska until September 29. During this time repairs were being made to the vessel's machinery. Having received on board mail and supplies for St. George Island, cast off from dock at Dutch Harbor at 11.10 a. m. and stood out of harbor, but, owing to severe gale, accompanied by rough sea, was compelled to lay to. On September 30, at 4 a. m., the gale having abated, set course for St. George Island, and at 3 p. m. anchored off the village. On October 1 delivered mail and stores from Unalaska. At the request of the agent, Bureau of Fisheries, took on board nine passengers for transportation to St. Paul Island. Received on board mail for St. Paul Island. On October 2 remained at anchor, owing to unfavorable weather conditions. On October 3, at 8.30 a. m., the gale having ceased, got under way and stood for St. Paul Island, anchoring in Lukanin Bay at 12.50 p. m. Delivered mail and packages of hardware received from St. George Island. The nine passengers went ashore. Got under way at 2.15 p. m. and stood to the northward. * * *.

Received from the postmaster at Nome mail for Juneau, Seattle, and Tacoma. Got under way at 2 p. m. (October 26) and stood to the southward. Arrived at St. Paul Island, anchoring in Lukanin Bay at 2.35 p. m. October 28. On the morning of October 29 shifted anchorage to Village Cove. Received mail for Seattle and Unalaska. At the request of superintendent, St. Paul Island, took aboard three persons for transportation to Seattle. Also took on board two radio men for transportation to Seattle. Twenty-two others came on board for transportation to Unalaska and one for St. George Island. Received on board 67 packages of provisions from the Naval Radio Station, St. Paul Island, for transportation to the Navy Yard, Puget Sound, Wash. Got under way at 12.45 p. m. (October 29) and stood for St. George Island, anchoring in Garden Cove at 4 p. m. Having received on board mail for Unalaska and Seattle, got under way at 4.40 p. m. and moored to the dock at Dutch Harbor at 8.35 a. m. October 30. Delivered mail to postmaster at Unalaska and took on board mail for Seattle. One passenger, a native student, came on board for transportation to Seattle. On October 31, at 5.35 a. m., cast off from the dock at Dutch Harbor, stood various courses out of the harbor and through Akutan Pass, then headed for the Strait of Juan de Fuca. Arrived at Port Townsend, Wash., at 1.06 p. m. November 5, 1922.

Algonquin.—On April 15, 1922, at 10.10 a. m., the *Algonquin*, in company with the *Haida*, left Seattle, Wash., on her Alaskan cruise. Proceeded up the coast of Vancouver Island, and on the morning of April 16 boarded 22 small vessels engaged in fishing off Barclay Sound, then continued up the coast at a distance of 30 miles off. * * *. Boarded three vessels off Forrester Island on April 27. * * *. Arrived at Unalaska on June 3 at 3 p. m. During this cruise sighted 24 seals. * * *.

During the period from July 4 to 9 the *Algonquin* remained at Unalaska cleaning boiler and making necessary repairs to the vessel's machinery. Received on board C. H. Huston, Assistant Secretary of Commerce, Ward T. Bower, of the Bureau of Fisheries, and four others to be transported to the Pribilof Islands in the interest of the Department of Commerce; also took on board six natives to be sent to St. George Island as laborers for the Bureau of Fisheries. After receiving on board stores and mail for the Pribilof Islands got under way at 6.05 p. m. July 10 and arrived at St. George at 11.50 a. m. July 11. The official party left the vessel to transact certain business. Landed mail, stores, and native workmen. Took on board five natives for transportation to St. Paul Island. Upon return of the official party got under way at 4.40 p. m. for St. Paul but owing to thick fog was forced to anchor at 8.15 p. m., near Halfway Point. Got under way at 4.45 a. m. July 12 and steamed for Village Cove, coming to anchor at 5.40 a. m. The official party left the ship at 7.30 a. m. All mail, stores, and passengers for this point were landed. Got under way at 1.15 p. m. and arrived at Dutch Harbor at 12.45 p. m. July 13. During the vessel's stay in port stores were obtained, fuel-oil and fresh-water tanks were filled, and passengers whose transportation was authorized were taken on board. At 10.05 a. m. July 14 got under way, but owing to heavy sea and threatening storm was forced to return to Dutch Harbor. Made a second start, however, at 2.55 p. m. July 15 but was again forced to return to Dutch Harbor, owing to unfavorable weather conditions. Remained in port until July 17, at which time sailed at 12.40 p. m. and made fairly good progress against the heavy sea. Arrived at Glinka, Copper Island, at 10.30 p. m. July 22. The official party visited Glinka Village in the forenoon of July 23. Only the native guards were found at this place. Got under way at 11.45 a. m. same day for Preobrajeniya, Copper Island, arriving at 2.15 p. m. A party was sent ashore to interview the superintendent. Finding the food and tobacco supply to be very limited, made up a purse among the officers, crew, and passengers, with which certain staples were purchased from the various messes for presentation to the natives. Necessary work having been completed left Preobrajeniya at 10.45 p. m. July 23 anchoring near North Rookery, Bering Island, at 9.35 a. m. July 24 to await better weather conditions. At 5.30 a. m. the following day proceeded to Nikolskoe, arriving there at 9.50 a. m. July 25. Landed several passengers. Made another donation of supplies at this point. Got under way at 12 noon July 25 and anchored in Chichagof Harbor, Attu, at 8.15 p. m. July 26. * * *.

From the evening of September 12 until the next date of sailing the *Algonquin* remained in port at Unalaska, her personnel prosecuting such duties as completing the annual inspection, serving on boards, transferring stores from storehouses to ship, making minor repairs to vessel, cleaning boiler, and fueling. Having received on board several passengers and mail for delivery at Seattle, the *Algonquin* got under way from Unalaska at 11 a. m. September 24 and proceeded, via Unalga Pass, for Seattle, where she arrived at 8 p. m. September 30, 1922.

Mojave.—While the *Mojave* was not assigned to duty as a unit of the regular patrol force, this cutter made an extended cruise within the limits of the scope of operations of the patrol vessels and performed certain duties similar to those devolving upon the vessels of the regular patrol. The *Mojave* sailed from Seattle, Wash., at 2.30 p. m. June 20, 1922, having on board Assistant Secretary of Commerce C. H. Huston and party, and proceeded, via the inside passage, to Juneau, Alaska. During the trip numerous stops were made in southeastern Alaska. From Juneau the *Mojave* proceeded to Unalaska, stopping at various places designated by Assistant Secretary Huston, and arrived there at 3.30 p. m. July 10. The *Mojave* remained at Unalaska until July 16. Assistant Secretary Huston and party had gone aboard the *Algonquin* for a cruise to the Pribilof Islands. On July 16, at 6 a. m., the *Mojave* left Unalaska and proceeded to Dutch Harbor. After taking on board a supply of fuel oil sailed for the Pribilof Islands at 3.35 p. m. July 17. A stop was made at St. George Island, where mail was delivered. Then proceeded to St. Paul Island, where came to anchor at 12.15 p. m. July 19. All mail and supplies from Unalaska were delivered. Assistant Secretary Huston and party having returned on board, the *Mojave* got under way at 3.30 p. m. and stood for Nome. The *Mojave* visited such points in northern Siberia as were designated by Assistant Secretary Huston, after which she proceeded to the southward and eastward from Anadir, Siberia, and again entered the patrol zone at 1 a. m. July 31. Arrived at Dutch Harbor at 3 p. m. August 1. At 9 a. m. August 2, having filled tanks with fuel oil, the *Mojave* steamed out of Dutch Harbor on her return journey. While on this cruise the *Mojave* maintained a vigilant lookout for seals and seal poachers. A few fur seals were sighted, but no indications of illegal sealing were observed.

Unalga.—Pursuant to her orders, the *Unalga* left Juneau, Alaska, on April 12, 1922, and on April 15 commenced the patrol off Dixon Entrance for the protection of the seal herd and sea otter. Stood to the northward about 30 miles offshore, arriving at Sitka on April 16. On account of inclement weather remained in Sitka Sound until April 23. The first fur seals were sighted on April 19, while the *Unalga* was anchored in Symonds Bay. On this occasion 35 fur seals were seen close to the entrance of the bay. In this locality it was discovered that Sitka natives had established a sealing camp. On April 23, left Sitka and cruised to the northward, standing offshore during the day and anchoring at night. A considerable number of fur seals were sighted offshore and a few inshore. Seals also were observed in Salisbury Sound, Fortuna Strait, and at the entrance to Khaz Bay. No vessels were sighted offshore and only one in the harbors visited by the cutter. On April 26 the *Unalga* stood into Cross Sound and proceeded to Juneau for coal and provisions, arriving there on April 28. On May 3 left Juneau and on the 4th stood out of Cross Sound for a cruise to the westward. Anchored at Yakutat on the night of the 5th and proceeded to the westward on the morning of the 7th. On May 8 cruised in the vicinity of Middleton Island for the purpose of boarding fishing vessels. On the evening of May 8 stood to the eastward and arrived at Sitka on May 10. On May 12 investigated the conditions at the natives' sealing camp at Symonds Bay, Biorka Island. Ascertained on arrival that, owing to continuous inclement weather, the natives had only a few opportunities for sealing and, therefore, had taken only 34 skins. It was also learned that the natives who were sealing from a camp on a neighboring island had obtained approximately the same number of skins. An examination of certain sealskins at Biorka Island disclosed the fact that none of the seals had been shot. On the afternoon of May 12 proceeded to the northward from Sitka Sound, anchoring in Nakwasina Passage that night. On May 13 visited Kalinin Bay and Leo Anchorage. On May 14 visited Dixon Harbor for the purpose of boarding fishing vessels which frequent these harbors. During this cruise numerous fur seals were sighted along the 100-fathom curve to the eastward of Yakutat Bay. Very few seals were sighted west of Yakutat, however, and none was seen at a considerable distance offshore of the 100-fathom curve. Such fishermen as were questioned claimed to have seen numerous seals in April but very few in May. They were of the opinion, however, that the main body of the seal herd had passed to the westward of Prince William Sound early in May. On May 15 the *Unalga* proceeded to Cross Sound, arriving at Juneau on May 16. On May 20 the *Unalga* left Juneau, standing out of Cross Sound on the 21st, and cruised to the westward as far as Yakutat Bay. A few fur seals were seen near the 100-fathom curve off Cape Spencer and Cape Fairweather, but in much smaller numbers than seen on previous occasions. On May 23 proceeded to the southeastward. On May 24 sighted six sealing boats from the native camps in Sitka Sound, about 15 miles southwestward of Biorka Island. At that time weather conditions were such as to make sealing impossible. Sighted no seals. On May 24 arrived at Sitka. From observation and from the most reliable information obtainable it was decided that the seal herd, with the possible exception of a few stragglers, had passed west of the *Unalga's* cruising ground. Therefore, on May 25, the patrol was discontinued and the cutter left Sitka for Juneau. During these cruises all fishing vessels fallen in with were boarded and examined, but no infractions of law were found. The fishermen were closely questioned as to illegal killing of seals, but no evidence in this regard was obtained. Government and Territorial officials, residents, and natives of the towns visited were interviewed for the purpose of verifying rumors of illegal killing of seals, both by natives and by fishermen, but no one advanced any information with regard to these supposed violations of law. Very few fishing vessels were found on the fishing banks. It was reported, however, that, owing to a poor market for fish, an unusually small number of vessels were engaged in fishing operations during the spring. So far as could be determined no sea otters have been seen in the waters of southeast Alaska for a number of years.

Snohomish.—The *Snohomish* maintained an active patrol of the waters between the Columbia River and Dixon Entrance for the protection of the seal herd during its migration northward. The cutter left Port Angeles, Wash., on April 8, 1922, and arrived at Astoria, Oreg., on April 9. On the following day began the patrol off the Columbia River entrance. From that date until June 1 the *Snohomish* maintained a continuous patrol of the waters named. The patrol was not discontinued, however, until it was ascertained beyond doubt that the seal herd had passed the section of the coast which the *Snohomish* was assigned to patrol. While engaged in the patrol duties the commanding officer of the cutter interviewed various persons with regard to sealing along the coasts of British Columbia and Washington. Among those consulted were the Indian agent, the Weather Bureau observer, and the general storekeeper, all of Neah Bay, the Indian agent and school-teacher at Quillayute, Wash., various Indians engaged in sealing off the coast of Washington, the collector of customs at Port Alberni, British Columbia, the commanding officer of the Canadian fisheries steamer *Thiepval*, and various fishermen. It appears that the Quillayute Indians of Quillayute, Wash., and the Makah Indians of Neah Bay, Wash., are the only tribes that engage in sealing along the Washington coast. Both of the above-mentioned villages were visited and investigations conducted. The Makah Indians seal from Ozette, which is more advantageously located to the sealing grounds than Neah Bay. It was ascertained that only two Indians remain of the Ozette tribe. During the current season 18 canoes were sealing out of Quillayute and 10 out of Ozette. When the weather is favorable the natives leave their villages about 3 a. m., paddle out to sea for a distance of 20 to 30 miles, hunt for four or five hours, and return to their villages by dark. From 10 to 12 hours each day is spent going to and from the sealing ground. The commanding officer of the *Snohomish* reports that, owing to the treacherous waters in the vicinity of Cape Flattery, canoes are caught frequently offshore in a gale, and being unable to land through the surf the sealers' lives are thus endangered. The commanding officer heartily concurs in the recommendation made not long ago by an official of the Indian Service, namely, that the Indians be permitted to take seals with firearms from motor boats, and that their total catch be limited. It appears that the natives are very jealous of their exclusive prerogative of taking sealskins and are quick to report any vessels that they suspect are conducting illegal sealing operations. No evidence has been found that persons other than Indians are engaged in sealing or that the Indians are employing illegal methods in killing the animals. The commanding officer of the Canadian fisheries steamer *Thiepval* reports that the bulk of the seal herd passed the British Columbia coast during the first two weeks of May. He also reports that the only sealing operations conducted along the British Columbia coast is between Clayoquot Sound and Kyuquot Sound, such operations being carried on by the natives in that locality, and that very little sealing has been done this year, as the Indians can obtain better pecuniary returns by fishing. He further states, however, that he has no evidence to substantiate the belief that seals are being taken illegally.

Summary.—In summarizing the season's operations the Bering Sea patrol commander reports that a number of trips were made over the fishing banks in the southeastern part of Bering Sea (Slime and Baird Banks), also Bowers and Petrel Banks, in the southern part of Bering Sea, and over Portlock, Albatross, Sanak, and Davidson Banks, in the North Pacific Ocean, for the purpose of determining whether vessels engaged in fishing were operating in accordance with the terms of the convention for the preservation and protection of fur seals; also for the purpose of rendering medical aid and other assistance to the fishing vessels. While on these cruises mail received from the postmaster at Unalaska was delivered to the fleet of fishing vessels. In a number of cases medical assistance was afforded to the fishermen. One man in need of hospital treatment was transported to Unalaska and transferred to the Jesse Lee Home, which institution maintains a hospital for the treatment of sick seamen and others. All assistance possible was given to the fishing fleet without neglecting other important duties required of the patrol force. During the cruises of the several cutters all vessels fallen in with were boarded and examined, but no evidence was found of illegal sealing. The patrol vessels at all times cooperated with the Government agents on the Pribilof Islands while cruising in the vicinity. In April mail, supplies, and passengers were transported from Seattle, Wash., to St. Paul Island and St. George Island. During the season mail and supplies for the islands were delivered as promptly as possible after each arrival of the mail steamer at Unalaska. On request of the agent of St. Paul Island transportation between St. Paul Island and St. George Island and between Unalaska and the islands was afforded to various officials, working parties, and natives. All villages on the Aleutian Islands were visited several times during the season and conditions investigated, vital statistics recorded, and medical assistance afforded to the sick. Aside from various other duties performed by the cutters assigned to patrol duty in Alaskan waters, there were transported for other departments of the Government 163 tons of freight, consisting of general merchandise, lumber, provisions, oil, gasoline, etc. During the cruise of the various cutters 38,729 miles were covered and 143 vessels boarded.

SEALING PRIVILEGES ACCORDED ABORIGINES.

Early in the year the form of certificate used in authenticating sealskins lawfully taken by Indians dwelling on the Pacific coast of the United States was revised. A certificate in triplicate is prepared for each skin by the officer authenticating the same, the original going to the owner of the skin, one copy to the office of the Bureau of Fisheries at Seattle, Wash., and one copy to the Washington (D. C.) office. When authenticated skins are shipped the original certificates must accompany them, and when the skins arrive at a port of entry the customs authorities will forward the original to the bureau's Seattle office, which will advise in regard to the legality of the shipment and forward copies of the certificates to the consignee. When the skins are dressed and dyed, the company doing the work shall indorse the owner's copy of each certificate to show the date and by whom each skin was dressed and dyed and shall then send them to the owner of the skin. The dresser and dyer will, before returning any skin to the owner, plainly and indelibly stamp it as follows: "U. S. Authenticated Certificate No. —", and the trade-mark or name of the dresser and dyer. Provision is made on the certificates for recording transfers in ownership of the skin. When the skins are authenticated, a numbered leather tag is attached to each skin, the number on the tag corresponding to that placed on the certificate. The tag will be removed by the dresser and dyer and forwarded to the Commissioner of Fisheries, Washington, D. C., together with the name and address of the person from whom the skin was received.

A total of 1,633 fur-seal skins was authenticated as having been lawfully taken in 1922 by Indians in the waters off the coasts of Washington and of southeast Alaska. Of the 1,633 skins 1,107 were taken during May and June by the Indians of Washington and were authenticated by A. D. Dodge, superintendent, United States Indian School, Neah Bay, Wash. Of these 641 were reported as having been taken from male seals and 462 from females. The sex of the remaining 4 seals from which skins were taken was not reported.

The rest of the 1,633 skins, 526 in number, were taken in the vicinity of Sitka, Alaska, mostly, if not entirely, by Indians who resided in that general locality. Of these 409 were reported as having been taken from male seals and 116 from females, while the sex of one was not determined. The earliest reported take was April 26 and the latest June 3.

JAPANESE SEALSKINS DELIVERED TO THE UNITED STATES.

The United States Government's share of the sealskins taken on Robben Island in 1920 was 56. These were received at St. Louis April 26, 1921, and after having been dressed, dyed, and machined were sold April 3, 1922. They brought $1,276, an average of $22.79 each.

The United States Government's share of the sealskins taken on Robben Island in 1921 was 55 skins and in 1922, 60 skins. These were shipped to St. Louis to be dressed, dyed, and machined and sold for the account of the United States. The 55 skins of the 1921 take were received at St. Louis in the latter part of October, 1922, the 60 of the 1922 take in February, 1923.

FUR-SEAL CENSUS, PRIBILOF ISLANDS, 1922.

By Edward C. Johnston.

The annual census of the fur-seal herd resorting to the Pribilof Islands in 1922 was taken at the height of the season. The harem count was made on St. Paul Island first; the count of pups on St. George Island first. Only one round trip between the islands was necessary. The pups were counted on all rookeries on both islands for the first time since 1916.

J. M. Orchard, school-teacher on St. George Island, assisted in the pup count on both islands. H. A. Peterson, sealing assistant on St. Paul Island, aided in the pup count at Northeast Point on St. Paul Island. The superintendent and the agents of both islands cooperated in providing assistance for the erection of the counting towers and in assigning to the census work the most intelligent natives. On St. Paul Island all but one of the native assistants were taken from the temporary employees, both because of their better understanding of English and their willingness, due to comparative ignorance of seal life, to obey orders. The fisheries vessel *Eider* furnished transportation between St. Paul and St. George Islands.

In 1917 the rookery areas were plotted upon the series of rookery charts. In 1922, in conjunction with the harem count, the rookery areas were again charted. A new series of photographs of the rookeries was made also, using the same stations as in 1917.

In addition to the two counting towers already in position on Reef rookery nine new ones were erected in the spring of 1922—two on Little Zapadni rookery, three on Zapadni rookery, and three on Vostochni rookery, all on St. Paul Island, and one on Staraya Artil rookery on St. George Island. Wooden markers were placed on various rookeries where they would be of service in the harem count. Construction of the towers and the placing of the markers were completed before the seals arrived.

PUPS.

Since 1916, when the last complete pup count was made, the total number of pups and of cows (by inference) had been estimated from actual counts made upon a few rookeries only. Due to the great yearly variation in the number of seals present on any one rookery, it would be possible for the herd, as a whole, to increase, while the number of seals upon the rookeries where pups were counted decreased. The estimate of pups on the uncounted rookeries had been based partly upon the average harem of all counted rookeries and partly upon field observations extending over a number of years.

In order to check the accuracy of these estimates since 1916, it was considered advisable to make another complete pup count, and, because of the increasing size of the seal herd, further delay would have been disadvantageous.

The pup count began on St. George Island on July 26, four days earlier than in 1921. There was no difficulty from the harem bulls, as the large average harem made it safe to go over the rookeries at such an early date. The count was completed on August 7 on St. Paul Island. Although the harems were not counted on Sivutch rookery, it was possible to make the pup count there. The results were more than satisfactory in every way.

Up to July 15 the weather on St. Paul Island was the driest that had occurred in recent years. Had the dryness continued through the pup count the fatalities due to suffocation would have been extremely large. It was, indeed, fortunate that only six pups were killed as a result of the counting. To balance this loss there were rescued from crevices and holes during the count 11 cows and about twice that number of pups, all of which would have died had they not been discovered and released. Six albino pups were noticed during the count.

Of the total of 185,914 pups in the seal herd in 1922, 95 per cent were actually counted. The remaining 5 per cent were necessarily estimated. On some of the rookeries there are areas made up of large bowlders under which the pups when they are disturbed pack themselves as closely as their strength allows. If the hole is a small one, they can be pulled out and counted, but otherwise there is no way to determine their number accurately. On one rookery on St. Paul Island a section was found with round rocks 2 to 3 feet in diameter. The holes between these rocks were 2 to 4 feet deep and pups falling into them were unable to climb out. To have counted the pups over this section would have caused many of them to fall into the holes where they would have starved to death. During the latter part of the count small groups of pups were on the edge of the water and it was impossible to make a perfect count of them. The number of pups thus estimated, however, was less than 10,000, conservatively figured.

C. E. Crompton reports, in the St. George Island journal, under date of November 3, 1921, the occurrence of the birth of a seal pup in the month of October. As practically all seal pups are born before August 7 such a late birth is remarkable. The journal entry follows:

> * * * During the work on the rookeries to-day a very young pup was noticed. The age of this pup was estimated at from 2 to 3 weeks and the writer feels certain that it was not more than 3 weeks of age at the most. It is to be regretted that this birth was not observed, as it is probably the latest one on record. The pup seen to-day could not yet swim and will most certainly have difficulty following the migrating seals in their journey south at the end of this month * * *.

Distribution of pups on Pribilof Islands in 1922 and comparison with distribution in 1921.

Rookery.	1922					1921	1922	
	Date of count.	Living pups.	Dead pups.	Total pups.	Per cent dead pups.	Total pups.	Increase (+) or decrease (−).	Per cent increase (+) or decrease (−).
St. Paul Island:								
Kitovi	Aug. 4	5,847	87	5,934	1.47	4,353	+1,581	+36.32
Lukanin	..do....	3,467	77	3,544	2.17	2,938	+606	+20.63
Gorbatch	Aug. 2	13,996	121	14,117	.86	10,909	+3,208	+29.41
Ardiguen	..do....	980	24	1,004	2.39	1,088	−84	−7.72
Reef	..do....	25,080	372	25,452	1.46	24,638	+814	+3.30
Sivutch	Aug. 4	7,962	199	8,161	2.44	8,854	−693	−7.83
Lagoon	Aug. 5	272	1	273	.37	287	−14	−4.88
Tolstoi	..do....	19,226	271	19,497	1.39	15,708	+3,789	+24.12
Zapadni	Aug. 3	15,823	277	16,100	1.72	16,830	−730	−4.34
Little Zapadni	..do....	8,625	221	8,846	2.50	10,037	−1,191	−11.87
Zapadni Reef	..do....	493	4	497	.80	502	−5	−1.00
Polovina	Aug. 5	8,636	134	8,770	1.53	6,071	+2,699	+44.46
Polovina Cliffs	..do....	3,876	73	3,949	1.85	2,785	+1,164	+41.80
Little Polovina	..do....	1,478	38	1,516	2.51	1,676	−160	−9.55
Morjovi	Aug. 6	3,839	79	3,918	2.02	2,994	+924	+30.86
Vostochni	Aug. 6-7	36,531	777	37,308	2.08	40,195	−2,887	−7.18
Total	....	156,131	2,755	158,886	1.73	149,865	+9,021	+6.02
St. George Island:								
North	July 26	10,219	145	10,364	1.40	9,986	+378	+3.79
Staraya Artil	July 28	6,874	182	7,056	2.58	6,620	+436	+6.59
Zapadni	July 27	885	10	895	1.12	895	....	....
South	..do....	228	4	232	1.72	187	+45	+24.06
East Reef	July 29	2,344	36	2,380	1.51	2,628	−248	−9.44
East Cliffs	July 30	6,010	91	6,101	1.49	6,474	−373	−5.76
Total	....	26,560	468	27,028	1.73	26,790	+238	+.89
Total (both islands)	....	182,691	3,223	185,914	1.73	176,655	+9,259	+5.24

The results of the complete pup count show conclusively that the estimates of pups made annually since 1916 have been, in general, correct. In fact, the largest differences between the percentage of increase in 1921 and that in 1922 are found on the rookeries that have been counted both years. Polovina and Polovina Cliffs rookeries, counted in 1920 and 1921, showed a percentage of increase of 1.08 and 8.24, respectively, in 1921. In 1922 the increase was 44.46 per cent for Polovina and 41.8 per cent for Polovina Cliffs. Reef rookery, next to Vostochni the largest rookery on the islands, was estimated in 1920 to have increased 5.26 per cent and in 1921 to have increased 4.23 per cent. The count of 1922 showed an increase of 3.3 per cent. The estimate of pups on Vostochni rookery in 1921 showed an increase of 22.33 per cent, but the count in 1922 showed a decline of 7.18 per cent. It may be that the 1921 figure was too high, but the difference between the 1921 and 1922 figures for this rookery is less than the difference between those for Polovina (counted in both years), proving that it is possible for Vostochni to vary as the figures show.

Since the variation in the annual rate of increase on one rookery and the variation in the increase of the different rookeries in the same year are so great, a constant rate of increase can not be given for any one rookery nor can the same rate of increase be applied to every rookery. The figure must be based largely upon yearly observations of rookery life.

The number of pups on St. George Island in 1922 is but little more than was estimated in 1921, the increase being 0.89 per cent. In 1921 the per cent gain was estimated to be 10.47, which was probably a little high. The total count of 1922 for both islands showed an increase of 5.24 per cent over the estimated figures of 1921.

That the number of dead pups on the rookeries was small was noticed early. In 1921 the percentage of dead pups was estimated to be 2.48 for both islands. In 1922 it dropped to 1.73, derived from actual counts. It is not believed that the 1921 figure was too high. From the top of the counting tower near rock 17 on Reef rookery in 1921 there were counted 22 dead pups just before the census of harems was taken. In 1922 at approximately the same time only 8 dead pups could be seen from the same tower. Of the 22 rookeries on both islands 9 show small increases and 13 show decreases in the percentage of dead pups. On Zapadni Reef rookery, St. Paul Island, the percentage of dead dropped from 3.19 (actual count) to 0.8 (actual count). On Gorbatch rookery it dropped from an estimated percentage of 2.74 to an actual percentage of 0.86. It is believed that the absence of rain and the constant temperature during June and the greater part of July tended to reduce the death rate of pups on the rookeries. The increase in the average harem also tended to decrease the percentage of dead pups.

COWS.

The table showing the distribution of pups will show the number of cows on the various rookeries, since the number of breeding cows is the same as the number of pups. The various percentages of increase or decrease of total pups will also apply to the cows. In all 90 dead cows were found during the pup count. This is a decrease of 29 from the number estimated in 1921. It is a little less than 0.05 of 1 per cent of the total number.

BRANDED SEALS.

Cows that as pups were branded with a single bar across the back between the years 1900 and 1903 continue to reappear on the rookeries of St. George Island. Four animals of this series were observed and each was raising a pup. These animals were at least 19 years old. When it is understood that seals born in 1903 passed through eight years of pelagic sealing, the continued presence of these cows is all the more remarkable.

Several cows bearing the 1912 brand appeared on St. George Island, and probably some were present on St. Paul, although none was observed there. Four bulls branded as pups in 1912 with the T-brand on the top of the head were also seen on St. George Island, each in charge of a harem.

HAREM AND IDLE BULLS.

The count of harem and idle bulls was made on St. Paul Island from July 16 to 20 and on St. George Island from July 22 to 23. The harems had begun to break up before the count was entirely finished and the harem masters had begun to leave their positions for the hauling grounds to rest and recuperate. As long as the average harem remains large there will be an early loss of harem formation with the consequent influx of idle bulls. In the future the counting dates on St. George Island should be the same as on St. Paul (July 16 to 20), or if there is no one on St. George available to make the count the census should start on St. Paul July 14 instead of 16, as at present. For the second successive season inclement weather has prevented a harem count on Sivutch rookery.

Harem and idle bulls and percentage of idle bulls to harem bulls compared to average harem, Pribilof Islands, 1922.

Rookery.	Date.	Harem bulls.	Idle bulls.	Total bulls.	Per cent idle to harem bulls.	Average harem.
St. Paul Island:						
Kitovi	July 20	158	10	168	6.33	37.56
Lukanin	..do.	96	12	108	12.50	36.92
Gorbatch	July 16	219	13	232	5.94	64.46
Ardiguen	..do.	24	3	27	12.50	41.83
Reef	..do.	425	40	465	9.41	59.89
Sivutch		[1] 171	[1] 27	[1] 198	15.79	47.73
Lagoon	July 20	8	....	8	....	34.13
Tolstoi	July 19	365	22	387	6.03	53.42
Zapadni	July 16	306	30	336	9.80	52.61
Little Zapadni	..do.	169	29	198	17.16	52.34
Zapadni Reef	..do.	17	....	17	....	29.24
Polovina	July 17	174	52	226	29.89	50.40
Polovina Cliffs	..do.	103	19	122	18.45	38.34
Little Polovina	..do.	43	17	60	39.53	35.26
Morjovi	July 18	103	50	153	48.54	38.04
Vostochni	..do.	803	169	972	21.05	46.46
Total		3,184	493	3,677	15.48	49.90
St. George Island:						
North	July 22	132	2	134	1.52	78.52
Staraya Artil	July 23	83	5	88	6.02	85.01
Zapadni	..do.	21	....	21	....	42.62
South	..do.	4	5	9	125.00	58.00
East Reef	July 22	49	2	51	4.08	48.57
East Cliffs	..do.	89	1	90	1.12	68.55
Total		378	15	393	3.97	71.50
Total (both islands)		3,562	508	4,070	14.26	52.19

[1] Weather had prevented a count of bulls on this rookery since 1920, when the number was 190. Applying the average decrease of harem bulls on all other rookeries on St. Paul Island (10 per cent) there should have been approximately 171 harem bulls in 1922. In the same manner the number of idle bulls is estimated to have been 27.

AVERAGE HAREM.

The average harem is computed by dividing the number of cows (females 3 years of age or over) by the number of harem bulls. The number of cows is obtained from the pup count, there being one cow for each pup.

The following table shows the average harem in 1922 for each rookery, for each island, and for the herd as a whole. For convenience the numbers of cows and harem bulls are also shown. The average harem on St. Paul Island increased from 43.53 in 1921 to 49.90 in 1922, on St. George Island from 57.49 in 1921 to 71.50 in 1922, and for the entire herd from 45.19 in 1921 to 52.19 in 1922.

Average harem in 1922 for all fur-seal rookeries on Pribilof Islands.

Rookery.	Breeding cows.	Harem bulls.	Average harem.
St. Paul Island:			
Kitovi	5,934	158	37.56
Lukanin	3,544	96	36.92
Gorbatch	14,117	219	64.46
Ardiguen	1,004	24	41.83
Reef	25,452	425	59.89
Sivutch	8,161	171	47.73
Lagoon	273	8	34.13
Tolstoi	19,497	365	53.42
Zapadni	16,100	306	52.61
Little Zapadni	8,846	169	52.34
Zapadni Reef	497	17	29.24
Polovina	8,770	174	50.40
Polovina Cliffs	3,949	103	38.34
Little Polovina	1,516	43	35.26
Morjovi	3,918	103	38.04
St. Paul Island—Con.			
Vostochni	37,308	803	46.46
Total	158,886	3,184	49.90
St. George Island:			
North	10,364	132	78.52
Staraya Artil	7,056	83	85.01
Zapadni	895	21	42.62
South	232	4	58.00
East Reef	2,380	49	48.57
East Cliffs	6,101	89	68.55
Total	27,028	378	71.50
Total (both islands)	185,914	3,562	52.19

ANNUAL INCREASE OF THE FUR-SEAL HERD.

The increase in the total number of seals in 1922 over 1921 was 23,519, or 4.04 per cent, as compared with an increase of 28,725, or 5.2 per cent, in 1921 over 1920.

The minimum reserve of 5,000 three-year-old males for breeding purposes as required by law will be wholly inadequate in the future for the proper upbuilding of the fur-seal herd. Not less than 10,000 seals of this class must be reserved annually in order to provide sufficient male strength.

COMPLETE CENSUS.

The figures given below are as nearly correct as it has been possible to make them. They are based upon a complete pup count on all rookeries, a harem count in which 11 elevated counting stations were used, and a close approximation of the numbers of those classes of seals that can not be counted. The seal herd shows a satisfactory growth, although the decrease in number of breeding bulls and the increase of average harem should be corrected as soon as possible. This can be done, of course, by reserving a large number of 3-year-old males.

Details of census of fur seals, Pribilof Islands, as of August 10, 1922.

	St. Paul.	St. George.
Pups, counted	158,886	27,028
Breeding cows, 3 years and over, by inference	158,886	27,028
Harem bulls, counted	3,184	378
Idle bulls, counted	493	15
Yearlings, male and female, estimated:		
Females born in 1921	74,933	13,395
Natural mortality, 35 per cent	26,227	4,688
Yearling females, Aug. 10, 1922	48,706	8,707
Males born in 1921	74,932	13,395
Natural mortality, 40 per cent	29,973	5,358
Yearling males beginning 1922	44,959	8,037
Yearling males killed 1922	8	....
Yearling males Aug. 10, 1922	44,951	8,037
2-year-olds, male and female, estimated:		
Yearling females, Aug. 10, 1921	46,565	7,882
Natural mortality, 15 per cent	6,985	1,182
2-year-old females, Aug. 10, 1922	39,580	6,700
Yearling males, Aug. 10, 1921	42,973	7,276
Natural mortality, 17½ per cent	7,520	1,273
2-year-old males beginning 1922	35,453	6,003
2-year-old males killed 1922	510	26
2-year-old males, Aug. 10, 1922	34,943	5,977
3-year-old males, estimated:		
2-year-old males, Aug. 10, 1921	35,678	6,215
2-year-old males killed fall 1921	38	13
2-year-old males end of 1921	35,640	6,202
Natural mortality, 12½ per cent	4,455	775
3-year-old males beginning 1922	31,185	5,427
3-year-old males killed 1922	24,398	4,755
3-year-old males, Aug. 10, 1922	6,787	672
4-year-old males, estimated:		
3-year-old males, Aug. 10, 1921	13,301	1,367
3-year-old males killed fall 1921	672	365
3-year-old males end of 1921	12,629	1,002
Natural mortality, 10 per cent	1,263	100
4-year-old males beginning 1922	11,366	902
4-year-old males killed 1922	416	45
4-year-old males, Aug. 10, 1922	10,950	857
5-year-old males, estimated:		
4-year-old males, Aug. 10, 1921	6,405	375
4-year-old males killed fall 1921	2	13
5-year-old males, estimated—Continued.		
4-year-old males end of 1921	6,403	362
Natural mortality, 10 per cent	640	36
5-year-old males beginning 1922	5,763	326
5-year-old males killed 1922	8	1
5-year-old males, Aug. 10, 1922	5,755	325
6-year-old males, estimated:		
5-year-old males, Aug. 10, 1921	3,841	888
5-year-old males killed fall 1921	....	10
5-year-old males end of 1921	3,841	878
Natural mortality, 20 per cent	768	176
6-year-old males beginning 1922	3,073	702
6-year-old males killed 1922	4	....
6-year-old males, Aug. 10, 1922	3,069	702
Surplus bulls, 7 years and over, estimated:		
6-year-old males, Aug. 10, 1921	3,895	96
6-year-old males killed fall 1921	....	....
6-year-old males end of 1921	3,895	96
Natural mortality, 20 per cent	779	19
7-year-old males beginning 1922	3,116	77
Surplus bulls, Aug. 10, 1921	2,921	380
Surplus bulls killed fall 1921	....	....
Surplus bulls end of 1921	2,921	380
Natural mortality, 30 per cent	876	114
Remaining surplus for 1922	2,045	266
Breeding bulls of 1921	4,154	502
Natural mortality, 30 per cent	1,246	151
1921 bulls remaining 1922	2,908	351
Breeding bulls of 1922	3,677	393
1921 bulls remaining, deducted	2,908	351
Increment new bulls 1922	769	42
7-year-old males computed for 1922	3,116	77
Surplus bulls computed for 1922	2,045	266
Total theoretical surplus bull stock for 1922	5,161	343
7-year-old males killed in 1922	....	1
Total surplus in 1922	5,161	342
New increment breeding bulls deducted	769	42
Surplus bulls in 1922	4,392	300
50 per cent deducted for losses due to fighting, natural causes, and errors in loss percentage in previous years	2,196	150
Surplus bulls, Aug. 10, 1922	2,196	150

RECAPITULATION.

	St. Paul.	St. George.	Both islands.
Pups	158,886	27,028	185,914
Cows	158,886	27,028	185,914
Harem bulls	3,184	378	3,562
Idle bulls	493	15	508
Yearling females	48,706	8,707	57,413
Yearling males	44,951	8,037	52,988
2-year-old females	39,580	6,700	46,280
2-year-old males	34,943	5,977	40,920
3-year-old males	6,787	672	7,459
4-year-old males	10,950	857	11,807
5-year-old males	5,755	325	6,080
6-year-old males	3,069	702	3,771
Surplus bulls (7 years and over)	2,196	150	2,346
Total, 1922	518,386	86,576	604,962
Total, 1921			581,443
Numerical increase, 1922			23,519
Per cent increase, 1922			4.04

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FISHERY INDUSTRIES OF THE UNITED STATES.

REPORT OF THE DIVISION OF FISHERY INDUSTRIES FOR 1922.[1]

By HARDEN F. TAYLOR, *Assistant in Charge*.[2]

(With the collaboration of the division staff.)

CONTENTS.

[1] Appendix V to the Report of the U. S. Commissioner of Fisheries for 1923. B. F. Doc. 954.
[2] Lewis Radcliffe was in charge of the Division of Fishery Industries until November 15, 1922.

INTRODUCTION.

The depression that existed in the fishery industries in 1920 and 1921 was, in some respects, relieved in 1922. The vessel landings in New England showed a slight increase in quantity, but because of lower prices the aggregate value was slightly less than that of 1921. At Seattle both quantity and value were about the same as for 1921, although the distribution of catch among the species was considerably different. The products of the fisheries of California amounted to 168,969,733 pounds, an increase of 32.3 per cent over the 127,728,623 pounds in 1921. The amount of fish frozen was 75,453,674 pounds, a decrease of 4.9 per cent from the amount frozen in 1921. The cold-storage holdings, especially in the latter part of the year, were smaller than they had been for several years. The indications are that this decrease in freezing and cold storage is due to a better market demand rather than to poorer supply.

There were some gratifying increases in the canning of fishery products. There was a decrease in canned shrimp; all other canned fishery products for which statistics are available increased. The canned salmon increase was due entirely to Alaska; there was a sharp decrease in the pack in the Pacific Coast States. The total pack of canned salmon was 5,234,898 cases, valued at $38,420,717, an increase of 45.4 per cent in quantity and 53.1 per cent in value over 1921. The pack of all canned fishery products amounted to 10,094,549 cases, valued at $60,464,947, an increase of 35.2 per cent in quantity and 29.6 per cent in value. The exports of canned fish in 1922 were 88,416,266 pounds, valued at $10,271,740, which is equivalent to 18 per cent in quantity and 17 per cent in value of the total pack.

The market surveys of Boston and Seattle brought forth some interesting and significant facts. Particularly significant is the fact that over half of the total amount of fish landed at Boston is consumed in Massachusetts, and over 80 per cent is consumed in Massachusetts and neighboring States. This indicates that little advantage is taken of the potential markets inland by the New England fisheries. From Seattle, however, the bulk of the shipments are to the interior and eastern markets.

SUMMARY OF OPERATIONS.

During the year, statistical canvasses were made of the fisheries of New York, New Jersey, Pennsylvania, and Delaware for 1921, and the take of shad and alewives in the Potomac and Hudson Rivers in 1922, and of the canned fisheries products and by-products of the United States for 1922. The last was confined to the number of plants operated, the raw products utilized, and the quantity and value of the finished products. The landings of the vessel fisheries at the ports of Boston and Gloucester, Mass., Portland, Me., and Seattle, Wash., have been collected as heretofore, and published as monthly and annual bulletins. In addition, there have been published monthly bulletins showing the amount of the several species of fish frozen and held in cold storage in the several sections of the country. The results of the canvasses mentioned, and summary analyses of the freezing and cold-storage data are embodied in the present report, together with quantity of fishery products taken in

California in 1922, the fishery products received at the Municipal Fish Wharf and Market, Washington, D. C.

Market surveys were made of the two primary producing markets of Seattle and Boston, and the results published as documents of this bureau.

In fisheries technology, notable progress has been made in net preservation, brine freezing of fish, and in the methods of canning sardines.

PUBLICATIONS OF THE DIVISION.

During the calendar year 1922 the following publications, prepared in this division, were issued. This list does not include the monthly statistical bulletins for Boston and Gloucester, Mass.; Portland, Me.; and Seattle, Wash.

DOCUMENTS.

Principles involved in the preservation of fish by salt; by Harden F. Taylor, 8°, 22 pp., Document No. 919.

Deductions concerning the air bladder and the specific gravity of fishes; by Harden F. Taylor, royal 8°, 6 pp., Document No. 921.

Trade in fresh and frozen fishery products and related marketing considerations in Seattle, Wash.; by L. T. Hopkinson, 8°, 16 pp., Document No. 930.

Fisheries and market for fishery products in Mexico, Central America, South America, West Indies, and Bermudas; by Lewis Radcliffe, 8°, 105 pp., 1 text fig., Document No. 931.

Fishery industries of the United States. Report of the division of statistics and methods of the fisheries for 1921; by Lewis Radcliffe, 8°, 136 pp., 8 figs., Document No. 932.

ECONOMIC CIRCULARS.

Trade in fresh and frozen fishery products and related marketing considerations in Minneapolis and St. Paul, Minn.; by L. T. Hopkinson, 8°, 21 pp., Economic Circular No. 55.

STATISTICAL BULLETINS.

Statement, by fishing grounds and by months, of quantities and values of certain fishery products landed at Seattle, Wash., by American fishing vessels during the calendar year 1921. Statistical Bulletin No. 516.

Statement, by months, of the quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American and Canadian fishing vessels, during the calendar year 1921. Statistical Bulletin No. 517.

Statement, by fishing grounds, of the quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American and Canadian fishing vessels, during the calendar year 1921. Statistical Bulletin No. 518.

Fisheries of Maryland and Virginia, 1920. Statistical Bulletin No. 520.

Canned fishery products and by-products of United States and Alaska, 1921. Statistical Bulletin No. 526.

IMPROVEMENTS IN MERCHANDISING FISHERY PRODUCTS.

There has been evident, particularly for the past year or two, an increasing perception by the fish industry of the necessity for better methods of merchandising fish. This field of activity includes not only technical methods of preparing, shipping, and handling fish, but also favorable publicity that will increase the demand for and consumption of fish.

FILLETING FISH.

Perhaps the most conspicuous expression of this growing demand for better technical methods is to be found in the recent development of filleting fish at the point of production. The practice began in New England, by way of an effort to stimulate a better demand for haddock, and has since been taken up at New York and other points.

The haddock are split, the backbone is removed, and the fillets are brined about 20 minutes in strong brine. Some cracked ice is added to the brine, if necessary, to keep it cool. After having been brined, the fillets are each wrapped in a vegetable parchment paper and are laid in pans or other vessel to be stored over night in a cold room. The temperature of the room is above 32° F., so as not to freeze the fillets. Pans of fillets, without lids, are stacked one above the other so as to press the fillets firmly, but not excessively.

Next morning the fillets are packed in tinned lard cans, each can containing about 30 pounds of the fillets. The lid is put on and the can is put into a wooden packing case, surrounded by cracked ice. These cans are shipped to retailers, delicatessens, butchers, and others, who dispose of one or more cans in each week's trade.

A variation in this practice is, instead of wrapping each fillet individually, to pack the fillets in the can in layers, following each layer with a cut circle of parchment paper.

Among the advantages of filleting fish are: (1) The entire piece purchased by the housewife is edible, and the price charged for it is fully competitive without making any allowance for waste; (2) there is no scaling, gutting, and cleaning to be done—a very disagreeable task to most women; (3) the shipping weight of the fish is reduced; (4) the waste, which is usually around 50 per cent of the round fish, remains in the hands of the producer, where it may be possible to use it economically; (5) fillets receive a more careful and cleanly handling all along the line, from producer to consumer, for the reason that they are wrapped, are more delicate, and will not endure the rough handling that round fish are subjected to.

It might be supposed that the retail customer would object to this method of distributing the fish, on the ground that he has little or no means of determining the identity of the fish, or judging its quality, since the distinguishing marks of both identity and quality are gone. Yet such an objection, if it exists, has not prevented a very rapid growth in the past year of this method of distributing fresh fish.

MARKET SURVEYS.

During 1922 the bureau continued its surveys of the fish industry of important or representative cities. In 1921, the surveys were of consuming markets; in 1922, two primary producing markets, Seattle and Boston, were studied, Seattle for 1921, and Boston for the month of September, 1922.

Seattle, with a population of 315,312, is the principal landing port for the northern Pacific fisheries. More than 83 per cent of the fish business is in salmon and halibut. The remaining business is in sablefish, rockfish, smelts, crabs, oysters, and shrimp, with 26 others in moderate or limited demand. There are 19 wholesalers and 48 retailers in Seattle, a ratio of 1 retailer to each 6,569 people. The production of fish (that is, fish landed) at Seattle amounted to 45,246,000 pounds. Of fresh and frozen fish, 29,778,000 pounds were shipped to points in the United States and foreign countries. Part of this was in less-than-carload shipments, but 635 full carloads went forward from Seattle in 1921, 78.5 per cent of which went to seven cities—Chicago, New York, Kansas City, Boston, Omaha, St. Louis, and Buffalo. Fish were frozen in Seattle in 1921 to the extent of 12,025,501 pounds. Thirteen carloads of oysters were received into Seattle from eastern points.

Boston, with a population of 748,060, is the principal landing port for the fisheries of the North Atlantic. It is also the greatest fishing port in the United States and is one of the world's fishing ports. More than 80 per cent of its fishing business, on the basis of quantity, is in cod, haddock, halibut, mackerel, swordfish, and lobsters, a very different group of fish from those prominent in Seattle. A moderate or limited business is also done in alewives, butterfish, carp, flounders, salmon, smelts, suckers, clams, crabs, oysters, and some 54 other species. In Boston there were 108 wholesale fish dealers and 171 retailers, there being 1 retailer for each 6,926 people. The production or landings of fish in the year ended September 30, 1922, was 101,949,725 pounds, valued at $4,051,350. In the month of September, 1922, the following products were landed at Boston: Fish, 13,244,074 pounds; lobsters, 616,355 pounds; clams, 338,964 pounds; oysters, 10,068 gallons or 80,554 pounds; scallops 478 gallons or 3,824 pounds. The amount of fish frozen during 1922 was 8,946,183 pounds, and the amount distributed from Boston during September, 1922, was 11,056,709 pounds. In the month of September, 56 per cent of all Boston's fish was consumed in Massachusetts; and in Massachusetts, Rhode Island, Connecticut, New York, and Pennsylvania, 89 per cent of Boston's fish was consumed. Boston is thus unlike Seattle in this respect, where the great bulk of shipments goes to distant cities.

TECHNOLOGICAL INVESTIGATIONS.

As has been pointed out in previous reports of this division the need for technological investigations is urgent. This fact is evident both from the consumer's and the producer's standpoints. The former may wonder why, when the fisherman spends no money to raise his crop of fish, the price approaches that of meats produced at much expense; the producer, on the other hand, readily recognizes that the serious limits set upon his business by the perishable character of his goods and by the large overhead expense prevent an economic and profitable operation and an increase in the demand.

Fish are about 50 per cent edible, the remaining 50 per cent being heads, fins, viscera, etc. In the case of cattle and swine such waste is kept and utilized at a considerable profit. There is little doubt that similar use can be more extensively made of waste from fish, if processes are made available by technological research. It is also evident to the producer of fish, if not to the consumer, that the great total losses in transportation increase the price of fish without increasing its value; much of the loss resides in inferior quality after transportation, which stifles demand. The obvious remedy for this condition is to devise methods of transportation of fish that will prevent both the total losses and the losses of quality in transit, so that the consumer may be offered a more attractive article at a competitive price, and that will stabilize the business generally. A reduction in the fisherman's overhead expense for nets will make the business more profitable and stable at its foundation and help to compensate for the arduous character of the fisherman's calling. We are concerned here, not so much with the immediate profits of the fish business, how large they are, and who gets them—important as these questions are—but with the more significant fact that one of our large natural resources stands poorly developed, because of waste, excessive overhead expenses, and difficulty in reaching the great inland markets with a first-class product. The waste can not be avoided, the overhead expenses can not be reduced, and the distant markets can not be reached except through scientific technological investigations. These have been conducted as far as possible during the year with such funds and personnel as were available, as will now be discussed more particularly.

BRINE FREEZING.

In the report of this division for 1921 mention was made of the status of brine freezing at that time; it was pointed out that in principle brine freezing seemed to have received sufficient test and approval by various scientific investigators and that the chief problem ahead was the engineering one of constructing a plant that would freeze fish on a large commercial scale, with a minimum of labor and expense and in a sufficiently simple way to be practicable in the ordinary fish freezer. The requirements of such a plant are: (1) It should apply brine at the lowest possible temperature to the entire surface of the fish; (2) the brine should move at the highest practicable speed past the surfaces of the fish; (3) the fish should be held straight and trim during the freezing; (4) operation should preferably be continuous and automatic; (5) the other necessary operations of washing and glazing should be performed, if possible, without additional handling. The prospects of meeting these requirements seem good in an experimental plant that has been constructed in the Fishery Products Laboratory in Washington. Fish are suspended on a horizontal bar and while so suspended are conveyed by mechanical means successsively through a shower of water for washing, through a violent shower or rainstorm of brine at a very low temperature for freezing, and again through a shower of water that washes off the brine and applies a glaze. The fish emerge from the apparatus frozen and glazed, ready for storage or shipment. During 1922 the plant was constructed and to some extent tested. Its operating characteristics appear promising, but it will need to be given more thorough trial before definite conclusions can be reached.

PRESERVATION OF NETS.

Mention was made in the report of this division for 1921 of the work undertaken on the preservation of fish nets. Extensive experiments brought out interesting and useful data concerning many preservatives in common use, and also concerning materials not hitherto used as net preservatives. These data are published in a separate document.[3]

Perhaps the most significant result of the work was the discovery of the valuable properties of copper oleate as a net preservative. This substance, from its fundamental properties, seemed to offer good prospects as a net preservative and was accordingly included in various combinations among the substances tested. It was dissolved in gasoline or benzol and the twine was dipped in the solution. By testing before and after various periods of exposure it was found to preserve lines well, to reduce if not entirely prevent fouling by barnacles and the like, and in addition to these two fundamental essential properties, to affect stiffness and increase weight of twine very little. It does not diminish mechanical wearing quality of twine, as many other preservatives do, does not shrink the line appreciably, and is not very expensive or difficult to apply. Announcement of the results was made at the annual meetings of the American Fisheries Society at Madison, Wis., September 6, 1922, and the United States Fisheries Association at Atlantic City, N. J., September 22, 1922, followed by short publications of summaries of results in the fishery trade journals. The interest of the fishing industry in this work was immediate and widespread. The next step in the investigation was a practical trial of the material by several fishermen in different localities, to whom the bureau supplied a sufficient amount of copper oleate for the tests, with directions for use. About 700 pounds of copper oleate were made for this purpose in the Fishery Products Laboratory.

Meanwhile, several companies entered into the manufacture of copper oleate for a fish-net preservative, and much of it has been sold and is in use by fishermen. The 1923 season will probably be conclusive of its actual value. Further experiments are in progress on a still larger scale, including several other proposed preservatives and also combinations of copper oleate designed to make it more suitable for use in fresh water, since earlier experiments were less satisfactory in fresh water than in salt water.

CANNING SARDINES.

By far the greater part of sardines canned in California are packed in sauce, principally tomato. The usual procedure is to clean the fish, brine, dry, fry in oil, cool and pack the fish, exhaust, seal, and retort the cans.

In this process, the most objectionable feature is the frying in oil. This part of the process was studied at the San Pedro (Calif.) laboratory in 1921, and the results of that investigation were discussed in the division's report for that year. The results have since been published by the California Fish and Game Commission.[4] The principal conclusion arrived at in that work was that the fry bath is responsible for the existence in canned sardines of a rancid, indigestible oil, which greatly detracts from the quality of the goods. Since the primary purpose of the fry bath is to cook out the excess water from the fish before canning, the problem resolved itself into one of removing the

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[3] Taylor, Harden F., and Arthur W. Wells: Properties and Values of Certain Fish-net Preservatives. Appendix I, Report of the U. S. Commissioner of Fisheries for 1923, Document 947, 69 pp., 35 figs. Washington, 1923.

[4] Beard, Harry R.: Changes in Oil used for Frying Sardine, State of California, Fish and Game Commission Circular No. 1, March, 1922, 8 pp.

water by some other means. Three methods of doing this were tried at the San Pedro laboratory, namely, steaming, cooking in brine, and packing raw after brining and drying.

Steaming has been tried before—in fact, the method was at one time practiced on a considerable scale in California, but the practice was discontinued. Later, the method was practiced at Santa Cruz and Monterey, and the product found favor with the public. Steaming causes the skin to break, both during the processing and after the cooling. This effect was diminished by brining and drying, and oiling the trays helped to prevent the fish from sticking to the trays. A product was thus prepared that was apparently the equal, if not the superior, of the usual fried-in-oil product.

Good results were obtained also by precooking the fish in strong brine instead of oil. The usual operation of brining the fish is omitted. Preliminary drying was necessary, however, to prevent the skins from breaking during the cooking, and precautions were also necessary to prevent the fish from sticking to each other and to the trays.

The third method of removing the water consisted of brining in saturated brine, drying, canning, and processing. The brining is carried as far as possible without excessively salting the fish. A thick tomato sauce is used to take up the excess moisture released in the processing. Certain common losses are prevented by this method, but there is a disadvantage in the necessity of carrying out the process within a few hours after the fish are landed.

The investigator who did this work also visited the Maine sardine industry during the summer in order to acquaint himself with the problems in that field and to throw any possible light on the methods employed in California.

SALTING OF PACIFIC COAST MACKEREL.

Attention was also given by the San Pedro laboratory to the salting of the Pacific coast mackerel (*Scomber japonicus*). The fish is, in general, less fat than the Atlantic mackerel, and its flesh is more likely to be dark in color. It was found, however, that the method that had previously been found in the bureau's salting experiments to be applicable in warm climates was here successful. This process consists in using high purity salt, applied dry to perfectly fresh fish that have been thoroughly cleaned of all blood and viscera. These points all seem to be essential. Packers who have themselves hit upon most of these points have found by experience that salt of inferior quality produces inferior fish and that any blood left in the fish darkens the fish. Freshness is also important, so much so that salting aboard the boats seems advisable.

PEARL ESSENCE.

Pearl essence, an incidental product of the fisheries, has continued to attract considerable attention, perhaps more because of its spectacular beauty and novel application than because of its real importance. Nevertheless, the business of manufacturing imitation pearls, which was at one time an exclusively European and Japanese industry, has migrated to America to a very large extent. New York city and environs are now the center of a considerable imitation-pearl

FIG. 1.—View of the fisheries exhibit at the Brazilian Centennial Exposition.

FIG. 2.—View of the fisheries exhibit at the Brazilian Centennial Exposition.

industry, based largely on the supply of pearl essence produced in the United States, principally from herring and alewife scales.

A process of making a pearl essence has been elaborated in the Fishery Products Laboratory, which in technique is a radical departure from any methods known to have been used hitherto. By this method, the lustrous material from the scales is removed in water, together with any dirt, blood, slime, etc., that may accompany the scales. The crude suspension is then treated chemically in such a way that the lustrous or nacreous particles are removed bodily from the crude liquor, leaving all else behind, and are transferred to ether and then to ethyl or amyl acetate. These latter substances are solvents of nitrocellulose, which, when dissolved in the suspension, makes a pearl lacquer. This, applied to glass beads, makes the "indestructible" pearl of commerce. "Essence" has been prepared by this process from the alewife, herring, gizzard shad (*Dorosoma cepedianum*), shad, silver carp or quillback (*Carpiodes velifer*), and no doubt could be prepared successfully in large quantities from the California pilchard or sardine and from many other fishes. The details of the process will be published in a separate document.

FISHERIES EXHIBIT AT THE BRAZILIAN INTERNATIONAL CENTENNIAL EXPOSITION.

The act of Congress authorizing the United States to participate officially in the Brazilian International Centennial Exposition at Rio de Janeiro, contained the following clause:

> SEC. 6. That the Secretary of Commerce is hereby authorized to collect and prepare a suitable exhibit of the fisheries industry of the United States for exhibit at the said exposition and accompany the same with a report respecting such industry, to be printed in the English, Spanish, and Portuguese languages, the expense of the same to be paid out of the appropriation hereinafter provided for.

Under authority from the Secretary of Commerce, the Bureau of Fisheries prepared and managed that part of the exhibit that related to the fisheries of the United States. (See figs. 1 and 2.)

The organization and functions of the Bureau of Fisheries were shown by a chart and an automatic projection machine, which showed successively 70 slides. The salmon industry was exhibited by means of an illustrated chart, showing life history of the salmon, the methods of propagation, the fishery, and methods of canning and salting the salmon. The chart was supplemented by an exhibit of salmon eggs in various stages of development, a model salmon-pile trap, a display of canned salmon, a projection machine showing 20 slides, and 2 motion-picture films.

The New England bank fisheries were represented also by illustrated charts, dealing with fish-cultural and industrial aspects of the fishery, two vessel models, and 120 implements, and a variety of exhibits of canned, smoked, and salted fishery products, nets, lines, twine, models of fish, and several large transparencies showing New England fishing operations, hatchery work, etc. An exhibit was made also of the bureau's work on the preservation of nets.

The sardine industry was represented by two large illustrated charts, supplemented by a model of a sardine weir and a display of canned sardines. Seventy-five pictures of the oyster industry were shown successively by an automatic projection machine. The chief implements and products of this industry were on exhibition. The menhaden industry was shown by an illustrated chart and a comprehensive assembly of oils, fertilizers, fish meal, and other by-products of the fisheries.

An exhibit of canned fishery products was comprehensive and of a variety that might surprise anyone who was not familiar with the field. Other exhibits included oceanographic apparatus, the mother-of-pearl industry, retail marketing methods, fishery colleges, and an assembly of publications of the Bureau of Fisheries, including one specially prepared for the purpose and printed in English, Spanish, and Portuguese, being a general description of American fisheries.

AGREEMENT BETWEEN BUREAU OF THE CENSUS AND BUREAU OF FISHERIES RELATIVE TO COLLECTION OF STATISTICS ON FISH AND MARINE ANIMAL OILS.

According to an agreement reached on May 18, 1922, between the Bureau of the Census and the Bureau of Fisheries, the statistics of production and consumption of fish and marine animal oils in the United States are now taken by the Bureau of Fisheries. Cards are sent out quarterly to all producers, who are asked to fill out and return to this bureau the data required. The data are tabulated and supplied to the Bureau of the Census. The agreement is as follows:

The Bureau of the Census is required to collect quarterly reports on the production, consumption, and stocks of animal and vegetable fats and oils. The Bureau of Fisheries has been collecting annual statistics concerning the commercial catch of fish, the pack of fish, and the manufacture of by-products, which includes fish oils. The collection of these statistics by the two bureaus results in the duplication in the same department of the collection of similar reports on the production of fish oils from the same concerns. In order to avoid this condition it is agreed that the Bureau of the Census will discontinue the collection of statistics concerning the production of fish oils and stocks held by the producers.

It is further agreed that the Bureau of Fisheries will canvass the producers of fish oils quarterly and furnish these statistics to the Bureau of the Census to be incorporated in the quarterly reports on the production, consumption, and stocks of animal and vegetable fats and oils.

The Bureau of the Census will furnish the Bureau of Fisheries its list of producers of fish oils. The Bureau of Fisheries will canvass the estabishments listed as well as any others which may be added from time to time from any available sources. The Bureau of Fisheries will be responsible for the completeness of the canvasses and the accuracy of the statistics, and if desired will furnish the Bureau of the Census a list of the producers of fish oils.

Every effort will be made by the Bureau of the Census to expedite the issuance of the preliminary press bulletins showing the production, factory consumption, and stocks of fish oils. Due credit is to be given to the Bureau of Fisheries for its collection of the data.

Details not covered by this agreement can be adjusted by the two bureaus.

THE PRODUCTION OF CERTAIN FISHERY PRODUCTS IN 1921 AND 1922.

The following table has been prepared to show the general trend of the fish industry in so far as changes can be shown by data available that apply to 1921 and 1922:

Production and value of certain fishery products in 1921 and 1922, compared.

Products.	1921		1922		Increase (+) or decrease (−).	
	Quantity.	Value.	Quantity.	Value.	Quantity (per cent).	Value (per cent).
Fish landed by fishing vessels at Boston and Gloucester, Mass., and Portland, Me ....pounds..	150,865,106	$5,722,629	159,875,391	$5,465,932	+6.0	−4.5
Trips.................number..	7,206	....	6,349	....	−11.9	....
Fish landed by fishing and collecting vessels at Seattle, Wash...............pounds..	26,005,225	2,202,181	26,415,440	2,214,654	+1.2	+.6
Trips.................number..	866	....	836	....	−3.4	....
Products of the fisheries of California..............pounds..	127,728,623	....	168,969,733	....	+32.3	....
Fish received at Washington, D. C., Municipal Fish Wharf..............pounds..	9,066,744	....	6,442,663	....	−28.9	....
Sponges sold at Sponge Exchange, Tarpon Springs, Fla.................pounds..	386,390	540,093	526,885	699,092	+36.4	+29.4
Canned salmon:						
Pacific Coast States..cases..	1,002,948	9,234,425	733,246	8,633,524	−26.9	−6.5
Alaska...............do....	2,596,826	19,632,744	4,501,652	29,787,193	+73.3	+51.7
Total, canned salmon ....cases..	3,599,774	28,867,169	5,234,898	38,420,717	+45.4	+33.1
Canned sardines:						
Maine................do....	1,350,631	3,960,916	1,775,878	5,750,109	+31.5	+45.2
California............do....	415,587	2,346,446	728,979	3,361,480	+75.4	+43.2
Total, canned sardines ....cases..	1,766,218	6,307,362	2,504,857	9,111,589	+41.8	+44.4
Canned albacore and tuna, bluefin, yellowfin, and striped...............cases..	418,821	3,073,681	614,926	4,294,912	+46.8	+39.7
Canned shrimp..........do....	667,558	3,804,781	586,691	3,064,087	−12.1	−19.4
Canned clams, hard, soft, and razor..................cases..	226,130	1,166,507	308,640	1,716,365	+36.5	−47.1
Canned oysters..........do....	455,550	2,179,271	522,549	2,423,616	+14.7	+11.2
All canned fishery products ....cases..	7,464,210	46,634,706	10,094,549	60,464,947	+35.2	+29.6
Menhaden industry:						
Fish utilized.....number..	1,031,540,831	1,929,219	1,212,450,669	2,457,690	+17.5	+27.4
Fish meal and scrap produced.............tons..	82,662	2,288,095	93,576	3,221,758	+13.2	+40.9
Oil.................gallons..	6,260,478	1,719,892	7,102,677	2,904,833	+13.4	+68.9
Fish oils, other than menhaden ....gallons..	1,017,074	264,011	1,185,651	441,213	+16.6	+67.1
Fish meal and scrap, other than menhaden........tons..	24,611	1,271,047	22,590	1,114,919	−8.2	−12.3
Liquid glue...........gallons..	347,048	364,415	323,003	278,424	−6.9	−23.6
All by-products...............	....	8,351,827	....	11,390,693	....	+36.4
Fish, frozen...........pounds..	79,173,892	....	75,453,674	....	−4.7	....

CANNED FISHERY PRODUCTS AND BY-PRODUCTS OF THE UNITED STATES AND ALASKA, 1922.

The bureau has made a canvass of the canned fishery products and by-products of the United States and Alaska for 1922, and the statistics were published and distributed to the trade as Statistical Bulletin No. 570. The total value of canned products in 1922 amounted to $60,464,947 and of by-products to $11,390,693. As compared with 1921 there was an increase in the value of canned products of $13,830,241, or 29.65 per cent, and in the value of by-products of $3,038,866, or 36.38 per cent. The canned products consisted principally of canned salmon, sardines, shad, alewives, albacore, tuna, shrimp, crabs, clams, and oysters, and the by-products of fish scrap, fish meal, and fish oil, and ground oyster shells for use as poultry grit and lime. The fish scrap, fish meal, and fish oil prepared in the menhaden industry are also included under by-products of the fisheries.

CANNED FISHERY PRODUCTS.

CANNED SALMON.

In 1922 there were 179 plants engaged in canning salmon in the Pacific Coast States and Alaska. Of this number 123 were operated in Alaska, 34 in Washington, 20 in Oregon, and 2 in California. The pack of canned salmon in 1922, on the basis of 48 pounds to the case, amounted to 5,234,898 cases, valued at $38,420,717.

In the Pacific Coast States the pack amounted to 733,246 cases, valued at $8,633,524, as follows: Chinook, 314,126 cases, valued at $4,572,607; coho or silver, 204,262 cases, valued at $1,533,173; sockeye, 97,927 cases, valued at $1,816,901; chum, 87,583 cases, valued at $365,303; humpback or pink, 3,551 cases, valued at $18,546; and steelhead, 25,797 cases, valued at $326,994. The pack in Washington amounted to 441,667 cases, valued at $4,823,074; in Oregon, 279,748 cases, valued at $3,614,140; and in California, 11,831 cases, valued at $196,310. The pack in California consisted entirely of chinook salmon.

In Alaska the pack amounted to 4,501,652 cases, valued at $29,787,193, divided as follows: Red or sockeye, 2,070,658 cases, valued at $19,135,696; humpback or pink, 1,658,423 cases, valued at $7,189,494; chum or keta, 565,918 cases, valued at $2,251,540; coho or silver, 175,993 cases, valued at $962,790; and king, chinook, or spring, 30,660 cases, valued at $247,673.

Compared with the previous year there was an increase of 42 salmon canneries in Alaska and a decrease of 1 cannery in the Pacific Coast States, or a total increase of 41 canneries. There was an increase in the pack of canned salmon of 1,635,124 cases, or 45.42 per cent, in quantity and of $9,553,548, or 33.09 per cent, in value. There was an increase in the pack in Alaska of 1,904,826 cases, or 73.35 per cent, in quantity and of $10,154,449, or 51.72 per cent, in value. In the Pacific Coast States there was a decrease of 269,702 cases, or 26.89 per cent, in quantity and of $600,901, or 6.51 per cent, in value. This decrease was due to a falling off in the pack in Washington of 312,379 cases, or 41.43 per cent, in quantity and of $1,201,515, or 19.94 per cent, in value. There was an increase in the pack in Oregon of 40,142 cases, or 16.75 per cent, in quantity and of $537,914, or 17.49 per cent, in value, and also in the pack of California, of 2,535 cases, or 27.26 per cent, in quantity and of $62,700, or 46.93 per cent, in value.

Pack of canned salmon of the Pacific Coast States and Alaska in 1922.

Products.	Pacific Coast States.								Alaska.	
	Washington.		Oregon.		California.		Total.		Southeast.	
	Cases.	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*
Coho or silver:										
½-pound flat	48,551	$470,494	25,706	$215,445	...	...	74,257	$685,939	20,013	$151,666
1-pound flat	49,244	337,320	27,618	194,877	...	...	76,862	532,197	10,773	63,515
1-pound tall	45,704	271,854	7,439	43,183	...	...	53,143	315,037	91,861	462,365
Total	143,499	1,079,668	60,763	453,505	...	...	204,262	1,533,173	122,647	677,546
Chum or keta:										
½-pound flat	4,627	27,203	636	3,816	...	...	5,263	31,109	3,698	21,228
1-pound flat	76	532	...	...	...	...	76	532	6,185	25,693
1-pound tall	78,387	317,745	3,857	15,917	...	...	82,244	333,662	414,383	1,640,135
Total	83,090	345,570	4,493	19,733	...	...	87,583	365,303	424,266	1,687,056
Humpback or pink:										
½-pound flat	1,506	9,779	...	...	...	...	1,506	9,779	30,725	197,953
1-pound flat	...	...	...	...	...	...	...	...	28,148	134,268
1-pound tall	2,045	8,767	...	...	...	...	2,045	8,767	1,273,679	5,461,536
Total	3,551	18,546	...	...	...	...	3,551	18,546	1,332,552	5,793,757
King, chinook, or spring:										
½-pound flat	69,086	1,097,429	105,475	1,772,959	7,669	$138,042	182,230	3,008,430	2,695	30,640
½-pound oval	300	7,440	76	1,885	...	...	376	9,325	...	...
1-pound flat	36,036	446,488	51,356	652,707	4,162	58,268	91,554	1,157,463	1,735	15,209
1-pound oval	2,998	56,961	19,552	207,679	...	...	22,550	264,640	...	...
1-pound tall	11,304	87,701	6,112	45,048	...	...	17,416	132,749	1,703	11,448
Total	119,724	1,696,019	182,571	2,680,278	11,831	196,310	314,126	4,572,607	6,133	57,297
Red or sockeye:										
½-pound flat	70,625	1,332,887	12,972	231,755	...	...	83,597	1,564,642	57,783	779,582
1-pound flat	13,440	238,236	...	...	...	...	13,440	238,236	17,579	171,509
1-pound tall	575	9,550	315	4,473	...	...	890	14,023	57,783	530,278
Total	84,640	1,580,673	13,287	236,228	...	...	97,927	1,816,901	133,145	1,481,369
Steelhead:										
½-pound flat	5,525	79,701	11,944	162,457	...	...	17,469	242,158	...	...
1-pound flat	1,551	21,714	6,675	61,783	...	...	8,226	83,497	...	...
1-pound tall	87	1,183	15	156	...	...	102	1,339	...	...
Total	7,163	102,598	18,634	224,396	...	...	25,797	326,994	...	...
Grand total	441,667	4,823,074	279,748	3,614,140	11,831	196,310	733,246	8,633,524	2,018,743	9,697,025

Products.	Alaska—Continued.						Grand total.	
	Central.		Western.		Total.			
	Cases.	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*
Coho or silver:								
½-pound flat	2,224	$17,039	...	...	22,237	$168,705	96,494	$854,644
1-pound flat	1,291	8,005	35	$166	12,099	71,686	88,961	603,883
1-pound tall	36,919	192,234	12,877	67,800	141,657	722,399	194,800	1,037,436
Total	40,434	217,278	12,912	67,966	175,993	962,790	380,255	2,495,963
Chum or keta:								
½-pound flat	...	...	...	...	3,698	21,228	8,961	52,337
1-pound flat	...	...	...	...	6,185	25,693	6,261	26,225
1-pound tall	91,239	362,440	50,413	202,044	556,035	2,204,619	638,279	2,538,281
Total	91,239	362,440	50,413	202,044	565,918	2,251,540	653,501	2,616,843
Humpback or pink:								
½-pound flat	12,011	75,746	...	...	42,736	273,698	44,242	283,477
1-pound flat	2,731	13,655	...	...	30,879	147,923	30,879	147,923
1-pound tall	298,226	1,251,399	12,903	54,938	1,584,808	6,767,873	1,586,853	6,776,640
Total	312,968	1,340,799	12,903	54,938	1,658,423	7,189,494	1,661,974	7,208,040

Pack of canned salmon of the Pacific Coast States and Alaska in 1922—Continued.

Products.	Alaska—Continued.						Grand total.	
	Central.		Western.		Total.			
	Cases.	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*
King, chinook, or spring:								
½-pound flat	1,022	$13,341	53	$742	3,770	$44,723	186,090	$3,053,153
½-pound oval							376	9,325
1-pound flat	2,067	20,538	165	2,002	3,967	37,749	95,521	1,195,212
1-pound oval							22,550	264,640
1-pound tall	7,076	53,168	14,144	100,585	22,923	165,201	40,339	297,950
Total	10,165	87,047	14,362	103,329	30,660	247,673	344,786	4,820,280
Red or sockeye:								
½-pound flat	89,603	1,257,544	24,510	384,901	171,896	2,422,027	255,403	3,986,669
1-pound flat	59,799	614,403	44,071	437,530	121,449	1,223,442	134,889	1,461,678
1-pound tall	383,935	3,447,679	1,335,595	11,512,270	1,777,313	15,490,227	1,778,203	15,501,250
Total	533,337	5,319,626	1,404,176	12,334,701	2,070,658	19,135,696	2,168,585	20,952,597
Steelhead:								
½-pound flat							17,469	242,158
1-pound flat							8,226	83,497
1-pound tall							102	1,339
Total							25,797	326,994
Grand total	988,143	7,327,190	1,494,766	12,762,978	4,501,652	29,787,193	5,234,898	38,420,717

CANNED SARDINES.

In 1922 there was a marked increase in the pack of sardines in both Maine and California. In Maine, 1,775,878 cases were packed, valued at $5,750,109, an increase of 31.5 per cent in the number of cases and 45.2 per cent in value over the pack in 1921, when 1,350,631 cases, valued at $3,960,916, were packed. Of the 1922 pack, 1,454,146 cases were quarter oils, valued at $4,645,436, an average of $3.19 per case, an increase of 10.4 per cent over the average value per case of quarter oils in 1921, which was $2.89. The quantity of herrings utilized was 96,458,400 pounds, valued at $623,198.

In California, 728,979 cases of sardines were packed, valued at $3,361,480, an increase of 75.4 per cent in number of cases and 43.2 per cent in value over the pack in 1921, when 415,587 cases, valued at $2,346,446, were packed. Of the 1922 pack, 697,643 cases, valued at $3,078,760, were pound ovals, with an average value of $4.41 per case, a decrease of 18.4 per cent from the value per case in 1921, when 379,928 cases of pound ovals, valued at $2,056,367, were packed, the average value per case being $5.41.

Pack of sardines in Maine and California, 1922.

Sardines (herring).[1]	Maine.		Sardines (pilchard).	California.	
	Cases.	*Value.*		*Cases.*	*Value.*
In oil: Quarters (100 cans)	1,454,146	$4,645,436	¼-pound oval (48 cans)	7,239	$32,182
In mustard:			1-pound oval (48 cans):		
Quarters (100 cans)	101,290	378,163	In tomato sauce	601,111	2,518,843
Three-quarters (48 cans)	213,276	689,008	In mustard	53,993	295,111
In tomato sauce: Quarters (100 cans)	7,166	37,502	All others	42,539	264,806
			1-pound tall (48 cans)	78	232
			¼-pound square (100 cans)	21,124	217,953
			½-pound square (100 cans)	2,895	32,353
Total	1,775,878	5,750,109	Total	728,979	3,361,480

[1] The quantity of herring utilized was 96,458,400 pounds, valued at $623.198.

CANNED SHAD AND ALEWIVES.

The pack of canned shad and shad roe is confined to the Pacific Coast States. In 1922 the pack of shad amounted to 2,257 cases, valued at $9,961; and of shad roe to 433 cases, valued at $8,517. In 1921 the pack of shad was 841 cases, valued at $2,455, and the pack of shad roe was 53 cases, valued at $142.

The pack of alewives and alewife roe was prepared in Maryland, Virginia, and North Carolina, mostly in the Chesapeake Bay district. In 1922 the pack of canned alewives was 1,043 cases, valued at $1,994, and of canned roe 38,298 cases, valued at $137,514. In 1921 the pack of canned alewives was 312 cases, valued at $813, and of canned roe, 40,530 cases, valued at $157,841.

Pack of shad and alew

Shad.	Washington, Oregon, and California.			a, and olina.	
	Cases.	Value.			alue.
½-pound flat (48 cans)	779	$1,620	No. 2 (		1,994
½-pound oval (48 cans)	174	3,480	Roe:		
1-pound tall (48 cans)	1,304	4,861	N		4,608
Roe:			N		4,134
½-pound flat (48 cans)	283	6,045	N		8,772
1-pound oval (48 cans)	150	2,472			
Total	2,690	18,478	....	39,341	139,508

CANNED ALBACORE, TUNA, AND MA NIA.

The total pack of tuna of all varie a, where this industry is located, was, in 1922, 614,9 at $4,294,912, an increase of 46.8 per cent in number .7 per cent in value over the pack of 1921, which es, valued at $3,073,681.

Data are also given in the table for to, yellowtail, and miscellaneous, which includes fis ne, mackerel, squid, and "tonno." "Tonno" is strip ellowfin tuna, canned Italian style, and sold under the Italian label.

Pack of albacore, tuna, bonito, and yellowtail in California, 1922.

Products.	One-fourth pound round cans (48 to case).		One-fourth pound round cans (100 to case).		One-half pound round cans (48 to case).		One-half pound round cans (50 to case).	
	Cases.	Value.	Cases.	Value.	Cases.	Value.	Cases.	Value.
Albacore	24,962	$126,139	14,820	$222,300	188,235	$1,368,883	9,436	$108,514
Tuna, bluefin and yellowfin	37,537	164,757	2,390	24,083	101,764	613,344		
Tuna, striped	34,772	120,678	3,162	33,690	122,310	622,565		
Bonito			5,223	34,879	5,368	24,021		
Yellowtail					4,088	17,104		
Miscellaneous [1]	22,557	115,785	1,467	14,670	4,049	25,194		

[1] Includes fish flakes, abalone, mackerel, squid, and "tonno."

Pack of albacore, tuna, bonito, and yellowtail in California, 1922—Continued.

Products.	One-pound round cans (48 to case).		One-pound tall cans (48 to case).		One-pound oval cans (48 to case).		Four-pound tall cans (12 to case).		Total.	
	Cases.	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*
Albacore	34,475	$466,399					635	$12,700	272,563	$2,304,935
Tuna, bluefin and yellowfin	22,926	255,437							164,617	1,047,621
Tuna, striped	17,502	159,423							177,746	912,356
Bonito									10,591	58,900
Yellowtail			315	$1,890					4,403	18,994
Miscellaneous [1]	219	1,861	3,051	22,883	205	$1,640			31,548	182,033

[1] Includes fish flakes, abalone, mackerel, squid, and "tonno."

CANNED SHRIMP AND CRABS.

In 1922 the pack of shrimp was 586,691 cases, valued at $3,064,087, a decrease of 12.1 per cent in number of cases and 19.4 per cent in value from the pack in 1921, which was 667,558 cases, valued at $3,804,781. The pack of crabs in 1922 was 9,111 cases, valued at $104,171, also a decrease from the pack of 1921, which was 11,960 cases, valued at $115,800.

Pack of shrimp in South Atlantic and Gulf States, 1922.

States.	No. 1 cans (4 dozen).		No. 1½ cans (2 dozen).		No. 2½ and No. 10 cans (2 dozen and ½ dozen).		Total.	
	Cases.	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*
Georgia and North Carolina	71,004	$360,161	6,289	$33,078			77,293	$393,239
Florida	93,094	512,054	1,724	9,310			94,818	521,364
Alabama	56,434	290,676	3,704	19,333	812	$5,784	60,950	315,793
Mississippi	166,198	840,319	8,268	42,070			174,466	882,389
Louisiana	158,672	840,306	20,492	110,996			179,164	951,302
Total	545,402	2,843,516	40,477	214,787	812	5,784	586,691	3,064,087

Pack of crabs, 1922.

States.	7½-ounce, 8-ounce, and 9-ounce cans (4 dozen).		15-ounce and 16-ounce cans (2 dozen).		Total.	
	Cases.	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*
Virginia, Washington, Maine, and Alaska.	8,401	$95,364	710	$8,807	9,111	$104,171

CANNED CLAMS.

The total pack of hard clams, soft clams, and razor clams in 1922 was 308,640 cases, valued at $1,716,365, which compared with the total pack of 1921—226,130 cases, valued at $1,166,507—was an increase of 36.5 per cent in number of cases and 47.1 per cent in value.

Pack of clams, by States, 1922.

RAZOR CLAMS.

Sizes.	Washington.		Oregon.		Alaska		Total.	
	Cases.	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*
Whole:								
No. 1 cans (4 dozen)	9,134	$78,185	500	$5,500			9,634	$83,685
No. 2 cans (2 dozen)	1,394	9,061	300	1,950			1,694	11,011
No. 10 cans (½ dozen)	138	966					138	966
1-pound cans (4 dozen)					1,434	$11,604	1,434	11,604
Minced:								
½-pound flat cans (4 dozen)	51,099	291,422	1,907	11,349	18,078	74,520	71,084	377,291
No. 1 cans (4 dozen)	33,677	238,622	3,971	29,576			37,648	268,198
No. 2 cans (2 dozen)	3,209	19,027	909	5,699			4,118	24,726
10-ounce cans (4 dozen)					11,732	89,634	11,732	89,634
1-pound cans (4 dozen)					1,046	9,249	1,046	9,249
Juice:								
No. 2 cans (2 dozen)	1,076	3,228					1,076	3,228
No. 10 cans (½ dozen)	52	364					52	364
Total	99,779	640,875	7,587	54,074	32,290	185,007	139,656	879,956

HARD CLAMS.

Sizes.	Florida and Washington.		Sizes.	Florida and Washington.	
	Cases.	*Value.*		*Cases.*	*Value.*
Whole:			Bouillon, chowder, and juice:		
No. 1 cans (4 dozen)	15,018	$104,633	No. 1 cans (4 dozen)	9,015	$42,078
No. 1 cans (2 dozen)	291	989	No. 2 cans (2 dozen)	2,391	7,699
No. 2 cans (2 dozen)	11,423	61,064	No. 3 cans (2 dozen)	2,854	15,902
No. 10 cans (½ dozen)	2,048	12,775	No. 10 cans (½ dozen)	650	4,168
Minced:			1½ and 3 ounce bottles	1,102	2,371
½-pound flat cans (4 dozen)	358	1,792	7 and 14 ounce bottles (2 dozen)	3,874	24,554
No. 1 cans (4 dozen)	2,355	14,219			
No. 2 cans (2 dozen)	883	4,415			
No. 10 cans (½ dozen)	87	783	Total	52,349	298,042

SOFT CLAMS.

Sizes.	Maine, Massachusetts, and Rhode Island.		Sizes.	Maine, Massachusetts, and Rhode Island.	
	Cases.	*Value.*		*Cases.*	*Value.*
Whole:			Bouillon, chowder, and broth:		
5 and 5½ ounce cans (4 dozen)	33,589	$157,809	8, 10, and 16 ounce cans (4 dozen)	14,334	$74,320
6 and 8 ounce cans (2 dozen)	6,155	22,916	32-ounce cans (2 dozen)	15,267	81,760
8 and 10 ounce cans (4 dozen)	14,099	84,015	1-gallon cans (½ dozen)	1,126	6,000
8½ and 10-ounce cans (2 dozen)	4,110	19,547	No. 1 cans (2 dozen)	20,000	49,000
1-pound cans (4 dozen)	4,212	25,000	Total	116,635	538,367
2-pound cans (2 dozen)	3,743	18,000			

CANNED OYSTERS.

In 1922 the pack of oysters was 522,549 cases, valued at $2,423,616, an increase of 14.7 per cent in number of cases and 11.2 per cent in value over the pack of 1921, which was 455,550 cases, valued at $2,179,271. The industry is located in the States of Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana. There was a noteworthy decrease in the pack of Maryland, where 80,872 cases were packed, as compared with 156,431 cases in 1921.

Packs of oysters, by States, 1922.

Sizes.	Maryland.		North Carolina.		South Carolina.		Georgia.	
	Cases.	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*
4-ounce cans (4 dozen)	9,710	$47,023	3,756	$16,526	7,601	$28,797		
5-ounce cans (4 dozen)	39,312	203,099	18,881	78,924	84,710	369,240	17,639	$78,308
6-ounce cans (4 dozen)	11,320	119,747			96	768	500	4,000
8-ounce cans (2 dozen)	2,414	11,927	2,500	9,500	3,425	12,127		
10-ounce cans (2 dozen)	16,657	85,352	3,863	16,117	24,065	100,933	648	2,863
12-ounce cans (2 dozen)	1,459	12,424					25	200
Total	80,872	479,572	29,000	121,067	119,897	511,865	18,812	85,371

Sizes.	Florida.		Alabama.		Louisiana and Mississippi.		Total.	
	Cases.	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*	*Cases.*	*Value.*
4-ounce cans (4 dozen)			568	$2,386	46,381	$199,250	68,016	$293,982
5-ounce cans (4 dozen)	14,019	$66,357	27,168	117,607	117,650	534,544	319,379	1,448,079
6-ounce cans (4 dozen)							11,916	124,515
8-ounce cans (2 dozen)			816	3,229	19,112	82,320	28,267	119,103
10-ounce cans (2 dozen)	15	68	10,745	48,485	37,494	171,495	93,487	425,313
12-ounce cans (2 dozen)							1,481	12,624
Total	14,034	66,425	39,297	171,707	220,637	987,609	522,549	2,423,616

MISCELLANEOUS CANNED FISHERY PRODUCTS.

In addition to the products shown in the tables, there were packed in Maine, Massachusetts, New York, New Jersey, Maryland, Virginia, North Carolina, and Washington, 224,304 cases of miscellaneous fishery products, valued at $840,329. The pack of preserved salmon eggs in Washington amounted to 79,976 pounds, valued at $55,976, and in Oregon, to 33,130 pounds, valued at $16,080.

EXPORTS OF CANNED FISHERY PRODUCTS IN 1922.

Data showing the amount of canned fish exported from the United States during the calendar year 1922, collected and compiled by the Bureau of Foreign and Domestic Commerce, are given in the following table:

Domestic exports of canned fish from the United States, by countries, 1922.

Countries.	Canned salmon.		Sardines.		Flaked fish.		Other canned fish.	
	Pounds.	*Dollars.*	*Pounds.*	*Dollars.*	*Pounds.*	*Dollars.*	*Pounds.*	*Dollars.*
Azores and Madeira Islands	360	31	120	39				
Belgium	2,608,391	250,333	221,300	16,625			110,020	12,570
Denmark	102,144	10,301	29,000	2,400			3,405	2,228
Finland			180	26	39	6		
France	32,540	2,743	48,000	6,000			281,363	50,879
Germany	93,431	11,768	14,057	1,956			116	44
Greece	11,350	1,200	8,235	901			11,938	2,263
Hungary	48	6						
Iceland, and Faroe Islands	150	8						
Italy	1,212,351	108,904	96,081	9,458			1,160	675
Malta, Gozo, and Cyprus Islands	14,400	1,400						
Netherlands	618,028	77,002					3,405	852
Norway	36,590	3,909						
Poland and Danzig	107	22						
Rumania							825	165
Russia in Europe	33,000	4,329						
Spain	214	20					14,658	2,601
Sweden	69,506	13,912					4,360	1,266
Switzerland	75,998	10,127						
Turkey in Europe	48,760	4,640					70,000	7,500

Domestic exports of canned fish from the United States, by countries, 1922—Continue

Countries.	Canned salmon.		Sardines.		Flaked fish.		Other canned fish.	
	Pounds.	*Dollars.*	*Pounds.*	*Dollars.*	*Pounds.*	*Dollars.*	*Pounds.*	*Dollars.*
Ukraine	329,840	28,134	16,450	705			1,974	309
England	23,937,667	3,732,859	244,727	17,740			252,761	54,612
Scotland	346,200	67,407					619	232
Canada:								
Maritime Provinces	25,438	3,537	1,734,662	126,327	450	105	251,928	19,037
Quebec and Ontario	599,834	67,487	4,492	1,101	452	86	104,169	21,933
Prairie Provinces	79,840	14,241	4,861	454			8,546	2,306
British Columbia and Yukon	3,175,943	321,872	2,561	567	1,412	189	82,101	13,491
British Honduras	27,234	3,193	40,740	4,551	276	53	1,307	151
Costa Rica	187,848	17,193	134,530	12,415			23,389	2,157
Guatemala	50,271	5,168	113,908	12,354	15	3	29,381	3,514
Honduras	66,924	9,021	142,708	15,854	456	90	6,347	1,345
Nicaragua	42,003	4,309	44,848	5,595	30	7	5,836	689
Panama	283,390	35,599	160,474	17,798	1,547	126	23,315	5,997
Salvador	8,564	994	45,110	4,573			18,628	2,033
Mexico	2,819,248	227,649	2,736,099	251,103	986	207	556,312	59,399
Miquelon and St. Pierre Islands	2,400	200						
Newfoundland and Labrador			600	106			118	40
Bermuda	41,302	6,440	17,053	2,764			1,208	489
Barbados	22,262	3,450	780	102			44	15
Jamaica	85,548	10,038	235,979	20,851			1,888	450
Trinidad and Tobago	117,381	18,670	62,073	5,875			1,528	490
Other British West Indies	48,284	8,048	28,225	3,966	136	28	4,593	944
Cuba	434,803	38,397	1,122,349	96,433	2,006	290	139,390	13,445
Dominican Republic	167,784	15,417	322,668	39,181	169	33	4,250	890
Dutch West Indies	32,418	5,553	26,158	2,866	30	5	2,658	553
French West Indies	912	73	725	90				
Haiti	2,356	398	1,343	227	12,299	1,200	406	187
Virgin Islands of the U. S.	42,014	5,178	20,163	3,148	230	41	1,408	301
Argentina	477,872	48,188	333,035	28,124			143,700	12,440
Bolivia	125,560	10,483	114,156	10,260			32,410	2,953
Brazil	14,400	3,075	8,762	360			2,476	2,013
Chile	1,893,557	181,242	174,148	15,979			1,810	261
Colombia	290,178	31,592	175,396	20,020	277	43	16,690	3,860
Ecuador	237,196	23,317	265,640	23,973			77,266	6,814
British Guiana	99,632	17,144	77,479	9,384	240	40	5,470	830
Dutch Guiana	76,928	9,517	28,715	4,024			145	45
French Guiana	2,783	400	610	102				
Peru	42,353	4,342	497,397	44,716	204	41	8,641	1,256
Uruguay	3,120	556					218	113
Venezuela	555,873	56,473	57,622	5,757	625	79	6,596	1,756
Aden	24,000	1,900						
Armenia and Kurdistan	350	36						
British India	769,867	95,127	119,859	15,895			12,223	2,339
Ceylon	88,276	10,282	1,290	149	375	82	1,749	277
Straits Settlements	1,893,804	160,220	2,653,713	236,536			234,162	20,812
Other British East Indies	1,516	88	5,371	570				
China	83,459	13,321	284,863	31,049			42,363	4,864
Chosen	1,692	343	365	85			215	78
Java and Madura	1,687,365	149,187	1,385,590	128,496	1,750	109	54,047	5,805
Other Dutch East Indies	249,466	25,830	211,657	21,760			40,867	4,173
Far Eastern Republic			3,640	506	40	28		
French Indo-China	9,168	1,187	6,750	637			75	38
Greece in Asia	9,600	940					44,000	1,760
Hongkong	86,364	13,297	351,440	33,337			26,758	2,865
Japan	5,606	714	9,070	1,559			47,637	3,060
Kwangtung			140,776	12,976				
Palestine and Syria	54,321	5,076	3,644	388			147	43
Philippine Islands	7,719,124	610,114	5,405,313	441,066	777	173	1,573,122	143,750
Russia in Asia			768	100				
Siam	158,538	13,775	2,734	329			508	114
Turkey in Asia	4,800	500						
Australia	6,663,952	1,045,545	992	289			7,072	1,319
British Oceania	88,472	8,487	5,016	220	48	11	848	131
French Oceania	164,122	18,547	25,942	3,957			4,807	620

Domestic exports of canned fish from the United States, by countries, 1922—Continued.

Countries.	Canned salmon.		Sardines.		Flaked fish.		Other canned fish.	
	Pounds.	*Dollars.*	*Pounds.*	*Dollars.*	*Pounds.*	*Dollars.*	*Pounds.*	*Dollars.*
New Zealand	149,598	26,413	96	12			537	230
Other Oceania	108,454	10,674	1,741	239			1,644	247
Belgian Kongo	1,268	205	600	50				
British West Africa	59,998	6,363	8,042	1,109			42,265	2,616
British South Africa	1,724,928	181,061	11,600	1,579			31,689	5,964
British East Africa	15,360	1,591						
Canary Islands	44,792	4,586						
Egypt	73,408	9,193					36,024	3,630
Other French Africa	732	75	167	47				
Liberia	3,930	403					1,563	69
Morocco	4,925	606	25	5			1,120	260
Portuguese East Africa	88,973	8,814	8,662	1,161			5,467	1,393
Other Portuguese Africa	48	11					68	18
Spanish Africa	2,475	355					2,400	465
Total	63,797,279	7,962,375	20,059,845	1,780,956	24,869	3,075	4,634,273	525,334

BY-PRODUCTS OF THE FISHERIES.

The utilization of waste products of the fisheries to produce valuable by-products continues to hold the attention of the fish trade. In this direction lies a possibility of reducing the excess overhead expense in the fish industry. The principal by-products are fish oils and fish meal and scrap. The total value of all by-products of the fisheries in 1922 was $11,390,693, an increase of 36.4 per cent over the value of the production in 1921, which was $8,351,827.

FISH OILS.

The fish-oil production in the United States and Alaska in 1922 amounted to 8,288,328 gallons, valued at $3,346,046. This does not include the production of whale oil, which in 1922 was 1,863,015 gallons, valued at $731,000, nor sperm oil, which was 384,130 gallons, valued at $153,714. The largest item of fish oil is menhaden oil, of which 7,102,677 gallons were produced, valued at $2,904,833. In 1921 the total production of fish oil was 7,446,281 gallons, valued at $2,078,670. There was thus in 1922 an increase of 11.3 per cent in the total quantity of fish oils (exclusive of whale and sperm) and 61 per cent in the value. The oils produced in 1922 include besides menhaden, whale, and sperm oils, salmon, 25,989 gallons; sardine, 428,859 gallons; tuna, 86,099 gallons; herring, 450,362 gallons; liver, 67,459 gallons; cod liver, 4,080 gallons; miscellaneous fish oils, 122,803 gallons.

FISH SCRAP AND MEAL.

The total value of all fish scrap and meal, green and dry, including that prepared from shrimp and menhaden, was, in 1922, 116,166 tons, valued at $4,336,677, an increase of 8.29 per cent in quantity and 21.9 per cent in value over the production in 1921, which was 107,273 tons, valued at $3,557,142. Of the total amount 93,576 tons, or 80.5 per cent, was produced by menhaden, and 22,590 tons, or 19.5 per cent, by all other fish, the latter amount, valued at $1,114,919, representing a decrease of 8.2 per cent in quantity and

12.3 per cent in value from the amount produced by all other fish in 1921, which was 24,611 tons, valued at $1,271,047. Included in the production of meal and scrap in 1922 are 21,638 tons of dried scrap or meal, 390 tons of crude or green scrap, and 562 tons of shrimp bran.

LIQUID FISH GLUE.

In 1922 the production of liquid fish glue was 323,003 gallons, valued at $278,424, a decrease of 6.9 per cent in quantity and 23.6 per cent in value from the production of 1921, which was 347,048 gallons, valued at $364,415.

POULTRY GRIT AND LIME.

The production of poultry grit from oyster shells in 1922 was 236,021 tons, valued at $2,005,838; in 1921, 185,474 tons, valued at $1,759,120. The production of lime in 1922 was 93,168 tons, valued at $431,213, an increase of 26.3 per cent in quantity, but a decrease of 14.2 per cent in value over the production in 1921, which was 73,764 tons, valued at $502,634. This industry is carried on on the Atlantic coast from Massachusetts to Texas.

Production of various by-products of the fisheries, 1922.

Products.	Massachusetts and Maine.		Maryland.		New York, Virginia, North Carolina, and Florida.	
	Quantity.	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*
Fish scrap and meal:						
Dried .... tons..	3,455	$146,103	1,236	$28,970	1,593	$52,521
Crude or green .... do....	390	9,175	....	....	....	....
Oil:						
Herring .... gallons..	25,121	5,726	....	....	....	....
Sperm .... do....	152,986	81,082	....	....	....	....
Liver .... do....	67,459	31,774	....	....	....	....
Cod-liver .... do....	3,980	1,792	....	....	....	....
Miscellaneous .... do....	99	1,150	3,500	595	11,877	3,469
Liquid glue .... do....	323,003	278,424	....	....	....	....
Miscellaneous by-products[1] . pounds..	291,421	58,198	....	....	87,835	8,733
Total	....	613,424	....	29,565	....	64,723

Products.	Louisiana.		Washington, Oregon, California, and Alaska.		Total.	
	Quantity.	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*
Fish scrap and meal:						
Dried .... tons..	....	....	15,354	$862,752	21,638	$1,090,346
Crude or green .... do....	....	....	....	....	390	9,175
Shrimp bran .... do....	562	$15,398	....	....	562	15,398
Oil:						
Salmon .... gallons..	....	....	25,989	9,435	25,989	9,435
Sardine .... do....	....	....	428,859	145,668	428,859	145,668
Tuna .... do....	....	....	86,099	62,702	86,099	62,702
Herring .... do....	....	....	425,241	144,418	450,362	150,144
Whale .... do....	....	....	1,863,015	731,000	1,863,015	731,000
Sperm .... do....	....	....	231,144	72,632	384,130	153,714
Liver .... do....	....	....	....	....	67,459	31,774
Cod-liver .... do....	....	....	100	100	4,080	1,892
Miscellaneous .... do....	....	....	107,327	34,384	122,803	39,598
Liquid glue .... do....	....	....	....	....	323,003	278,424
Miscellaneous by-products[1] . pounds..	....	....	1,256,500	40,850	1,635,256	107,781
Total	....	15,398	....	2,103,941	....	2,827,051

[1] Includes shark hides, agar-agar, pearl or fish-scale essence, shark fins, whale bones (skeletons), whale tails, ambergris, herring skins, and alewife scales.

Production of poultry grit and lime from ground oyster shells, 1922.

States.	Poultry grit.		Lime.		Total.	
	Tons.	*Value.*	*Tons.*	*Value.*	*Tons.*	*Value.*
Rhode Island, Pennsylvania, and New Jersey	20,493	$200,831	7,799	$31,873	28,292	$232,704
Maryland	90,249	803,388	38,211	155,119	128,460	958,507
Virginia	26,173	230,115	27,445	182,680	53,618	412,795
North Carolina, South Carolina, and Georgia	6,740	56,165	1,815	9,075	8,555	65,240
Florida	13,800	96,400	112	1,008	13,912	97,408
Alabama	7,154	56,987	510	760	7,664	57,747
Mississippi	32,646	251,872	780	780	33,426	252,652
Louisiana	34,684	274,944	15,956	47,218	50,640	322,162
Texas	4,082	35,136	540	2,700	4,622	37,836
Total	236,021	2,005,838	93,168	431,213	329,189	2,437,051

THE MENHADEN INDUSTRY.

In the menhaden industry in 1922 substantial increases were made in the amount of fish utilized and in the quantities and values of all the important products. Forty-five factories were engaged in the manufacture of products from menhaden, as compared with 39 in 1921. These 45 factories were located as follows: Massachusetts, 1; Connecticut, 1; New York, 2; New Jersey, 3; Delaware, 1; Virginia, 18; North Carolina, 15; Georgia, 1; Florida, 2; and Texas, 1.

The number of fish utilized was 1,212,450,669, or 747,470,402 pounds, valued at $2,457,690, as compared with 1,031,540,831 fish, or 618,924,499 pounds, valued at $1,929,219, produced in 1921, an increase in 1922 of 17.5 per cent in number of fish and 27.4 per cent in value. The amount of fish meal and scrap produced from menhaden in 1922 was 93,576 tons, valued at $3,221,758, an increase of 12.2 per cent in quantity and 40.9 per cent in value over the 82,662 tons produced in 1921, valued at $2,286,905. The 1922 production of meal and scrap was 67,821 tons of dry scrap, valued at $2,665,441, of which 7,172 tons, valued at $390,667, were reported sold as fish meal; 25,712 tons of acidulated scrap, valued at $555,973; and 43 tons of crude or green scrap, valued at $344. The meal and scrap derived from menhaden was 80.5 per cent of all the fish meal and scrap produced in 1922.

The amount of menhaden oil produced in 1922 was 7,102,677 gallons, valued at $2,904,833, as compared with 6,260,478 gallons, valued at $1,719,892, produced in 1921, an increase of 13.4 per cent in quantity and 68.9 per cent in value. The oil derived from menhaden was 85.7 per cent of the total quantity of fish oils produced in 1922 and 86.8 per cent of the total value.

Products of the menhaden industry, by States, 1922.

Products.	Massachusetts, Connecticut, and New York.		New Jersey and Delaware.		Virginia.	
	Quantity.	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*
Fish utilized: Menhaden ....number..	258,086,285	$515,344	169,504,000	$358,994	460,612,000	$947,995
Manufactured products:						
Dry scrap and fish meal ....tons..	18,024	530,606	690	30,538	34,244	1,526,864
Acidulated scrap......do....	....	....	15,097	311,632	....	....
Crude or green scrap..do....	43	344	....	....	....	....
Total	18,067	530,950	15,787	342,170	34,244	1,526,864
Oil........gallons..	2,066,461	904,252	916,570	416,169	2,560,065	958,831
Grand total	....	1,435,202	....	758,339	....	2,485,695

Products of the menhaden industry, by States, 1922—Continued.

Products.	North Carolina.		Georgia, Florida, and Texas.		Total.	
	Quantity.	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*
Fish utilized: Menhaden ....number..	188,162,430	$376,320	136,085,954	$259,037	[1] 1,212,450,669	$2,457,690
Manufactured products:						
Dry scrap and fish meal ....tons..	8,783	320,817	6,080	256,616	67,821	2,665,441
Acidulated scrap...do....	6,615	160,341	4,000	84,000	25,712	555,973
Crude or green scrap ....tons..	....	....	....	....	43	344
Total..............	15,398	481,158	10,080	340,616	93,576	3,221,758
Oil..........gallons..	967,606	396,055	591,885	229,526	7,102,677	2,904,833
Grand total..........	....	877,213	....	570,142	....	6,126,591

[1] 747,470,402 pounds.

FROZEN FISH.

COLD-STORAGE HOLDINGS IN 1922.

The year 1922 was the first year of publication by the Bureau of Fisheries of the statistics on frozen fish collected by the Bureau of Markets and Crop Estimates of the Department of Agriculture. Monthly bulletins were issued, showing the holdings, by sections of the country, of the several species. The following table shows the total holdings of all the freezers, 274 in number, which are devoted wholly or in part to the cold storage of fish, together with the totals for the years 1917 to 1921, inclusive, for comparison. It will be seen that the holdings were very much smaller in 1922 than they had been on corresponding dates in several previous years. The time of least holdings was in May, and of greatest holdings in November.

Monthly holdings of frozen fish in the United States in 1922, by species, and in 1917–1921, by totals.

Species.	Month ending—					
	Jan. 15.	Feb. 15.	Mar. 15.	Apr. 15.	May 15.	June 15.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Bluefish (all trade sizes)........	560,281	288,842	154,308	84,573	76,625	65,731
Butterfish (all trade sizes).....	517,671	392,633	226,769	174,142	31,974	45,869
Catfish..................	(1)	(1)	(1)	(1)	(1)	(1)
Ciscoes (including bluefin, blackfin, chub, lake herring, etc.)........	5,561,416	4,431,776	3,110,959	2,022,514	1,420,733	1,080,265
Ciscoes (tullibees)...........	1,563,492	1,919,122	1,398,898	1,293,296	1,228,155	1,136,446
Cod, haddock, hake, pollock..	1,361,438	1,136,103	912,639	673,813	501,345	391,435
Croakers..................	72,555	22,802	12,431	27,455	36,916	24,395
Flounders.................	(1)	(1)	(1)	(1)	(1)	(1)
Halibut (all trade sizes).......	6,306,402	4,804,504	3,792,067	2,552,146	2,879,457	3,877,505
Herring, sea (including alewives and bluebacks)......	4,147,828	2,493,750	1,157,587	756,686	595,294	1,121,368
Lake trout................	1,866,261	1,256,408	700,022	262,413	400,243	497,994
Mackerel (excepting Spanish).	1,480,099	1,333,111	907,933	381,666	670,696	1,929,491
Pike perches and pike or pickerel..................	(1)	(1)	(1)	(1)	(1)	(1)
Rockfishes................	28,939	34,209	62,690	42,489	39,044	(2)
Sablefish (black cod).........	1,234,632	1,069,903	934,305	707,126	651,426	580,391
Salmon, silver and fall........	2,392,877	1,532,008	1,129,168	535,507	406,181	343,956
Salmon, steelhead trout.......	549,797	525,122	526,350	208,136	183,498	117,643
Salmon, all other.............	2,817,996	2,265,775	1,501,731	868,091	725,315	718,773
Sea bass..................	74,368	61,340	53,123	47,320	49,009	(2)
Scup (porgies).............	(1)	(1)	(1)	(1)	(1)	(1)
Shad.....................	279,235	250,502	85,334	62,289	65,719	272,814
Shad roe..................	22,391	10,564	4,008	37,374	55,013	

[1] Included in "Miscellaneous frozen fish" previous to July 15, 1922.
[2] Included in "Miscellaneous frozen fish" after June 15, 1922.

Monthly holdings of frozen fish in the United States in 1922, by species, and in 1917–1921, by totals—Continued.

Species.	Month ending—					
	Jan. 15.	Feb. 15.	Mar. 15.	Apr. 15.	May 15.	June 15.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Shellfish	[1]	[1]	[1]	[1]	[1]	[1]
Smelts, eulachon, etc	383,769	982,110	1,153,317	447,520	300,663	351,032
Squeteagues or "sea trout"	1,484,601	1,150,765	659,069	415,236	359,431	282,955
Squid	1,879,094	1,438,138	1,008,871	513,843	640,205	1,036,268
Sturgeon and spoonbill cat	[1]	[1]	[1]	[1]	[1]	[1]
Suckers	[1]	[1]	[1]	[1]	[1]	[1]
Whitefish	2,201,436	1,990,535	1,413,991	1,633,224	1,488,930	1,427,316
Whiting	3,440,123	1,971,639	939,166	601,533	681,941	1,445,202
Miscellaneous frozen fish	8,093,511	6,390,541	3,629,918	3,076,583	3,528,104	4,074,226
Total, 1922	48,320,212	37,742,262	25,474,714	17,484,975	17,075,917	20,821,345
Total, 1921	53,851,000	42,116,000	33,404,000	28,444,000	26,346,000	32,311,000
Total, 1920	61,510,357	47,904,057	29,958,132	20,632,834	19,803,817	27,779,230
Total, 1919	80,683,761	67,617,473	50,036,475	37,110,856	37,174,104	48,840,359
Total, 1918	51,116,037	35,907,071	28,457,301	26,548,272	31,403,425	50,298,027
Total, 1917	32,234,530	14,727,099	13,374,429	9,516,217	14,040,024	27,791,047

Species.	Month ending—					
	July 15.	Aug. 15.	Sept. 15.	Oct. 15.	Nov. 15.	Dec. 15.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Bluefish (all trade sizes)	146,500	217,436	412,499	616,902	822,088	750,217
Butterfish (all trade sizes)	139,011	270,914	331,408	413,172	698,229	560,308
Catfish	93,850	226,185	223,567	286,840	294,897	276,165
Ciscoes (including bluefin, blackfin, chub, lake herring, etc.)	987,020	2,784,763	4,921,011	6,396,242	6,065,777	6,035,490
Ciscoes (tullibees)	1,065,332	1,107,863	1,262,472	1,102,933	726,353	691,601
Cod, haddock, hake, pollock	339,608	401,952	399,663	374,282	467,872	578,789
Croakers	75,107	36,631	21,983	6,187	18,105	8,992
Flounders	232,922	253,371	260,994	294,205	368,583	323,004
Halibut (all trade sizes)	4,380,814	4,834,598	6,287,404	6,825,076	5,741,218	4,534,336
Herring, sea (including alewives and bluebacks)	1,086,214	1,584,969	1,939,373	6,426,458	4,064,862	2,936,146
Lake trout	564,824	496,889	426,471	592,295	1,616,778	1,853,804
Mackerel (excepting Spanish)	2,425,336	2,846,563	2,982,542	5,024,591	5,602,906	4,953,093
Pike perches and pike or pickerel	294,740	309,971	326,227	544,572	1,221,608	2,284,614
Rockfishes	[2]	[2]	[2]	[2]	[2]	[2]
Sablefish (black cod)	488,369	527,449	609,989	808,067	904,713	813,479
Salmon, silver and fall	600,519	968,776	2,000,351	3,391,007	4,265,068	3,414,927
Salmon, steelhead trout	208,593	491,643	620,807	674,078	680,250	709,845
Salmon, all other	1,193,740	1,795,048	4,389,069	5,973,497	5,392,880	4,175,559
Sea bass	[2]	[2]	[2]	[2]	[2]	[2]
Scup (porgies)	1,043,186	1,994,110	2,056,438	2,019,059	1,837,128	1,695,801
Shad Shad roe	300,415	316,930	337,193	349,533	350,019	214,345
Shellfish	234,951	207,485	196,044	297,906	492,780	563,496
Smelts, eulachon, etc	334,332	332,124	336,185	326,580	299,418	203,858
Squeteagues or "sea trout"	260,400	178,590	439,231	535,027	612,389	531,436
Squid	1,038,565	1,037,814	881,371	801,356	497,286	268,207
Sturgeon and spoonbill cat	257,338	319,535	389,402	434,463	406,616	366,914
Suckers	16,271	14,385	7,739	7,330	12,779	16,954
Whitefish	1,439,629	1,444,187	1,755,583	2,182,448	2,277,889	2,146,540
Whiting	3,047,540	3,786,091	4,009,602	4,048,788	3,931,149	3,406,502
Miscellaneous frozen fish	3,324,856	3,439,898	3,316,526	4,003,889	4,832,643	4,880,408
Total, 1922	25,620,042	32,226,170	41,141,144	54,756,783	54,502,283	48,689,830
Total, 1921	40,160,000	47,431,000	54,469,000	58,899,000	61,228,000	59,125,646
Total, 1920	36,617,706	47,140,132	56,295,975	64,730,531	67,549,377	65,841,000
Total, 1919	59,674,801	65,145,234	69,580,555	76,763,253	78,769,101	74,202,339
Total, 1918	64,864,532	82,554,798	89,203,946	93,811,909	99,631,789	96,600,247
Total, 1917	38,431,221	44,024,666	47,197,660	60,676,722	70,938,957	69,986,671

[1] Included in "Miscellaneous frozen fish" previous to July 15, 1922.
[2] Included in "Miscellaneous frozen fish" after June 15, 1922.

QUANTITIES FROZEN IN 1922.

The following table shows the amount of fish frozen in the United States in 1922, by months, with totals for 1920 and 1921 for comparison. If we reckon the total catch of edible fish in the United States and Alaska as 1,600,000,000 pounds, the total amount of fish frozen—75.453.674 pounds—is about 4.7 per cent of the total.

Fish frozen monthly in 1922, by species, and in 1920 and 1921, by totals.

Species.	Month ending—						
	Jan. 15.	Feb. 15.	Mar. 15.	Apr. 15.	May 15.	June 15.	July 15.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Bluefish (all trade sizes)	....	87	3,038	3,184	4,710	96,538	107,860
Butterfish (all trade sizes)	....	....	3,954	....	20,477	82,516	153,349
Catfish	(1)	(1)	(1)	(1)	(1)	82,995	144,875
Ciscoes (including bluefin, blackfin, chub, lake herring, etc.)	1,495	16,111	54,955	14,995	9,035	167,351	2,160,231
Ciscoes (tullibees)	20,551	21,655	5,352	....	54	1,883	100,794
Cod, haddock, hake, pollock	7,240	38,814	121,318	51,615	81,415	26,138	140,489
Croakers	....	....	15,245	11,490	....	64,720	22,527
Flounders	(1)	(1)	(1)	(1)	(1)	22,608	52,854
Halibut (all trade sizes)	366,656	132,730	86,702	60,016	327,932	742,023	602,336
Herring, sea (including alewives and bluefins)	237,800	118,170	180,085	116,995	413,227	127,355	588,875
Lake trout	16,771	16,767	3,914	100,725	164,412	109,125	38,228
Mackerel (excepting Spanish)	59,566	88,077	6,268	272,610	1,332,947	624,264	502,729
Pikeperches and pike or pickerel	(1)	(1)	(1)	(1)	(1)	27,941	23,684
Sablefish (black cod)	9,115	20,363	27,696	89,569	10,300	56,114	126,593
Salmon, silver and fall	113,716	66,106	10,639	11,740	79,488	345,895	441,724
Salmon, steelhead trout	2,330	11,820	31,723	....	4,015	103,436	300,391
Salmon, all other	10,296	11,491	17,718	148,786	286,177	785,093	687,818
Scup (porgies)	(1)	(1)	(1)	(1)	(1)	912,682	991,728
Shad and shad roe	1,312	1,029	36,639	50,806	167,699	22,329	38,644
Shellfish	(1)	(1)	(1)	(1)	(1)	32,194	30,558
Smelts, eulachon, etc	151,053	116,021	33,407	1,381	767	900	2,865
Squeteagues or "sea trout"	7,748	....	6,753	9,507	15,175	40,383	9,030
Squid	5,000	1,164	....	207,013	422,219	91,845	124,291
Sturgeon and spoonbill cat	(1)	(1)	(1)	(1)	(1)	88,032	97,009
Suckers	(1)	(1)	(1)	(1)	(1)	....	151
Whitefish	4,885	8,410	18,781	8,135	4,235	50,273	49,133
Whiting	67,271	308,484	220,225	104,547	953,820	1,856,675	910,336
Miscellaneous frozen fish	309,987	437,143	612,126	717,321	1,551,433	864,929	686,058
Total frozen fish, 1922	1,452,801	1,363,042	1,496,538	1,980,435	5,849,537	7,376,237	9,121,160
Total frozen fish, 1921	2,843,000	1,770,000	2,413,000	2,698,000	9,624,000	10,151,000	9,845,000
Total frozen fish, 1920	2,273,744	2,630,482	2,465,375	3,687,538	10,094,367	12,761,791	13,620,232

Species.	Month ending—					Total.
	Aug. 15.	Sept. 15.	Oct. 15.	Nov. 15.	Dec. 15.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Bluefish (all trade sizes)	185,485	218,183	191,012	2,067	3,056	815,220
Butterfish (all trade sizes)	88,069	106,410	328,709	85,437	330	869,251
Catfish	8,069	102,914	44,338	15,443	214,550	563,184
Ciscoes (including bluefin, blackfin, chub, lake herring, etc.)	2,823,391	2,094,303	584,432	1,397,871	921,082	10,245,252
Ciscoes (tullibees)	55,278	13,747	91,512	290,976	139,217	741,019
Cod, haddock, hake, pollock	60,515	112,181	201,621	170,562	33,604	1,045,462
Croakers	9,999	....	12,691	....	....	136,672
Flounders	36,828	52,826	88,017	48,482	4,372	305,487
Halibut (all trade sizes)	1,260,915	1,001,999	234,217	145,975	160,895	5,122,396
Herring, sea (including alewives and bluefins)	397,892	4,696,844	645,882	403,228	58,425	7,964,778
Lake trout	57,219	174,429	1,036,142	434,674	26,204	2,178,610
Mackerel (excepting Spanish)	354,543	2,016,328	606,200	160,424	191,207	6,165,248
Pike perches and pike or pickerel	30,539	248,609	605,551	1,175,429	43,074	2,154,827
Sablefish (black cod)	164,715	282,358	228,486	82,806	17,243	1,115,358
Salmon, silver and fall	938,467	1,583,684	1,247,996	74,517	93,203	5,007,175
Salmon, steelhead trout	122,472	85,983	11,081	16,175	2,485	691,420
Salmon, all other	2,287,400	1,767,568	328,967	86,795	26,490	6,444,599
Scup (porgies)	93,559	50,861	2,829	10,890	782	2,063,331
Shad and shad roe	18,066	27,925	4,886	139	1,009	370,483
Shellfish	68,550	192,902	240,625	222,797	123,762	912,388
Smelts, eulachon, etc	10,103	6,910	8,144	25,211	28,200	384,962
Squeteagues or "sea trout"	303,168	115,169	87,481	1,898	2,275	598,587
Squid	1,870	19,102	31,461	8,796	....	912,261
Sturgeon and spoonbill cat	78,208	77,024	16,113	963	3,550	855,899
Suckers	398	892	5,679	12,480	838	20,433
Whitefish	280,189	172,720	276,228	301,446	80,463	1,254,898
Whiting	382,197	381,168	323,837	317,680	231,886	6,058,126
Miscellaneous frozen fish	719,388	1,227,596	1,860,332	1,576,834	833,251	10,956,848
Total frozen fish, 1922	10,826,942	16,830,080	9,344,469	7,069,995	2,741,538	75,453,674
Total frozen fish, 1921	9,856,000	9,990,000	9,869,000	8,173,000	2,441,892	79,173,892
Total frozen fish, 1920	11,808,606	11,168,810	9,711,800	9,750,844	4,005,000	98,973,589

(1) Included in "Miscellaneous frozen fish" prior to June 15, 1922.

The amounts of the different species frozen are shown graphically in Figure 3, in which it will be observed that salmon (of all species) stands first in the amount frozen.

QUANTITIES FROZEN IN 1921 AND 1922 COMPARED.

The following table compares the amounts of fish frozen in 1922 with those of the previous year. It will be observed that some

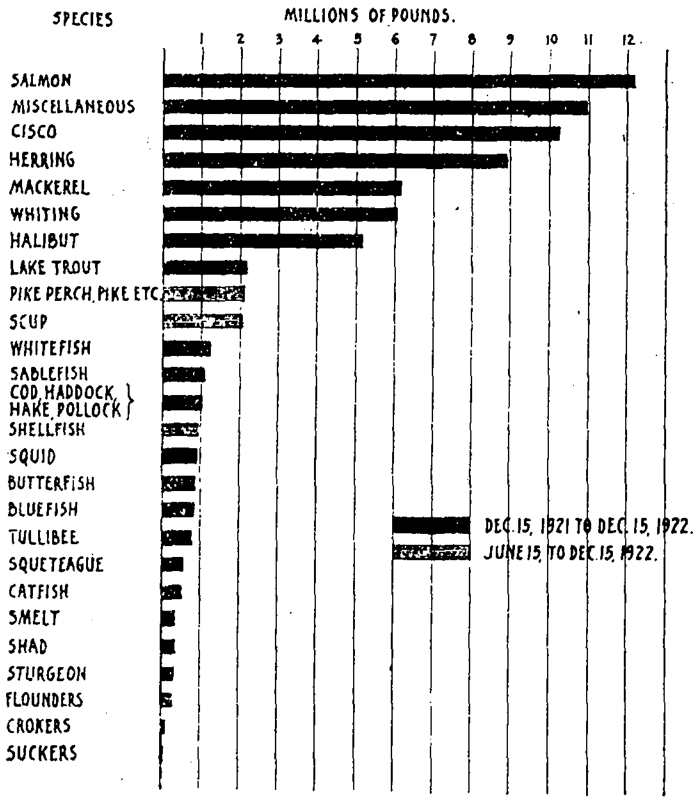


FIG. 3.—Amounts of different species of fish frozen in 1922.

striking changes took place. In 1921 halibut stood first in the order of amount frozen, while in 1922 it dropped to sixth place; salmon changed from second to first place; ciscoes, which were fourth in 1921, were second only to salmon in 1922. Mackerel showed the most phenomenal increase of 129 per cent and moved from seventh place in 1921 to fourth in 1922. This was caused by the unusually large run of tinker mackerel on the New England coast in the fall of 1922. Only the four groups, salmon, ciscoes, mackerel, and whiting increased; all others showed a decrease in quantity frozen.

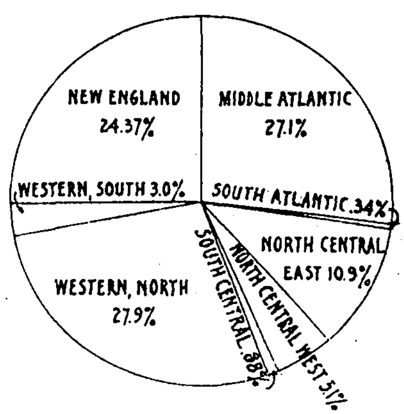
Comparison of amounts of fish frozen in 1922 with those frozen in 1921.

Species.	1922	1921	Increase (+) or decrease (−).
	Pounds.	*Pounds.*	*Per cent.*
Salmon, all species	12,143,194	10,033,619	+ 21.0
Ciscoes, all species	10,245,252	8,649,315	+ 18.4
Herring, sea (including alewives and bluefins)	7,964,778	9,827,671	− 18.9
Mackerel (excepting Spanish)	6,165,248	2,694,684	+128.8
Whiting	6,058,126	5,527,047	+ 9.6
Halibut (all trade sizes)	5,122,396	10,773,803	− 52.4
Lake trout	2,178,610	2,501,995	− 12.9
Pike perches and pike or pickerel	[1] 2,154,827	[2]	....
Scup (porgies)	[1] 2,063,331	[2]	....
Whitefish	1,254,898	2,403,900	− 47.8
Sablefish (black cod)	1,115,358	1,677,548	− 33.5
Cod, haddock, hake, pollock	1,045,462	1,992,154	− 47.5
Shellfish	[1] 912,388	[2]	....
Squid	912,261	2,943,311	− 69.0
Butterfish (all trade sizes)	869,251	959,112	− 9.4
Bluefish (all trade sizes)	815,220	932,727	− 12.6
Tullibees	741,019	[2]	....
Squeteagues or "sea trout"	598,587	2,230,253	− 73.0
Catfish	[1] 563,184	[2]	....
Smelts, eulachon, etc	384,962	610,753	− 36.9
Shad and shad roe	370,483	428,400	− 13.5
Sturgeon and spoonbill cat	[1] 355,899	[2]	....
Flounders	[1] 305,487	[2]	....
Croakers	136,672	341,439	− 60.0
Suckers	[1] 20,433	[2]	....

[1] From June 15 to Dec. 15 only.
[2] Included in "Miscellaneous frozen fish" prior to June 15, 1922.

QUANTITIES FROZEN IN 1922, BY GEOGRAPHICAL SECTIONS.

The distribution of the fish-freezing business among the several geographical sections of the country by months and by species is shown in the following tables. Eighty per cent of all freezing was in the New England, Middle Atlantic, and North Pacific Coast States. (The Great Lakes fish frozen in New York and Pennsylvania are included in the Middle Atlantic section.) The percentages of the total amount frozen for the different sections are: New England States, 24.67 per cent; Middle Atlantic, 27.12 per cent; South Atlantic, 0.34 per cent; North Central, East, 10.88 per cent; North Central West, 5.11 per cent; South Central, 0.88 per cent; Western, North, 27.94 per cent; Western, South, 3.04 per cent. The smallest amount frozen in any one month was 1,980,435 pounds, or 1.32 per cent of the total, in April; the largest amount frozen in any one month was 16,830,080 pounds, or 22.30 per cent of the total, in September. The distribution of the fish-freezing business is also shown graphically in Figure 4.



G. 4.—Percentages of the total amount of fish frozen by the several sections of the country.

Fish frozen in 1922, by geographical sections.[1]

BY MONTHS.

Month ending the 15th of—	New England.	Middle Atlantic.	South Atlantic.	North Central, East.	North Central, West.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
January	267,709	400,050	4,242	53,251	158,068
February	307,300	237,530	13,214	131,968	440,979
March	361,124	287,765	22,956	188,171	321,190
April	402,727	414,591	29,445	297,043	222,824
May	3,085,487	787,601	22,245	918,406	198,601
June	3,884,579	929,973	15,691	393,032	163,298
July	3,419,877	2,491,997	13,115	500,319	301,028
August	1,439,081	3,606,289	2,300	777,609	189,581
September	3,705,641	3,825,968	46,850	768,849	352,664
October	1,303,363	3,062,085	83,250	1,955,076	486,513
November	212,941	3,301,666	6,740	1,742,806	506,431
December	227,819	1,123,376	215	482,679	513,979
Total	18,617,648	20,468,891	260,263	8,209,809	3,855,146
Per cent of total	24.67	27.12	0.344	10.88	5.11

Month ending the 15th of—	South Central.	Western, North.	Western, South.	Total.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*
January	28,094	335,375	206,012	1,452,801	19.2
February	16,262	73,817	142,872	1,363,942	18.1
March	95,000	103,010	117,332	1,496,538	19.8
April	35,026	282,225	295,954	1,980,435	1.32
May	22,526	569,633	245,038	5,849,537	7.75
June	63,342	1,722,917	203,405	7,376,237	9.77
July	67,570	2,175,550	151,704	9,121,160	12.09
August	127,446	4,565,569	119,067	10,826,942	14.35
September	91,223	7,883,660	155,225	16,830,080	22.30
October	11,919	2,337,223	105,040	9,344,469	12.38
November	25,871	957,341	316,199	7,069,995	9.37
December	82,319	76,236	234,915	2,741,538	3.63
Total	666,598	21,082,556	2,292,763	75,453,674	100
Per cent of total	0.88	27.94	3.04	....	....

BY SPECIES.

Species.	New England.	Middle Atlantic.	South Atlantic.	North Central, East.	North Central, West.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Bluefish (all trade sizes)	4,851	775,849	....	14,151	1,480
Butterfish (all trade sizes)	191,081	674,544	2,600	426	....
Catfish [2]	....	7,590	....	33,514	507,648
Ciscoes (including bluefin, blackfin, chub, lake herring, etc.)	113,586	7,962,830	....	1,995,430	169,506
Ciscoes (tullibees)	....	438,799	....	152,733	148,787
Cod, haddock, hake, pollock	342,127	443,409	4,965	56,714	26,594
Croaker	....	136,672	....	....	....
Flounders [2]	71,435	212,381	....	....	74
Halibut (all trade sizes)	603,923	241,244	150	299,060	112,513
Herring, sea (including alewives and bluebacks)	3,293,073	924,166	2,900	70,234	75,855
Lake trout	1,238	528,455	....	1,405,133	243,394
Mackerel (excepting Spanish)	4,291,906	1,324,435	21,200	42,968	85,572
Pike perches and pike or pickerel [2]	5,467	1,504,202	....	629,746	15,262
Sablefish (black cod)	....	138	....	9,049	8,876
Salmon, silver and fall	301,759	216,443	215	62,574	73,183
Salmon, steelhead trout	....	37,407	....	10,101	....
Salmon, all other	182,282	140,831	....	411,091	19,752
Scup (porgies)[2]	2,023,704	39,627	....	....	....
Shad and shad roe	33,295	88,777	1,588	45,689	10,698
Shellfish [2]	71,012	525,069	81,740	28,572	76,710
Smelts, eulachon, etc	273,490	36,717	....	20,228	4,678
Squeteagues or "sea trout"	476	598,111	....	....	....

[1] New England includes the six States of that section: Middle Atlantic—New York, New Jersey, and Pennsylvania: South Atlantic—Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida; North Central, East—Ohio, Indiana, Illinois, Michigan, and Wisconsin; North Central, West—Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas; South Central—Kentucky, Tennessee, Alabama, Mississippi, Louisiana, Texas, Oklahoma, and Arkansas; Western, North—Montana, Wyoming, Idaho, Washington, Oregon, and Alaska; Western, South—Colorado, New Mexico, Arizona, Utah, Nevada, and California.

[2] Figures show amount frozen after June 15, 1921. Prior to that date, this species was included in "Miscellaneous frozen fish."

Fish frozen in 1922, by geographical sections—Continued.

BY SPECIES—Continued.

Species.	New England.	Middle Atlantic.	South Atlantic.	North Central, East.	North Central, West.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Squid	805,709	96,156	1,164	1,340	7,892
Sturgeon and spoonbill cat [2]	749	192,032		12,897	2,265
Suckers [2]		490		19,792	151
Whitefish	26,000	351,777		768,648	108,423
Whiting	4,282,956	499,509	800	400	1,274,461
Miscellaneous frozen fish	1,696,929	2,471,731	142,946	2,119,319	931,927
Total	18,617,648	20,468,891	260,263	8,209,809	3,855,146

Species.	South Central.	Western, North.	Western, South.	Total.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*
Bluefish (all trade sizes)	18,899			815,220	1.08
Butterfish (all trade sizes)				869,251	1.15
Catfish [2]	14,432			563,184	.75
Ciscoes (including bluefin, blackfin, chub, lake herring, etc.)	3,900			10,215,252	13.58
Ciscoes (tullibees)	700			741,019	.98
Cod, haddock, hake, pollock		24,018	147,635	1,045,462	1.38
Croakers				136,672	.18
Flounders [2]		9,547	12,050	305,487	.40
Halibut (all trade sizes)	475	3,724,940	140,091	5,122,396	6.79
Herring, sea (including alwives and bluebacks)		8,597,470	1,580	7,964,778	10.55
Lake trout	390			2,178,610	2.89
Mackerel (excepting Spanish)		7,819	441,848	6,165,248	8.17
Pike perches and pike or pickerel [2]	150			2,154,827	2.85
Sablefish (black cod)		937,990	159,305	1,115,358	1.48
Salmon, silver and fall		3,927,881	425,170	5,007,175	6.63
Salmon, steelhead trout	2,985	635,410	5,517	691,420	.92
Salmon, all other	8,300	5,499,970	182,878	6,444,599	8.54
Scup (porgies) [2]				2,063,331	2.73
Shad and shad roe	1,906	155,399	33,136	370,483	.49
Shellfish [2]	1,734	52,546	75,005	912,388	1.21
Smelts, eulachon, etc	45	49,809		384,962	.51
Squeteagues or "sea trout"				598,587	.79
Squid				912,261	1.21
Sturgeon and spoonbill cat [2]	4,130	143,826		355,899	.47
Suckers [2]				20,433	.03
Whitefish	50			1,254,898	1.66
Whiting				6,058,126	8.03
Miscellaneous frozen fish	608,512	2,315,931	669,053	10,956,348	14.52
Total	666,598	21,082,550	2,292,763	75,453,674	100

[2] Figures show amount frozen after June 15, 1922. Prior to that date, this species was included in "Miscellaneous frozen fish."

NEW ENGLAND VESSEL FISHERIES.

GENERAL STATISTICS.

In the vessel fisheries at Boston and Gloucester, Mass., and Portland, Me., during 1922 there was a decrease in the number of trips with an increase in the quantity and a decrease in the value of the products as compared with 1921. The decrease in the number of trips at Boston was 6.01 per cent, at Gloucester 20.26 per cent, and at Portland 12.26 per cent. At Boston there was an increase in the products landed of 1.74 per cent in the quantity and a decrease of 4.05 per cent in the value; at Gloucester, an increase of 14.34 per cent in the quantity and a decrease of 11.61 per cent in the value; and at Portland, an increase in the products landed of 18.2 per cent in the quantity and 3.3 per cent in the value. Statistics of these fisheries have been collected by the local agents and published in monthly bulletins, showing by species and fishing grounds the quantities and values of fishery products landed by

American fishing vessels during the year at these ports. Two annual bulletins have been issued, one showing the catch by months and the other by fishing grounds.

The fishing fleet at these ports during the calendar year 1922 numbered 338 sail, steam, and gasoline screw vessels, including 28 steam trawlers. These vessels landed at Boston 2,893 trips, aggregating 106,190,403 pounds of fish, valued at $4,020,105; at Gloucester, 1,653 trips, aggregating 37,751,223 pounds, valued at $813,353; and at Portland, 1,803 trips, aggregating 15,933,765 pounds, valued at $632,474. The total for the three ports amounted to 6,349 trips, aggregating 159,875,391 pounds of fresh and salted fish, having a value to the fishermen of $5,465,932.

Compared with the previous year there was a decrease of 857 trips, or 11.89 per cent, in the total number landed at Boston, Gloucester, and Portland, and an increase of 9,010,285 pounds, or 5.97 per cent, in the quantity, with a decrease of $256,697, or 4.48 per cent, in the value of the products landed. There was an increase in the quantity of all the important species except pollock and halibut, and a decrease in the value of all except hake, herring, and swordfish. The catch of cod increased 1,665,151 pounds, or 3.11 per cent, in quantity and decreased $95,488, or 5.51 per cent, in value; haddock increased 2,783,289 pounds, or 4.12 per cent, in quantity and decreased $236,770, or 11.57 per cent, in value; cusk increased 149,035 pounds, or 7.10 per cent, in quantity and decreased $3,277, or 8.66 per cent, in value; and mackerel increased 1,342,567 pounds, or 39.67 per cent, in quantity and decreased $59,127, or 17.61 per cent, in value. Hake increased 838,139 pounds, or 18.47 per cent, in quantity and $1,728, or 15.76 per cent, in value; herring, 30,814 pounds, or 1.10 per cent, in quantity and $40,747, or 100.84 per cent, in value; and swordfish, 1,684,103 pounds, or 105.41 per cent, in quantity and $128.610, or 40.39 per cent, in value. Pollock decreased 1,847,926 pounds, or 26.60 per cent, in quantity and $46,636, or 28.32 per cent, in value, and halibut, 41,879 pounds, or 0.73 per cent in quantity and $19,017, or 2.36 per cent, in value. The catch of Newfoundland herring increased from 551,400 pounds, valued at $19,584, in 1921, to 2,302,420 pounds, valued at $76,855, in 1922. In the various other species combined there was an increase of 2,406,992 pounds, or 77.73 per cent, in quantity and of $32,533, or 23.90 per cent, in value.

The catch of scrod cod landed at these ports decreased from 1,150,577 pounds, valued at $10,844, in 1921, to 815,371 pounds, valued at $9,200, in 1922, and the catch of scrod haddock increased from 30,562 pounds, valued at $535, in 1921, to 253,283 pounds, valued at $4,261, in 1922. The small quantity of these grades landed, as compared with other grades of these species, is said to be due to the fact that the price is so low that the fishermen do not save all that are caught.

The following tables present in detail, by fishing grounds and also by months, the fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels for the calendar year 1922. The weights of fresh and salted fish given in these statistics represent the fish as landed from the vessels, and the values are those received by the fishermen. The grades, or sizes, given for certain species are those recognized in the trade.

Statement, by fishing grounds, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the calendar year 1922.

Fishing grounds.	Number of trips.	Cod. Large (10 pounds and over). Fresh.		Salted.	
		Pounds.	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON.					
East of 66° W. longitude.					
La Have Bank	28	540,200	$17,980		
Western Bank	73	1,350,660	54,888	20,750	$726
Quereau Bank	25	29,900	1,748	3,000	105
Green Bank	6	13,600	680		
Grand Bank	41	10,600	443	5,000	175
Cape Shore	36	80,305	3,847		
The Gully	4	6,350	413		
West of 66° W. longitude.					
Browns Bank	289	3,893,106	160,905	2,000	70
Georges Bank	709	7,524,584	275,902	17,000	595
Cashes Bank	1	8,500	375		
Fippenies Bank	1	7,700	193		
Middle Bank	51	107,975	4,531		
Platts Bank	4	8,680	263		
Jeffreys Ledge	159	184,435	12,362		
South Channel	674	2,806,704	134,829		
Nantucket Shoals	49	78,600	4,467		
Off Highland Light	1	775	39		
Off Chatham	39	103,287	5,237		
Seal Island	1	4,150	249		
Shore, general	604	958,186	39,767		
Total	2,893	17,718,297	719,118	47,750	1,671
LANDED AT GLOUCESTER.					
East of 66° W. longitude.					
La Have Bank	20	895,470	17,792	49,215	2,046
Western Bank	81	2,482,205	49,004	1,084,955	43,444
Quereau Bank	24	156,830	3,050	209,170	8,603
Green Bank	25	38,620	915	125,955	4,802
Grand Bank	57	138,975	2,809	772,105	29,881
St. Peters Bank	5			296,780	12,088
Cape Shore	18	14,840	366	16,035	774
St. Anns Bank	1			66,020	2,289
The Gully	6	15,160	300	31,210	1,078
West of 66° W. longitude.					
Browns Bank	47	615,930	11,758	48,130	1,847
Georges Bank	202	2,882,511	47,371	380,265	15,329
South Channel	22	76,545	1,525		
Shore, general	1,133	1,888,828	58,353	1,545	63
Total	1,653	8,705,914	193,243	3,081,385	122,244
LANDED AT PORTLAND.					
East of 66° W. longitude.					
La Have Bank	5	4,500	150	9,465	402
Western Bank	29	1,235,545	23,859	31,010	1,295
Quereau Bank	17	33,200	870	29,730	1,356
Green Bank	11	7,500	150	15,350	599
Grand Bank	10			14,085	600
St. Peters Bank	4	9,500	152	9,320	350
The Gully	4	2,840	57		
West of 66° W. longitude.					
Browns Bank	2	4,900	436		
Georges Bank	15	3,870	116	3,120	140
Fippenies Bank	4	9,760	505		
Platts Bank	56	83,044	4,762		
Jeffreys Ledge	174	236,326	13,836		
Shore, general	1,464	1,542,288	87,290	11,305	457
Total	1,803	3,173,273	182,183	123,385	5,199
Grand total	6,349	29,597,484	1,044,544	3,252,520	129,114

Statement, by fishing grounds, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the calendar year 1922—Continued.

Fishing grounds.	Number of trips.	Cod—Continued.							
		Market (under 10 and over 2½ pounds).				Scrod (1 to 2½ pounds).			
		Fresh.		Salted.		Fresh.		Salted.	
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON.									
East of 66° W. longitude.									
La Have Bank	28	80,630	$1,499						
Western Bank	73	711,830	13,619			20,280	$148		
Quereau Bank	25	25,475	832						
Cape Shore	36	152,368	2,815			3,600	27		
The Gully	4	3,840	115						
West of 66° W. longitude.									
Browns Bank	289	3,304,292	73,356			99,930	887		
Georges Bank	709	4,595,347	99,399			94,840	1,439		
Cashes Bank	1	1,000	30						
Fippenies Bank	1	3,100	54						
Middle Bank	51	68,050	1,685			22,820	351		
Platts Bank	4	7,080	126			3,570	25		
Jeffreys Ledge	159	158,148	5,488			77,355	917		
South Channel	674	3,147,284	70,933			128,765	1,215		
Nantucket Shoals	49	138,730	3,425			5,605	41		
Off Highland Light	1	1,200	36						
Off Chatham	39	78,555	2,369			11,300	120		
Seal Island	1	6,250	125			900	5		
Shore, general	694	376,236	9,717			25,130	253		
Total	2,893	12,859,415	285,623			494,095	5,428		
LANDED AT GLOUCESTER.									
East of 66° W. longitude.									
La Have Bank	20	727,390	10,811	32,120	$1,197	4,620	46	1,580	$43
Western Bank	81	2,050,285	30,023	898,120	31,869	8,687	90	48,340	1,191
Quereau Bank	24	105,115	1,573	97,085	3,599			6,085	165
Green Bank	25	2,985	47	16,403	537			782	16
Grand Bank	57	8,970	135	299,545	10,164			23,670	599
St. Peters Bank	5			114,545	3,354			2,775	61
Cape Shore	18	2,025	35	690	29	215	5		
St. Anns Bank	1			125,950	3,741			11,375	284
The Gully	6	2,315	34	5,815	163				
West of 66° W. longitude.									
Browns Bank	47	493,470	7,522	8,845	289	5,620	45	205	5
Georges Bank	202	2,838,054	41,784	45,915	1,612	14,465	135		
South Channel	22	182,590	2,739			4,780	41		
Shore, general	1,133	3,705	54	325	11	265	2		
Total	1,653	6,416,904	94,757	1,645,358	56,565	38,652	364	94,812	2,304
LANDED AT PORTLAND.									
East of 66° W. longitude.									
La Have Bank	5	240	5	820	31				
Western Bank	29	1,600	23	3,000	113				
Quereau Bank	17	2,870	63	2,900	141				
Green Bank	11	760	11	575	23			200	7
Grand Bank	10			115	5			300	7
St. Peters Bank	4	2,000	25	4,105	133				
The Gully	4	300	5						
West of 66° W. longitude.									
Browns Bank	2	5,400	188			600	3		
Georges Bank	15			550	19			135	3
Fippenies Bank	4	6,490	131			1,255	7		
Platts Bank	56	70,290	1,881			17,790	89		
Jeffreys Ledge	174	194,097	5,104			67,423	357		
Shore, general	1,464	296,556	7,555	445	20	99,774	564	335	7
Total	1,803	580,603	14,991	12,510	485	186,842	1,020	970	24
Grand total	6,349	19,856,922	395,371	1,657,868	57,050	719,589	6,812	95,782	2,388

Statement, by fishing grounds, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the calendar year 1922—Continued.

Fishing grounds.	Number of trips.	Haddock. Large (over 2½ pounds). Fresh.		Haddock. Large (over 2½ pounds). Salted.		Haddock. Scrod (1 to 2½ pounds). Fresh.		Hake. Large (6 pounds and over). Fresh.		Hake. Large (6 pounds and over). Salted.	
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON											
East of 66° W. longitude.											
La Have Bank	28	137,475	$2,836								
Western Bank	73	2,291,038	49,921								
Cape Shore	36	93,965	2,552								
West of 66° W. longitude.											
Mrowns Bank	289	7,433,658	249,408			300	$2				
Peorges Bank	709	13,808,265	330,041			9,000	242				
FippeniesBank	1	1,045	84								
Middle Bank	51	404,080	15,706			5,460	39	3,385	$192		
Platts Bank	4	8,280	248								
Jeffreys Ledge	159	839,650	38,508			27,205	435	20,590	843		
South Channel	674	24,978,222	709,287			119,100	2,666	67,960	1,966		
Nantucket Shoals	49	2,005,590	62,352			35,800	444				
Off Highland Light	1	4,050	162								
Off Chatham	39	771,640	28,982			920	18	5,595	321		
Seal Island	1	26,400	792								
Shore, general	694	361,131	10,691			640	9	280	8		
Total	2,893	52,664,489	501,570			198,425	3,855	97,810	3,330		
LANDED AT GLOUCESTER.											
East of 66° W. longitude.											
La Have Bank	20	230,896	2,156					26,990	268		
Western Bank	81	2,976,910	29,574	130,055	$2,710			25,975	653	3,010	$35
Quereau Bank	24	3,960	40	465	7			9,730	98	205	5
Green Bank	25	220	2					4,155	54	5,950	104
Grand Bank	57			310	8			4,555	45	9,735	152
St Peters Bank	5			555	11						
The Gully	6							1,850	14		
West of 66° W. longitude.											
Browns Bank	47	339,340	3,394					14,900	151	300	5
Georges Bank	202	5,349,130	53,828					43,825	450	1,135	13
South Channel	22	1,548,820	16,184			675	7	8,330	84		
Shore, general	1,133	2,004,140	57,744					698,345	18,739	1,615	28
Total	1,653	12,453,416	162,922	131,385	2,736	675	7	838,655	20,556	21,950	342
LANDED AT PORTLAND.											
East of 66° W. longitude.											
Western Bank	29	3,108,120	59,968								
West of 66° W. longitude.											
Browns Bank	2	39,630	1,540			750	4				
FippeniesBank	4	12,275	695			1,435	8				
Platts Bank	56	91,598	4,851			7,885	65	24,515	699		
Jeffreys Ledge	174	891,079	41,749			30,883	210	10,405	366		
Shore, general	1,464	550,723	29,108			13,230	100	5,280	97	300	5
Total	1,803	4,693,425	137,911			54,183	399	40,200	1,162	300	5
Grand total	6,349	69,811,330	1,802,403	131,385	2,736	253,283	4,261	976,665	25,048	22,250	347

Statement, by fishing grounds, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the calendar year 1922—Continued.

Fishing grounds.	Number of trips.	Hake—Continued. Small (under 6 pounds). Fresh.		Salted.		Pollock. Fresh.		Salted.	
		Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
LANDED AT BOSTON.									
East of 66° W. longitude.									
La Have Bank	28	8,825	$126	....	....	10,495	$175	....	....
Western Bank	73	11,345	241	....	....	168,385	3,709	250	$5
Quereau Bank	25	500	35	....	....	290	4	....	....
Grand Bank	41	1,500	36	....	....	70	1	....	....
Cape Shore	36	265	5	....	....	11,160	200	....	....
West of 66° W. longitude.									
Browns Bank	289	39,505	1,069	....	....	424,400	9,984	....	....
Georges Bank	709	51,950	1,223	....	....	698,628	14,690	....	....
Cashes Bank	1	400	10	....	....	3,600	72	....	....
Fippenies Bank	1	3,400	68	....	....	1,030	31	....	....
Middle Bank	51	159,970	3,841	....	....	24,499	851	....	....
Platts Bank	4	31,520	467	....	....	3,105	91	....	....
Jeffreys Ledge	159	532,892	11,926	....	....	250,600	6,671	....	....
South Channel	674	2,390,642	43,588	....	....	909,040	19,793	....	....
Nantucket Shoals	49	46,600	764	....	....	35,979	925	....	....
Off Highland Light	1	2,400	24	....	....	800	8	....	....
Off Chatham	39	57,700	2,065	....	....	20,883	729	....	....
Seal Island	1	....	....	....	....	200	4	....	....
Shore, general	694	81,122	2,619	1,200	$36	852,637	20,719	....	....
Total	2,893	3,420,536	68,107	1,200	36	3,415,801	78,657	250	
LANDED AT GLOUCESTER.									
East of 66° W. longitude.									
La Have Bank	20	....	....	....	....	23,095	209	125	3
Western Bank	81	....	....	....	....	126,440	1,211	32,060	636
Quereau Bank	24	....	....	....	....	1,070	11	670	13
Green Bank	25	....	....	....	....	....	....	205	3
Grand Bank	57	....	....	....	....	....	....	4,100	77
St. Peters Bank	5	....	....	....	....	....	....	100	2
Cape Shore	18	....	....	....	....	675	7	....	....
St. Anns Bank	1	....	....	....	....	....	....	3,850	58
The Gully	6	....	....	....	....	110	1	3,315	65
West of 66° W. longitude.									
Browns Bank	47	....	....	....	....	37,760	308	1,145	18
Georges Bank	202	....	....	....	....	263,843	2,503	3,355	55
South Channel	22	....	....	....	....	17,875	174	....	....
Shore, general	1,133	....	....	....	....	587,857	22,757	80	2
Total	1,653	....	....	....	....	1,058,725	27,181	49,005	932
LANDED AT PORTLAND.									
East of 66° W. longitude.									
La Have Bank	5	2,350	24	....	....	....	....	....	....
Western Bank	29	....	....	5,800	131	98,665	2,074	....	....
Quereau Bank	17	1,740	16	1,255	19	....	....	....	....
Green Bank	11	5,575	56	....	....	....	....	....	....
Grand Bank	10	....	....	55	1	....	....	....	....
West of 66° W. longitude.									
Browns Bank	2	....	....	....	....	655	13	....	....
Georges Bank	15	....	....	....	....	325	7	....	....
Fippenies Bank	4	10,815	127	....	....	6,650	76	....	....
Platts Bank	56	163,305	2,455	....	....	49,555	735	....	....
Jeffreys Lodge	174	387,762	7,751	....	....	175,786	4,016	....	....
Shore, general	1,464	372,589	7,192	2,350	21	241,623	4,309	45	1
Total	1,803	944,136	17,621	9,460	172	573,259	11,230	45	1
Grand total	6,349	4,364,672	85,728	10,660	208	5,047,785	117,068	49,300	938

Statement, by fishing grounds, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the calendar year 1922—Continued.

Fishing grounds.	Number of trips.	Cusk.				Halibut.			
		Fresh.		Salted.		Fresh.		Salted.	
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON.									
East of 66° W. longitude.									
La Have Bank	28	14,135	$174			73,975	$10,148		
Western Bank	73	16,315	204			153,458	26,535		
Quereau Bank	25	9,685	160			682,498	95,160		
Green Bank	6					186,349	27,511		
Grand Bank	41	1,000	20			1,371,081	162,977		
St. Peters Bank	3					115,440	15,167		
Cape Shore	36	4,445	35			869	154		
The Gully	4	150	3			111,294	16,233		
West of 66° W. longitude.									
Browns Bank	289	687,010	9,602			244,015	43,139		
Georges Bank	709	46,392	843			788,260	115,131		
Cashes Bank	1	2,250	45			610	95		
Fippenies Bank	1	2,100	32			138	26		
Middle Bank	51	47,530	785			3,042	476		
Platts Bank	4	27,145	257			255	29		
Jeffreys Ledge	159	196,870	3,944			6,594	1,411		
South Channel	674	116,830	1,829			177,184	32,007		
Nantucket Shoals	49	2,500	25			2,265	415		
Off Highland Light	1					90	23		
Off Chatham	39	8,855	230			2,849	618		
Seal Island	1	3,700	37			30	3		
Shore, general	694	10,020	192			28,160	3,477		
Total	2,893	1,196,932	18,417			3,948,456	550,735		
LANDED AT GLOUCESTER.									
East of 66° W. longitude.									
La Have Bank	20	53,685	510					60	$3
Western Bank	81	112,810	1,102	2,550	$51	180	7	3,850	230
Quereau Bank	24	17,725	214	4,825	96	160	4	380	27
Green Bank	25	2,169	80	2,480	48	14,982	2,624	310	28
Grand Bank	57	17,620	220	12,855	376			6,495	376
St. Peters Bank	5							1,820	91
Cape Shore	18	2,550	30	200	5	1,810	453		
The Gully	6	3,460	40	2,085	36				
West of 66° W. longitude.									
Browns Bank	47	129,800	1,260	3,485	53			190	17
Georges Bank	202	123,950	1,219	25,050	531	25,220	3,693	2,601	143
South Channel	22	810	10						
Shore, general	1,133	1,200	13						
Total	1,653	465,779	4,698	53,030	1,196	42,352	6,781	15,706	915
LANDED AT PORTLAND.									
East of 66° W. longitude.									
La Have Bank	5	7,650	119			108,150	16,415		
Western Bank	29	5,065	89			244,984	32,537		
Quereau Bank	17	3,600	66			393,090	56,087		
Green Bank	11	3,490	44			296,837	42,373		
Grand Bank	10					264,728	35,444		
St. Peters Bank	4			245	5	73,249	11,836		
The Gully	4					130,632	16,546		
West of 66° W. longitude.									
Browns Bank	2	2,730	79			15,507	2,010		
Georges Bank	15	2,000	40	160	3	73,903	10,090		
Fippenies Bank	4	6,100	89			752	115		
Platts Bank	56	98,495	1,733			3,359	450		
Jeffreys Ledge	174	213,205	3,756			5,176	726		
Shore, general	1,464	188,969	4,218			7,268	997		
Total	1,803	531,304	10,233	405	8	1,617,635	225,626		
Grand total	6,349	2,194,015	33,348	53,435	1,204	5,608,443	783,142	15,706	915

Statement, by fishing grounds, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the calendar year 1922—Continued.

Fishing grounds.	Number of trips.	Mackerel.				Miscellaneous.			
		Fresh.		Salted.		Fresh.		Salted.	
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON.									
East of 66° W. longitude.									
La Have Bank	28					1,376	$156		
Western Bank	73					21,558	554		
Quereau Bank	25					601	77		
Grand Bank	41					6,524	907		
Off Newfoundland	2					[1] 410,000	20,500		
Cape Shore	36	879,235	$68,282	64,400	$4,019	7,541	1,001		
Gulf of St. Lawrence	3	65,105	7,979						
West of 66° W. longitude.									
Browns Bank	289					44,147	2,882		
Georges Bank	709					4,025,104	461,828	34,300	$829
Middle Bank	51	63,090	6,470			4,655	375		
Jeffreys Ledge	159	177,655	18,662			11,996	1,200	2,000	61
South Channel	674	573	146			828,471	44,352	7,300	183
Nantucket Shoals	49	19,100	3,438			141,504	8,024		
Off Chatham	39	19,545	838			4,285	456		
Shore, general	694	1,646,697	76,147	1,000	90	1,639,185	54,097		
Total	2,893	2,871,000	181,962	65,400	4,109	7,146,947	596,409	43,600	1,073
LANDED AT GLOUCESTER.									
East of 66° W. longitude.									
Off Newfoundland	6							[1] 1,892,420	56,355
Cape Shore	18	62,100	3,696	294,890	20,557				
Gulf of St. Lawrence	6			75,665	11,472				
West of 66° W. longitude.									
Shore, general	1,133	312,445	23,470						
Total	1,653	374,545	27,166	370,555	32,029			1,892,420	56,355
LANDED AT PORTLAND.									
East of 66° W. longitude.									
La Have Bank	5					1,705	256		
Western Bank	29					24,648	1,823		
Quereau Bank	17					1,594	193	495	41
Green Bank	11					783	105		
Grand Bank	10					503	60		
Cape Shore	8	168,566	8,105	14,285	844	8,274	955		
West of 66° W. longitude.									
Browns Bank	2					200	10		
Georges Bank	15	393	31			134,385	15,838		
Platts Bank	56					330	5		
Jeffreys Ledge	174	893	178			21,832	828		
Shore, general	1,464	850,970	21,669	10,140	406	2,151,834	22,857		
Total	1,803	1,020,822	29,983	24,425	1,250	2,346,088	42,930	495	41
Grand total	6,349	4,266,367	239,111	460,380	37,388	9,493,035	639,339	1,936,515	57,469

[1] Herring. Other items under "Miscellaneous" include bluebacks, 90,300 pounds, value $760; bonito; 50 pounds, value $5; butterfish, 44,416 pounds, value $3,172; flounders, 3,281,327 pounds, value $134,749, herring, 341,934 pounds, value $4,299; menhaden, 1,699,600 pounds, value $16,888; rosefish, 18,970 pounds, value $473; shad, 540 pounds, value $55; sharks, 8,203 pounds, value $153; skates, 1,150 pounds, value $20; smelt, 3,973 pounds, value $347; sturgeon, 1,050 pounds, value $207; swordfish, 3,281,748 pounds, value $447,016; wolffish, 209,422 pounds, value $3,705; lobster, 107 pounds, value $27; livers, 1,650 pounds, value $21; spawn, fresh, 98,595 pounds, value $6,942; spawn, salted, 43,600 pounds, value $1,073; and tongues, salted, 495 pounds, value $41.

Statement, by fishing grounds, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the calendar year 1922—Continued.

Fishing grounds.	Number of trips.	Total.				Grand total.	
		Fresh.		Salted.			
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON.							
East of 66° W. longitude.							
La Have Bank	28	867,111	$33,094			867,111	$33,094
Western Bank	73	4,744,869	149,819	21,000	$731	4,765,869	150,550
Quereau Bank	25	748,949	98,016	3,000	105	751,949	98,121
Green Bank	6	199,949	28,191			199,949	28,191
Grand Bank	41	1,390,775	164,384	5,000	175	1,395,775	164,559
St. Peters Bank	3	115,440	15,167			115,440	15,167
Off Newfoundland	2	410,000	20,500			410,000	20,500
Cape Shore	86	1,233,753	78,918	64,400	4,019	1,298,153	82,937
Gulf of St. Lawrence	3	65,105	7,979			65,105	7,979
The Gully	4	121,634	16,764			121,634	16,764
West of 66° W. longitude.							
Browns Bank	289	16,170,363	551,234	2,000	70	16,172,363	551,304
Georges Bank	709	31,142,370	1,300,738	51,300	1,424	31,193,670	1,302,162
Cashes Bank	1	16,360	627			16,360	627
Fippenies Bank	1	18,513	488			18,513	488
Middle Bank	51	914,556	35,302			914,556	35,302
Platts Bank	4	89,635	1,506			89,635	1,506
Jeffreys Ledge	159	2,483,990	102,367	2,000	61	2,485,990	102,428
South Channel	674	35,670,775	1,062,611	7,300	183	35,678,075	1,062,794
Nantucket Shoals	49	2,512,273	84,320			2,512,273	84,320
Off Highland Light	1	9,315	292			9,315	292
Off Chatham	39	1,085,414	41,983			1,085,414	41,983
Seal Island	1	41,630	1,215			41,630	1,215
Shore, general	694	5,979,424	217,696	2,200	126	5,981,624	217,822
Total	2,893	106,032,203	4,013,211	158,200	6,894	106,190,403	4,020,105
LANDED AT GLOUCESTER.							
East of 66° W. longitude.							
La Have Bank	20	1,962,146	31,792	83,100	3,292	2,045,246	35,084
Western Bank	81	7,783,492	111,664	2,202,940	80,166	9,986,432	191,830
Quereau Bank	24	294,590	4,990	318,385	12,515	612,975	17,505
Green Bank	25	63,131	3,722	152,085	5,538	215,216	9,260
Grand Bank	57	170,120	3,209	1,128,815	41,633	1,298,935	44,842
St. Peters Bank	5			416,575	15,607	416,575	15,607
Off Newfoundland	6			1,892,420	56,355	1,892,420	56,355
Cape Shore	18	84,215	4,592	311,815	21,365	396,030	25,957
Gulf of St. Lawrence	6			75,665	11,472	75,665	11,472
St. Anns Bank	1			207,195	6,372	207,195	6,372
The Gully	6	22,895	389	42,425	1,342	65,320	1,731
W. of 66° W. longitude.							
Browns Bank	47	1,636,820	24,438	62,300	2,234	1,699,120	26,672
Georges Bank	202	11,040,998	150,983	458,321	17,683	11,499,319	168,666
South Channel	22	1,840,425	20,764			1,840,425	20,764
Shore, general	1,133	5,496,785	181,132	3,565	104	5,500,350	181,236
Total	1,653	30,395,617	537,675	7,355,606	275,678	37,751,223	813,353
LANDED AT PORTLAND.							
East of 66° W. longitude.							
La Have Bank	5	124,595	16,969	10,285	433	134,880	17,402
Western Bank	29	4,718,627	120,373	39,810	1,539	4,758,437	121,912
Quereau Bank	17	436,094	57,295	34,380	1,557	470,474	58,852
Green Bank	11	314,945	42,739	16,125	629	331,070	43,368
Grand Bank	10	265,231	35,504	14,555	613	279,786	36,117
St. Peters Bank	4	84,749	12,013	13,670	488	98,419	12,501
Cape Shore	8	176,840	9,060	14,285	844	191,125	9,904
The Gully	4	133,772	16,608			133,772	16,608
West of 66° W. longitude.							
Browns Bank	2	70,372	4,283			70,372	4,283
Georges Bank	15	214,876	26,122	3,965	165	218,841	26,287
Fippenies Bank	4	55,532	1,753			55,532	1,753
Platts Bank	56	610,166	17,725			610,166	17,725
Jeffreys Ledge	174	2,234,867	78,883			2,234,867	78,883
Shore, general	1,464	6,321,104	185,962	24,920	917	6,346,024	186,879
Total	1,803	15,761,770	625,289	171,995	7,185	15,933,765	632,474
Grand total	6,349	152,189,590	5,176,175	7,685,801	289,757	159,875,391	5,465,932

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the year 1922.

Months.	Number of trips.	Cod.			
		Large (10 pounds and over).			
		Fresh.		Salted.	
		Pounds.	Value.	Pounds.	Value.
LANDED AT BOSTON.					
January	158	521,773	$40,895		
February	228	2,042,393	73,832		
March	239	2,951,045	73,694	17,000	$595
April	288	1,900,605	55,959	3,000	105
May	261	1,572,600	56,436		
June	232	1,594,837	63,024	10,000	350
July	296	1,231,524	56,315	12,750	446
August	272	1,466,591	71,360		
September	256	1,413,465	58,725		
October	242	1,123,724	59,473	5,000	175
November	286	1,018,607	54,474		
December	185	881,633	54,331		
Total	2,893	17,718,297	719,118	47,750	1,671
LANDED AT GLOUCESTER.					
January	111	23,370	931	805	24
February	79	165,040	4,225	28,420	977
March	371	1,633,893	34,125	90,245	3,237
April	191	717,864	15,154	120,545	4,366
May	59	597,921	11,955	207,530	8,197
June	76	1,247,155	24,878	512,315	19,319
July	59	904,015	17,483	440,980	17,342
August	75	1,019,278	19,886	860,465	34,412
September	72	584,590	11,927	448,055	18,813
October	184	751,875	20,750	353,185	14,752
November	234	815,485	23,179	17,205	715
December	142	245,428	8,750	1,635	90
Total	1,653	8,705,914	193,243	3,081,385	122,244
LANDED AT PORTLAND.					
January	129	104,169	8,697		
February	136	132,806	6,113		
March	127	669,622	14,128		
April	162	392,959	8,966	365	14
May	208	623,029	15,234	25,425	1,001
June	193	348,866	33,850	21,580	844
July	241	294,654	13,123	5,090	179
August	169	193,678	9,553	17,085	735
September	150	138,550	5,806	15,350	629
October	129	91,664	4,918	25,565	1,086
November	97	111,972	6,732		
December	62	71,304	5,063	12,925	711
Total	1,803	3,173,273	132,183	123,385	5,199
Grand total	6,349	29,597,484	1,044,544	3,252,520	129,114
Grounds east of 66° W. longitude	558	7,066,800	179,473	2,789,155	110,613
Grounds west of 66° W. longitude	5,791	22,530,684	865,071	463,365	18,501
Landed at Boston in 1921	3,078	19,439,796	815,904	23,110	896
Landed at Gloucester in 1921	2,073	7,777,379	188,094	3,438,992	148,488
Landed at Portland in 1921	2,055	2,345,199	92,116	213,931	10,097

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the year 1922—Continued.

Months.	Number of trips.	Cod—Continued. Market (under 10 and over 2½ pounds). Fresh.		Salted.		Scrod (1 to 2½ pounds). Fresh.		Salted.	
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON.									
January	158	595,702	$21,442	....	....	87,830	$1,321	....	....
February	228	676,082	18,483	....	....	58,795	646	....	....
March	239	793,128	15,118	....	....	16,740	123	....	....
April	238	865,713	16,880	....	....	32,540	211	....	....
May	261	1,374,725	25,033	....	....	54,490	913	....	....
June	232	1,286,719	25,349	....	....	37,860	243	....	....
July	296	1,287,419	27,272	....	....	42,345	287	....	....
August	272	1,546,525	33,486	....	....	30,540	219	....	....
September	256	1,181,433	21,970	....	....	34,875	232	....	....
October	242	1,397,118	33,789	....	....	28,365	308	....	....
November	286	1,038,969	24,627	....	....	22,335	262	....	....
December	185	815,882	22,174	....	....	47,880	663	....	....
Total	2,893	12,859,415	285,623	....	....	494,095	5,428	....	....
LANDED AT GLOUCESTER.									
January	111	8,465	85	4,440	$111	900	5	500	$8
February	79	9,820	126	2,495	61	200	2	105	2
March	871	251,790	4,048	12,800	386	735	7	....	....
April	191	406,865	6,133	19,380	607	4,255	34	657	13
May	59	567,510	8,458	36,470	1,264	5,055	50	....	....
June	76	1,083,615	16,121	271,660	8,653	6,265	62	14,890	872
July	59	892,249	13,144	372,075	13,055	3,397	34	32,080	809
August	75	1,541,575	21,509	331,895	11,049	9,825	91	4,840	86
September	72	1,051,900	15,570	348,103	12,583	4,740	36	29,050	749
October	184	483,895	7,642	243,350	8,699	1,185	9	10,565	272
November	234	98,840	1,564	2,890	97	1,230	24	2,125	53
December	142	20,380	357	....	....	865	10	....	....
Total	1,653	6,416,904	94,757	1,645,358	56,565	38,652	364	94,812	2,864
LANDED AT PORTLAND.									
January	129	87,427	3,089	....	....	41,970	268	....	....
February	136	73,467	1,832	....	....	33,504	183	....	....
March	127	46,614	869	....	....	14,969	75	....	....
April	162	39,442	696	....	....	13,945	70	....	....
May	208	27,184	446	....	....	8,952	46	200	7
June	193	24,324	497	4,955	163	4,085	21	135	3
July	241	13,862	385	....	....	4,831	22	....	....
August	169	13,774	452	115	5	2,996	15	300	7
September	150	19,583	551	575	23	8,645	18	....	....
October	129	50,510	1,237	3,820	144	11,145	60	....	....
November	97	114,800	2,762	....	....	80,740	158	....	....
December	62	70,116	2,175	3,045	150	16,560	84	385	7
Total	1,803	580,603	14,991	12,510	485	186,842	1,020	970	24
Grand total	6,349	19,856,922	395,371	1,657,868	57,050	719,589	6,812	95,782	2,388
Grounds east of 66° W. longitude	558	3,880,998	61,670	1,601,788	55,099	37,402	316	95,107	2,373
Grounds west of 66° W. longitude	5,791	15,975,924	333,701	56,080	1,951	682,187	6,496	675	15
Landed at Boston in 1921	3,078	12,256,004	316,372	6,995	210	613,115	5,621	....	....
Landed at Gloucester in 1921	2,073	4,230,836	68,002	1,594,449	59,406	75,060	651	107,265	2,435
Landed at Portland in 1921	2,055	1,014,395	24,573	23,351	765	354,462	2,124	675	13

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the year 1922—Continued.

Months.	Number of trips.	Haddock. Large (over 2½ pounds). Fresh.		Haddock. Large (over 2½ pounds). Salted.		Haddock. Scrod (1 to 2½ pounds). Fresh.		Hake. Large (6 pounds and over). Fresh.		Hake. Large (6 pounds and over). Salted.	
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON.											
January	158	3,816,020	$206,615	......	......	12,750	$566	6,320	$460	......	......
February	228	5,846,805	165,892	......	......	......	......	10,635	688	......	......
March	239	5,321,155	87,991	......	......	600	3	11,765	528	......	......
April	238	3,619,533	108,495	......	......	2,915	15	1,000	50	......	......
May	261	4,346,375	104,552	......	......	......	......	250	10	......	......
June	232	3,310,782	82,915	......	......	4,250	43	100	4	......	......
July	296	3,191,784	81,414	......	......	......	......	150	2	......	......
August	272	3,846,315	82,979	......	......	......	......	......	......	......	......
September	256	4,462,830	88,939	......	......	2,300	46	12,700	95	......	......
October	242	4,793,130	144,685	......	......	17,370	281	8,400	230	......	......
November	286	5,252,935	174,019	......	......	53,370	950	35,705	925	......	......
December	185	4,856,825	173,074	......	......	104,870	1,951	10,785	338	......	......
Total	2,893	52,664,489	1,501,570	......	......	198,425	3,856	97,810	3,330	......	......
LANDED AT GLOUCESTER.											
January	111	17,070	1,128	......	......	......	......	2,515	209	......	......
February	79	202,825	4,326	......	......	......	......	2,810	126	......	......
March	371	3,070,935	53,058	......	......	......	......	935	9	175	$3
April	191	359,155	11,556	......	......	......	......	6,720	55	2,040	34
May	59	1,135,340	11,354	......	......	......	......	2,960	27	875	10
June	76	1,583,951	15,888	......	......	......	......	890	7	1,230	18
July	59	1,663,735	16,929	54,215	$813	......	......	8,810	80	3,180	47
August	75	1,750,250	17,896	135	2	675	7	38,720	769	4,130	57
September	72	1,655,795	16,548	76,005	1,900	......	......	37,470	536	2,740	55
October	184	797,550	7,976	1,030	21	......	......	280,485	7,642	5,330	95
November	234	124,975	1,250	......	......	......	......	365,250	8,144	2,250	23
December	142	91,835	5,013	......	......	......	......	91,090	2,952	......	......
Total	1,653	12,453,416	162,922	131,385	2,736	675	7	838,655	20,556	21,950	342
LANDED AT PORTLAND.											
January	129	135,252	11,289	......	......	2,290	18	1,155	58	......	......
February	136	651,153	25,665	......	......	6,857	68	2,030	92	......	......
March	127	1,339,815	29,774	......	......	3,773	24	220	7	......	......
April	162	1,149,552	24,273	......	......	1,505	9	21,770	702	......	......
May	208	960,189	19,676	......	......	......	......	385	7	300	5
June	193	14,014	995	......	......	845	15	230	2	......	......
July	241	29,058	1,727	......	......	2,688	29	......	......	......	......
August	169	14,284	759	......	......	1,750	18	575	7	......	......
September	150	82,802	1,668	......	......	1,770	13	1,650	33	......	......
October	129	52,708	2,847	......	......	4,893	29	8,720	206	......	......
November	97	174,249	10,288	......	......	16,927	108	3,050	42	......	......
December	62	140,349	8,950	......	......	10,885	68	415	6	......	......
Total	1,803	4,693,425	137,911	......	......	54,183	399	40,200	1,162	300	5
Grand total	6,349	69,811,330	1,802,403	131,385	2,736	253,283	4,261	976,665	25,048	22,250	347
Grounds east of 66° W. longitude	558	8,842,584	147,049	131,385	2,736	......	......	73,255	1,132	18,900	296
Grounds west of 66° W. longitude	5,791	60,968,746	1,655,354	......	......	253,283	4,261	903,410	23,916	3,350	51
Landed at Boston in 1921	3,078	55,220,576	1,730,948	......	......	21,150	408	485,164	16,054	......	......
Landed at Gloucester in 1921	2,073	9,212,239	201,898	15,290	182	......	......	591,864	17,807	41,973	759
Landed at Portland in 1921	2,055	2,934,042	112,607	......	......	9,412	127	59,734	1,619	260	6

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the year 1922—Continued.

Months.	Number of trips.	Hake—Continued. Small (under 6 pounds). Fresh.		Salted.		Pollock. Fresh.		Salted.	
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON.									
January	158	97,395	$5,015			94,909	$4,012		
February	228	130,540	4,782			93,949	4,044		
March	239	97,355	3,223			99,111	3,450		
April	238	172,540	3,138			154,218	3,962		
May	201	105,955	2,238			217,054	5,778		
June	232	150,739	3,394	1,200	$36	228,378	5,535		
July	296	222,778	5,562			374,874	7,605	250	$5
August	272	196,762	4,869			417,858	9,546		
September	256	425,010	6,158			407,925	7,677		
October	242	516,928	10,480			523,135	11,666		
November	286	1,017,305	12,291			383,820	6,783		
December	185	287,229	6,954			420,570	8,599		
Total	2,893	3,420,536	68,107	1,200	36	3,415,801	78,657	250	5
LANDED AT GLOUCESTER.									
January	111					279,840	14,719	240	4
February	79					12,000	656	190	3
March	371					28,750	215	3,720	72
April	191					33,595	280	1,340	20
May	59					24,840	232	1,365	21
June	76					39,648	331	5,085	77
July	59					58,375	510	7,405	145
August	75					84,945	849	8,420	148
September	72					144,065	1,450	17,485	366
October	184					75,560	743	3,755	76
November	234					9,185	95		
December	142					267,922	7,098		
Total	1,653					1,058,725	27,181	49,005	932
LANDED AT PORTLAND.									
January	129	71,466	2,532			62,731	2,071		
February	136	94,214	2,920			93,971	2,700		
March	127	57,887	1,503			101,216	2,157		
April	162	33,043	642			27,517	549	45	1
May	208	35,663	531			11,893	169		
June	193	21,680	254	2,240	19	14,819	152		
July	241	35,102	433	1,255	19	33,707	325		
August	169	46,626	685	55	1	31,460	692		
September	150	60,799	1,049			35,356	445		
October	129	104,370	1,789	5,800	131	54,011	781		
November	97	295,765	3,475			70,523	829		
December	62	87,521	1,808	110	2	36,049	660		
Total	1,803	944,136	17,621	9,460	172	573,259	11,230	45	1
Grand total	6,349	4,364,672	85,728	10,660	208	5,047,785	117,068	49,300	938
Grounds east of 66° W. longitude	*558*	*32,100*	*539*	*7,110*	*151*	*440,455*	*7,602*	*44,675*	862
Grounds west of 66° W. longitude	5,791	4,332,572	85,189	3,550	57	4,607,330	109,466	4,625	76
Landed at Boston in 1921	3,078	2,474,738	54,598			2,748,216	67,537		
Landed at Gloucester in 1921	2,073					3,429,405	83,338	48,307	831
Landed at Portland in 1921	2,055	882,375	18,760			715,398	12,854	3,685	82

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the year 1922—Continued.

Months.	Number of trips.	Cusk.				Halibut.			
		Fresh.		Salted.		Fresh.		Salted.	
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON.									
January	158	113,155	$2,750	....	....	38,692	$8,889	....	....
February	228	132,445	2,653	....	....	188,834	32,115	....	....
March	239	163,438	1,889	....	....	483,722	76,255	....	....
April	238	157,295	1,805	....	....	486,342	57,171	....	....
May	261	97,445	1,102	....	....	479,871	64,920	....	....
June	232	33,520	562	....	....	395,476	56,843	....	....
July	296	35,407	538	....	....	614,356	68,277	....	....
August	272	57,905	726	....	....	549,087	67,383	....	....
September	256	45,790	673	....	....	404,696	59,709	....	....
October	242	112,302	1,735	....	....	230,620	39,231	....	....
November	286	89,145	1,392	....	....	47,091	11,310	....	....
December	185	159,085	2,592	....	....	29,669	8,632	....	....
Total	2,893	1,196,932	18,417	....	....	3,948,456	550,735	....	....
LANDED AT GLOUCESTER.									
January	111	210	2	....	....	....	....	....	....
February	79	3,899	35	1,385	$26	....	....	....	....
March	371	18,860	188	980	22	14,982	2,624	....	....
April	191	89,915	871	1,685	28	....	....	....	....
May	59	47,145	496	4,490	75	9,140	1,043	180	$22
June	76	46,920	513	22,470	485	....	....	2,050	231
July	59	60,185	624	8,125	165	340	11	5,190	190
August	75	86,530	813	5,900	232	....	....	6,366	344
September	72	44,400	510	5,400	111	16,080	2,650	1,480	97
October	184	36,385	367	1,785	36	....	....	365	26
November	234	21,760	207	810	16	....	....	75	5
December	142	9,570	72	....	....	1,810	453	....	....
Total	1,653	465,779	4,698	53,030	1,196	42,352	6,781	15,706	915
LANDED AT PORTLAND.									
January	129	65,105	2,049	....	....	1,090	184	....	....
February	136	80,711	1,425	....	....	31,822	4,888	....	....
March	127	74,625	807	....	....	65,964	11,971	....	....
April	162	51,110	720	....	....	91,141	12,654	....	....
May	208	14,283	340	....	....	313,628	42,043	....	....
June	193	10,632	245	405	8	186,854	26,351	....	....
July	241	12,778	364	....	....	243,168	29,207	....	....
August	169	16,992	619	....	....	260,388	30,373	....	....
September	150	20,137	508	....	....	211,581	30,595	....	....
October	129	56,896	1,020	....	....	197,472	33,569	....	....
November	97	81,055	1,095	....	....	2,767	347	....	....
December	62	46,980	1,041	....	....	11,760	3,444	....	....
Total	1,803	531,304	10,233	405	8	1,617,635	225,626	....	....
Grand total	6,349	2,194,015	33,348	53,435	1,204	5,608,443	783,142	15,706	915
Grounds east of 66° W. longitude	558	275,554	3,110	24,740	617	4,223,766	568,211	12,915	755
Grounds west of 66° W. longitude	5,791	1,918,461	30,238	28,695	587	1,384,677	214,931	2,791	160
Landed at Boston in 1921	3,078	881,288	16,111	800	16	3,808,468	556,592	....	....
Landed at Gloucester in 1921	2,073	576,995	7,368	37,550	761	385,040	39,447	48,321	7,063
Landed at Portland in 1921	2,055	601,699	13,569	83	4	1,424,089	199,959	110	13

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the year 1922—Continued.

Months.	Number of trips.	Mackerel.				Miscellaneous.[1]			
		Fresh.		Salted.		Fresh.		Salted.	
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON.									
January	158					252,700	$14,092	1,800	$34
February	228					381,149	17,543	15,800	393
March	239	100	$61			914,341	36,149	26,000	646
April	238					319,735	9,997		
May	261	92,552	15,227			484,567	9,875		
June	232	816,565	59,530	65,400	$4,109	308,453	39,351		
July	296	15,238	761			1,632,707	203,506		
August	272	21,045	836			1,231,758	148,963		
September	256	637,382	25,054			799,390	75,797		
October	242	729,789	25,579			417,052	17,251		
November	286	558,329	54,914			231,426	12,563		
December	185					173,669	11,322		
Total	2,893	2,871,000	181,962	65,400	4,109	7,146,947	596,409	43,600	1,073
LANDED AT GLOUCESTER.									
January	111							387,600	8,500
February	79								
March	371							103,800	2,595
April	191								
May	59								
June	76	62,100	3,696	292,090	20,137				
July	59	11,725	352						
August	75								
September	72								
October	184	104,467	2,030	45,902	6,966				
November	234	196,253	21,088	32,563	4,926				
December	142							1,401,020	45,260
Total	1,653	374,545	27,166	370,555	32,029			1,892,420	56,355
LANDED AT PORTLAND.									
January	129					5,855	250		
February	136					18,443	673		
March	127					3,962	113		
April	162					1,535	29		
May	208					216,301	2,739		
June	193	160,833	7,551	14,285	844	119,722	1,556		
July	241	5,753	618			1,617,490	22,590	95	6
August	169	103,475	3,873			276,915	11,180	400	35
September	150	339,415	9,107			66,225	3,224		
October	129	393,379	6,962	10,140	406	18,034	490		
November	97	17,967	1,872			1,311	69		
December	62					295	17		
Total	1,803	1,020,822	29,983	24,425	1,250	2,346,088	42,930	495	41
Grand total	6,349	4,266,367	239,111	460,380	37,388	9,493,035	639,339	1,936,515	57,469
Grounds east of 66° W. longitude	558	1,175,006	88,062	449,240	36,892	485,107	26,587	1,892,915	56,396
Grounds west of 66° W. longitude	5,791	3,091,361	151,049	11,140	496	9,007,928	612,752	43,600	1,073
Landed at Boston in 1921	3,078	1,993,286	201,473	60,400	5,244	4,335,523	402,151		
Landed at Gloucester in 1921	2,073	244,994	36,734	586,100	40,038	222,707	12,364	351,400	9,584
Landed at Portland in 1921	2,055	496,400	51,957	3,000	180	2,397,411	70,788	600	33

[1] Includes herring from Newfoundland, 410,000 pounds frozen, value $20,500, and 1,892,420 pounds salted, value $56,855.

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels during the year 1922—Continued.

Months.	Number of trips.	Total.				Grand total.	
		Fresh.		Salted.			
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
LANDED AT BOSTON.							
January	158	5,637,246	$306,057	1,800	$34	5,639,046	$306,091
February	228	9,561,627	320,678	15,800	393	9,577,427	321,071
March	239	10,852,500	298,484	43,000	1,241	10,895,500	299,725
April	238	7,712,436	257,683	3,000	105	7,715,436	257,788
May	261	8,825,884	286,084	....	....	8,825,884	286,084
June	232	8,167,179	337,393	76,600	4,495	8,243,879	341,888
July	296	8,648,582	451,539	13,000	451	8,661,582	451,990
August	272	9,364,386	420,367	....	....	9,364,386	420,367
September	256	9,827,296	345,075	....	....	9,827,296	345,075
October	242	9,897,933	344,708	5,000	175	9,902,933	344,883
November	286	9,749,037	354,513	....	....	9,749,037	354,513
December	185	7,788,097	290,630	....	....	7,788,097	290,630
Total	2,893	106,032,203	4,013,211	158,200	6,894	106,190,403	4,020,105
LANDED AT GLOUCESTER.							
January	111	332,370	17,079	393,585	8,647	725,955	25,726
February	79	396,594	9,496	32,595	1,069	429,189	10,565
March	371	5,020,880	94,274	211,720	6,315	5,232,600	100,589
April	191	1,618,369	34,083	145,647	5,068	1,764,016	39,151
May	59	2,389,911	33,615	250,910	9,589	2,640,821	43,204
June	76	4,070,544	61,499	1,121,790	49,292	5,192,334	110,791
July	59	3,602,831	49,167	923,250	32,566	4,526,081	81,733
August	75	4,531,798	61,820	1,222,151	46,330	5,753,949	108,150
September	72	3,539,040	49,227	928,318	34,674	4,467,358	83,901
October	184	2,531,402	47,159	665,267	30,943	3,196,669	78,102
November	234	1,632,978	55,551	57,718	5,835	1,690,696	61,386
December	142	728,900	24,705	1,402,655	45,350	2,131,555	70,055
Total	1,653	30,395,617	537,675	7,355,606	275,678	37,751,223	813,353
LANDED AT PORTLAND.							
January	129	578,510	30,505	....	....	578,510	30,505
February	136	1,218,978	46,559	....	....	1,218,978	46,559
March	127	2,378,667	61,428	....	....	2,378,667	61,428
April	162	1,823,519	49,310	410	15	1,823,929	49,325
May	208	2,211,507	81,231	25,925	1,013	2,237,432	82,244
June	193	906,904	71,489	43,600	1,881	950,504	73,370
July	241	2,292,091	68,823	6,440	204	2,298,531	69,027
August	169	962,919	57,926	17,955	783	980,874	58,709
September	150	931,513	53,017	15,925	652	947,438	53,669
October	129	1,043,802	53,908	45,325	1,767	1,089,127	55,675
November	97	921,126	27,777	....	....	921,126	27,777
December	62	492,234	23,316	16,415	870	508,049	24,186
Total	1,803	15,761,770	625,289	171,995	7,185	15,933,765	632,474
Grand total	6,349	152,189,590	5,176,175	7,685,801	289,757	159,875,391	5,465,932
Grounds east of 66° W. longitude	558	26,533,027	1,083,751	7,067,930	266,790	33,600,957	1,350,541
Grounds west of 66° W. longitude	5,791	125,656,563	4,092,424	617,871	22,967	126,274,434	4,115,391
Landed at Boston in 1921	3,078	104,277,324	4,183,769	91,305	6,366	104,368,629	4,190,135
Landed at Gloucester in 1921	2,073	26,746,519	655,703	6,269,647	264,547	33,016,166	920,250
Landed at Portland in 1921	2,055	13,234,616	601,051	245,695	11,193	13,480,311	612,244

The greater part of the fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by fishing vessels each year are taken from fishing grounds off the coast of the United States. In the calendar year 1922, 78.96 per cent of the quantity and 75.27 per cent of the value landed by fishing vessels were from these grounds; 4.16 per cent of the quantity and 8.17 per cent of the value, consisting mostly of cod, halibut, and herring, were from fishing banks off the coast of Newfoundland; and 16.88 per cent of the quantity and 16.56 per cent of the value from fishing grounds off the Canadian

Provinces. There was some falling off from the previous year in the percentage of products from grounds off the United States, with a small increase in that for Newfoundland and the Canadian Provinces. Newfoundland herring constituted 1.44 per cent of the quantity and 1.4 per cent of the value of the fishery products landed at these ports during the year. The herring were taken from the treaty coast of Newfoundland, and the cod, haddock, hake, halibut, and other species from that region were obtained from fishing banks on the high seas. All fish caught by American fishing vessels off the coast of the Canadian Provinces were from offshore fishing grounds. The catch from each of these regions is given in detail in the following table:

Quantity and value of fish landed by American fishing vessels at Boston and Gloucester, Mass., and Portland, Me., in 1922, from fishing grounds off the coast of the United States, Newfoundland, and Canadian Provinces.

Species.	United States.		Newfoundland.		Canadian Provinces.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Cod:								
Fresh	39,177,495	$1,204,889	233,510	$5,367	10,762,990	$236,471	50,173,995	$1,446,727
Salted	520,120	20,467	1,701,610	63,401	2,784,440	104,684	5,006,170	188,552
Haddock:								
Fresh	61,195,629	1,658,823	220	2	8,868,764	147,839	70,064,613	1,806,664
Salted	....	....	865	19	130,520	2,717	131,385	2,736
Hake:								
Fresh	5,235,982	109,105	15,785	191	89,570	1,480	5,341,337	110,776
Salted	6,900	108	15,740	257	10,270	190	32,910	555
Pollock:								
Fresh	4,607,130	109,462	70	1	440,585	7,605	5,047,785	117,068
Salted	4,625	76	4,405	82	40,270	780	49,300	938
Cusk:								
Fresh	1,914,761	30,201	24,279	364	254,975	2,783	2,194,015	33,348
Salted	28,695	587	15,580	429	9,160	188	53,435	1,204
Halibut:								
Fresh	1,384,647	214,928	2,322,666	297,932	1,901,130	270,282	5,608,443	783,142
Salted	2,791	160	8,625	495	4,290	260	15,706	915
Mackerel:								
Fresh	3,091,361	151,049	....	....	1,175,006	88,062	4,266 367	239,111
Salted	11,140	496	....	....	449,240	36,892	460,380	37,388
Herring:								
Fresh	341,934	4,299	410,000	20,500	....	....	751,934	24,799
Salted	....	....	1,892,420	56,355	....	....	1,892,420	56,355
Swordfish: Fresh	3,229,137	441,370	7,810	1,072	44,801	4,574	3,281,748	447,016
Miscellaneous:								
Fresh	5,436,857	167,083	....	....	22,496	441	5,459,353	167,524
Salted	43,600	1,073	....	....	495	41	44,095	1,114
Total	126,232,804	4,114,176	6,653,585	446,467	26,989,002	905,289	159,875,891	5,465,932

SPECIES.

COD.

In 1922 there was a decrease of 60 vessels in the fishing fleet landing fish at Boston, Gloucester, and Portland, as compared with 1921. There were 17 vessels in the salt-bank fishery, or 6 fewer than in 1921, and 94 in the market fishery, or 4 fewer than in 1921. These vessels landed their fares of cod and other ground fish at these ports during the year, and large quantities were also landed by vessels fishing on the shore grounds. The catch of cod landed at these ports during the year was 55,180,165 pounds, valued at $1,635,279, of which 50,173,995 pounds, valued at $1,446,727 were landed fresh, and 5,006,170 pounds, valued at $188,552, were landed salted. Cod ranked second in both quantity and value among the various species landed.

HADDOCK.

The catch of haddock ranked first in both quantity and value, exceeding that of cod by 15,015,833 pounds in quantity and $174,121 in value. The quantity of haddock landed at these ports by fishing vessels during the year was 70,195,998 pounds, valued at $1,809,400, all landed fresh except 131,385 pounds salted, valued at $2,736. These fish were taken chiefly from Western Bank, Browns Bank, Georges Bank, and South Channel, and the greater part of the catch, or 52,862,914 pounds, valued at $1,505,425, was landed at Boston.

HAKE.

The catch of hake amounted to 5,374,247 pounds, valued at $111,331, all landed fresh except 32,910 pounds salted, valued at $555. Of this catch, 3,519,546 pounds, valued at $71,473, were landed at Boston, 860,605 pounds, valued at $20,898, at Gloucester, and 994,096 pounds, valued at $18,960, at Portland.

POLLOCK.

The catch of pollock amounted to 5,097,085 pounds, valued at $118,006, all landed fresh, except 49,300 pounds salted, valued at $938. The greater part of this catch, or 3,416,051 pounds, valued at $78,662, was landed at Boston. The catch was obtained principally from Browns Bank, Georges Bank, Jeffreys Ledge, South Channel, and shore grounds.

CUSK.

The catch of cusk was 2,247,450 pounds, valued at $34,552, all fresh except 53,435 pounds salted, valued at $1,204. More than half of the catch was landed at Boston. There was an increase in the catch of cusk of 149,035 pounds in quantity, with a decrease of $3,277 in value as compared with 1921.

HALIBUT.

The catch of halibut was 5,624,149 pounds, valued at $784,057, all landed fresh except 15,706 pounds salted, valued at $915. There was a small decrease in the catch in both quantity and value as compared with 1921. The quantity landed at Boston was 3,948,456 pounds, valued at $550,735; at Gloucester, 58,058 pounds, valued at $7,696; and at Portland, 1,617,635 pounds, valued at $225,626.

MACKEREL.

The total catch of fresh mackerel taken by the American fishing fleet in 1922 was 53,703 barrels, compared with 40,323 barrels in 1921, an increase of 13,380 barrels. The total catch of salted mackerel was 2,749 barrels, compared with 3,242 barrels in 1921, a decrease of 493 barrels. The quantity of mackerel landed at Boston, Gloucester, and Portland during the year was 4,726,747 pounds, valued at $276,499, of which 4,266,367 pounds, valued at $239,111, were fresh and 460,380 pounds, valued at $37,388, were salted. There was an increase in the total catch of mackerel landed by fishing vessels at these ports of 1,342,567 pounds in quantity and a decrease of $59,127 in value, as compared with 1921.

In 1922 the total catch of mackerel up to July 1 was 25,000 barrels fresh and 2,344 barrels salted, compared with 33,632 barrels fresh and 3,143 barrels salted for the same period in 1921. In the southern mackerel fishery both the purse-seine vessels and the gill-net vessels had a poor season. The weather was favorable for fishing, but the mackerel were not abundant. The fish landed were practically all of large and medium size and sold from 9 to 30 cents per pound, according to market conditions. The first mackerel landed sold at 60 cents per pound. The southern fleet was about the same size as in 1921. The Cape Shore fleet was larger than last year but less successful. The first arrival was on May 25 and consisted of large and medium fish, which sold at 18.6 cents per pound. On June 2, fresh mackerel sold at 6½ cents per pound from the vessel, the lowest price since 1919. Cape Shore salted mackerel sold from $12 to $13 per barrel.

SWORDFISH.

The catch of swordfish amounted to 3,281,748 pounds, valued at $447,016. There were 50 vessels engaged in this fishery, or 16 fewer than in the previous year, but there was an increase in the catch of 105.41 per cent in quantity and 40.39 per cent in value.

FLOUNDERS.

The catch of flounders in the vessel fishery was 3,281,327 pounds, valued at $134,749, an increase of 676,670 pounds, or 25.97 per cent in quantity and of $22,793, or 20.35 per cent, in value, as compared with 1921. The catch taken by boats under 5 tons net tonnage is not included in these statistics.

HERRING.

The catch of herring amounted to 2,644,354 pounds, valued at $81,154. Of this quantity, 341,934 pounds, valued at $4,299, were taken off the coast of the United States and landed fresh, and the remainder, including 410,000 pounds, fresh, frozen, valued at $20,500, and 1,892,420 pounds, salted, valued at $56,355, were Newfoundland herring.

OTTER-TRAWL FISHERY.

In 1922 there were 578 trips landed at Boston, Gloucester, and Portland by otter-trawl vessels, amounting to 50,804,604 pounds of fish, valued at $1,259,487, or 31.78 per cent of the quantity and 23.04 per cent of the value of the total catch landed by fishing vessels at these ports during the year. The catch included cod, 11,161,947 pounds, valued at $279,585; haddock, 35,878,524 pounds, valued at $824,963; hake, 576,370 pounds, valued at $11,288; pollock, 919,177 pounds, valued at $19,181; cusk, 3,785 pounds, valued at $30; halibut, 157,813 pounds, valued at $28,446; mackerel, 120,960 pounds, valued at $13,202; and other species, 1,986,028 pounds, valued at $82,792. The catch by otter trawls consists principally of haddock, which in 1922 amounted to 51.11 per cent of the quantity and 45.59 per cent of the value of the entire catch of this species landed. The greater part of the catch by otter trawls was taken from Georges Bank and South Channel.

The following tables give, by fishing grounds and by months, the catch landed by otter trawlers at these ports in 1922, and also the catch of cod, haddock, and hake landed by them in various years:

Fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by otter trawlers in 1922.

	Number of trips.	Cod.		Haddock.		Hake.	
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
BY FISHING GROUNDS.							
East of 66° W. longitude.							
Western Bank	94	5,541,716	$125,209	7,696,371	$129,285	9,925	$132
West of 66° W. longitude.							
Browns Bank	2	29,500	1,030	37,000	1,741	550	17
Georges Bank	217	3,919,720	103,883	12,110,375	276,132	56,810	1,109
South Channel	228	1,592,256	46,915	14,063,788	357,667	463,165	9,363
Nantucket Shoals	29	78,755	2,548	1,970,990	60,138	45,385	651
Shore, general	5					535	16
Total	578	11,161,947	279,585	35,878,524	824,963	576,370	11,288
BY MONTHS.							
January	40	317,010	19,866	1,930,595	102,799	8,040	468
February	48	567,060	19,996	2,924,730	72,534	8,605	246
March	61	1,543,970	32,418	4,081,650	67,639	22,705	879
April	33	830,130	17,124	2,720,420	63,405	8,990	122
May	48	1,072,251	22,103	3,958,915	74,243	33,870	759
June	55	941,745	20,057	3,293,738	57,174	121,060	2,368
July	46	1,211,141	25,025	2,973,795	47,679	63,820	1,102
August	52	1,256,395	22,084	3,238,995	50,605	47,745	965
September	43	1,184,720	23,722	2,583,371	40,681	44,755	731
October	41	842,700	23,125	2,693,235	75,292	44,220	839
November	54	650,650	21,972	2,762,515	81,113	113,580	1,168
December	57	744,175	32,093	2,716,565	91,799	58,980	1,641
Total	578	11,161,947	279,585	35,878,524	824,963	576,370	11,288

	Number of trips.	Pollock.		Cusk.		Halibut.	
		Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
BY FISHING GROUNDS.							
East of 66° W. longitude.							
Western Bank	94	349,265	$6,550	3,285	$25	29,518	$5,021
West of 66° W. longitude.							
Browns Bank	2	2,935	23			213	44
Georges Bank	217	148,268	3,211			64,399	11,360
South Channel	228	384,595	8,471	500	5	61,659	11,639
Nantucket Shoals	29	32,364	847			2,024	382
Shore, general	5	1,750	79				
Total	578	919,177	19,181	3,785	30	157,813	28,446
BY MONTHS.							
January	40	17,424	786			5,306	1,839
February	48	57,850	1,704			13,680	3,062
March	61	117,795	3,044			27,800	5,742
April	33	46,385	1,150			9,858	1,401
May	48	36,015	819			16,187	2,470
June	55	38,358	490	3,285	25	26,326	3,710
July	46	28,785	593			8,833	1,252
August	52	55,560	954			6,004	741
September	43	93,585	1,173			9,108	1,082
October	41	30,555	717			13,591	2,025
November	54	101,040	1,767	500	5	15,256	3,339
December	57	295,195	5,984			5,804	1,783
Total	578	919,177	19,181	3,785	30	157,813	28,446

Fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by otter trawlers in 1922—Continued.

	Number of trips.	Mackerel.		Miscellaneous.		Total.	
BY FISHING GROUNDS.							
East of 66° W. longitude.		*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Western Bank	94	....	....	20,551	$379	13,650,631	$266,601
Cape Shore	3	108,990	$12,776	....	....	108,990	12,776
West of 66° W. longitude.							
Browns Bank	2	....	....	....	....	70,198	2,855
Georges Bank	217	....	....	973,657	42,762	17,273,229	438,457
South Channel	228	245	74	864,558	33,817	17,430,766	467,951
Nantucket Shoals	29	....	....	107,837	5,159	2,237,355	69,725
Shore, general	5	11,725	352	19,425	675	33,435	1,122
Total	578	120,960	13,202	1,986,028	82,792	50,804,604	1,259,487
BY MONTHS.							
January	40	....	....	40,986	4,663	2,319,361	130,421
February	48	....	....	72,206	5,146	3,644,131	102,688
March	61	100	61	146,976	5,895	5,940,990	115,678
April	33	....	....	87,430	3,433	3,703,213	86,635
May	48	39,400	7,320	283,768	5,776	5,440,436	113,490
June	55	69,735	5,469	183,521	5,331	4,706,568	94,624
July	46	11,725	352	135,787	6,375	4,433,886	81,378
August	52	....	....	178,338	7,412	4,783,037	82,761
September	43	....	....	252,110	8,320	4,167,649	75,709
October	41	....	....	353,242	13,445	3,977,543	115,443
November	54	....	....	186,482	11,295	3,830,623	120,659
December	57	....	....	65,182	6,701	3,885,961	140,001
Total	578	120,960	13,202	1,986,028	82,792	50,804,604	1,259,487

Cod, haddock, and hake landed at Boston and Gloucester, Mass., and Portland, Me., by otter trawlers in various years, 1908 to 1922.

Year.	Trips.	Cod.	Haddock.	Hake.	Year.	Trips.	Cod.	Haddock.	Hake.
	No.	*Pounds.*	*Pounds.*	*Pounds.*		*No.*	*Pounds.*	*Pounds.*	*Pounds.*
1908	44	209,800	1,542,000	46,600	1913	326	1,667,806	12,488,992	209,485
1909	47	159,800	1,719,000	74,400	1914	387	1,149,595	15,383,550	259,913
1910	59	125,850	2,775,000	46,600	1920	646	6,311,389	51,962,457	....
1911	178	564,500	7,367,100	151,700	1921	346	2,482,833	26,734,893	241,650
1912	295	1,952,950	12,966,700	105,500	1922	578	11,161,947	85,878,524	576,370

VESSEL LANDINGS OF COD, HADDOCK, AND HALIBUT.

The following tables give the catch of cod, haddock, and halibut landed at Boston and Gloucester, Mass., and Portland, Me., by fishing vessels in 1922, taken from each fishing bank each month by otter trawls and by all other forms of fishing apparatus. The landings include both fresh and salted fish, but the latter have been converted to the equivalent weights of fresh fish in the condition landed.

Vessel landings of cod, haddock, and halibut at Boston and Gloucester, Mass., and Portland, Me., for each month of 1922, shown by apparatus and fishing banks.

[Salt fish have been reduced to the basis of weights of fresh fish.]

JANUARY.

	Trips.	Cod.		Haddock.		Trips.	Halibut.	
BY OTTER TRAWLS.								
East of 66° W. longitude.	*Number.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Number.*	*Pounds.*	*Value.*
Western Bank	1	20,525	$1,150	57,000	$1,729	1	954	$289
West of 66° W. longitude.								
Browns Bank	1	13,100	281	17,500	841	...	...	...
Georges Bank	17	178,430	12,103	847,565	41,712	16	2,897	1,079
South Channel	19	102,030	6,195	909,130	53,679	13	1,438	466
Nantucket Shoals	2	2,925	137	99,400	4,838	1	17	5
Total	40	317,010	19,866	1,930,595	102,799	31	5,306	1,839
BY OTHER APPARATUS.								
East of 66° W. longitude.								
Western Bank	1	25,819	313	...	...	...	...	...
Quereau Bank	1	17,800	834	...	...	1	23,747	3,909
West of 66° W. longitude.								
Browns Bank	41	659,926	30,498	1,481,325	77,704	35	5,385	1,931
Georges Bank	5	54,489	3,827	84,710	3,899	5	1,360	509
Middle Bank	1	3,740	213	2,890	210	1	10	1
Platts Bank	5	12,139	597	8,565	690	2	71	9
Jeffreys Ledge	41	147,475	7,822	228,125	16,936	21	1,703	366
South Channel	8	30,755	1,761	110,090	6,859	6	763	175
Off Chatham	6	16,605	990	67,510	4,893	5	733	214
Shore, general	248	196,982	10,155	69,572	5,626	19	704	120
Total	357	1,165,730	57,010	2,052,787	116,817	95	34,476	7,234
Grand total	397	1,482,740	76,876	3,983,382	219,616	126	39,782	9,073

FEBRUARY.

BY OTTER TRAWLS.								
East of 66° W. longitude.								
Western Bank	2	40,000	$1,200	200,550	$6,017	1	2,000	$200
West of 66° W. longitude.								
Browns Bank	1	16,400	749	19,500	900	1	213	44
Georges Bank	39	474,625	16,760	2,480,715	58,951	37	9,676	2,411
South Channel	5	34,045	1,245	223,965	6,666	4	1,791	407
Nantucket Shoals	1	1,990	42	...	...	...	...	...
Total	48	567,060	19,996	2,924,730	72,534	43	13,680	3,062
BY OTHER APPARATUS.								
East of 66° W. longitude.								
Western Bank	1	12,168	188	...	...	...	...	...
Quereau Bank	6	30,277	1,397	...	...	3	117,191	19,500
Green Bank	2	8,477	128	105	1	1	31,988	4,500
St. Peters Bank	...	...	...	...	...	1	28,813	4,535
The Gully	3	44,433	1,154	...	...	1	17,068	2,411
West of 66° W. longitude.								
Browns Bank	29	550,065	18,938	1,090,365	37,532	23	3,755	1,002
Georges Bank	35	1,503,252	45,872	923,900	21,037	25	3,992	1,172
Middle Bank	14	34,120	1,415	137,115	5,620	4	407	53
Jeffreys Ledge	70	169,786	5,687	662,350	25,477	35	1,774	323
South Channel	18	60,294	2,403	420,125	15,885	9	1,409	283
Off Chatham	9	31,162	1,245	232,575	8,486	5	517	155
Shore, general	205	240,060	8,059	316,375	9,379	3	62	7
Total	392	2,684,094	86,486	3,782,910	123,417	110	206,976	33,941
Grand total	440	3,251,154	106,482	6,707,640	195,951	153	220,656	37,003

Vessel landings of cod, haddock, and halibut at Boston and Gloucester, Mass., and Portland, Me., for each month of 1922, shown by apparatus and fishing banks—Continued.

MARCH.

	Trips.	Cod.		Haddock.		Trips.	Halibut.	
BY OTTER TRAWLS.								
East of 66° W. longitude.	*Number.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Number.*	*Pounds.*	*Value.*
Western Bank	14	873,050	$16,620	1,463,755	$29,234	5	699	$121
West of 66° W. longitude.								
Georges Bank	28	481,100	11,229	1,722,640	22,858	21	10,345	2,025
South Channel	13	189,655	4,564	893,990	15,522	14	16,657	3,581
Nantucket Shoals	1	165	5	1,265	25	1	99	15
Total	56	1,543,970	32,418	4,081,650	67,639	41	27,800	5,742
BY OTHER APPARATUS.								
East of 66° W. longitude.								
Western Bank	5	128,225	2,521	76,445	765	2	60,774	10,895
Quereau Bank	7	48,821	960	....	....	4	147,289	22,644
Green Bank	5	101,180	1,835	115	1	1	14,982	2,624
St. Peters Bank	2	23,407	430	....	....	3	115,440	15,167
The Gully	2	36,924	656	....	....	4	129,366	20,215
West of 66° W. longitude.								
Browns Bank	15	458,965	9,706	576,275	9,542	13	21,402	4,899
Georges Bank	121	3,523,591	77,962	2,215,050	27,979	29	43,138	7,783
Middle Bank	5	12,690	333	88,920	2,314	1	64	13
Platts Bank	2	1,785	42	12,490	293	1	15	2
Jeffreys Ledge	38	85,195	2,009	327,178	8,147	12	400	81
South Channel	25	174,692	4,000	651,730	11,471	14	1,916	410
Shore, general	460	467,690	13,533	1,706,425	42,699	8	2,082	375
Total	687	5,063,165	113,987	5,654,628	103,211	92	536,868	85,108
Grand total	743	6,607,135	146,405	9,736,278	170,850	133	564,668	90,850

APRIL.

	Trips.	Cod.		Haddock.		Trips.	Halibut.	
BY OTTER TRAWLS.								
East of 66° W. longitude.								
Western Bank	14	587,770	$12,010	1,590,605	$31,602	5	746	$77
West of 66° W. longitude.								
Georges Bank	10	173,855	3,779	650,265	17,816	9	6,055	818
South Channel	6	51,940	985	316,500	8,082	6	2,523	445
Nantucket Shoals	2	16,565	350	163,050	5,905	2	534	61
Total	32	830,130	17,124	2,720,420	63,405	22	9,858	1,401
BY OTHER APPARATUS.								
East of 66° W. longitude.								
La Have Bank	3	88,320	1,939	35,700	759	4	52,940	6,928
Western Bank	4	123,446	2,325	46,553	940	3	1,196	215
Quereau Bank	2	14,080	263	....	....	7	198,670	24,105
Green Bank	4	47,551	830	....	....	....	....	....
Grand Bank	....	....	....	....	....	1	45,205	5,872
The Gully	3	20,029	355	....	....	1	17,167	2,419
West of 66° W. longitude.								
Browns Bank	49	1,809,795	42,976	997,025	28,686	32	61,227	6,411
Georges Bank	21	625,200	11,963	51,180	1,107	13	162,920	19,113
Fippenos Bank	1	10,800	247	1,045	84	1	138	26
Middle Bank	14	96,955	2,513	109,640	4,327	10	1,493	240
Platts Bank	8	30,155	600	16,305	419	3	185	21
Jeffreys Ledge	9	58,265	1,380	38,575	1,488	4	499	80
South Channel	16	185,322	4,867	374,815	15,690	15	2,040	324
Nantucket Shoals	1	490	19	....	....	1	10	1
Off Chatham	14	83,190	2,248	359,805	11,478	10	963	140
Shore, general	369	624,788	19,599	381,597	15,965	15	22,972	2,529
Total	518	3,818,386	92,084	2,412,240	80,943	120	567,625	68,424
Grand total	550	4,648,516	109,208	5,132,660	144,348	142	577,483	69,825

Vessel landings of cod, haddock, and halibut at Boston and Gloucester, Mass., and Portland, Me., for each month of 1922, shown by apparatus and fishing banks—Continued.

MAY.

	Trips.	Cod.		Haddock.		Trips.	Halibut.	
	Number.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Number.*	*Pounds.*	*Value.*
BY OTTER TRAWLS.								
East of 66° W. longitude.								
Western Bank	11	823,610	$16,018	1,240,745	$20,904	3	1,794	$283
West of 66° W. longitude.								
Georges Bank	4	81,340	1,681	301,900	3,921	2	1,868	258
South Channel	30	154,351	4,172	2,246,170	45,037	25	11,936	1,819
Nantucket Shoals	2	12,950	232	170,100	4,381	2	589	110
Total	47	1,072,251	22,103	3,958,915	74,243	32	16,187	2,470
BY OTHER APPARATUS.								
East of 66° W. longitude.								
La Have Bank	2	59,810	1,263	11,060	111	1	455	90
Western Bank	10	270,432	4,842	161,745	1,599	3	103,196	14,573
Quereau Bank	8	180,715	3,256			6	188,840	23,525
Green Bank	1	6,096	112			1	20,420	2,101
Grand Bank	1	54,478	1,048			3	81,478	11,023
Cape Shore	1	20,893	331	16,400	298	1	819	136
The Gully						2	78,325	7,734
West of 66° W. longitude.								
Browns Bank	38	768,047	16,721	1,043,920	20,563	29	65,811	11,399
Georges Bank	56	1,721,740	42,183	182,315	3,450	42	212,317	29,084
Cashes Bank	1	9,500	405			1	610	95
Middle Bank	3	22,730	558	10,435	494	3	872	127
Platts Bank	1	6,790	171	2,300	69	1	127	16
Jeffreys Ledge	3	20,646	437	5,148	152	3	221	38
South Channel	40	455,610	11,605	871,410	26,177	37	30,271	5,073
Nantucket Shoals	1	7,825	160	185	7			
Off Chatham	3	36,040	2,018	52,900	2,304	1	207	34
Shore, general	241	631,628	21,827	125,171	6,115	23	2,943	510
Total	410	4,272,980	106,937	2,482,989	61,339	157	786,812	105,558
Grand total	457	5,345,231	129,040	6,441,904	135,582	189	802,999	108,028

JUNE.

	Trips.	Cod.		Haddock.		Trips.	Halibut.	
BY OTTER TRAWLS.								
East of 66° W. longitude.								
Western Bank	12	539,680	$11,239	717,990	$8,288	6	15,775	$2,072
West of 66° W. longitude.								
Georges Bank	9	160,660	2,795	383,375	5,807	4	1,520	184
South Channel	32	241,405	6,023	2,192,373	43,079	23	9,031	1,454
Total	53	941,745	20,057	3,293,738	57,174	33	26,326	3,710
BY OTHER APPARATUS.								
East of 66° W. longitude.								
La Have Bank	21	1,596,855	32,109	176,851	2,002	8	6,037	1,018
Western Bank	8	933,736	18,523	77,940	844	7	41,924	6,837
Quereau Bank	3	29,680	625			4	56,464	6,822
Green Bank						2	88,211	11,275
Grand Bank	15	558,964	10,852			11	255,213	36,133
St. Peters Bank	1	37,172	660			1	35,787	5,387
Cape Shore	1	34,725	1,179	625	13			
St. Anns Bank	1	392,304	6,314					
West of 66° W. longitude.								
Browns Bank	9	418,410	10,302	204,673	3,364	9	7,786	1,409
Georges Bank	35	1,178,740	34,496	211,660	3,401	26	59,773	9,392
Platts Bank	3	4,000	129	1,772	113	3	623	103
Jeffreys Ledge	2	1,887	38	4,560	309	2	170	13
South Channel	40	531,485	16,800	885,810	29,927	33	5,490	947
Nantucket Shoals	6	56,400	1,536	440	8	1	178	18
Shore, general	189	516,908	40,729	55,773	2,701	12	2,448	361
Total	334	6,291,266	174,292	1,620,104	42,682	119	560,104	79,715
Grand total	387	7,233,011	194,349	4,913,842	99,856	152	586,430	83,425

Vessel landing of cod, haddock, and halibut at Boston and Gloucester, Mass., and Portland, Me., for each month of 1922, shown by apparatus and fishing banks—Continued.

JULY.

	Trips.	Cod.		Haddock.		Trips.	Halibut.	
BY OTTER TRAWLS.								
East of 66° W. longitude.	Number.	Pounds.	Value.	Pounds.	Value.	Number.	Pounds.	Value.
Western Bank	9	856,671	$17,471	810,110	$8,588	5	1,509	$165
West of 66° W. longitude.								
Georges Bank	19	285,750	5,529	893,040	11,286	8	4,942	643
South Channel	15	65,570	1,961	1,163,745	24,653	10	2,382	444
Nantucket Shoals	1	3,150	64	106,900	3,152	......	....	......
Total	44	1,211,141	25,025	2,973,795	47,679	23	8,833	1,252
BY OTHER APPARATUS.								
East of 66° W. longitude.								
La Have Bank	7	189,760	5,771	24,890	341	10	90,218	12,326
Western Bank	11	849,192	15,199	134,485	1,345	4	57,316	5,622
Quereau Bank	6	245,812	4,876	4,918	47	5	88,130	11,746
Grand Bank	16	1,129,430	21,381	....	....	14	512,330	51,211
West of 66° W. longitude.								
Browns Bank	24	970,683	26,333	147,420	3,250	16	19,231	2,778
Georges Bank	26	592,552	19,803	319,605	5,363	16	81,881	11,262
Platts Bank	2	2,385	67	3,630	161	1	279	29
Jeffreys Ledge	2	1,080	37	3,390	232	2	27	5
South Channel	58	761,484	25,324	1,335,464	40,072	46	9,192	1,366
Shore, general	162	376,880	16,080	51,351	2,422	16	807	88
Total	314	5,119,258	134,871	2,025,153	53,233	130	859,411	96,433
Grand total	358	6,330,399	159,896	4,998,948	100,912	153	868,244	97,685

AUGUST.

	Trips.	Cod.		Haddock.		Trips.	Halibut.	
BY OTTER TRAWLS.								
East of 66° W. longitude.								
Western Bank	5	642,700	$10,859	243,285	$2,433	1	375	$71
West of 66° W. longitude.								
Georges Bank	23	544,010	9,336	1,204,600	17,058	11	3,179	359
South Channel	18	55,775	1,594	1,334,435	23,969	11	1,995	246
Nantucket Shoals	5	13,910	295	456,675	7,145	5	455	65
Total	51	1,256,395	22,084	3,238,995	50,605	28	6,004	741
BY OTHER APPARATUS.								
East of 66° W. longitude.								
La Have Bank	6	237,315	4,461	67,070	517	2	3,004	375
Western Bank	14	1,920,914	37,164	76,043	834	7	41,700	3,716
Quereau Bank	......	....	....	....	....	4	128,154	17,662
Grand Bank	21	456,421	9,581	....	....	14	480,300	55,094
St. Peters Bank	1	464,231	8,821	....	....	1	3,640	91
Cape Shore	1	48,715	1,726	2,300	12	......	....	......
West of 66° W. longitude.								
Browns Bank	31	1,245,688	38,806	80,670	1,148	20	23,570	3,080
Georges Bank	40	1,296,355	32,558	449,725	6,044	21	119,520	14,891
Platts Bank	5	6,157	215	10,556	471	5	309	28
South Channel	56	932,583	34,551	1,622,725	40,365	48	14,797	2,290
Off Chatham	1	21,540	979	41,650	778	1	64	8
Shore, general	137	260,091	11,919	23,818	887	10	1,145	129
Total	313	6,890,010	180,781	2,374,557	51,056	133	816,203	97,359
Grand total	364	8,146,405	202,865	5,613,552	101,661	161	822,207	98,100

Vessel landings of cod, haddock, and halibut at Boston and Gloucester, Mass., and Portland, Me., for each month of 1922, shown by apparatus and fishing banks—Continued.

SEPTEMBER.

	Trips.	Cod.		Haddock.		Trips.	Halibut.	
BY OTTER TRAWLS.								
East of 66° W. longitude.	*Number.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Number.*	*Pounds.*	*Value.*
Western Bank	3	301,070	$5,444	478,161	$5,103	1	320	$10
West of 66° W. longitude.								
Georges Bank	20	572,635	11,219	936,045	14,301	9	5,190	611
South Channel	20	311,015	7,059	1,169,165	21,277	18	3,598	461
Total	43	1,184,720	23,722	2,583,371	40,681	28	9,108	1,082
BY OTHER APPARATUS.								
East of 66° W. longitude.								
La Have Bank	2	43,150	1,792	19,000	490	2	1,268	234
Western Bank	7	1,283,400	27,168	35,461	396	4	40,044	6,374
Quereau Bank	7	209,136	4,498			4	87,697	12,855
Green Bank	6	107,020	2,277			5	124,901	16,821
Grand Bank	7	81,816	1,781	639	8	9	239,056	34,282
Cape Shore	1	44,164	1,050					
West of 66° W. longitude.								
Browns Bank	3	148,744	5,966	43,135	1,144	3	2,960	561
Georges Bank	71	2,106,535	51,141	868,935	11,283	34	106,057	16,838
Platts Bank	3	5,303	181	5,725	297	1	45	2
Jeffreys Ledge	7	12,847	395	16,280	861	1	300	32
South Channel	67	656,854	20,694	2,726,065	53,400	60	23,575	3,924
Nantucket Shoals	1	12,810	388	500	8	1	53	14
Shore, general	98	155,207	6,579	12,947	546	5	253	32
Total	280	4,861,986	123,910	3,728,697	63,433	119	626,209	91,969
Grand total	323	6,046,706	147,632	6,312,068	109,114	147	635,317	93,051

OCTOBER.

	Trips.	Cod.		Haddock.		Trips.	Halibut.	
BY OTTER TRAWLS.								
East of 66° W. longitude.								
Western Bank	2	65,555	$989	159,520	$1,595			
West of 66° W. longitude								
Georges Bank	29	671,790	19,231	1,853,295	50,789	25	11,569	$1,657
South Channel	10	105,355	2,905	680,420	22,908	8	2,022	368
Total	41	842,700	23,125	2,693,235	75,292	33	13,591	2,025
BY OTHER APPARATUS.								
East of 66° W. longitude.								
La Have Bank	3	183,264	3,874			3	28,082	5,510
Western Bank	5	513,253	10,207	125,529	1,256	3	25,377	4,507
Quereau Bank	2	210,105	4,483			2	30,203	5,352
Green Bank	9	82,904	1,925			9	216,818	34,877
Grand Bank	1	9,500	175			2	35,217	5,182
St. Peters Bank	2	303,956	6,252	1,143	11	1	8,649	1,914
Cape Shore	2	53,670	1,402	2,400	120	1	50	18
West of 66° W. longitude.								
Browns Bank	17	446,723	15,969	168,325	4,555	12	25,166	4,515
Georges Bank	45	1,289,768	40,002	720,000	10,192	30	24,834	5,000
Fippenies Bank	3	14,615	538	5,940	355	1	671	105
Middle Bank	1	3,680	151	9,575	284	1	135	27
Platts Bank	12	44,485	2,016	19,160	906	8	1,622	227
Jeffreys Ledge	16	63,430	3,390	62,058	2,608	12	1,959	319
South Channel	58	467,305	18,758	1,832,225	59,038	45	16,052	3,174
Nantucket Shoals	1	17,200	1,352					
Shore, general	213	622,478	19,695	28,183	1,222	8	396	74
Total	390	4,326,336	130,189	2,974,538	80,547	138	415,231	70,801
Grand total	431	5,169,036	153,314	5,667,773	155,839	171	428,822	72,826

Vessel landings of cod, haddock, and halibut at Boston and Gloucester, Mass., and Portland, Me., for each month of 1922, shown by apparatus and fishing banks—Continued.

NOVEMBER.

	Trips.	Cod.		Haddock.		Trips.	Halibut.	
BY OTTER TRAWLS.								
East of 66° W. longitude.	*Number.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Number.*	*Pounds.*	*Value.*
Western Bank	4	199,650	$8,383	176,000	$3,631	3	1,545	$611
West of 66° W. longitude.								
Georges Bank	11	246,100	7,098	370,025	12,035	11	6,839	1,195
South Channel	29	187,360	5,560	1,488,540	38,804	24	6,585	1,427
Nantucket Shoals	10	17,540	931	727,950	26,643	4	287	106
Total	54	650,650	21,972	2,762,515	81,113	42	15,256	3,339
BY OTHER APPARATUS.								
East of 66° W. longitude.								
La Have Bank	2	33,100	793	33,800	772	2	241	85
Western Bank	11	220,741	5,217	138,285	2,380	4	3,116	799
Green Bank	1	13,600	680			1	1,468	338
Cape Shore	2	55,970	1,052	3,740	54			
West of 66° W. longitude.								
Browns Bank	18	281,040	8,166	251,365	6,881	13	6,727	2,058
Georges Bank	22	436,001	17,713	413,560	10,859	19	10,611	2,302
Fippenies Bank	1	2,890	105	7,770	348	1	81	10
Middle Bank	2	7,840	222	18,200	591	1	61	15
Platts Bank	12	54,225	1,760	17,000	923	3	286	38
Jeffreys Ledge	61	211,863	8,922	216,203	10,821	36	2,762	419
South Channel	72	461,433	21,993	1,617,710	65,731	45	8,596	2,128
Nantucket Shoals	3	41,475	1,226	69,275	2,635			
Off Highland Light	1	1,975	75	4,050	162	1	90	23
Seal Island	1	11,300	379	26,400	792	1	30	3
Shore, general	205	810,992	24,372	42,583	2,553	11	683	105
Total	414	2,644,445	92,675	2,859,941	105,502	138	34,752	8,323
Grand total	468	3,295,095	114,647	5,622,456	186,615	180	50,008	11,662

DECEMBER.

	Trips.	Cod.		Haddock.		Trips.	Halibut.	
BY OTTER TRAWLS.								
East of 66° W. longitude.								
Western Bank	16	591,435	$23,826	558,650	$10,161	16	3,801	$1,122
West of 66° W. longitude.								
Georges Bank	8	49,425	3,123	466,910	19,598	6	319	120
South Channel	29	93,755	4,652	1,445,355	53,991	21	1,701	521
Nantucket Shoals	4	9,560	492	245,650	8,049	1	43	20
Total	57	744,175	32,093	2,716,565	91,799	44	5,864	1,783
BY OTHER APPARATUS.								
East of 66° W. longitude.								
Western Bank	3	41,700	1,416	75,125	2,529	2	2,261	750
Quereau Bank	1	32,594	913			1	10,123	3,158
Cape Shore	2	27,022	1,158	68,500	2,055	1	1,810	453
West of 66° W. longitude.								
Browns Bank	48	753,475	31,900	1,692,180	58,238	43	16,669	5,079
Georges Bank	5	56,870	2,441	115,380	3,365	5	1,783	351
Middle Bank	5	17,090	1,162	32,765	1,905			
Platts Bank	7	23,030	1,368	10,250	822	1	52	9
Jeffreys Ledge	54	145,310	7,947	224,950	13,877	27	1,955	461
South Channel	9	36,595	1,611	134,800	5,862	7	1,424	274
Nantucket Shoals	1	7,980	704					
Off Chatham	2	4,605	246	18,120	1,061	1	365	67
Shore, general	186	313,837	11,606	116,069	7,543	11	933	144
Total	323	1,460,108	62,472	2,488,199	97,257	99	37,375	10,746
Grand total	380	2,204,283	94,565	5,204,764	189,056	143	43,239	12,529

Vessel landings of cod, haddock, and halibut at Boston and Gloucester, Mass., and Portland, Me., for each month of 1922, shown by apparatus and fishing banks—Continued.

GRAND TOTAL.

	Trips.	Cod.		Haddock.		Trips.	Halibut.	
BY OTTER TRAWLS.								
East of 66° W. longitude.	*Number.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Number.*	*Pounds.*	*Value.*
Western Bank	93	5,541,716	$125,209	7,696,371	$129,285	47	29,518	$5,021
West of 66° W. longitude.								
Browns Bank	2	29,500	1,030	37,000	1,741	1	213	44
Georges Bank	217	3,919,720	103,883	12,110,375	276,132	159	64,399	11,360
South Channel	226	1,592,256	46,915	14,063,788	357,667	177	61,659	11,639
Nantucket Shoals	28	78,755	2,548	1,970,990	60,138	16	2,024	382
Total	566	11,161,947	279,585	35,878,524	824,963	400	157,813	28,446
BY OTHER APPARATUS.								
East of 66° W. longitude.								
La Have Bank	46	2,431,574	52,002	368,371	4,992	32	182,245	26,566
Western Bank	80	6,323,026	125,083	947,611	12,888	39	376,804	54,288
Quereau Bank	43	1,019,020	22,105	4,918	47	41	1,076,508	151,278
Green Bank	28	366,828	7,787	220	2	20	498,788	72,536
Grand Bank	61	2,290,609	44,818	639	8	54	1,648,799	198,797
St. Peters Bank	6	828,766	16,163	1,143	11	7	192,329	27,094
Cape Shore	10	285,159	7,898	93,965	2,552	3	2,679	607
St. Annes Bank	1	392,304	6,314	....	....	....	....	....
The Gully	8	101,386	2,165	....	....	8	241,926	32,779
West of 66° W. longitude.								
Browns Bank	322	8,506,561	256,281	7,776,678	252,607	248	259,689	45,122
Georges Bank	482	14,385,093	379,981	6,556,020	107,979	265	828,186	117,697
Cashes	1	9,500	405	....	....	1	610	95
Fippenies Bank	5	28,305	890	14,755	787	3	890	141
Middle Bank	45	198,846	6,567	409,540	15,745	21	3,042	476
Platts Bank	60	190,454	7,146	107,763	5,164	29	3,614	479
Jeffreys Ledge	303	917,784	38,064	1,788,817	80,908	155	11,770	2,137
South Channel	467	4,754,412	164,367	12,583,029	370,477	355	115,525	20,368
Nantucket Shoals	14	144,180	5,385	70,400	2,658	3	241	33
Off Highland Light	1	1,975	75	4,050	162	1	90	23
Off Chatham	35	193,142	7,726	772,560	29,000	23	2,849	618
Seal Island	1	11,300	379	26,400	792	1	30	3
Shore, general	2,713	5,217,541	204,113	2,929,864	97,658	141	35,428	4,474
Total	4,732	48,597,764	1,355,694	34,456,743	984,437	1,450	5,482,042	755,611
Grand total	5,298	59,759,711	1,635,279	70,335,267	1,809,400	1,850	5,639,855	784,057

VESSEL FISHERIES AT SEATTLE, WASH.

In the vessel fisheries at Seattle, Wash., there was a decrease, as compared with 1921, in the total quantity and value of products landed by the fishing fleet, and an increase in the total quantity and value of products landed by collecting vessels, the increase being due chiefly to an increase in the landings of salmon. Statistics of the vessel fisheries at Seattle have been collected by the local agent and published as monthly and annual statistical bulletins, giving the quantity and value of fishery products landed by American fishing and collecting vessels at that port.

In 1922 the fishing fleet at Seattle landed 836 trips, amounting to 11,332,050 pounds of fish, having a value to the fishermen of $1,249,-822. This catch was taken from fishing grounds along the coast from Oregon to Portlock Bank, Alaska. The fishing areas from which the largest quantities of fish were taken were Flattery Banks, west coast of Vancouver Island, and Hecate Strait. The products included halibut, 9,938,150 pounds, valued at $1,196,390; sablefish, 1,014,100 pounds, valued at $46,652; "lingcod," 258,200 pounds, valued at $4,509; and rockfishes, 121,600 pounds, valued at $2,271. Compared with 1921 there was a decrease of 30 trips by fishing vessels, and of 2,334,650 pounds, or 17.08 per cent, in the quantity and of $173,481, or 12.18 per cent, in the value of the products landed. There was a decrease in the catch of halibut of 1,542,850 pounds, or 13.43 per cent, in quantity and of $139,268, or 10.42 per cent, in value. The catch of sablefish decreased 505,300 pounds, or 33.25 per cent, in quantity and $17,033, or 26.74 per cent, in value. The catch of "lingcod" decreased 205,100 pounds, or 44.27 per cent, in quantity and $11,882, or 72.49 per cent, in value; and the catch of rockfishes decreased 81,400 pounds, or 40.09 per cent, in quantity and $5,298, or 69.99 per cent, in value.

The fishery products taken in Puget Sound and landed at Seattle by collecting vessels during the year amounted to 15,083,390 pounds, valued at $964,832. The products included salmon, 13,615,780 pounds, valued at $882,481; herring, 261,890 pounds, valued at $3,158; sturgeon, 1,100 pounds, valued at $130; steelhead trout, 122,820 pounds, valued at $12,542; smelt, 192,350 pounds, valued at $16,795; perch, 30,800 pounds, valued at $2,114; rockfishes, 115,490 pounds, valued at $6,720; "lingcod," 8,000 pounds, valued at $160; flounders, 94,100 pounds, valued at $1,683; sole, 163,500 pounds, valued at $5,679; and crabs, 477,560 pounds, valued at $33,370. Compared with 1921 there was an increase in the products landed by collecting vessels of 2,654,865 pounds, or 21.36 per cent, in quantity and of $185,954, or 23.87 per cent, in value.

Statement, by fishing grounds and months, of quantities and values of certain fresh fishery products landed at Seattle, Wash., by American fishing vessels, 1922.

	Number of trips.	Halibut.		Sablefish.	
		Pounds.	*Value.*	*Pounds.*	*Value.*
BY FISHING GROUNDS.					
Oregon Coast	2	12,000	$2,430	3,500	$195
Flattery Banks	342	2,455,500	326,059	805,400	37,962
West Coast, Vancouver Island	195	1,849,500	220,752	99,000	4,635
Queen Charlotte Islands grounds	38	512,000	67,061	10,500	450
Hecate Strait	237	4,385,150	500,507	93,200	3,285
Noyes Island grounds	5	74,000	7,120		
Forrester Island grounds	2	36,000	2,981		
Coronation Island	2	43,000	4,350		
Yakutat grounds	10	420,000	47,950	2,500	125
Portlock Bank	3	151,000	11,180		
Total	836	9,938,150	1,196,390	1,014,100	46,652
BY MONTHS.					
January	20	493,500	50,720	22,000	740
February	34	379,000	50,190	18,000	700
March	53	543,200	72,059	7,000	340
April	94	844,500	101,153		
May	118	1,252,300	141,967	7,500	375
June	113	1,720,500	162,373	20,000	940
July	88	1,423,000	149,834	69,700	2,481
August	80	940,200	113,681	234,000	8,270
September	80	947,600	127,321	128,200	6,721
October	86	853,000	137,841	291,200	13,815
November	51	345,600	59,121	155,000	8,855
December	19	195,750	30,130	61,500	3,415
Total	836	9,938,150	1,196,390	1,014,100	46,652

Statement, by fishing grounds and months, of quantities and values of certain fresh fishery products landed at Seattle, Wash., by American fishing vessels, 1922—Continued.

	Number of trips.	"Lingcod."		Rockfishes.		Total.	
BY FISHING GROUNDS.		*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Oregon Coast	2					15,500	$2,625
Flattery Banks	342	122,900	$1,961	42,800	$787	3,426,600	366,769
West Coast, Vancouver Island	195	80,800	1,508	67,800	689	2,067,100	233,584
Queen Charlotte Islands grounds	38	25,500	470	6,500	130	554,500	68,111
Hecate Strait	237	21,000	410	29,500	565	4,528,850	504,767
Noyes Island grounds	5	8,000	160	4,000	80	86,000	7,360
Forrester Island grounds	2			1,000	20	37,000	3,001
Coronation Island	2					43,000	4,350
Yakutat grounds	10					422,500	48,075
Portlock Bank	3					151,000	11,180
Total	836	258,200	4,509	121,600	2,271	11,332,050	1,249,822
BY MONTHS.							
January	20	11,000	220	4,000	80	530,500	51,760
February	34	27,000	600	11,500	230	435,500	51,720
March	53	33,500	560	8,500	150	592,200	73,109
April	94	60,900	709	17,000	200	922,400	102,062
May	118	17,500	175	7,200	72	1,284,500	142,589
June	113	43,000	750	27,500	530	1,811,000	161,593
July	88	34,300	603	30,000	535	1,557,000	153,453
August	80	3,600	116	3,600	190	1,181,400	122,257
September	80	4,700	47	2,000	20	1,082,500	134,109
October	86	9,700	409	1,500	30	1,155,400	152,095
November	51	9,500	240	8,300	224	518,400	68,440
December	19	3,500	80	500	10	201,250	33,635
Total	836	258,200	4,509	121,600	2,271	11,332,050	1,249,822

Fishery products, by months, taken in Puget Sound and landed at Seattle, Wash., by collecting vessels, 1922.

Species.	January.		February.		March.		April.		May.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Sturgeon									1,100	$130
Herring	90,000	$1,450	108,400	$1,084	23,490	$234				
Salmon:										
King or spring									370,000	35,400
Sockeye or red									6,000	720
Trout: Steelhead									30,600	3,320
Smelt	22,500	2,500	6,600	924	14,840	1,484	9,640	$964		
Perch			8,200	502	6,000	360	8,600	602		
Rockfishes	7,000	490	10,250	820	8,500	510	14,500	1,015	2,000	160
Flounders	5,850	117	4,000	60	3,600	54	6,450	130	16,500	165
Sole	21,500	645	24,600	575	20,100	603	16,300	470	8,500	255
Crabs	83,600	5,700	78,100	5,325	39,600	2,700	27,500	1,825	21,120	1,440
Total	230,450	10,902	240,150	9,290	116,130	5,945	82,990	5,015	455,820	41,590

Species.	June.		July.		August.		September.	
Salmon:	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Humpback or pink			52,000	$1,040	150,000	$4,500	28,000	$840
Chum or keta			33,600	672	116,000	3,480	83,080	2,077
King or spring	660,000	$66,000	2,350,000	235,000	1,557,200	155,720	307,200	30,720
Coho or silver	47,000	4,700	118,400	5,620	2,254,300	141,258	1,813,200	90,660
Sockeye or red	26,000	2,600	20,000	1,000				
Trout: Steelhead	34,500	3,450	24,500	2,450	16,500	1,650		
Smelt							37,400	2,976
Rockfishes	12,000	240	16,200	324	5,600	448	8,500	680
Flounders	14,300	280	12,000	240	10,000	200	6,600	132
Sole	8,000	320	11,000	440	16,400	1,312	7,000	280
Total	801,800	77,590	2,637,700	246,786	4,126,000	308,568	2,290,980	128,365

Fishery products, by months, taken in Puget Sound and landed at Seattle, Wash., by collecting vessels, 1922—Continued.

Species.	October.		November.		December.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Sturgeon							1,100	$130
Herring					40,000	$390	261,890	3,158
Salmon:								
Humpback or pink	12,000	$240					242,000	6,620
Chum or keta	1,400,000	25,000	464,000	$18,560			2,096,680	49,789
King or spring	108,500	10,850	14,500	1,160			5,367,400	534,850
Coho or silver	1,320,600	26,412	304,200	18,252			5,857,700	280,902
Sockeye or red							52,000	4,320
Trout: Steelhead	10,450	1,045	6,270	627			122,820	12,542
Smelt	32,300	2,740	14,070	1,407	55,000	3,800	192,350	16,795
Perch					8,000	650	30,800	2,114
Rockfishes	10,140	800	8,300	498	12,500	735	115,490	6,720
"Lingcod"	8,000	160					8,000	160
Flounders			6,800	136	8,000	160	94,100	1,683
Sole	7,600	304	4,000	120	18,500	355	163,500	5,679
Crabs	63,800	4,350	70,840	4,830	93,000	7,200	[1] 477,560	33,370
Total	2,973,390	71,901	892,980	45,590	235,000	13,290	15,083,390	964,832

[1] 21,590 dozen.

FISHERIES OF CALIFORNIA IN 1922.

Through the courtesy of the California Fish and Game Commission the bureau has received copies of its monthly sheets showing the catch of fish, by species and by counties, for California, and also the quantity of fish imported into California from Mexico, during the calendar year 1922. These statistics have been compiled by species and by months, as shown in the appended tables.

In 1922 the catch of fish for California amounted to 168,969,733 pounds, an increase of 41,241,110 pounds, or 32.28 per cent over the catch of 1921. The species taken in largest quantities were pilchard, 93,399,900 pounds; albacore and tuna, 17,920,019 pounds; flounders, 11,341,262 pounds; bonito or skipjack, 10,998,855 pounds; salmon, 7,235,124 pounds; barracuda, 4,710,753 pounds; rockfishes, 4,238,480 pounds; yellowtail, 3,111,198 pounds; mackerel, 2,466,762 pounds; white sea bass or squeteague, 2,195,932 pounds; abalones, 1,523,394 pounds; and shad, 1,109,445 pounds.

The imports of fresh fish from Mexico in 1922 amounted to 12,146,066 pounds, an increase of 5,446,249 pounds, or 81.29 per cent, as compared with 1921. The principal species imported were albacore and tuna, 6,179,754 pounds; barracuda, 1,528,770 pounds; bonito or skipjack, 1,792,592 pounds; flounders, 817,304 pounds; white sea bass or squeteague, 736,220 pounds; sea crawfish or spiny lobster, 640,466 pounds; and yellowtail, 303,292 pounds.

Products, in pounds, of the fisheries of California, 1922.

Species.	January.	February.	March.	April.	May.	June.	July.
Albacore and tuna	695	1,440	296		149	875,364	9,386,822
Anchovies	32,613	27,633		7,375	96,717	27,511	37,470
Barracuda	25,220	115,880	554,140	527,589	1,213,656	634,650	369,462
Bluefish, California or squeteague	3,352	3,422	17,806	1,440	925	1,735	5,677
Bonito or skipjack	17,947	2,853	9,591	4,190	695	5,580	31,471
Carp	2,851	5,835	10,776	3,367	16,723	4,140	3,894
Catfish	18,374	14,547	28,648	7,114	8,206		
Flounders	988,803	1,022,552	1,174,570	879,955	867,028	1,253,309	838,590
"Hake"	345	870	260	4,424	3,600	13,998	7,537
Hardhead	5,644	3,160	14,685				

Products, in pounds, of the fisheries of California, 1922—Continued.

Species.	January.	February.	March.	April.	May.	June.	July.
Herring	126,788	98,592	44,085	.....	.....	.....	.....
Kingfish	30,323	52,722	127,350	109,600	81,419	36,250	27,861
"Lingcod"	45,530	39,314	47,565	32,826	40,217	35,075	52,327
Mackerel	175,667	120,150	241,695	273,872	228,454	233,197	245,445
Mullet	.....	.....	1,027	.....	4,250	761	899
"Perches," surf	17,995	19,950	38,723	52,875	6,296	4,013	15,577
Pike, Sacramento	1,245	1,038	198	190	611	298	149
Pilchard	6,830,874	20,949,556	14,420,451	2,184,939	491,487	58,215	1,487,755
Pompano, California	210	150	2,100	1,396	2,053	2,658	1,541
Rockfishes	584,065	566,356	602,278	326,968	282,612	200,746	160,162
Sablefish	12,502	24,344	61,393	34,213	8,294	40,677	31,715
Salmon	11,786	29,248	108,341	501,938	560,469	1,725,650	1,469,933
Sculpin	5,458	4,940	3,914	2,619	8,464	500	.....
Sea bass, black	8,518	4,520	2,158	3,009	5,152	13,301	9,222
Sea basses, or "rock bass"	9,394	6,383	6,410	7,968	34,734	58,349	74,263
Sea bass, white or squeteague	26,139	11,305	188,160	191,496	321,209	475,425	324,465
Shad	991	186	52,009	348,261	675,248	11,080	.....
Sharks	52,620	31,647	36,315	15,380	43,055	23,545	14,413
Sheepshead	2,249	3,150	880	42	643	.....	60
Skates	14,661	15,920	18,069	20,230	6,650	2,370	6,063
"Smelt"	30,388	47,749	74,130	64,998	77,103	44,326	65,100
Split-tail	2,056	6,047	279	102	87	.....	.....
Striped bass	69,162	37,115	17,629	114,193	142,959	1,285	.....
Suckers	710	394	.....	.....	.....	.....	.....
Swordfish	.....	105	.....	80	.....	300	1,524
Tomcod	4,829	2,975	1,034	450	2,659	2,008	564
Whitebait	386	.....	.....	485	6,315	39,081	11,031
Whitefish	2,641	2,259	4,187	2,615	9,319	187	25
Yellowtail	12,329	2,633	133,730	65,930	207,289	162,614	243,893
Other fish	16,353	44,392	16,037	5,828	16,142	21,086	13,706
Crabs	116,512	147,180	46,420	84,722	101,288	41,492	27,940
Shrimps	51,213	38,311	71,031	141,406	124,252	128,020	62,210
Sea crawfish or spiny lobster	66,074	51,335	.....	.....	.....	.....	.....
Abalones	79,043	.....	120,907	83,770	162,052	203,535	243,308
Clams	48,233	44,411	54,027	46,125	53,047	48,776	53,898
Cockles	1,445	863	2,562	3,490	6,024	4,496	2,104
Mussels	2,679	2,546	1,814	2,559	4,576	8,381	8,812
Oysters, eastern	5,547	6,453	7,346	4,738	2,498	2,435	2,077
Octopus	5,547	10,296	15,452	8,943	12,805	14,288	9,701
Squid	471	15,743	11,784	3,188	64,169	74,098	120
Turtles	.....	.....	.....	10	.....	.....	.....
Frogs	540	.....	.....	100	.....	.....	.....
Total	9,569,017	23,638,470	18,392,562	6,177,008	6,002,200	6,534,805	15,348,796

Species.	August.	September	October.	November.	December.	Total.
Albacore and tuna	4,711,620	1,965,151	772,025	168,607	37,850	17,920,019
Anchovies	31,353	19,275	21,919	56,950	.....	358,816
Barracuda	322,480	140,457	339,118	378,585	89,516	4,710,753
Bluefish, California or squeteague	5,118	5,073	3,849	2,160	9,174	60,031
Bonito or skipkack	2,741,407	6,216,812	1,910,044	46,947	11,318	10,998,855
Carp	9,573	171	1,065	3,201	5,257	66,913
Catfish	677	2,804	15,836	19,244	10,229	125,679
Eels	.....	20	.....	.....	.....	20
Flounders	971,155	863,697	938,136	864,202	679,265	11,341,262
"Hake"	9,077	8,045	21,860	4,050	450	74,516
Hardhead	.....	.....	1,316	5,848	1,490	32,143
Herring	.....	.....	.....	295	57,911	327,671
Kingfish	7,708	6,852	17,003	37,972	46,638	581,698
"Lingcod"	69,979	63,406	68,509	48,039	25,694	568,481
Mackerel	127,592	172,353	179,854	215,886	252,597	2,466,762
Mullet	1,023	641	.....	5,095	10,668	24,364
"Perches," surf	16,976	8,302	16,960	25,131	14,841	237,639
Pike, Sacramento	305	131	34	364	2,876	7,439
Pilchard	6,637,365	7,838,542	10,200,583	9,295,815	13,004,318	93,399,900
Pompano, California	961	1,509	1,682	1,121	669	16,050
Rockfishes	293,219	195,592	278,012	375,381	373,089	4,238,480
Sablefish	11,158	1,408	5,594	15,358	21,598	268,554
Salmon	1,706,929	865,816	102,931	111,786	40,297	7,235,124
Sculpin	110	1,189	1,676	8,955	4,105	41,930
Sea bass, black	11,716	3,751	5,309	9,943	7,093	83,692
Sea basses or "rock bass"	67,065	26,813	4,897	9,544	5,542	311,362
Sea bass, white or squeteague	368,348	177,958	57,022	32,222	22,183	2,195,932
Shad	13,247	829	3	5,567	2,024	1,109,445
Sharks	9,093	8,562	13,360	13,225	20,813	282,018
Sheepshead	118	30	.....	1,374	9,637	18,183
Skates	3,851	1,654	10,535	8,362	12,845	121,210
"Smelt"	43,136	84,130	124,286	96,573	71,009	822,928

Products, in pounds, of the fisheries of California, 1922—Continued.

Species.	August.	September.	October.	November.	December.	Total.
Split-tail	206	812		16	803	10,408
Steelhead trout		2,345		145		2,490
Striped bass	90,590	52,279		64,049	94,937	684,198
Suckers				14	234	1,352
Swordfish	8,190	11,921	328	485	323	23,256
Tomcod	11,911	5,332	319		33	32,114
Whitebait	12,390	7,365	4,451	2,503		84,007
Whitefish		2,308	375	2,028	1,845	27,789
Yellowtail	424,997	637,364	757,430	418,850	44,139	3,111,198
Other fish	10,620	8,405	27,010	52,803	18,836	251,218
Crabs				102,806	120,274	788,634
Shrimps	74,659	112,602	88,935	58,607	39,103	990,349
Sea crawfish or spiny lobster			65,420	99,651	93,630	376,310
Abalones	214,277	202,731	63,371	84,739	65,661	1,523,394
Clams	50,616	48,896	42,655	41,427	39,108	571,819
Cockles	1,269	1,631	1,484	3,223	2,973	31,564
Mussels	5,218	4,114	463	2,060	650	43,872
Oysters, eastern	3,578	4,964	6,394	6,557	6,534	59,121
Octopus	2,891	1,956	3,270	6,605	6,834	98,588
Squid			70	219	39,661	209,533
Turtles						10
Frogs						640
Total	19,103,771	19,785,998	16,175,383	12,814,649	15,427,074	168,969,733

Mexican fishery products, in pounds, imported into California, 1922.

Species.	January.	February.	March.	April.	May.	June.	July.
Albacore and tuna	1,991			73,811	159,409		
Barracuda	320,614	224,424	235,027	16,519	2,824		550
Bonito or skipjack	21,145	1,876	895	1,675			
Flounders	48,411	39,668	16,287	16,948	37,680	72,337	97,646
Kingfish			30			65	
Mackerel	15,162	4,565	788		165		630
Mullet	442		585				
Rockfishes	18,327	1,765	599			305	135
Sculpin		90	91				
Sea bass, black	3,903	2,390				90	480
Sea basses or "rock bass"	447	650	799				20
Sea bass, white or squeteague	40,693	312	15,250	17,952	1,400	1,697	49,615
Smelt	1,349	305				123	666
Whitefish	2,256		235				
Yellowtail	130,501	54,706	83,885	3,866			8,135
Other fish	328	105					
Sea crawfish or spiny lobster	109,561	115,332	195,524	46,363			
Abalones			6,265	7,575	21,085	2,115	
Turtles	110			5,255			
Total	715,240	446,188	556,260	189,964	222,563	76,732	157,877

Species.	August.	September.	October.	November.	December.	Total.
Albacore and tuna		832,033	2,417,017	1,961,417	734,076	6,179,754
Barracuda	40	203,398	126,669	189,636	209,069	1,528,770
Bonito or skipjack	160	1,144	307,325	1,184,091	274,281	1,792,592
Flounders	162,374	200,415	25,981	5,060	4,497	817,304
Kingfish		70				165
Mackerel		7,208	220	355	73	29,166
Mullet					5,555	6,582
"Perches," surf	70	75	250	2,255	3,492	6,142
Pompano, California				260	112	372
Rockfishes	30	1,265	1,607	165		24,198
Sculpin						181
Sea bass, black		1,200	170		5,429	13,662
Sea basses or "rock bass"		1,404		215	1,154	4,689
Sea bass, white or squeteague	116,401	209,841	258,824	5,954	18,281	736,220
Sheepshead			22			22
Smelt	738	542	1,506	70	1,913	7,212
Whitefish						2,491
Yellowtail	1,630	10,488	3,159	1,095	5,827	303,292
Other fish		400			2,167	3,000
Sea crawfish or spiny lobster			16,233	85,628	71,825	640,466
Abalones						37,040
Clams					225	225
Turtles		135	555	3,407	3,059	12,521
Total	281,443	1,559,618	3,159,538	3,439,608	1,341,035	12,146,066

FISHERY PRODUCTS RECEIVED AT MUNICIPAL FISH WHARF AND MARKET, WASHINGTON, D. C.[6]

The receipts of fishery products at the Municipal Fish Wharf and Market, Washington, D. C., in 1922 amounted to 6,442,663 pounds, a decrease of 2,624,081 pounds, or 28.94 per cent, as compared with 1921. The five most important products in quantity were squeteagues or "sea trout," 1,138,730 pounds; oysters, 1,744,918 pounds, or 249,274 bushels; croaker, 779,776 pounds; river herring, 559,070 pounds; and shad, 438,148 pounds; total of 4,660,642 pounds, or 72.34 per cent, of the receipts at this market. The species ranking next in abundance include bass, butterfish, catfish, halibut, perch, striped bass, and crabs.

Fishery products, in pounds, received at Municipal Fish Wharf and Market, Washington, D. C., 1922.

Species.	January.	February.	March.	April.	May.	June.	July.
Bass, black or sea	29,500	25,850	25,400		6,800	4,600	400
Baffalofish		1,200					
Bluefish	800				700	1,600	2,400
Butterfish	9,700	4,600	2,000	3,450	15,200	16,100	14,700
Carp	17,881	10,900	15,835	6,400	8,787	4,440	1,850
Catfish	18,060	21,300	64,545	21,285	9,442	7,529	1,540
Cod	4,700	4,300	2,600	800	100	800	400
Crappie		800					
Croaker	20,200	13,100	78,708	148,408	120,100	117,305	135,955
Eels			415	256	130		
Flounders	16,900	10,300	21,450	3,003	4,066	6,760	2,050
Gizzard shad	7,400						
Haddock	1,600	3,300	9,950	1,200	1,240	5,200	4,100
Hake	15,300	7,400	1,300				
Halibut	26,000	16,400	15,250	9,345	9,502	6,600	5,250
Herring, river	6,000	33,200	261,835	206,955	50,050	1,030	
Hickory shad or "jacks"			950	400			
Mackerel		7,900	9,600	3,400	4,900	10,000	3,650
Perch	12,300	12,300	72,300	17,608	4,420	1,828	725
Pike or pickerel	1,180		250	100			
Pollock	5,200	5,300	800			400	
Redfish or red drum		800				1,000	
Red snapper	500	1,000					
Salmon	4,200	3,700	6,100	1,100	100	4,550	800
Scup or porgy					2,500	600	
Shad	17,900	27,900	84,590	224,828	80,903	27	
Smelt	1,100		2,500				
Spot				2,100	3,200	3,400	5,810
Squeteagues or "sea trout"	80,000	66,700	34,000	87,400	294,700	165,300	67,330
Striped bass	10,530	9,375	54,995	28,335	5,890	11,751	7,385
Sturgeon						250	
Tilefish		1,100	2,025	850	400	200	
Whiting	8,300						
Clams, hard [1]	2,176	2,048	7,136	31,264	5,376	6,688	6,528
Oysters:[1]							
In the shell	338,800	250,600	240,289	1,736	560		
Opened	261,525	170,775	162,731	454			
Scallops				110			
Crabs				1,995	15,345	57,398	50,875
Crab meat			895	2,250	6,900	8,460	7,965
Frogs				600	611		
Lobster					150	50	
Shrimp	1,250	800	150	750	700	400	300
Turtles				16	851		
Total	919,002	712,948	1,178,599	806,398	653,623	444,266	320,013

[6] Daily reports of the quantity of fishery products received at this market are received by the bureau for tabulation through the courtesy of the health department of the District of Columbia.

Fishery products, in pounds, received at Municipal Fish Wharf and Market, Washington, D. C., 1922—Continued.

Species.	August.	September.	October.	November.	December.	Total.
Bass, black or sea	600	5,600	640	3,400	12,245	115,035
Buffalofish						1,200
Bluefish	5,400	6,250	6,600	7,000	1,200	31,950
Butterfish	21,000	12,200	8,400	12,400	800	120,550
Carp	1,100	4,850	4,200	2,350	2,150	80,743
Catfish	1,240	18,220	17,110	18,720	11,320	210,811
Cod		1,200	1,200	3,300	2,200	21,600
Crappie						800
Croaker	59,200	55,100	17,900	11,600	2,200	779,776
Eels		800	555	1,300	3,065	6,521
Flounders	2,600	5,200	4,400	7,200	2,800	86,729
Gizzard shad		200	600	5,600	9,000	22,800
Haddock	2,600	5,400	6,500	4,400	6,300	51,790
Hake			400	4,800	11,800	41,000
Halibut	3,404	4,050	3,900	6,200	27,000	132,901
Herring, river						559,070
Hickory shad or "jacks"						1,350
Kingfish			200			200
Mackerel	200	2,610		5,600	7,000	54,860
Mullet		245			430	675
Perch	900	5,100	13,750	16,515	8,870	166,616
Pike or pickerel		360	100		890	2,870
Pollock		400				12,100
Redfish or red drum						1,800
Red snapper						1,500
Salmon		1,600	3,275	1,500	11,400	38,325
Scup or porgy		1,400				4,500
Shad		200	1,800			438,148
Smelt					600	4,200
Spot		6,655	12,700	4,200		38,065
Squeteagues or "sea trout"	78,000	163,900	68,100	19,000	14,300	1,138,730
Striped bass	1,000	16,325	23,675	17,400	5,975	192,636
Sturgeon						250
Tilefish						4,575
Whiting					400	8,700
Clams, hard [1]	3,392	4,256	2,304	2,464	1,344	[2] 74,976
Oysters:[1]						
In the shell		18,837	68,600	70,672	52,955	[3] 1,048,049
Opened		5,858	13,332	38,882	48,812	[4] 701,869
Scallops						110
Crabs	26,790	39,840	9,900			202,148
Crab meat	4,900	6,025	2,250	152	240	40,037
Frogs						1,211
Lobster						200
Shrimp		175			800	5,325
Turtles						867
Total	212,326	392,846	292,391	264,655	245,596	6,442,663

[1] The clams have been reduced to pounds on the basis of 8 pounds of meat to a bushel, the oysters on a basis of 7 pounds of meat to a bushel and 8½ pounds to a gallon.
[2] 9,372 bushels.
[3] 149,007 bushels.
[4] 85,075 gallons.

NOTES ON SPONGE FISHERY.

In 1922 the quantity of sponges sold at the Sponge Exchange, Tarpon Springs, Fla., was 526,885 pounds, valued at $699,092, of which 248,475 pounds, valued at $596,199 were large wool; 70,478 pounds, valued at $42,286, small wool; 115,455 pounds, valued at $37,637, yellow; 84,892 pounds, valued at $20,379, grass; and 7,585 pounds, valued at $2,588, wire. It is estimated that sponges to the value of $50,000 were sold outside of the Exchange at Tarpon Springs.

FISHERIES OF NEW YORK, NEW JERSEY, PENNSYLVANIA. AND DELAWARE IN 1921.

The statistics of the fisheries of New York, New Jersey, Pennsylvania, and Delaware contained in this report are based on a canvass of the coast fisheries of these States for the calendar year

1921, and have been published already in condensed form and distributed to the trade as Statistical Bulletin No. 569. The statistics given for the oyster product are for the oyster season beginning in 1921, and those of the shad fishery of the Hudson River are for the calendar years 1921 and 1922 in accordance with the previous practice of making an annual canvass of this fishery. The statistics for New York and Pennsylvania do not include any fisheries of the Great Lakes or other inland waters of those States.

EARLIER PUBLICATIONS.

Some of the earlier publications relating to the fisheries of New York, New Jersey, Pennsylvania, and Delaware, published in Washington, D. C., follow:

1887. New York and Its Fisheries. By Fred. Mather. *In* The Fisheries and Fishery Industries of the United States, by George Brown Goode and associates, 1880 (1887), Section II, Part VI, pp. 341–377.

New Jersey and Its Fisheries. By R. Edward Earll. *Ibid.*, part VII, pp. 379–400.

Pennsylvania and Its Fisheries. By R. Edward Earll. *Ibid.*, part VIII, pp. 401–405.

Delaware and Its Fisheries. By Joseph W. Collins. *Ibid.*, part IX, pp. 407–419.

1890. The Sturgeons and Sturgeon Industries of the Eastern Coast of the United States, with an Account of Experiments Bearing upon Sturgeon Culture. By John A. Ryder. Bulletin, U. S. Fish Commission, Vol. VIII, for 1888 (1890), pp. 231–328.

1892. IV. Fisheries of the Middle Atlantic States [1887 and 1888]. *In* Statistical Review of the Coast Fisheries of the United States, prepared under the direction of J. W. Collins. Report, U. S. Commission of Fish and Fisheries, 1888 (1892), pp. 323–351.

1894. Notes on the Oyster Industry of New Jersey. By Ansley Hall. Report of the Commissioner of Fish and Fisheries for 1892 (1894), pp. 463–528.

1895. A Statistical Report on the Fisheries of the Middle Atlantic States [1889–1893]. By Hugh M. Smith. Bulletin, U. S. Fish Commission, Vol. XIV, 1894 (1895), pp. 339–467.

1898. Shad and Alewife Fisheries [1896–1897]. *In* Report of the Division of Statistics and Methods of the Fisheries. By Hugh M. Smith. Report of the Commissioner of Fish and Fisheries for 1897 (1898), pp. cxxv–cxxx.

1899. Statistics of Certain Fisheries of the New England and Middle Atlantic States and the Great Lakes [1897]. *In* Report of the Division of Statistics and Methods of the Fisheries. By C. H. Townsend. Report of the Commissioner of Fish and Fisheries for 1898 (1899), pp. clxvi–clxxv.

Notes on the Extent and Condition of the Alewife Fisheries of the United States in 1896. By Hugh M. Smith. Appendix to the Report of the Commissioner of Fish and Fisheries for 1898 (1899), pp. 31–43.

1899. The Shad Fisheries of the Atlantic Coast of the United States. By Charles H. Stevenson. Appendix to the Report of the Commissioner of Fish and Fisheries for 1898 (1899), pp. 101–269.

1900. The Sturgeon Fishery of Delaware River and Bay [1890–1898]. By John N. Cobb. Report of the Commissioner of Fish and Fisheries for 1899 (1900), pp. 369–380.

1901. Statistics of the Fisheries of the Middle Atlantic States [1897]. By C. H. Townsend. Appendix to the Report of the Commissioner of Fish and Fisheries for 1900 (1901), pp. 195–310.

1904. The Lobster Fishery [1900]. *In* Report of the Division of Statistics and Methods of the Fisheries. By C. H. Townsend. Report of the Commissioner of Fish and Fisheries for 1902 (1904), pp. 156–158.

Statistics of the Fisheries of the Middle Atlantic States [1901]. By Barton W. Evermann. Report of the Commissioner of Fish and Fisheries for 1902 (1904), pp. 433–540.

1905. Statistics of the Fisheries of the Middle Atlantic States for 1904. Report, U. S. Commissioner of Fisheries, 1905, 122 pp. Bureau of Fisheries Doc. No. 609.

1911. Shad and Alewife Fisheries [1909]. Report, U. S. Commissioner of Fisheries, 1910 (1911), pp. 27–28.
1913. Shad Fisheries [1910]. Report, U. S. Commissioner of Fisheries, 1911 (1913), pp. 35–37.
1914. The Oyster Industry [1911]. Report, U. S. Commissioner of Fisheries, 1912 (1914), pp. 7–23.
1915. The Menhaden Industry [1912]. Report, U. S. Commissioner of Fisheries, 1914 (1915), pp. 18–22.
The Sturgeon Industry of Delaware River [1914]. *Ibid.*, p. 23.
1917. The Lobster Fishery [1913]. Report, U. S. Commissioner of Fisheries, 1915 (1917), pp. 37–43.
Coastal Fisheries of New York and New Jersey [1915]. Report, U. S. Commissioner of Fisheries, 1916 (1917), pp. 72–75.
Shad Fishery of the Hudson River [1915–1916]. *Ibid.*, pp. 76–77.
1920. Coastal Fisheries of New York and New Jersey [1917]. Report, U. S. Commissioner of Fisheries, 1918 (1920), pp. 66–70.
Shad Fishery of the Hudson River [1917–1918]. *Ibid.*, p. 72.
Statistics of the Wholesale Fish Trade of New York City [1918]. *Ibid.*, pp. 73–76.
1921. Shad Fishery of the Hudson River [1919]. *In* Fishery Industries of the United States. Report of the Division of Statistics and Methods of the Fisheries for 1919. By Lewis Radcliffe. Appendix X to the Report of the U. S. Commissioner of Fisheries for 1919 (1921), pp. 49–50. Bureau of Fisheries Doc. No. 892.
Shad Fishery of the Hudson River [1920]. *In* Fishery Industries of the United States. Report of the Division of Statistics and Methods of the Fisheries for 1920. By Lewis Radcliffe. Appendix V to the Report of the U. S. Commissioner of Fisheries for 1921 (1922), p. 51. Bureau of Fisheries Doc. No. 908

COMMON AND SCIENTIFIC NAMES OF FISHES.

Following is a list of the common and scientific names of the fishes of New York, New Jersey, Pennsylvania, and Delaware to which reference is made in this report:

Albacore	*Gymnosarda alleterata.*
Alewives	*Pomolobus æstivalis.* *Pomolobus pseudoharengus.*
Black drum	*Pogonias cromis.*
Bluefish	*Pomatomus saltatrix.*
Bonito	*Sarda sarda.*
Butterfish	*Poronotus triacanthus.*
Carp	*Cyprinus carpio.*
Catfish and bullheads	Siluridæ (species).
Cod	*Gadus callarias.*
Croaker	*Micropogon undulatus.*
Cunner	*Tautogolabrus adspersus.*
Eels	*Anguilla rostrata.* *Leptocephalus conger.*
Flounders	*Paralichthys dentatus.* *Pseudopleuronectes americanus.* *Lophopsetta maculata.*
Gizzard shad	*Dorosoma cepedianum.*
Grayfish	*Squalus acanthias.* *Galeorhinus lævis.*
Haddock	*Melanogrammus æglifinus.*
Hake	*Phycis chuss.* *Phycis tenuis.*
Herring, sea	*Clupea harengus.*
Herring, round	*Etrumeus sadina.*
Hickory shad	*Pomolobus mediocris.*
King whiting	*Menticirrhus saxatilis.*
Lance, sand	*Ammodytes americanus.*
Mackerel	*Scomber scombrus.*
Menhaden	*Brevoortia tyrannus.*
Mullet	*Mugil cephalus.*

Mummichog	Fundulus (species).
Perch	*Morone americana.*
Perch, yellow	*Perca flavescens.*
Pigfish	*Orthopristis chrysopterus.*
Pike or pickerel	Esox (species).
Pilot fish	*Naucrates ductor.*
Pollock	*Pollachius virens.*
Pompano	*Trachinotus carolinus.*
Redfish or red drum	*Sciænops ocellatus.*
Roach, or shiners	*Abramis crysoleucas.*
Scup or porgy	*Stenotomus chrysops.*
Sea bass	*Centropristes striatus.*
Sea robin	Prionotus (species).
Shad	*Alosa sapidissima.*
Silversides	Menidia (species).
Spanish mackerel and cero	*Scomberomorus maculatus* *Scomberomorus regalis.*
Spot	*Leiostomus xanthurus.*
Squeteagues, weakfish, or "sea trout"	*Cynoscion regalis.* *Cynoscion nebulosus.*
Striped bass	*Roccus lineatus.*
Sturgeon	*Acipenser sturio.*
Suckers	Catostomidæ (species).
Sunfish	Centrarchidæ (species).
Swellfish	Tetraodontidæ (species).
Swordfish	*Xiphias gladius.*
Tautog	*Tautoga onitis.*
Tilefish	*Lopholatilus chamæleonticeps.*
Tomcod	*Microgadus tomcod.*
Whiting	*Merluccius bilinearis.*
Tuna	*Thunnus thynnus.*

GENERAL STATISTICS.

In 1921, the total number of persons engaged in the fisheries of New York, New Jersey, Pennsylvania, and Delaware was 14,483 as compared with 23,898 in 1904, a decrease of 9,415, or 39.4 per cent. The total investment was $20,498,498, as compared with $16,075,122 in 1904, an increase of $4,423,376, or 27.52 per cent. The products of the fisheries of these States amounted to 332,931,742 pounds, valued at $11,667,393, as compared with 375,412,398 pounds, valued at $10,043,062, in 1904, a decrease of 42,480,656 pounds, or 11.32 per cent, in quantity and an increase of $1,624,331, or 16.17 per cent, in value.

Fisheries of New York, New Jersey, Pennsylvania, and Delaware, 1921.

Items.	New York.		New Jersey.		Pennsylvania.		Delaware.	
	Number.	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
PERSONS ENGAGED.								
On vessels fishing	1,799		2,164		42		279	
On vessels transporting	62		28		2		2	
In shore fisheries	2,365		2,982		105		540	
Shoresmen	2,919		597		442		155	
Total	7,145		5,771		591		976	
INVESTMENT.								
Vessels, fishing, steam	31	$3,270,000					4	$165,382
Tonnage	1,555						492	
Outfit		242,057						7,591
Vessels, fishing, gasoline	229	791,515	215	$830,100	3	$26,000	12	38,900
Tonnage	2,775		2,493		93		135	
Outfit		240,859		203,940		5,050		9,050

Fisheries of New York, New Jersey, Pennsylvania, and Delaware, 1921—Continued.

Items.	New York.		New Jersey.		Pennsylvania.		Delaware.	
INVESTMENT—con.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
Vessels, fishing, sail	7	$5,150	127	$300,600			13	$26,200
Tonnage	55		1,818				133	
Outfit		1,525		56,295				6,920
Vessels, transporting, steam	2	13,000						
Tonnage	41							
Outfit		2,380						
Vessels, transporting, gasoline	48	182,300	24	49,500			1	600
Tonnage	783		252				7	
Outfit		30,249		2,175				
Vessels, transporting, sail	2	13,500	4	850	1	$800	3	2,000
Tonnage	103		27		10		21	
Outfit		1,100				75		100
Boats, sail, row, etc.	1,249	61,005	1,135	36,759	37	1,205	303	7,770
Boats, power, etc.	838	443,980	1,551	647,920	8	3,100	113	31,265
Apparatus, vessel fisheries:								
Purse seines	37	86,600	20	23,000	1	1,000	4	6,000
Gill nets	26	2,375	991	17,165				
Pound nets	8	27,000	82	315,850				
Fyke nets	180	960						
Drag nets	2	15						
Otter trawls	46	3,655	23	1,630				
Lines, hand, trawl and set		4,710		1,296		250		
Harpoons		150						
Eel pots	150	300	50	125				
Lobster pots	1,175	2,548	350	450				
Dredges	848	11,302	520	10,605			4	90
Tongs, rakes, etc.	122	995	62	630				
Apparatus, shore fisheries:								
Pound nets, floating traps, and weirs	414	163,285	217	135,220			5	1,000
Gill nets	918	52,442	3,657	100,742	13	1,370	156	6,930
Fyke nets	2,767	22,235	1,285	9,580	25	35	431	1,629
Haul seines	155	14,185	184	13,550	22	1,912	93	9,000
Purse seines			1	600				
Drag nets	30	192						
Scap nets	138	3,281						
Dip nets	22	25						
Stop nets	14	1,405	86	12,365	5	625		
Bag nets			58	1,160				
Otter trawls	50	3,140	8	540				
Lines, hand and trawl		4,678		5,023				25
Eel pots	3,780	8,537	4,102	4,632			101	101
Lobster pots	13,363	33,700	10,345	10,944			180	180
Harpoons		185						
Spears	46	224						
Dredges	1,236	7,838	52	775				
Tongs, rakes, and hoes	765	5,088	1,321	6,728			208	1,040
Other apparatus		93		143				888
Shore and acessory property		7,140,497		1,587,762		1,074,156		153,400
Cash capital		936,200		313,100		260,200		108,500
Total		13,836,455		4,701,704		1,375,778		584,561
PRODUCTS.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore	29,354	$1,420	125,642	$3,985				
Alewives	377,793	11,283	408,193	11,914	20,085	$405	351,590	$6,431
Bluefish	1,082,917	176,726	2,243,425	390,947	600	108	1,325	265
Bonito	255,887	30,350	1,503,253	91,046				
Butterfish	630,076	64,109	2,862,491	159,286	200	6		
Carp	421,642	63,678	329,555	53,184	9,712	1,511	87,820	13,166
Catfish	43,435	6,722	101,067	5,976	2,125	128	35,291	2,574
Cod	667,860	37,783	687,277	37,353				
Croaker			3,815,554	126,700	2,400	48	418,873	18,682
Drum, black			67,659	1,365			1,150	22
Drum, red			500	10				
Eels, fresh	463,552	58,008	274,754	26,450	220	22	16,012	1,598
Eels, smoked			4,680	1,497				
Flounders	4,471,161	283,412	1,985,340	140,586	200	10	34,429	1,798
Gizzard shad							7,320	292

Fisheries of New York, New Jersey, Pennsylvania, and Delaware, 1921—Continued.

Items.	New York.		New Jersey.		Pennsylvania.		Delaware.	
PRODUCTS—con.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Haddock	18,515	$876	6,300	$338				
Hake	35,006	1,430	821,018	25,563				
Herring	6,575	206	172,732	4,464				
Hickory shad	23,455	1,441	28,145	1,582				
King whiting	70,447	13,589	24,119	3,334				
Mackerel	282,075	40,356	584,386	100,556				
Menhaden	179,447,799	1,117,235	30,405,093	121,451			18,082,000	$67,970
Mullet, fresh	1,250	85	18,460	1,136			513	25
Mullet, salted			1,200	240				
Perch, white	64,041	7,578	130,970	18,791			6,923	922
Perch, yellow	25,500	2,896	31,282	4,708			2,758	273
Pigfish					2,000	$80		
Pike or pickerel	215	48	500	100			272	25
Pollock	84,300	2,325	4,540	127				
Pompano	35	7						
Scup or porgy	1,297,375	76,253	4,115,552	200,046	142,000	7,100		
Sea bass	148,434	21,412	1,378,330	86,823	135,000	12,500	250	12
Sea robin	38,419	1,140	63,640	1,340				
Shad	115,692	27,128	168,637	44,460	18,872	5,834	86,836	16,312
Sharks	10,659	284	60,459	1,232				
Skates and rays	75,550	1,149	43,100	1,186				
Smelt	6,200	1,185	450	335				
Spanish mackerel	25	5	3,982	979				
Spot	43,757	3,728	189,548	11,502			14,600	928
Squeteagues or weakfish	1,921,036	228,524	11,651,735	902,439	240,000	14,400	886,550	53,317
Striped bass	94,525	18,662	70,348	21,691			4,915	1,426
Sturgeon	33,917	9,199	45,825	7,120			12,090	1,813
Sturgeon caviar	940	1,706	74	194				
Sturgeon roe			3,572	10,746			1,872	5,139
Suckers	132,618	16,731	50,664	5,139	21,199	2,469	983	118
Swordfish	44,865	9,125						
Tautog	54,722	4,362	44,043	2,650			1,500	75
Tilefish	1,133,000	76,984						
Tomcod	57,200	2,083	1,950	97				
Tuna	32,413	2,745	87,734	3,493				
Whitebait	13,561	1,335						
Whiting	939,287	12,212	3,280,833	64,371				
Other fish	171,240	7,652	789	34				
Lobster	1,037,395	196,762	397,841	88,588			10,400	2,600
Shrimp	88,450	28,890	20,000	400				
Crabs, hard	477,242	17,807	119,244	7,290				
Crabs, soft	5,885	1,855	16,800	6,132			4,600	1,150
Crabs, king	750	11	3,313,174	10,416			630,000	1,890
Squid	330,117	18,500	433,902	20,008				
Clams, hard, public	[1] 764,824	214,528	[2] 782,088	364,548			[3] 4,040	2,340
Clams, hard, private	[4] 5,400	1,950						
Clams, soft, public	[5] 186,150	32,670	[6] 143,500	20,650				
Clams, soft, private	[7] 2,000	325						
Skimmers, or surf clams	[8] 48,160	11,300						
Mussels	[9] 50,000	2,500	[10] 791,000	6,070				
Oysters, market, public	[11] 292,453	41,790	[12] 69,300	10,190			[13] 870,219	74,140
Oysters, market, private	[14] 9,131,017	1,733,663	[15] 10,977,855	2,060,306			[16] 1,942,563	293,975
Oysters, seed, public	[17] 69,825	9,710	[18] 11,638,900	666,905			[19] 1,502,949	82,758
Oysters, seed, private	[20] 7,000	750	[21] 311,500	22,529				
Scallops	[22] 1,235,760	217,108	[23] 540	90				
Turtles	800	19	13,715	334			2,250	112
Terrapin	600	350	225	225			300	300
Shells	1,760,000	1,480						
Miscellaneous products	14,099	9,780	7,800	159				
Total	210,377,152	4,986,918	96,936,784	5,983,406	594,613	44,621	25,023,193	652,448

[1] 95,603 bushels.
[2] 97,761 bushels.
[3] 505 bushels.
[4] 675 bushels.
[5] 18,615 bushels.
[6] 14,350 bushels.
[7] 200 bushels.
[8] 6,020 bushels.
[9] 5,000 bushels.
[10] 79,100 bushels.
[11] 41,779 bushels.
[12] 9,900 bushels.
[13] 124,317 bushels.
[14] 1,304,431 bushels.
[15] 1,568,265 bushels.
[16] 277,509 bushels.
[17] 9,975 bushels.
[18] 1,662,700 bushels.
[19] 214,707 bushels.
[20] 1,000 bushels.
[21] 44,500 bushels.
[22] 205,960 bushels.
[23] 90 bushels.

NOTE.—The above statistics do not include any fisheries of the Great Lakes or other inland waters. The statistics for New York include 83,718 bushels of market oysters from private grounds, valued at $83,718, taken by vessels owned and employed, mainly in Connecticut.

SHAD FISHERY OF THE HUDSON RIVER.

In 1921 there were 307 persons engaged in the fishery of the Hudson River in New York and New Jersey. The investment amounted to $44,607, and the catch was 35,448 shad in number, or 130,803 pounds, valued at $30,623. Of this quantity 28,948 shad in number, or 104,883 pounds, valued at $24,329, were taken in New York and 6,500 in number, or 25,920 pounds, valued at $6,294, in New Jersey.

In 1922 there were 272 persons engaged in this fishery, the investment amounted to $40,342, and the catch was 48,336 shad in number, or 175,186 pounds, valued at $39,706. The catch in New York was 36,111 shad in number, or 128,324 pounds, valued at $27,451, and in New Jersey 12,225 in number, or 46,862 pounds, valued at $12,255.

Compared with 1920 there was a decrease in 1921 of 61 persons and of 13,867 shad in number, or 69,041 pounds, and of $25,706 in the value, but an increase of $4,256 in the investment. In 1922, as compared with 1920, there was a decrease of 96 persons and of 979 in the number of shad, 24,658 in the number of pounds, and $16,603 in the value, with practically no change in the amount of capital invested. In 1922 the number of persons engaged and the investment in the fishery were not as large as in 1921, but there was an increase in the catch of 4,888 shad in number, or 44,383 pounds, and of $9,103 in the value. The statistics for 1921 and 1922, and also comparative statistics of the catch from 1915 to 1922, are given in the following tables:

Shad fishery of the Hudson River, 1921 and 1922.

Items.	1921								
	New York.			New Jersey.			Total.		
	Number.	*Pounds.*	*Value.*	*Number.*	*Pounds.*	*Value.*	*Number.*	*Pounds.*	*Value.*
Fishermen	286			21			307		
Rowboats	185		$8,560	13		$1,000	198		$9,560
House boats	1		150				1		150
Gasoline boats	34		5,300	4		200	38		5,500
Gill nets	159		19,687	8		2,910	167		22,597
Haul seines	5		590				5		590
Shore and accessory property			2,635			3,575			6,210
Total			36,922			7,685			44,607
Shad caught:									
With gill nets	27,991	101,465	23,469	6,500	25,920	6,294	34,491	127,385	29,763
With seines	747	2,603	601				747	2,603	601
With other apparatus incidentally	210	815	259				210	815	259
Total	28,948	104,883	24,329	6,500	25,920	6,294	35,448	130,803	30,623

Shad fishery of the Hudson River, 1921 and 1922—Continued.

Items.	1922								
	New York.			New Jersey.			Total.		
	Number.	*Pounds.*	*Value.*	*Number.*	*Pounds.*	*Value.*	*Number.*	*Pounds.*	*Value.*
Fishermen	251			21			272		
Rowboats	164		$7,680	13		$1,000	177		$8,680
House boats	1		150				1		150
Gasoline boats	22		4,050	4		200	26		4,250
Gill nets	133		17,532	8		2,910	141		20,442
Haul seines	5		610				5		610
Shore and accessory property			2,635			3,575			6,210
Total			32,657			7,685			40,342
Shad caught:									
With gill nets	34,763	123,469	26,327	12,225	46,862	12,255	46,988	170,331	38,582
With seines	1,348	4,855	1,124				1,348	4,855	1,124
With other apparatus incidentally									
Total	36,111	128,324	27,451	12,225	46,862	12,255	48,336	175,186	39,706

Comparative statistics of shad fishery of the Hudson River, 1915–1922.

Year.	New York.			New Jersey.			Total.		
	Number.	*Pounds.*	*Value.*	*Number.*	*Pounds.*	*Value.*	*Number.*	*Pounds.*	*Value.*
1915	11,606	48,564	$5,969	4,249	20,104	$2,674	15,855	68,668	$8,643
1916	7,787	32,923	4,540	1,500	7,250	925	9,287	40,173	5,465
1917	10,615	38,344	5,810	1,400	5,040	720	12,015	43,384	6,540
1918	63,404	220,602	44,784	3,999	14,000	3,400	67,403	234,602	48,184
1919	76,501	301,306	60,690	13,800	73.668	23,034	90,301	374,974	83,724
1920	39,692	157,715	43,382	9,623	42,129	12,427	49,315	199,844	56,309
1921	28,948	104,883	24,329	6,500	25,920	6,294	35,448	130,803	30,623
1922	36,111	128,324	27,451	12,225	46,862	12,255	48,336	175,186	39,706

FISHERIES OF NEW YORK.

In 1921 the number of persons employed in the fisheries of New York was 7,145, of whom 1,799 were on vessels fishing, 62 on transporting vessels, 2,365 in the shore or boat fisheries, and 2,919 on shore in wholesale establishments and other fishery industries.

The investment in the fisheries and fishery industries amounted to $13,836,455 and included 319 fishing and transporting vessels, valued at $4,275,465, with a tonnage of 5,262 net tons, and outfits valued at $518,170; 2,087 boats, valued at $504,985; fishing apparatus valued at $461,138; shore and accessory property valued at $7,140,497; and cash capital amounting to $936,200.

The products of the fisheries amounted to 210,377,152 pounds, valued at $4,986,918. The principal species taken, arranged in the order of their value, were: Oysters, 9,500,295 pounds, or 1,357,185 bushels, valued at $1,785,913; menhaden, 179,447,799 pounds, valued at $1,117,235; flounders, 4,471,161 pounds, valued at $283,-412; clams, 1,006,538 pounds, or 121,113 bushels, valued at $260,773; squeteaques, "sea trout," or weakfish, 1,921,036 pounds, valued at $228,524; scallops, 1,235,760 pounds, or 205,960 bushels, valued at $217,108; lobster, 1,037,395 pounds, valued at $196,762; and bluefish, 1,082,917 pounds, valued at $176,726.

Compared with 1904 there was a decrease in the number of persons employed of 4,348, or 37.83 per cent, and an increase in the investment of $3,214,839, or 30.26 per cent. There was a decrease in the products of 67,272,595 pounds, or 24.23 per cent, in quantity and of $1,243,640, or 19.96 per cent, in value.

The following table gives the number of persons employed, investment, and products of the fisheries of New York, by counties, in 1921:

Persons engaged, investment, and products of the fisheries of New York in 1921, by counties.

Items.	Albany.		Bronx.		Broome, Delaware, Sullivan, and Tioga.		Columbia.	
PERSONS ENGAGED.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
In shore fisheries	45		14		23		50	
Shoresmen			1					
Total	45		15		23		50	
INVESTMENT.								
Boats:								
Sail, row, etc.	29	$1,060	8	$210	20	$275	32	$1,485
Power	5	625	6	1,450			4	1,000
Apparatus, shore fisheries:								
Pound nets, floating traps, and weirs					18	855		
Gill nets	1	50					16	1,590
Fyke nets	132	2,270					98	1,400
Haul seines	11	1,345			1	200	8	645
Scap nets	16	398					11	293
Eel pots							6	18
Lobster pots			48	100				
Hoes			10	10				
Shore and accessory property		110		8,600		160		655
Cash capital				1,200				
Total		5,858		11,570		1,490		7,086
PRODUCTS.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Alewives	1,610	131					3,450	253
Carp	26,697	3,791					59,428	6,083
Catfish and bullheads	7,955	1,398					2,472	608
Eels	3,538	422			33,700	4,452	955	189
Perch, yellow	1,592	171					2,944	410
Pickerel	50	15					10	3
Shad	1,016	217			1,000	200	2,750	714
Sturgeon							304	106
Suckers	19,329	2,846					30,501	3,739
Other fish	1,000	10					115	11
Lobster			1,000	200				
Miscellaneous products			322	515				
Total	62,787	9,001	1,322	715	34,700	4,652	102,929	12,116

Items.	Dutchess.		Greene.		Kings.		Nassau.	
PERSONS ENGAGED.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
On vessels fishing					64		73	
On vessels transporting							4	
In shore fisheries	110		48		222		282	
Shoresmen					125		46	
Total	110		48		411		405	
INVESTMENT.								
Vessels fishing:								
Steam							1	$3,000
Tonnage							36	
Outfit								800
Gasoline					11	$53,655	23	71,400
Tonnage					178		264	
Outfit						25,850		18,630

Persons engaged, investment, and products of the fisheries of New York in 1921, by counties—Continued.

Items.	Dutchess.		Greene.		Kings.		Nassau.	
INVESTMENT—continued.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
Vessels transporting:								
Gasoline							5	$9,800
Tonnage							53	
Outfit								3,113
Boats:								
Sail, row, etc.	94	$4,235	38	$2,170	37	$1,370	133	9,595
Power	10	1,475	1	1,000	91	54,025	111	53,275
Apparatus, vessel fisheries:								
Purse seines					2	2,200		
Gill nets							12	350
Otter trawls					5	440	5	330
Lines, hand and trawl						710		
Harpoons						100		
Lobster pots					90	158		
Dredges					2	50	41	1,375
Tongs							2	20
Rakes					3	35		
Apparatus, shore fisheries:								
Pound nets, floating traps, and weirs							2	15,000
Gill nets	48	4,952	8	1,110	2	600	208	12,975
Fyke nets	75	1,054	35	430				
Haul seines	3	200	5	400	8	575	4	415
Drag nets							3	25
Scap nets	21	495	15	320				
Dip nets							12	14
Stop nets			5	725				
Otter trawls					5	400		
Lines, hand and trawl		40				310		1,660
Eel pots	28	66			80	145	120	315
Lobster pots					5,265	14,435	225	550
Spears							32	168
Dredges							66	1,195
Tongs					18	171	119	964
Rakes					19	210	16	77
Hoes					45	45	36	37
Other apparatus						1		
Shore and accessory property		790		125		224,685		60,060
Cash capital						66,300		5,500
Total		13,307		6,280		446,470		271,243
PRODUCTS.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore							6,000	$300
Alewives	13,740	$1,267	21,425	$1,522			2,685	125
Bluefish					204,233	$32,225	40,425	9,390
Bonito							42,060	5,150
Butterfish							23,400	2,600
Carp	16,518	1,998	25,655	3,158				
Catfish and bullheads	3,130	601	1,794	320				
Cod					69,500	2,800	88,950	5,815
Eels	6,514	723	86	16	13,335	1,600	68,925	8,605
Flounders					438,050	21,960	233,025	13,735
Haddock					7,000	100	6,490	400
Hake					3,150	250	4,375	205
Hickory shad							900	52
King whiting							600	120
Mackerel							60,105	7,700
Perch, yellow	2,938	350	1,415	168				
Pickerel	10	2						
Pollock							2,850	160
Scup					426,000	21,300	22,400	1,940
Sea bass					17,050	2,065	7,650	1,525
Shad	35,449	7,982	80	25	2,757	1,000	1,200	240
Sharks							800	30
Spot							1,600	145
Squeteagues					28,575	950	350,325	46,708
Striped bass							2,450	570
Sturgeon	3,335	716	150	10			1,200	410
Sturgeon cavair	99	299						
Suckers	8,700	945	2,845	358				
Swordfish					30,000	6,000		
Tautog					1,400	200	200	18
Tilefish					300,000	21,000		
Tuna							12,000	1,000
Whiting							32,570	405
Other fish	751	75			16,140	2,950		
Lobster					406,300	62,880	10,450	2,425

Persons engaged, investment, and products of the fisheries of New York in 1921, by counties—Continued.

Items.	Dutchess.		Greene.		Kings.		Nassau.	
PRODUCTS—continued.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Shrimp					1,125	$250	6,000	$2,000
Crabs, soft							5,795	1,825
Squid							4,500	285
Clams, hard, public					3,400	1,275	60,152	24,245
Clams, hard, private							5,400	1,950
Clams, soft, public					3,000	600	74,300	12,950
Clams, soft, private							2,000	325
Skimmers or surf clams					48,160	11,300		
Mussels							50,000	2,500
Oysters, market, public					5,250	750	2,520	575
Oysters, market, private							1,174,733	277,813
Oysters, seed, public					5,600	800		
Scallops, sea					10,740	2,150	42,096	13,880
Miscellaneous products					12,902	8,125	180	290
Total	91,244	$14,958	53,450	$5,577	2,053,667	202,530	2,451,311	448,361

Items.	New York.		Orange.		Putnam.		Queens.	
PERSONS ENGAGED.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
On vessels fishing	136						8	
On vessels transporting	9							
In shore fisheries	7		57		4		37	
Shoremen	1,591							
Total	1,743		57		4		45	
INVESTMENT.								
Vessels fishing:								
Gasoline	11	$115,080					1	$2,000
Tonnage	378						43	
Outfit		48,380						600
Vessels transporting:								
Steam	1	9,000						
Tonnage	26							
Outfit		1,000						
Gasoline	1	10,000						
Tonnage	63							
Outfit		3,000						
Boats:								
Sail, row, etc			40	$1,590	4	$175	15	320
Power	7	6,150	5	600			25	6,250
Apparatus, vessel fisheries:								
Purse seines	8	11,500						
Otter trawls	2	260						
Lines, hand and trawl		3,950						40
Dredges	4	275						
Apparatus, shore fisheries:								
Pound nets, floating traps, and weirs			4	165				
Gill nets			14	2,145	1	110		
Fyke nets			114	1,425				
Haul seines			16	1,075				
Scap nets			8	200	2	45		
Otter trawls	1	80						
Lines, hand and trawl				63				160
Eel pots			25	50			40	80
Spears							8	42
Tongs	2	18						
Hoes	2	2					13	12
Other apparatus								90
Shore and accessory property		3,882,638		1,720		20		275
Cash capital		767,900						
Total		4,859,233		9,033		350		9,869
PRODUCTS.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Alewives			3,129	$197				
Bluefish	663,650	$105,023						
Carp			25,075	3,752	300	$60		
Catfish and bullheads			1,603	276				
Cod	5,000	200					31,000	$2,100
Eels			7,652	1,075			4,050	925
Flounders	90,000	4,200					7,755	1,315
Perch, yellow			1,757	225	100	10		
Scup	580,400	30,596						
Sea bass	11,800	1,290						

Persons engaged, investment, and products of the fisheries of New York in 1921, by counties—Continued.

Items.	New York.		Orange.		Putnam.		Queens.	
PRODUCTS—continued.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Shad			7,060	$1,833	480	$120		
Squeteagues	130,600	$3,938					5,000	$1,150
Striped bass							60	20
Suckers			24,972	3,492	550	110		
Tautog							500	100
Tilefish	833,000	55,984						
Tomcod			4,800	219			1,700	200
Other fish	3,000	90	11,343	151			9,500	950
Shrimp							4,700	1,100
Clams, hard, public	2,200	1,100					896	450
Clams, soft, public							6,500	875
Oysters, market, private	455,000	87,500						
Miscellaneous products	90	150					405	550
Total	2,774,740	290,071	87,391	11,220	1,430	300	72,066	9,735

Items.	Rensselaer.		Richmond.		Rockland.		Suffolk.	
PERSONS ENGAGED.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
On vessels fishing			61				1,454	
On vessels transporting							49	
In shore fisheries	30		39		52		1,071	
Shoresmen							1,123	
Total	30		100		52		3,697	
INVESTMENT.								
Vessels fishing:								
Steam							30	$3,267,000
Tonnage							5,619	
Outfit								241,257
Gasoline			16	$56,800			166	487,580
Tonnage			214				1,669	
Outfit				33,800				113,399
Sail			1	1,200			6	3,950
Tonnage			23				32	
Outfit				500				1,025
Vessels transporting:								
Steam							1	4,000
Tonnage							15	
Outfit								1,380
Gasoline							42	162,500
Tonnage							617	
Outfit								24,136
Sail							2	13,500
Tonnage							103	
Outfit								1,100
Boats:								
Sail, row, etc	22	$1,065	15	550	28	$1,050	543	28,155
Power	1	150	13	9,550	7	1,950	522	300,130
Apparatus, vessel fisheries:								
Purse seines							27	72,900
Gill nets							14	2,025
Pound nets							8	27,000
Fyke nets							180	960
Drag nets							2	15
Otter trawls							34	2,625
Lines, hand and trawl								10
Harpoons								50
Eel pots							150	300
Lobster pots							1,085	2,385
Dredges			34	1,190			752	8,112
Tongs							107	884
Rakes			4	50			6	6
Apparatus, shore fisheries:								
Pound nets, floating traps, and weirs							390	147,265
Gill nets					55	1,955	382	13,655
Fyke nets	78	1,130			2	60	2,016	11,425
Haul seines	10	705			9	1,100	63	5,155
Drag nets							27	167
Scap nets	10	235			2	50		
Dip nets							10	11
Otter trawls			1	75			43	2,585
Lines, hand and trawl		15		75		43		2,168
Eel pots			20	40	170	305	3,114	7,060
Lobster pots			910	1,820			6,885	16,735
Harpoons								185

Persons engaged, investment, and products of the fisheries of New York in 1921, by counties—Continued.

Items.	Rensselaer.		Richmond.		Rockland.		Suffolk.	
INVESTMENT—contd.								
Apparatus—Continued.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
Spears							6	$14
Dredges			6	$100			1,164	6,543
Tongs			8	50			219	1,617
Rakes			14	150			179	1,571
Hoes							57	79
Forks							1	2
Other apparatus								2
Shore and accessory property		$240		1,380		$850		2,924,769
Cash capital								90,300
Total		3,540		107,330		7,363		7,997,692
PRODUCTS.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore							23,354	$1,120
Alewives					910	$76	296,120	4,970
Bluefish							174,609	30,088
Bonito							213,827	25,200
Butterfish							606,676	61,509
Carp	23,488	$3,050			5,783	729	156,913	30,095
Catfish and bullheads	4,586	816			160	19	15,335	1,555
Cod			26,000	$1,400			447,410	25,468
Eels	293	61	1,000	175	9,105	1,007	290,089	35,693
Flounders			37,000	3,000			3,665,331	239,202
Haddock							5,025	376
Hake							28,381	975
Herring							6,575	206
Hickory shad							22,555	1,392
King whiting							69,847	13,469
Mackerel							221,970	32,656
Menhaden							179,447,799	1,117,235
Mullet							1,250	85
Perch, white					1,055	120	62,086	7,363
Perch, yellow	1,612	170			115	17	400	60
Pickerel	45	9						
Pollock							81,450	2,165
Pompano							35	7
Scup							268,575	22,417
Sea bass							111,934	16,532
Sea robin							38,419	1,140
Shad					5,985	1,635	5,852	1,359
Sharks							0,859	254
Skates							75,550	1,149
Smelt							6,200	1,185
Spanish mackerel							25	5
Spot							42,157	3,583
Squeteagues							1,400,536	175,778
Striped bass					5,400	1,239	83,275	15,937
Sturgeon	2,080	373			538	86	16,416	5,257
Sturgeon caviar							496	602
Suckers	6,668	803			1,420	137		
Swordfish							14,865	3,125
Tautog							52,622	4,044
Tomcod							47,200	1,579
Tuna							20,413	1,745
Whitebait							13,561	1,335
Whiting							906,717	11,807
Other fish	700	60					117,444	3,063
Lobster			45,400	11,700			573,845	119,477
Shrimp							76,625	25,540
Crabs, hard							463,242	17,107
Crabs, soft							90	30
Crabs, king							750	11
Squid							325,617	18,215
Clams, hard, public			9,240	4,400			688,536	182,758
Clams, soft, public							81,350	13,745
Oysters, market, public			13,300	2,000			264,383	36,565
Oysters, market, private			[1]2,534,714	514,741			4,966,570	853,609
Oysters, seed, public			19,950	2,850			44,275	6,060
Oysters, seed, private							7,000	750
Scallops, bay							1,152,528	192,376
Scallops, sea							30,396	8,752
Turtles							800	19
Terrapin							600	350
Shells							1,760,000	1,480
Miscellaneous products							200	150
Total	39,472	5,348	2,686,604	540,266	30,471	5,065	199,511,960	3,379,779

[1] Includes 83,718 bushels, valued at $83,718, taken up by vessels owned and employed mainly in Connecticut.

Persons engaged, investment, and products of the fisheries of New York in 1921, by counties—Continued.

Items.	Ulster.		Westchester.		Total.	
PERSONS ENGAGED.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
On vessels fishing			3		1,799	
On vessels transporting					62	
In shore fisheries	167		107		2,365	
Shoresmen			33		2,919	
Total	167		143		7,145	
INVESTMENT.						
Vessels fishing:						
Steam					31	$3,270,000
Tonnage					1,555	
Outfit						242,057
Gasoline			1	$5,000	229	791,515
Tonnage			29		2,775	
Outfit				200		240,859
Sail					7	5,150
Tonnage					55	
Outfit						1,525
Vessels transporting:						
Steam					2	13,000
Tonnage					41	
Outfit						2,380
Gasoline					48	182,300
Tonnage					733	
Outfit						30,249
Sail					2	13,500
Tonnage					103	
Outfit						1,100
Boats:						
Sail, row, etc	115	$4,485	76	3,215	1,249	61,005
Power	15	2,700	15	3,650	838	443,980
Apparatus, vessel fisheries:						
Purse seines					37	86,600
Gill nets					26	2,375
Pound nets					8	27,000
Fyke nets					180	960
Drag nets					2	15
Otter trawls					46	3,655
Lines, hand and trawl						4,710
Harpoons						150
Eel pots					150	300
Lobster pots					1,175	2,543
Dredges			15	300	848	11,302
Tongs					109	904
Rakes					13	91
Apparatus, shore fisheries:						
Pound nets, floating traps, and weirs					414	163,285
Gill nets	89	10,395	34	2,905	918	52,442
Fyke nets	126	1,910	81	1,131	2,757	22,235
Haul seines	16	1,325	11	1,045	155	14,185
Drag nets					30	192
Scap nets	51	1,195	2	50	138	3,281
Dip nets					22	25
Stop nets	9	680			14	1,405
Otter trawls					50	3,140
Lines, hand and trawl		50		94		4,678
Eel pots	25	58	154	400	3,780	8,537
Lobster pots			30	60	13,363	33,700
Harpoons						185
Spears					46	224
Dredges					1,236	7,838
Tongs			8	64	374	2,884
Rakes					228	2,008
Hoes			9	9	162	194
Forks					1	2
Other apparatus						93
Shore and accessory property		875		31,945		7,140,497
Cash capital				5,000		936,200
Total		23,673		55,068		13,836,455
PRODUCTS.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore					29,354	$1,420
Alewives	34,299	$2,719	425	$23	377,793	11,283
Bluefish					1,082,917	176,726
Bonito					255,887	30,350
Butterfish					630,076	04,109
Carp	51,099	7,948	30,686	3,014	421,642	63,678
Catfish and bullheads	3,909	773	2,491	356	43,435	6,722
Cod					667,860	37,783
Eels	2,547	397	21,763	2,668	463,552	58,008

Persons engaged, investment, and products of the fisheries of New York in 1921, by counties—Continued.

Items.	Ulster.		Westchester.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
PRODUCTS—Continued						
Flounders					4,471,161	$283,412
Haddock					18,515	876
Hake					35,906	1,430
Herring					6,575	206
Hickory shad					23,455	1,444
King whiting					70,447	13,589
Mackerel					282,075	40,356
Menhaden					179,447,799	1,117,235
Mullet					1,250	85
Perch, white			900	$95	64,041	7,578
Perch, yellow	5,186	$549	7,441	766	25,500	2,896
Pickerel	79	16	21	3	215	48
Pollock					84,300	2,325
Pompano					35	7
Scup					1,297,375	76,253
Sea bass					148,434	21,412
Sea robin					38,419	1,140
Shad	43,866	9,853	8,197	1,950	115,692	27,128
Sharks					10,659	284
Skates					75,550	1,149
Smelt					6,200	1,185
Spanish mackerel					25	5
Spot					43,757	3,728
Squeteagues					1,921,030	228,524
Striped bass			3,340	896	94,525	18,662
Sturgeon	3,744	984	6,150	1,257	33,917	9,199
Sturgeon caviar			345	805	940	1,706
Suckers	18,870	2,263	18,703	2,038	132,618	16,731
Swordfish					44,865	9,125
Tautog					54,722	4,362
Tilefish					1,133,000	76,984
Tomcod			3,500	85	57,200	2,083
Tuna					32,413	2,745
Whitebait					13,561	1,335
Whiting					939,287	12,212
Other fish	10,555	224	692	62	171,240	7,652
Lobster			400	80	1,037,395	196,762
Shrimp					88,450	28,890
Crabs, hard			14,000	700	477,242	17,807
Crabs, soft					5,885	1,855
Crabs, king					750	11
Squid					330,117	18,500
Clams, hard, public			400	300	[2] 764,824	214,528
Clams, hard, private					[3] 5,400	1,950
Clams, soft, public			21,000	4,500	[4] 186,150	32,670
Clams, soft, private					[5] 2,000	325
Skimmers or surf clams					[6] 48,160	11,300
Mussels					[7] 50,000	2,500
Oysters, market, public			7,000	1,900	[8] 292,453	41,790
Oysters, market, private					[9] 9,131,017	1,733,663
Oysters, seed, public					[10] 69,825	9,710
Oysters, seed, private					[11] 7,000	750
Scallops, bay					[12] 1,152,528	192,376
Scallops, sea					[13] 83,232	24,732
Turtles					800	35
Terrapin					600	480
Shells					[14] 1,760,000	1,480
Miscellaneous products					14,099	9,780
Total	174,154	25,726	147,454	21,498	210,377,152	4,986,918

[2] 95,603 bushels.
[3] 675 bushels.
[4] 18,615 bushels.
[5] 200 bushels.
[6] 6,020 bushels.
[7] 5,000 bushels.
[8] 41,779 bushels.
[9] 1,304,431 bushels.
[10] 9,075 bushels.
[11] 1,000 bushels.
[12] 192,088 bushels.
[13] 13,872 bushels.
[14] 44,000 bushels.

VESSEL AND SHORE FISHERIES.

The products of the vessel and shore or boat fisheries of New York are shown separately in the following table. The catch taken by vessels amounted to 194,276,310 pounds, valued at $3,478,037, and by boats in the shore fisheries to 16,100,842 pounds, valued at $1,508,881.

Products of the vessel and shore fisheries of New York, 1921.

Species.	Vessel fisheries.		Shore fisheries.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore	10,000	$500	19,354	$920	29,354	$1,420
Alewives	7,070	299	370,723	10,984	377,793	11,283
Bluefish	902,508	144,473	180,409	32,253	1,082,917	176,726
Bonito	95,000	14,050	160,887	16,300	255,887	30,350
Butterfish	55,000	6,500	575,076	57,609	630,076	64,109
Carp			421,642	63,678	421,642	63,678
Catfish and bullheads			43,435	6,722	43,435	6,722
Cod	75,000	2,720	592,860	35,063	667,860	37,783
Eels	8,390	1,170	455,162	56,838	463,552	58,008
Flounders	1,577,370	116,597	2,893,791	166,815	4,471,161	283,412
Haddock	7,000	100	11,515	776	18,515	876
Hake			35,906	1,430	35,906	1,430
Herring			6,575	206	6,575	206
Hickory shad	1,600	95	21,855	1,349	23,455	1,444
King Whiting	1,115	240	69,332	13,349	70,447	13,589
Mackerel	50,500	7,400	231,575	32,956	282,075	40,356
Menhaden	178,683,105	1,113,057	764,694	4,178	179,447,799	1,117,235
Mullet			1,250	85	1,250	85
Perch, white			64,041	7,578	64,041	7,578
Perch, yellow			25,500	2,896	25,500	2,896
Pickerel			215	48	215	48
Pollock	1,600	80	82,700	2,245	84,300	2,325
Pompano			35	7	35	7
Scup	1,046,750	55,933	250,625	20,320	1,297,375	76,253
Sea bass	29,250	3,584	119,184	17,828	148,434	21,412
Sea robin			38,419	1,140	38,419	1,140
Shad	1,950	389	113,742	26,739	115,692	27,128
Sharks	2,800	111	7,859	173	10,659	284
Skates			75,550	1,149	75,550	1,149
Smelt			6,200	1,185	6,200	1,185
Spanish mackerel			25	5	25	5
Spot	2,000	159	41,757	3,569	43,757	3,728
Squeteagues	831,165	104,897	1,089,871	123,627	1,921,036	228,524
Striped bass	100	30	94,425	18,632	94,525	18,662
Sturgeon	2,200	769	31,717	8,430	33,917	9,199
Sturgeon caviar	200	400	740	1,306	940	1,706
Suckers			132,618	16,731	132,618	16,731
Swordfish	35,800	7,000	9,065	2,125	44,865	9,125
Tautog	900	88	53,822	4,274	54,722	4,362
Tilefish	1,133,000	76,984			1,133,000	76,984
Tomcod	300	18	56,900	2,065	57,200	2,083
Tuna	15,500	1,300	16,913	1,445	32,413	2,745
Whitebait			13,561	1,335	13,561	1,335
Whiting	59,000	668	880,287	11,544	939,287	12,212
Other fish	3,000	90	168,240	7,562	171,240	7,652
Lobster	47,100	10,400	990,295	186,362	1,037,395	196,762
Shrimp	2,325	775	86,125	28,115	88,450	28,890
Crabs, hard	29,850	1,334	447,392	16,473	477,242	17,807
Crabs, soft			5,885	1,855	5,885	1,855
Crabs, king			750	11	750	11
Squid	13,000	840	317,117	17,660	330,117	18,500
Clams, hard, public	146,352	66,243	618,472	148,285	[2] 764,824	214,528
Clams, hard, private			5,400	1,950	[3] 5,400	1,950
Clams, soft, public			186,150	32,670	[4] 186,150	32,670
Clams, soft, private			2,000	325	[5] 2,000	325
Skimmers or surf clams			48,160	11,300	[6] 48,160	11,300
Mussels	30,000	1,500	20,000	1,000	[7] 50,000	2,500
Oysters, market, public	80,122	12,960	212,331	28,830	[8] 292,453	41,790
Oysters, market, private	[1] 8,790,803	1,648,235	340,214	85,428	[9] 9,131,017	1,733,663
Oysters, seed, public	44,275	6,260	25,550	3,450	[10] 69,825	9,710
Oysters, seed, private	7,000	750			[11] 7,000	750
Scallops, bay	422,790	62,369	729,738	130,007	[12] 1,152,528	192,376
Scallops, sea	22,920	6,320	60,312	18,412	[13] 83,232	24,732
Turtles			800	19	800	19
Terrapin	600	350			600	350
Shells			1,760,000	1,480	[14] 1,760,000	1,480
Miscellaneous products			14,099	9,780	14,099	9,780
Total	194,276,310	3,478,037	16,100,842	1,508,881	210,377,152	4,986,918

[1] Includes 83,718 bushels, valued at $83,718, taken up by vessels owned and employed mainly in Connecticut.

[2] 95,603 bushels.
[3] 675 bushels.
[4] 18,615 bushels.
[5] 200 bushels.
[6] 6,020 bushels.
[7] 5,000 bushels.
[8] 41,779 bushels.
[9] 1,304,431 bushels.
[10] 9,975 bushels.
[11] 1,000 bushels.
[12] 192,088 bushels.
[13] 13,872 bushels.
[14] 44,000 bushels.

FISHERIES BY APPARATUS.

The most important forms of fishing apparatus used in the fisheries of New York in 1921 were purse and haul seines, with a catch of 180,655,920 pounds, valued at $1,262,217; pound nets and trap nets, with 6,756,423 pounds, valued at $529,844; otter trawls, with 2,941,095 pounds, valued at $205,717; lines, with 3,348,876 pounds, valued at $297,640; dredges, tongs, rakes, etc., with 13,514,532 pounds, valued at $2,259,493, consisting chiefly of oysters, clams, and scallops; and lobster pots, with 1,028,460 pounds, valued at $194,952, of which 1,021,710 pounds, valued at $193,602, were lobsters, and the remainder sea bass. There were also 7,985 pounds of lobsters, valued at $1,615, taken in otter trawls, and 7,700 pounds, valued at $1,545, in pound nets. The catch with fyke nets, consisting chiefly of flounders, amounted to 917,568 pounds, valued at $41,279, and with gill nets, to 607,077 pounds, valued at $93,517. Considerable quantities of products were also taken with dip nets, scap nets, stop nets, harpoons, drag nets, eel pots, spears, and minor forms of apparatus. The entire catch of swordfish, amounting to 44,865 pounds, valued at $9,125, was taken with harpoons. The products taken with each form of fishing apparatus in the vessel and shore fisheries combined are shown in the appended tables.

Yield of the fisheries of New York in 1921, by counties, apparatus, and species.

BY PURSE SEINES AND HAUL SEINES.

Apparatus and species.	Albany.		Broome.		Columbia.		Dutchess.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Haul seines:								
Alewives	1,550	$119			3,000	$220	90	$11
Bullheads	4,270	591			400	100		
Carp	7,662	1,136			8,124	788	3,600	391
Minnows	1,000	10						
Perch, yellow	97	10			200	20	20	2
Shad			1,000	$200	250	66	125	29
Suckers	3,666	501			10,178	1,485	850	115
Total	18,245	2,367	1,000	200	22,152	2,679	4,685	548

Apparatus and species.	Greene.		Kings.		Nassau.		New York.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Purse seines:								
Bluefish			5,000	$1,000			550	$100
Scup			426,000	21,300			580,400	30,596
Sea bass			6,000	900			11,800	1,290
Squeteagues			26,700	800			130,600	3,938
Other fish							3,000	90
Total			463,700	24,000			726,350	36,014
Haul seines:								
Alewives	3,000	$220			285	$10		
Bluefish					525	115		
Bullheads	450	68						
Carp	2,500	204						
Eels					3,400	400		
Flounders					34,525	2,535		
Lance			2,585	775				
Mummichog			5,005	450				
Perch, yellow	220	23						
Roach, or shiners			3,750	1,125				
Spot					1,000	100		
Squeteagues			625	50	10,825	1,388		
Striped bass					1,600	400		
Suckers	220	22						
Total	6,390	597	11,965	2,400	52,160	4,948		

Yield of the fisheries of New York in 1921, by counties, apparatus, and species—Continued.

BY PURSE SEINES AND HAUL SEINES—Continued

Apparatus and species.	Orange.		Rensselaer.		Rockland.		Suffolk.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Purse seines: Menhaden							178,629,705	$1,112,666
Haul seines:								
Alewives	320	$30			210	$21	167,000	1,985
Bluefish							11,990	1,865
Bullheads			1,675	$304	50	8		
Carp	20,742	3,120	15,357	2,082	4,883	634	156,913	30,095
Catfish							15,335	1,555
Cod							150	15
Eels							50	7
King whiting							2,100	325
Mackerel							4,050	668
Menhaden							25,658	315
Minnows	9,163	113	700	66				
Mummichog							26,900	342
Perch, white					325	27	43,301	4,625
Perch, yellow	817	99	800	80			400	60
Roach, or shiners	2,180	38					1,000	100
Scup							500	25
Shad	128	26			92	25		
Silversides or spearing							5,550	975
Smelt							3,500	450
Squeteagues							42,065	4,817
Striped bass					4,390	1,011	50,399	8,654
Sturgeon			2,080	373				
Suckers	8,134	959	400	48	1,240	119		
Whitebait							13,561	1,335
Total	41,484	4,385	21,012	2,953	11,190	1,845	570,422	58,213

Apparatus and species.	Ulster.		Westchester.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Purse seines:						
Bluefish					5,550	$1,100
Menhaden					178,629,705	1,112,666
Scup					1,006,400	51,896
Sea bass					17,800	2,190
Squeteagues					157,300	4,738
Other fish					3,000	90
Total					179,819,755	1,172,680
Haul seines:						
Alewives	1,800	$95	25	$3	177,280	2,714
Bluefish					12,515	1,980
Bullheads	452	71	700	115	7,997	1,257
Carp	20,880	3,209	22,195	1,937	262,856	43,656
Catfish					15,335	1,555
Cod					150	15
Eels	75	9	50	6	3,575	422
Flounders					34,525	2,535
King whiting					2,100	325
Lance					2,585	775
Mackerel					4,050	668
Menhaden					25,658	315
Minnows	9,900	147	300	30	21,063	366
Mummichog					31,095	792
Perch, white					43,626	4,652
Perch, yellow	235	30	1,650	167	4,439	491
Roach, or shiners					6,930	1,263
Scup					500	25
Shad	2,275	545			3,870	891
Silversides or spearing					5,550	975
Smelt					3,500	450
Spot					1,000	100
Squeteagues					53,515	6,255
Striped bass			1,735	471	58,124	10,536
Sturgeon					2,080	373
Suckers	4,261	592	8,850	967	37,799	4,808
Sunfish	77	8			77	8
Whitebait					13,561	1,335
Total	39,955	4,706	35,505	3,696	836,165	89,537

Yield of the fisheries of New York in 1921, by counties, apparatus, and species—Continued.

BY GILL NETS.

Species.	Albany.		Columbia.		Dutchess.		Greene.		Kings.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Alewives			300	$18	12,790	$1,160	18,000	$1,260		
Bluefish									700	$100
Carp			28,620	2,860	2,895	373				
Perch, yellow					600	48				
Shad	1,016	$217	2,500	648	35,324	7,953			2,757	1,000
Sturgeon			304	106	3,335	716	150	10		
Sturgeon caviar					99	299				
Suckers			1,950	347	60	6				
Total	1,016	217	33,674	3,979	55,103	10,555	18,150	1,270	3,457	1,100

Species.	Nassau.		Orange.		Putnam.		Rockland.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Alewives			2,759	$164			500	$45
Bluefish	18,880	$4,620						
Bonito	9,500	800						
Carp							100	15
Mackerel	30,105	3,700						
Perch, white							680	88
Perch, yellow							115	17
Shad			6,932	1,807	480	$120	5,843	1,600
Squeteagues	84,700	8,620						
Striped bass							760	153
Sturgeon							488	81
Total	143,185	17,740	9,691	1,971	480	120	8,486	1,999

Species.	Suffolk.		Ulster.		Westchester.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Alewives			27,178	$2,168	100	$5	61,627	$4,820
Bluefish	66,227	$13,637					87,807	18,857
Bonito							9,500	800
Bullheads					98	11	98	11
Carp			3,845	547	3,021	409	38,481	4,204
Flounders	10,400	1,024					10,400	1,024
King whiting	765	121					765	121
Mackerel	37,910	4,598					68,015	8,298
Menhaden	13,500	250					13,500	250
Perch, white	1,250	150			600	60	2,530	298
Perch, yellow					3,954	401	4,669	466
Scup	150	7					150	7
Sea bass	300	45					300	45
Shad			41,193	9,178	8,177	1,946	104,222	24,469
Smelt	2,700	735					2,700	735
Spot	1,250	112					1,250	112
Squeteagues	80,065	10,644					164,765	19,264
Striped bass	3,150	805			1,330	352	5,240	1,310
Sturgeon	12,967	4,080	3,744	984	5,850	1,212	26,838	7,189
Sturgeon caviar	16	52			345	805	460	1,156
Suckers					1,750	228	3,760	581
Total	232,650	38,260	75,960	12,877	25,225	5,429	607,077	93,517

Yield of the fisheries of New York in 1921, by counties, apparatus, and species—Continued.

BY POUND NETS, TRAP NETS, AND WEIRS.

Species.	Broome.		Delaware.		Nassau.		Orange.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore					6,000	$300		
Alewives					2,400	115		
Bluefish					10,000	1,975		
Bonito					32,000	4,300		
Butterfish					23,400	2,600		
Cod					2,500	200		
Eels	4,200	$690	4,300	$587			4,150	$485
Flounders					12,400	1,000		
Hickory shad					900	52		
King whiting					600	120		
Mackerel					30,000	4,000		
Pollock					1,200	60		
Scup					22,400	1,940		
Sea bass					900	175		
Shad					1,200	240		
Sharks					800	30		
Spot					600	45		
Squeteagues					250,000	36,000		
Sturgeon					1,200	410		
Tautog					200	18		
Tuna					12,000	1,000		
Whiting					32,400	400		
Squid					4,500	285		
Total	4,200	690	4,300	587	447,600	55,265	4,150	485

Species.	Suffolk.		Sullivan.		Tioga.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore	23,354	$1,120					29,354	$1,420
Alewives	107,120	2,655					109,520	2,770
Bluefish	89,792	13,803					99,792	15,778
Bonito	213,627	25,180					245,627	29,480
Butterfish	606,676	61,509					630,076	64,109
Cero	75	16					75	16
Cod	37,020	1,703					39,520	1,903
Cunners	240	10					240	10
Eels	104,579	13,182	23,500	$2,945	1,700	$230	142,429	18,119
Flounders	877,911	66,998					890,311	67,998
Grayfish	7,487	174					7,487	174
Hake	18,916	392					18,916	392
Herring	6,575	206					6,575	206
Hickory shad	22,555	1,392					23,455	1,444
King whiting	66,982	13,023					67,582	13,143
Lance	5,625	50					5,625	50
Mackerel	160,435	25,320					190,435	29,320
Mackerel frigate	184	10					184	10
Menhaden	778,936	4,004					778,936	4,004
Mullet	1,250	85					1,250	85
Perch, white	3,535	388					3,535	388
Pilotfish	280	18					280	18
Pollock	22,450	930					23,650	990
Pompano	35	7					35	7
Round herring	1,700	185					1,700	185
Salmon, Atlantic	40	18					40	18
Scup	245,055	20,228					267,455	22,168
Sea bass	28,054	4,787					28,954	4,962
Sea robin	38,019	1,130					38,019	1,130
Shad	5,852	1,359					7,052	1,599
Sharks	9,859	254					10,659	284
Silversides, or spearing	33,750	900					33,750	900
Skates	51,850	349					51,850	349
Spanish mackerel	25	5					25	5
Spot	40,907	3,471					41,507	3,516
Squeteagues	1,273,396	159,190					1,523,396	195,190
Striped bass	29,726	6,478					29,726	6,478
Sturgeon	3,449	1,177					4,649	1,587
Sturgeon cavior	480	550					480	550
Swellfish	30,875	122					30,875	122
Tautog	45,197	3,399					45,397	3,417
Tomcod	13,500	419					13,500	419
Tuna	20,413	1,745					32,413	2,745
Whiting	906,717	11,807					939,117	12,207
Other fish	1,238	58					1,238	58
Squid	325,617	18,215					330,117	1',500
Crabs, hard	365	46					365	46
Crabs, king	750	11					750	11
Lobster	7,700	1,545					7,700	1,545
Turtles	800	19					800	19
Total	6,270,973	469,642	23,500	2,945	1,700	230	6,756,423	529,844

Yield of the fisheries of New York in 1921, by counties, apparatus, and species—Continued

BY FYKE NETS.

Species.	Albany.		Columbia.		Dutchess.		Greene.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Bullheads	3,550	$788	1,914	$479	2,676	$531	1,232	$230
Carp	5,625	933	15,100	1,296	4,926	581	1,020	123
Eels	210	50	765	165	200	37	86	16
Perch, yellow	1,495	161	2,089	306	1,993	244	1,075	130
Pickerel	50	15	10	3	10	2		
Suckers	12,945	2,033	12,993	1,092	3,849	395	2,050	263
Sunfish			40	2	651	70		
Total	23,875	3,980	32,911	3,343	14,305	1,860	5,463	762

Species.	Orange.		Rensselaer.		Rockland.		Suffolk.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Alewives					200	$10	22,000	$330
Bullheads	1,463	$261	2,659	$454				
Carp	1,483	230	2,631	343				
Eels	456	104	33	9			14,670	2,200
Flounders							678,800	15,894
Perch, white					50	5	14,000	2,200
Perch, yellow	890	118	762	85				
Pickerel			45	9				
Shad					50	10		
Suckers	15,817	2,428	4,737	585	30	3		
Tautog							600	35
Toadfish							2,000	30
Tomcod	4,800	219					33,700	1,160
Terrapin							600	350
Total	24,899	3,360	10,867	1,485	330	28	766,370	22,199

Species.	Ulster.		Westchester.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Alewives	180	$18	300	$15	22,680	$373
Bullheads	3,076	622	1,693	230	18,253	3,595
Carp	2,971	333	3,170	392	36,926	4,231
Eels	64	9	533	92	17,017	2,682
Flounders					678,800	15,894
Perch, white			300	85	14,350	2,240
Perch, yellow	4,606	468	1,737	188	14,647	1,700
Pickerel	75	15	21	3	211	47
Shad			20	4	70	14
Striped bass			275	73	275	73
Suckers	7,404	798	7,713	791	67,538	8,388
Sunfish	518	59	392	32	1,601	163
Tautog					600	35
Toadfish					2,000	30
Tomcod			3,500	85	42,000	1,464
Terrapin					600	350
Total	18,894	2,322	19,654	1,940	917,568	41,279

BY DIP NETS, SCAP NETS, HARPOONS, AND MINOR APPARATUS.

Apparatus and species.	Albany.		Columbia.		Dutchess.		Greene.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Scap nets:								
Alewives	60	$12	150	$15	860	$96	425	$42
Bullheads	135	19	158	29	360	51	112	22
Carp	13,410	1,722	7,584	1,139	5,097	653	6,135	786
Eels	3,328	372	10	2				
Perch, yellow			655	84	325	56	120	15
Shad							80	25
Suckers	2,718	312	5,380	815	4,001	429	575	73
Sunfish			75	9	100	5		
Total	19,651	2,437	14,012	2,093	10,743	1,290	7,447	963
Minor apparatus: Carp							16,000	1,985

Yield of the fisheries of New York in 1921, by counties, apparatus, and species—Continued.

BY DIP NETS, SCAP NETS, HARPOONS, AND MINOR APPARATUS—Continued.

Apparatus and species.	Kings.		Nassau.		Orange.		Putnam.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Dip nets: Crabs, soft			5,795	$1,825				
Scap nets:								
Alewives					50	$3		
Bullheads					50	3		
Carp					2,850	402	300	$60
Eels					100	10		
Perch, yellow					50	8	100	10
Suckers					1,021	105	550	110
Total					4,121	531	950	180
Harpoons: Swordfish	30,000	$6,000						
Minor apparatus:								
Shrimp	1,125	250						
Clams, hard, public			7,512	3,910				
Clams, hard, private			800	350				
Total	1,125	250	8,312	4,260				

Apparatus and species.	Queens.		Rensselaer.		Rockland.		Suffolk.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Dip nets:								
Mummichog							400	$50
Crabs, hard							120	10
Crabs, soft							90	30
Clams, soft, public							35,100	4,875
Total							35,710	4,965
Scap nets:								
Bullheads			252	$58				
Carp			5,500	625	800	$80		
Perch, yellow			50	5				
Suckers			1,531	170	150	15		
Total			7,333	858	950	95		
Harpoons: Swordfish							14,865	3,125
Minor apparatus:								
Mummichog	6,000	$600						
Shrimp	4,700	1,100						
Crabs, fiddler							200	150
Clams, hard, public							584	240
Total	10,700	1,700					784	390

Apparatus and species.	Ulster.		Westchester.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Dip nets:						
Mummichog					400	$50
Crabs, hard					120	10
Crabs, soft					5,885	1,855
Clams, soft, public					35,100	4,875
Total					41,505	6,790
Scap nets:						
Alewives	5,059	$430			6,604	598
Bullheads	200	54			1,267	236
Carp	16,463	2,598	2,300	$276	60,439	8,341
Eels	5	1			3,443	385
Perch, yellow	345	51			1,645	229
Pickerel	4	1			4	1
Shad	398	130			478	155
Suckers	6,591	799	390	52	22,907	2,880
Sunfish	60	10			235	24
Total	29,125	4,074	2,690	328	97,022	12,849
Harpoons: Swordfish					44,865	9,125
Minor apparatus:						
Alewives	82	8			82	8
Bullheads	111	19			111	19
Carp	6,780	1,235			22,780	3,220
Mummichog					6,000	600
Suckers	614	74			614	74
Shrimp					5,825	1,350
Crabs, fiddler					200	150
Clams, hard, public					8,096	4,150
Clams, hard, private					800	350
Total	7,587	1,336			44,508	9,921

Yield of the fisheries of New York in 1921, by counties, apparatus, and species—Continued.

BY OTTER TRAWLS, DRAG NETS, LOBSTER POTS, EEL POTS, AND SPEARS.

Apparatus and species.	Bronx.		Columbia.		Dutchess.		Kings.		Nassau.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Otter trawls:										
Cod							38,000	$700		
Flounders							428,200	21,160	178,000	$9,300
Haddock							7,000	100		
Scallops, sea							10,740	2,150	13,080	4,320
Total							483,940	24,110	191,080	13,620
Drag nets: Shrimp									6,000	2,000
Lobster pots:										
Sea bass									6,750	1,350
Lobster	1,000	$200					406,300	62,880	10,450	2,425
Total	1,000	200					406,300	62,880	17,200	3,775
Eel pots:										
Eels			180	$22	5,103	$517	13,335	1,600	3,875	550
Mummichog							4,800	600		
Total			180	22	5,103	517	18,135	2,200	3,875	550
Spears: Eels									61,650	7,655

Apparatus and species.	New York.		Orange.		Queens.		Richmond.		Rockland.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Otter trawls:										
Cod	5,000	$200								
Flounders	90,000	4,200					37,000	$3,000		
Total	95,000	4,400					37,000	3,000		
Lobster pots: Lobster							45,400	11,700		
Eel pots:										
Eels			1,250	$202	1,900	$375	1,000	175	8,355	$882
Mummichog					3,500	350				
Total			1,250	202	5,400	725	1,000	175	8,355	882
Spears: Eels					2,150	550				

Apparatus and species.	Suffolk.		Ulster.		Westchester.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Otter trawls:								
Cod							43,000	$900
Flounders	2,097,920	$155,262					2,831,120	192,922
Haddock							7,000	100
Sea bass	30	5					30	5
Sea robin	150	5					150	5
Scallops, bay	13,590	2,000					13,590	2,000
Scallops, sea	14,400	1,700					38,220	8,170
Lobster	7,985	1,615					7,985	1,615
Total	2,134,075	160,587					2,941,095	205,717
Drag nets: Shrimp	76,625	25,540					82,625	27,540
Lobster pots:								
Sea bass							6,750	1,350
Lobster	558,160	116,317			400	$80	1,021,710	193,602
Total	558,160	116,317			400	80	1,028,460	194,952
Eel pots:								
Eels	164,040	19,589	1,093	$125	19,145	2,207	219,276	26,244
Mummichog							8,300	950
Total	164,040	19,589	1,093	125	19,145	2,207	227,576	27,194
Spears: Eels	5,300	635					69,100	8,840

Yield of the fisheries of New York in 1921, by counties, apparatus, and species—Continued.

BY HAND LINES AND TRAWL LINES.

Species.	Dutchess.		Kings.		Nassau.		New York.		Orange.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Bluefish			198,533	$31,125	11,020	$2,680	663,100	$104,923		
Bonito					560	50				
Bullheads	94	$19							100	$12
Cod			31,500	2,100	86,450	5,615				
Eels	1,211	169							1,696	274
Flounders			9,850	800	8,100	900				
Haddock					6,490	400				
Hake			3,150	250	4,375	205				
Pollock					1,650	100				
Sea bass			11,050	1,165						
Squeteagues			1,250	100	4,800	700				
Striped bass					850	170				
Tautog			1,400	200						
Tilefish			300,000	21,000			833,000	55,984		
Whiting					170	5				
Total	1,305	188	556,733	56,740	124,465	10,825	1,496,100	160,907	1,796	286

Species.	Queens.		Rensselaer.		Richmond.		Rockland.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Bullheads							110	$11
Cod	31,000	$2,100			26,000	$1,400		
Eels			260	$52			750	125
Flounders	7,755	1,315						
Squeteagues	5,000	1,150						
Striped bass	60	20					250	75
Sturgeon							50	5
Tautog	500	100						
Tomcod	1,700	200						
Total	46,015	4,885	260	52	26,000	1,400	1,160	216

Species.	Suffolk.		Ulster.		Westchester.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Bluefish	4,600	$783					877,253	$139,511
Bonito	200	20					760	70
Bullheads			70	$7			374	49
Carp			160	26			160	26
Cod	410,240	23,750					585,190	34,965
Cunners	100	5					100	5
Eels	1,450	80	1,310	253	2,035	$363	8,712	1,316
Flounders	300	24					26,005	3,039
Haddock	5,025	376					11,515	776
Hake	9,465	583					16,990	1,038
Mackerel	19,575	2,070					19,575	2,070
Perch, yellow					100	10	100	10
Pollock	59,000	1,235					60,650	1,335
Scup	22,870	2,157					22,870	2,157
Sea bass	83,550	11,695					94,600	12,860
Sea robin	250	5					250	5
Skates	23,700	800					23,700	800
Squeteagues	11,010	1,127					22,060	3,077
Striped bass							1,160	265
Sturgeon					300	45	350	50
Tautog	6,825	610					8,725	910
Tilefish							1,133,000	76,984
Tomcod							1,700	200
Whiting							170	5
Crabs, hard	432,907	16,117					432,907	16,117
Total	1,091,067	61,437	1,540	286	2,435	418	3,348,876	297,640

Yield of the fisheries o[missing] *, by counties, apparatus, and species*—Continued.

BY I[missing] 3, RAKES, HOES, AND FORKS.

Apparatus and species.				...gs.	Nassau.		New York.		Queens.	
	Po...			*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Dredges:										
Clams, hard, public	....			......	3,200	$1,000	......	......	......	......
Clams, hard, private	....			......	3,000	1,500	......	......	......	......
Oysters, market, public	....			$750	2,520	575	......	......	......	......
Oysters, market, private	....			......	975,499	227,335	455,000	$87,500	......	......
Oysters, seed, public	....			800	......	......	......	......	......	......
Mussels	....			......	50,000	2,500	......	......	......	......
Scallops, sea	....			......	29,016	9,510	......	......	......	......
Total	....			1,550	1,063,235	242,420	455,000	87,500	......	......
Tongs:										
Clams, hard, public	....			......	44,640	17,510	2,200	1,100	......	......
Skimmers or surf clams	....			5,100	......	......	......	......	......	......
Oysters, market, private	......	......	......	......	199,234	50,478	......	......	......	......
Total	......	......	22,560	5,100	243,874	67,988	2,200	1,100	......	......
Rakes, hoes, and forks:										
Clams, hard, public	......	......	3,400	1,275	4,800	1,825	......	......	896	$450
Clams, hard, private	......	......	......	......	1,600	100	......	......	......	......
Clams, soft, public	......	......	3,000	600	74,300	12,950	......	......	6,500	875
Clams, soft, private	......	......	......	......	2,000	325	......	......	......	......
Skimmers or surf clams	......	......	25,600	6,200	......	......	......	......	......	......
Miscellaneous (for bait)	322	$515	12,902	8,125	180	290	90	150	405	550
Total	322	515	44,902	16,200	82,880	15,490	90	150	7,801	1,875

Apparatus and species.	Richmond.		Suffolk.		Westchester.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Dredges:								
Crabs, hard	......	......	29,850	$934	14,000	$700	43,850	$1,634
Clams, hard, public	......	......	......	......	400	300	3,600	1,300
Clams, hard, private	......	......	......	......	......	......	3,000	1,500
Oyster, market, public	10,500	$1,600	......	......	......	......	18,270	2,925
Oysters, market, private	[1] 2,534,714	514,741	4,949,070	849,009	......	......	8,914,283	1,678,585
Oysters, seed, public	19,950	2,850	......	......	......	......	25,550	3,650
Oysters, seed, private	......	......	7,000	750	......	......	7,000	750
Mussels	......	......	......	......	......	......	50,000	2,500
Scallops, bay	......	......	1,138,668	190,276	......	......	1,138,668	190,276
Scallops, sea	......	......	15,996	7,052	......	......	45,012	16,562
Shells	......	......	1,760,000	1,480	......	......	1,760,000	1,480
Total	2,565,164	519,191	7,900,584	1,049,501	14,400	1,000	12,009,233	1,901,162
Tongs:								
Clams, hard, public	960	500	281,976	129,149	......	......	329,776	148,259
Clams, soft, public	......	......	2,700	375	......	......	2,700	375
Skimmers or surf clams	......	......	......	......	......	......	22,560	5,100
Oysters, market, public	......	......	171,528	25,495	7,000	1,900	178,528	27,395
Oysters, market, private	......	......	17,500	4,600	......	......	216,734	55,078
Oysters, seed, public	......	......	44,275	6,060	......	......	44,275	6,060
Total	960	500	517,979	165,679	7,000	1,900	794,573	242,267

[1] Includes 83,718 bushels, valued at $83,718, taken up by vessels owned and employed mainly in Connecticut.

Yield of the fisheries of New York in 1921, by counties, apparatus, and species—Continued.

BY DREDGES, TONGS, RAKES, HOES, AND FORKS—Continued.

Apparatus and species.	Richmond.		Suffolk.		Westchester.		Total.	
Rakes, hoes, and forks:	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Clams, hard, public	8,280	$3,900	405,976	$53,369			423,352	$60,819
Clams, hard, private							1,600	100
Clams, soft, public			43,550	8,495	21,000	$4,500	148,350	27,420
Clams, soft, private							2,000	325
Skimmers or surf clams							25,600	6,200
Oysters, market, public	2,800	400	92,855	11,070			95,655	11,470
Scallops, bay			270	100			270	100
Miscellaneous (for bait)							13,899	9,630
Total	11,080	4,300	542,651	73,034	21,000	4,500	710,726	116,064

INDUSTRIES.

Wholesale trade.—In 1921 there were 132 wholesale establishments in New York City and 21 in localities outside of the city engaged in handling fishery products. The investment amounted to $3,929,404, and the cash or working capital to $749,200. There were 1,748 persons engaged, who received $2,910,864 in wages. There were 90 firms in the city handling fresh and frozen fishery products and 42 firms handling prepared products. The 21 firms in localities outside of the city handled fresh and frozen fish.

Smoked fish, etc.—In 1921 there were 22 establishments, 21 in New York City and 1 outside of the city, engaged in preparing smoked fish and various other products, as pickled herring, miscellaneous canned products, oil and scrap from menhaden and other fish, and crushed oyster shells for poultry grit. The value of these establishments was $637,735, and the cash capital amounted to $157,000. There were 302 persons engaged, who received $385,128 in wages. The products included 10,216,625 pounds of smoked fish, valued at $2,971,796, and miscellaneous products, valued at $71,937.

Menhaden industry.—The statistics of the menhaden industry given in the appended table for 1921 include 3 factories, 2 for New York and 1 for Delaware, valued at $2,397,000, with a cash capital amounting to $105,000. The number of persons engaged was 490, who received $182,603 in wages. The quantity of menhaden utilized in the factories was 171,973,400 pounds, valued at $662,910. The products prepared included 9,906 tons of dry scrap and fish meal, valued at $396,240; 23,000 tons of acidulated scrap, valued at $460,000; and 2,377,824 gallons of oil, valued at $688,897.

Statistics of the wholesale fishery trade and smoked fish and miscellaneous fishery products in New York City and vicinity, and of the menhaden industry for New York and Delaware are given in the following tables:

Investment, persons engaged, and wages paid in the wholesale fishery trade of New York City and vicinity in 1921.

Items.	Greater New York.		Outside of Greater New York.		Total.	
	Number.	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
Establishments	132	$3,505,633	21	$424,271	153	$3,929,904
Cash capital		683,400		65,800		749,200
Persons engaged	1,457		291		1,748	
Wages paid		2,773,055		137,809		2,910,864

Smoked fish and other fishery products prepared in New York City in 1921.[1]

Items.	Number.	Value.	Items.	Pounds.	Value.
Establishments	22	$637,735	Smoked fish—Continued.		
Cash capital		157,000	Kippered herring	43,000	$5,300
Persons engaged	302		Mackerel	35,000	7,000
Wages paid		385,128	Salmon	3,462,125	1,169,640
			Shad	79,000	14,890
Smoked fish:	*Pounds.*	*Value.*	Spoonbill cat	70,000	58,700
Buffalofish	495,000	$153,700	Sturgeon	886,600	621,800
Butterfish	374,000	105,600	Other fish	93,000	25,440
Carp	322,800	96,436			
Ciscoes	2,419,000	476,490	Total	10,216,625	2,971,796
Eels	54,600	17,200			
Finnan haddie	1,432,000	147,000	Miscellaneous products		71,937
Herring	460,500	72,600			

[1] Includes 1 firm outside of New York City engaged in preparing miscellaneous fishery products.

Menhaden industry of New York and Delaware in 1921.

Items.	Number.	Value.	Items.	Number.	Value.
Factories	3	$2,397,000	Products prepared:		
Cash capital		105,000	Dry scrap and fish meal.........tons..	9,906	$396,240
Persons engaged	490		Acidulated scrap.do..	23,000	460,000
Wages paid		182,603	Oil..........gallons..	2,377,824	688,897
Menhaden utilized.......pounds..	171,973,400	662,910	Total		1,545,137

FISHERIES OF NEW JERSEY.

The fisheries of New Jersey in 1921 gave employment to 5,771 persons, of whom 2,164 were on fishing vessels, 28 on transporting vessels, 2,982 in the shore or boat fisheries, and 597 on shore in the wholesale fishery trade, menhaden factories, and other fishery industries.

The investment in the fisheries and fishery industries amounted to $4,701,704, which included 370 fishing and transporting vessels, valued at $1,181,050, with a net tonnage of 4,590 tons, and outfits valued at $262,410; 2,686 boats, valued at $684,679; fishing apparatus valued at $672,703; shore and accessory property valued at $1,587,762; and cash capital amounting to $313,100.

The products of the fisheries amounted to 96,936,784 pounds, having a value to the fishermen of $5,983,406. The principal species in the order of their value were oysters, 22,997,555 pounds, or 3,285,365 bushels, valued at $2,759,930; squeteagues, "sea trout," or weakfish, 11,651,735 pounds, valued at $902,439; bluefish, 2,243,425 pounds, valued at $390,947; clams, 925,588 pounds, or 112,111 bushels, valued at $385,198; scup or porgy, 4,115,552 pounds, valued at $200,046; butterfish, 2,862,491 pounds, valued at $159,286; flounders, 1,985,340 pounds, valued at $140,586; croaker, 3,815,554 pounds, valued at $126,700; menhaden, 30,405,093 pounds, valued at $121,451; and mackerel, 584,386 pounds, valued at $100,556.

Compared with 1904, there was a decrease in the number of persons employed of 3,323, or 36.54 per cent, but an increase in the investment of $2,015,908, or 75.06 per cent, and in the products of 6,828,716 pounds, or 7.57 per cent, in quantity, and of $2,597,991, or 76.74 per cent, in value.

The following table gives the number of persons engaged, investment, and products of the fisheries of New Jersey, by counties, in 1921:

Persons engaged, investment, and products of the fisheries of New Jersey in 1921, by counties.

	Atlantic.		Bergen.		Burlington.		Camden.	
PERSONS ENGAGED.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
On vessels fishing	159				1			
On vessels transporting	2							
In shore fisheries	382		21		158		33	
Shoresmen	17							
Total	560		21		159		33	
INVESTMENT.								
Vessels fishing:								
Gasoline	18	$130,300						
Tonnage	283							
Outfit		24,415						
Vessels transporting:								
Gasoline	1	3,000			2	$2,500		
Tonnage	13				16			
Outfit		100				50		
Boats:								
Sail, row, etc	239	8,755	13	$1,000	90	2,470	15	$450
Power	193	73,400	4	200	88	32,150	16	4,200
Apparatus, vessel fisheries:								
Purse seines	10	10,700						
Gill nets	424	8,035						
Otter trawls	5	375						
Lines, hand, trawl, and set		430						
Apparatus, shore fisheries:								
Pound nets and weirs	2	1,500						
Haul seines	17	690			23	1,300	8	400
Purse seines	1	600						
Gill nets	565	11,360	8	2,910	21	1,015	9	850
Otter trawls	4	300						
Stop nets					20	2,545	5	800
Fyke nets	14	625			147	500	40	90
Bag nets	5	100			53	1,060		
Lines, hand, and trawl		1,078						
Eel pots			20	40				
Dredges	16	240			18	275		
Tongs, rakes, and hoes	382	1,971			70	440		
Other apparatus	6	19						
Shore and accessory property		35,750		3,575		1,550		600
Cash capital		11,000						
Total		324,738		7,725		45,855		7,390
PRODUCTS.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore	650	$20						
Alewives	19,985	420			5,000	$100	2,000	$80
Bluefish	286,146	47,610						
Bonito	17,900	1,078						
Butterfish	3,348	118						
Carp					26,361	4,026	19,590	3,490
Catfish	6,600	652			8,576	616	5,675	841
Cod	318,000	14,860						
Croaker	351,650	12,959			3,000	180		
Eels, fresh	14,050	1,407	2,500	$375	1,651	185	785	93
Flounders	438,033	30,971			11,800	984		
Haddock	2,000	100						
Hake	1,700	85						
King whiting	2,472	430						
Mackerel	288,617	41,642						
Menhaden	3,480,000	16,000						
Perch, white	13,385	1,463			18,620	2,705		
Perch, yellow					60	12		
Pike or pickerel					500	100		
Scup or porgy	1,122,200	50,287						
Sea bass	53,500	4,558						
Shad	1,005	246	25,920	6,294	6,750	1,729	4,841	1,302
Spot	10,476	488						
Squeteagues or weakfish	583,447	40,953			10,000	800		
Striped bass	7,584	1,921			49,250	16,610	2,000	500
Suckers	2,300	115			27,689	2,537	100	12
Tautog	700	72						
Whiting	6,400	128						

Persons engaged, investment, and products of the fisheries of New Jersey in 1921, by counties—Continued.

	Atlantic.		Bergen.		Burlington.		Camden.	
PRODUCTS—continued.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Crabs, soft	440	$193						
Clams, hard, public	230,320	104,220			54,000	$24,300		
Clams, soft, public	11,000	1,000						
Mussels	790,000	5,970						
Oysters, market, public					14,000	2,200		
Oysters, market, private	530,075	104,607			154,000	22,800		
Oysters, seed, public	56,000	3,895			28,000	2,000		
Oysters, seed, private	5,600	269			112,000	8,000		
Scallops	540	90						
Turtles	1,200	84						
Terrapin	225	225						
Total	8,657,548	489,086	28,420	$6,669	531,257	89,884	34,991	$5,818

	Cape May.		Cumberland.		Essex.		Gloucester.	
PERSONS ENGAGED.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
On vessels fishing	358		1,236					
On vessels transporting	2		8				4	
In shore fisheries	508		229				63	
Shoresmen	66		157		121			
Total	934		1,630		121		67	
INVESTMENT.								
Vessels fishing:								
Gasoline	60	$163,750	80	$406,050				
Tonnage	577		1,137					
Outfit		47,950		118,245				
Sail	1	300	124	299,000				
Tonnage	10		1,782					
Outfit		500		55,705				
Vessels transporting:								
Gasoline	1	3,000	8	12,600			2	$12,000
Tonnage	24		72				51	
Outfit		200		675				500
Sail			3	450				
Tonnage			18					
Boats:								
Sail, row, etc	122	5,380	116	3,205			29	799
Power	276	140,110	142	52,300			32	6,730
Apparatus, vessel fisheries:								
Purse seines	6	8,300						
Gill nets	467	7,160						
Pound nets	26	134,500						
Otter trawls	15	1,085	2	140				
Lines, hand, trawl, and set		741						
Dredges	6	130	408	9,700				
Apparatus, shore fisheries:								
Pound nets and weirs	78	4,380	77	1,540				
Haul seines	14	390	9	575				
Gill nets	1,220	33,020	406	15,242			29	1,460
Otter trawls	4	240						
Stop nets			13	1,210			14	2,000
Fyke nets	17	1,700	137	149			187	465
Lines, hand, and trawl		1,712		168				
Eel pots	210	335	275	275				
Dredges	2	30						
Tongs, rakes, and hoes	215	555	98	490				
Other apparatus			2	2			6	30
Shore and accessory property		283,950		207,759		$262,535		400
Cash capital		32,100		136,000		28,000		
Total		871,518		1,321,480		290,535		24,404
PRODUCTS.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore	2,800	$84	600	$6				
Alewives	30,400	512	10,000	300				
Bluefish	793,876	128,644	120,400	24,080				
Bonito	219,747	14,649	59,600	2,980				
Butterfish	502,505	32,087						

Persons engaged, investment, and products of the fisheries of New Jersey in 1921, by counties—Continued.

	Cape May.		Cumberland.		Essex.		Gloucester.	
PRODUCTS—continued.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Carp			35,600	$4,800			48,125	$8,282
Catfish	2,200	$176	11,650	656			8,593	464
Cod	100,900	7,964						
Croaker	894,365	31,167	940,600	29,296				
Drum, black	600	15						
Drum, red	500	10						
Eels, fresh	18,100	1,710	40,350	2,035			2,452	291
Flounders	745,995	52,147	43,170	3,158				
Haddock	3,300	198						
Hake	18,907	536						
Herring	62,200	1,244						
King whiting	8,690	873						
Mackerel	164,550	31,507						
Menhaden	2,607,035	12,880						
Mullet, fresh	12,000	820						
Mullet, salted	1,200	240						
Perch, white	1,500	54	1,000	100				
Perch, yellow	500	50					125	19
Pollock	3,000	60						
Scup or porgy	2,256,116	108,670	3,450	173				
Sea bass	1,240,889	77,034	16,000	810				
Sea robin	400	8						
Shad	2,978	745	26,695	7,773			6,609	1,613
Sharks	2,000	30						
Skates and rays	7,900	214						
Spanish mackerel	550	130						
Spot	48,865	3,189	400	20				
Squeteagues or weakfish	2,779,181	206,285	257,900	13,131				
Striped bass	818	205	2,400	380				
Sturgeon	940	216	30,356	4,557				
Sturgeon roe	80	240	1,566	4,736				
Suckers			700	78				
Tautog	4,650	172						
Tuna	6,800	132	1,500	18				
Whiting	45,000	645						
Other fish	464	17						
Crabs, hard	4,800	300	2,800	210				
Crabs, king	2,762,174	8,287	523,000	1,569				
Squid	22,000	1,100						
Clams, hard, public	90,192	48,851	800	300				
Mussels			1,000	100				
Oysters, market, public	42,000	6,000						
Oysters, market, private	40,607	7,912	9,912,280	1,869,702				
Oysters, seed, public	155,400	8,880	11,383,400	650,480				
Total	15,709,674	796,889	23,427,217	2,621,448			65,904	10,696

	Hudson.		Hunterdon.		Mercer.		Middlesex.	
PERSONS ENGAGED.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
On vessels fishing	2						2	
In shore fisheries	3		14		59		35	
Shoresman	13							
Total	18		14		59		37	
INVESTMENT.								
Vessels fishing:								
Gasoline	1	$500					1	$1,500
Tonnage	6						8	
Outfit		275						500
Boats:								
Sail, row, etc.			6	$160	22	$820	13	550
Power	2	500					7	3,250
Apparatus, vessel fisheries:								
Eel pots	50	125						
Dredges							2	50
Rakes							4	50
Apparatus, shore fisheries:								
Haul seines			5	410	12	1,075	8	3,350
Gill nets					5	150	2	400
Fyke nets	3	60						
Eel pots							210	420
Lobster pots	70	200					20	40
Tongs, rakes, and hoes							5	40
Shore and accessory property		8,075		150		2,500		590
Cash capital		2,500						
Total		12,235		720		4,545		10,740

Persons engaged, investment, and products of the fisheries of New Jersey in 1921, by counties—Continued.

PRODUCTS.	Hudson.		Hunterdon.		Mercer.		Middlesex.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Alewives					3,950	$75		
Bluefish							7,275	$1,695
Carp			1,205	$143	8,194	1,225		
Catfish					316	28		
Eels, fresh	10,000	$1,000					9,500	950
Menhaden							30,000	50
Shad			1,459	461	14,126	5,014	435	190
Smelt							450	335
Squeteagues or weakfish							15,600	1,115
Suckers			3,330	399	13,075	1,480		
Lobster	5,000	1,000					500	150
Clams, hard, public							1,800	900
Oysters, seed, public							14,000	1,500
Total	15,000	2,000	5,994	1,003	39,661	7,822	79,560	6,885

	Monmouth.		Ocean.		Salem.		Total.	
PERSONS ENGAGED.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
On vessels fishing	93		314				2,164	
On vessels transporting	9		2				28	
In shore fisheries	755		495		227		2,982	
Shoresmen	150		59		14		597	
Total	1,007		870		241		5,771	
INVESTMENT.								
Vessels fishing:								
Gasoline	19	$81,200	36	$46,800			215	$830,100
Tonnage	228		254				2,493	
Outfit		10,855		1,700				203,940
Sail	2	1,300					127	300,600
Tonnage	26						1,818	
Outfit		90						56,295
Vessels transporting:								
Gasoline	7	14,400	2	1,500	1	$500	24	49,500
Tonnage	56		11		9		252	
Outfit		550		100				2,175
Sail	1	400					4	850
Tonnage	9						27	
Boats:								
Sail, row, etc	200	5,625	203	5,750	67	1,795	1,135	36,759
Power	357	203,485	350	111,025	84	20,550	1,551	647,920
Apparatus, vessel fisheries:								
Purse seines	4	4,000					20	23,000
Gill nets	100	1,970					991	17,165
Pound nets			56	181,350			82	315,850
Otter trawls	1	30					23	1,630
Lines, hand, trawl, and set		125						1,296
Eel pots							50	125
Lobster pots	350	450					350	450
Dredges	96	565	8	160			520	10,605
Rakes	58	580					62	630
Apparatus, shore fisheries:								
Pound nets and weirs	60	127,800					217	135,220
Haul seines	2	325	42	3,715	44	1,320	184	13,550
Purse seines							1	600
Gill nets	422	12,664	845	8,632	125	13,039	3,657	100,742
Otter trawls							8	540
Stop nets					34	5,810	86	12,365
Fyke nets	25	1,170	425	4,046	290	725	1,285	9,530
Bag nets							58	1,160
Lines, hand, and and trawl		1,345		705		20		5,023
Eel pots	2,723	2,846	556	556	108	160	4,102	4,632
Lobster pots	10,215	10,654	40	50			10,345	10,944
Dredges	2	30	14	200			52	775
Tongs, rakes, and hoes	198	1,267	353	1,965			1,321	6,728
Other apparatus	40	41	2	1	10	50		143
Shore and accessory property		479,917		284,911		15,500		1,587,762
Cash capital		74,000		19,500		10,000		318,100
Total		1,037,684		672,666		69,469		4,701,704

Persons engaged, investment, and products of the fisheries of New Jersey in 1921, by counties—Continued.

PRODUCTS.	Monmouth.		Ocean.		Salem.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore	65,392	$2,158	55,600	$1,699	600	$18	125,642	$3,985
Alewives	22,158	872	308,700	9,375	6,000	180	408,193	11,914
Bluefish	685,331	125,860	345,397	62,258	5,000	800	2,243,425	390,947
Bonito	192,929	11,613	1,008,077	60,476	5,000	250	1,503,253	91,046
Butterfish	754,226	38,193	1,602,412	88,888			2,862,491	159,286
Carp					190,480	31,218	329,555	53,184
Catfish			1,430	112	56,027	2,931	101,067	5,976
Cod	177,132	8,968	91,245	5,561			687,277	37,353
Croaker	317,604	10,249	1,228,335	40,349	80,000	2,500	3,815,554	126,700
Drum, black	27,934	558	39,125	792			67,659	1,365
Drum, red							500	10
Eels, fresh	129,735	13,562	31,656	3,164	13,975	1,678	274,754	26,450
Eels, smoked	4,680	1,497					4,680	1,497
Flounders	198,349	14,262	542,343	38,669	5,650	395	1,985,340	140,686
Haddock	1,000	40					6,300	338
Hake	632,942	19,904	167,469	5,038			821,018	25,563
Herring	36,825	1,167	73,707	2,053			172,732	4,464
Hickory shad	6,574	293	21,571	1,289			28,145	1,582
King whiting	5,340	819	7,567	1,204	50	8	24,119	3,334
Mackerel	116,019	23,787	15,200	3,620			584,386	100,556
Menhaden	24,218,727	91,717	69,331	804			30,405,093	121,451
Mullet, fresh	4,060	204	2,400	112			18,460	1,136
Mullet, salted							1,200	240
Perch, white	2,353	353	93,862	14,078	250	38	130,970	18,791
Perch, yellow			20,210	3,031	10,387	1,596	31,282	4,708
Pike or pickerel							500	100
Pollock	1,240	52	300	15			4,540	127
Scup or porgy	183,467	11,033	547,469	29,741	2,850	142	4,115,552	200,046
Sea bass	34,067	2,285	31,244	2,005	2,630	131	1,378,330	86,823
Sea robin	43,740	866	19,500	466			63,640	1,340
Shad	6,820	1,651	30,839	7,649	40,160	9,793	168,637	44,460
Sharks	22,559	450	35,900	752			60,459	1,232
Skates and rays	23,600	616	11,600	356			43,100	1,186
Smelt							450	335
Spanish mackerel	624	146	2,808	703			3,982	979
Spot	51,612	3,167	77,800	4,668	395	20	189,548	11,502
Squeteagues or weakfish	1,982,975	160,050	6,008,632	479,165	14,000	940	11,651,735	902,439
Striped bass	2,990	554	5,306	1,521			70,348	21,691
Sturgeon	1,964	287	1,140	342	11,425	1,718	45,825	7,120
Sturgeon caviar			74	194			74	194
Sturgeon roe	241	715			1,685	5,055	3,572	10,746
Suckers			492	39	2,978	479	50,664	5,139
Tautog	37,192	2,310	1,500	96			44,043	2,650
Tomcod	1,750	87	200	10			1,950	97
Tuna	44,164	1,764	34,900	1,565	370	14	87,734	3,493
Whiting	1,720,403	34,408	1,509,030	29,190			3,280,833	64,371
Other fish	275	14	50	3			789	34
Lobster	390,941	87,088	1,400	350			397,841	88,588
Shrimp	20,000	400					20,000	400
Crabs, hard	110,644	6,720	1,000	60			119,244	7,290
Crabs, soft	14,560	5,464	1,800	475			16,800	6,132
Crabs, king	28,000	560					3,313,174	10,416
Squid	104,302	4,398	307,600	14,510			433,902	20,008
Clams, hard, public	95,576	46,737	309,400	139,240			782,088	364,548
Clams, soft, public	128,000	19,100	4,500	450			143,500	20,650
Mussels							791,000	6,070
Oysters, market, public	10,500	1,550	2,800	440			69,300	10,19[illegible]
Oysters, market, private	160,293	28,600	180,600	26,685			10,977,855	2,060,30[illegible]
Oysters, seed, public			2,100	150			11,638,900	666,905
Oysters, seed, private	15,400	1,760	178,500	12,500			311,500	22,529
Scallops							540	90
Turtles	8,015	160	4,500	90			13,715	334
Terrapin							225	225
Winkles	7,800	159					7,800	159
Total	32,853,025	789,327	15,038,621	1,096,002	449,912	59,904	96,936,784	5,983,406

VESSEL AND SHORE FISHERIES.

The products of the vessel and shore or boat fisheries of New Jersey are shown separately in the appended table. The catch taken by vessels amounted to 55,168,849 pounds, valued at $4,179,742, and by boats in the shore fisheries to 41,767,935 pounds, valued at $1,803,664.

Products of the vessel and shore fisheries of New Jersey, 1921.

Species.	Vessel fisheries.		Shore fisheries.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore	58,650	$1,795	66,992	$2,190	125,642	$3,985
Alewives	10,000	100	398,193	11,814	408,193	11,914
Bluefish	1,060,748	172,194	1,182,677	218,753	2,243,425	390,947
Bonito	857,224	52,661	646,029	38,385	1,503,253	91,046
Butterfish	2,104,917	120,975	757,574	38,311	2,862,491	159,286
Carp	....	....	329,555	53,184	329,555	53,184
Catfish	....	....	101,067	5,976	101,067	5,976
Cod	119,845	5,116	567,432	382,237	687,277	37,353
Croaker	1,803,400	59,440	2,012,154	67,260	3,815,554	126,700
Drum, black	39,725	807	27,934	558	67,659	1,365
Drum, red	500	10	....	....	500	10
Eels, fresh	7,000	699	267,754	25,751	274,754	26,450
Eels, smoked	....	....	4,680	1,497	4,680	1,497
Flounders	1,305,668	91,658	679,672	48,928	1,985,340	140,586
Haddock	2,200	124	4,100	214	6,300	338
Hake	183,776	5,430	637,242	20,133	821,018	25,563
Herring	135,907	3,297	36,825	1,167	172,732	4,464
Hickory shad	21,571	1,289	6,574	293	28,145	1,582
King whiting	13,057	2,027	11,062	1,307	24,119	3,334
Mackerel	326,477	54,636	257,909	45,920	584,386	100,556
Menhaden	10,147,631	48,760	20,257,462	72,691	30,405,093	121,451
Mullet, fresh	400	32	18,060	1,104	18,460	1,136
Mullet, salted	....	....	1,200	240	1,200	240
Perch, white	....	....	130,970	18,791	130,970	18,791
Perch, yellow	....	....	31,282	4,708	31,282	4,708
Pike	....	....	500	100	500	100
Pollock	3,300	75	1,240	52	4,540	127
Scup or porgy	3,765,135	181,940	350,417	18,106	4,115,552	200,046
Sea bass	769,533	48,620	608,797	38,203	1,378,330	86,823
Sea robin	19,900	474	43,740	866	63,640	1,340
Shad	32,007	7,941	136,630	36,519	168,637	44,460
Sharks	37,500	774	22,959	458	60,459	1,232
Skates and rays	18,700	538	24,400	648	43,100	1,186
Smelt	....	....	450	335	450	335
Spanish mackerel	3,358	833	624	146	3,982	979
Spot	114,065	7,177	75,483	4,325	189,548	11,502
Squeteagues	8,475,963	655,850	3,175,772	246,589	11,651,735	902,439
Striped bass	18	5	70,330	21,686	70,348	21,691
Sturgeon	1,680	408	44,145	6,622	45,825	7,120
Sturgeon caviar	74	194	....	....	74	194
Sturgeon roe	....	....	3,572	10,746	3,572	10,746
Suckers	....	....	50,664	5,139	50,664	5,139
Tautog	3,350	256	40,693	2,394	44,043	2,650
Tomcod	....	....	1,950	97	1,950	97
Tuna	31,100	1,449	56,634	2,044	87,734	3,403
Whiting	1,554,030	29,835	1,726,803	34,536	3,280,833	64,371
Other fish	514	20	275	14	789	34
Lobster	30,000	6,000	367,841	82,588	397,841	88,588
Shrimp	20,000	400	....	....	20,000	400
Crabs, hard	94,909	5,700	24,245	1,590	119,244	7,290
Crabs, soft	....	....	16,800	6,132	16,800	6,132
Crabs, king	....	....	3,313,174	10,416	3,313,174	10,416
Squid	329,600	15,610	104,302	4,398	433,902	20,008
Clams, hard	46,000	23,600	736,088	340,948	782,088	364,548
Clams, soft	....	....	143,500	20,650	143,500	20,650
Mussels	....	....	791,000	6,070	791,000	6,070
Oysters, market, public	10,500	1,550	58,800	8,640	69,300	10,190
Oysters, market, private	10,178,987	1,915,214	798,868	145,092	10,977,855	[1] 2,060,306
Oysters, seed, public	11,361,000	649,800	277,900	17,105	11,638,900	666,905
Oysters, seed, private	56,000	4,000	255,500	18,529	311,500	22,529
Scallops	540	90	....	....	540	90
Turtles	4,500	90	9,215	244	13,715	334
Terrapin	....	....	225	225	225	225
Winkles	7,800	159	....	....	7,800	159
Total	55,168,849	4,179,742	41,767,935	1,803,664	96,936,784	5,983,406

[1] In addition 1,543,059 pounds (220,435 bushels), valued at $232,850, were taken by New Jersey vessels in Delaware waters and are shown under that State.

FISHERIES BY APPARATUS.

The most important forms of fishing apparatus used in the fisheries of New Jersey include purse seines and haul seines, the former with a catch of 14,022,400 pounds, valued at $282,750, consisting chiefly of menhaden, scup or porgy, and squeteague, and the latter with a catch of 903,660 pounds of various species, valued at $77,239; gill nets, with 3,770,625 pounds, valued at $355,972; pound nets and weirs, with 46, 663,590 pounds, valued at $1,448,822; hand lines and trawl lines, with 4,523,537 pounds, valued at $401,510; dredges, with 22,348,286 pounds, valued at $2,676,244, consisting chiefly of oysters; and tongs, rakes, hoes, etc., with 2,468,881 pounds, valued at $481,038, consisting chiefly of oysters and clams. Other forms of apparatus that took considerable quantities of products were fyke nets, bag nets, stop nets, dip nets, cast nets, otter trawls, eel pots, lobster pots, and spears. The lobster catch, amounting to 379,841 pounds. valued at $88,588, was all taken in lobster pots. The products taken with each form of fishing apparatus in the vessel and shore fisheries combined are shown in the appended tables:

Yield of the fisheries of New Jersey in 1921, by counties, apparatus, and species.

BY PURSE SEINES AND HAUL SEINES.

Apparatus and species.	Atlantic.		Burlington.		Camden.		Cape May.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Purse seines:								
Albacore	650	$20						
Bluefish	3,700	460					13,000	$2,190
Butterfish							9,000	532
Croaker	89,000	1,850					170,000	8,300
Flounders	2,100	135					5,400	368
Menhaden	3,480,000	16,000					2,280,000	9,500
Scup or porgy	1,115,000	49,855					1,230,000	69,000
Sea bass	25,600	2,100					57,000	3,330
Squeteagues	475,000	29,700					1,054,285	68,800
Tautog	200	12					200	12
Total	5,191,250	100,132					4,818,885	162,032
Haul seines:								
Alewives	17,000	360	5,000	$100			6,400	132
Bluefish	250	50					225	55
Carp			3,009	431	2,430	$401		
Catfish	600	52	7,170	531	4,825	290		
Croaker	37,500	1,520					20,100	1,034
Eel	2,800	282					2,000	200
Flounders	4,100	390					4,300	344
King whiting	550	61					3,000	30
Mullet, fresh							12,000	820
Mullet, salted							1,200	240
Perch, white	2,000	195	3,250	550			300	30
Perch, yellow			60	12				
Pike			500	100				
Shad	500	125	625	150	600	146	150	38
Spot	4,150	208					6,000	380
Squeteagues	24,200	2,220					40,300	3,580
Striped bass	3,000	750	38,000	13,200			100	25
Suckers	400	20	27,609	2,525	100	12		
Total	97,050	6,233	85,223	17,599	7,955	849	96,075	6,908

Apparatus and species.	Cumberland.		Hunterdon.		Mercer.		Middlesex.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Haul seines:								
Alewives	10,000	$300			3,950	$75		
Bluefish							6,800	$1,600
Carp	5,500	780	1,205	$143	8,194	1,225		
Catfish	5,600	296			316	28		
Croaker	9,000	270						
Flounders	170	8						
Menhaden							30,000	50
Perch, white	500	50						
Shad	2,640	744	1,459	461	12,546	4,473	435	190
Smelt							450	335
Spot	400	20						
Squeteagues	6,000	300					10,600	765
Striped bass	2,000	300						
Suckers	700	78	3,330	899	13,075	1,480		
Total	42,510	3,146	5,994	1,003	38,081	7,281	48,285	2,940

Yield of the fisheries of New Jersey in 1921, by counties, apparatus, and species—Con

BY PURSE SEINES AND HAUL SEINES—Continued.

Apparatus and species.	Monmouth.		Ocean.		Salem.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Purse seines:								
Albacore							650	$20
Bluefish							16,700	2,650
Butterfish							9,000	532
Croaker							259,000	10,150
Flounders							7,500	503
Menhaden	4,005,265	$20,026					9,765,265	45,526
Scup or porgy							2,345,000	118,855
Sea bass							82,600	5,430
Squeteagues	7,000	560					1,536,285	99,060
Tautog							400	24
Total	4,012,265	20,586					14,022,400	282,750
Haul seines:								
Alewives			290,000	$8,700			332,350	9,667
Bluefish	1,500	270					8,775	1,975
Butterfish	100	6					100	6
Carp					37,130	$6,255	57,468	9,235
Catfish			1,430	112	38,600	2,060	58,541	3,369
Croaker							66,600	2,824
Eel	25	3					4,825	485
Flounders	500	40	1,050	63			10,120	845
King whiting							3,550	91
Menhaden	15,000	150					45,000	200
Mullet, fresh	4,000	200	2,000	80			18,000	1,100
Mullet, salted							1,200	240
Perch, white			57,780	8,666	250	38	64,080	9,529
Perch, yellow			3,710	557	7,882	1,221	11,652	1,790
Pike							500	100
Shad							18,955	6,327
Smelt							450	335
Spot	6,000	480					17,150	1,088
Squeteagues	1,800	144	6,000	420			88,900	7,429
Striped bass			3,430	1,000			46,530	15,275
Suckers					1,750	315	46,964	4,829
Tomcod			200	10			200	10
Crabs, hard	150	90					150	90
Crabs, soft			1,600	400			1,600	400
Total	29,075	1,383	367,200	20,008	85,612	9,889	903,660	77,239

BY GILL NETS.

Species.	Atlantic.		Bergen.		Burlington.		Camden.		Cape May.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Alewives							2,000	$80		
Bluefish	25,590	$5,118							73,360	$15,264
Bonito									9,000	540
Croaker	147,250	5,290			3,000	$180			190,000	5,700
Mackerel	288,617	41,642							161,850	30,853
Menhaden									9,000	900
Scup or porgy									1,000	54
Shad	450	110	25,920	$6,294	6,125	1,579	4,241	1,156	660	165
Spot	2,000	100								
Squeteagues	42,750	3,800			10,000	800			388,400	29,628
Sturgeon									200	30
Total	506,657	56,060	25,920	6,294	19,125	2,559	6,241	1,236	833,470	83,134

Species.	Cumberland.		Gloucester.		Mercer.		Middlesex.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Bluefish	69,000	$13,800					475	$95
Croaker	922,200	28,666						
Shad	24,055	7,029	6,609	$1,613	1,580	$541		
Squeteagues	216,000	11,000					5,000	350
Sturgeon	30,356	4,557						
Sturgeon roe	1,566	4,736						
Total	1,263,177	69,788	6,609	1,613	1,580	541	5,475	445

Yield of the fisheries of New Jersey in 1921, by counties, apparatus, and species—Con.

BY GILL NETS—Continued.

Species.	Monmouth.		Ocean.		Salem.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Alewives			16,200	$600	6,000	$180	24,200	$860
Bluefish	268,785	$51,393	21,300	4,398			459,510	90,228
Bonito	1,350	81					10,350	621
Butterfish	20,400	1,020					20,400	1,020
Croaker	162,700	5,472	48,600	2,316	75,000	2,250	1,548,750	49,874
Mackerel	103,403	21,233	3,600	720			557,470	94,448
Menhaden			5,000	50			14,000	950
Perch, white			31,282	4,692			31,282	4,692
Perch, yellow			3,300	495			3,300	495
Scup or porgy							1,000	54
Shad	3,384	789			40,160	9,793	113,184	29,069
Spot	2,600	176					4,600	276
Squeteagues	133,872	10,677	130,100	9,748	9,000	540	935,122	66,543
Striped bass			1,583	441			1,583	441
Sturgeon	167	16			11,425	1,718	42,148	6,321
Sturgeon, roe	83	258			1,685	5,055	3,334	10,049
Suckers			392	31			392	31
Total	696,744	91,115	261,357	23,491	144,270	19,696	3,770,625	355,972

BY POUND NETS AND WEIRS.

Species.	Atlantic.		Cape May.		Cumberland.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore			2,400	$76		
Alewives	2,985	$60	24,000	380		
Bluefish	206	52	30,035	5,158		
Bonito			42,210	3,736		
Butterfish	3,348	118	493,505	31,555		
Cero			200	14		
Cod			500	44		
Croaker	29,500	885	442,665	13,183		
Drum, black			600	15		
Drum, red			500	10		
Eels			900	90		
Flounders	5,283	423	87,345	6,699		
Hake			16,507	416		
Herring			62,200	1,244		
King whiting	1,622	324	5,690	843		
Mackerel			2,700	654		
Menhaden			318,035	2,480		
Perch, white	385	38	1,200	24		
Pollock			3,000	60		
Scup or porgy			844,916	31,986		
Sea bass			96,404	8,636		
Sea robin			400	8		
Shad	55	11	2,168	542		
Sharks			1,600	22		
Skates and rays			7,100	182		
Spanish mackerel			550	130		
Spot	4,326	130	42,265	2,809		
Squeteagues	4,169	334	1,230,396	99,155		
Striped bass	684	171	718	180		
Sturgeon			740	186		
Sturgeon roe			80	240		
Tautog			1,450	136		
Whiting	6,400	128	45,000	645		
Other fish			264	3		
Crabs, king			2,762,174	8,287	523,000	$1,569
Squid			22,000	1,100		
Total	58,963	2,674	6,592,417	220,928	523,000	1,569

Yield of the fisheries of New Jersey in 1921, by counties, apparatus, and species—Con.

BY POUND NETS AND WEIRS—Continued.

Species.	Monmouth.		Ocean.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore	65,392	$2,158	55,600	$1,699	123,392	$3,933
Alewives	20,658	812			47,643	1,252
Bluefish	156,391	27,918	296,697	53,610	483,320	86,[illegible]38
Bonito	50,028	3,001	778,577	46,958	870,815	53,[illegible]95
Butterfish	733,726	37,167	1,602,412	88,888	2,832,991	157,72[illegible]
Cero					200	14
Cod	33,732	1,686	45,745	2,376	79,977	4,106
Croaker	151,904	4,657	1,179,435	38,015	1,803,504	56,740
Drum, black	27,934	558	39,125	792	67,659	1,365
Drum, red					500	10
Eels	450	46	100	9	1,450	145
Flounders	171,699	12,310	453,823	31,929	718,150	51,361
Hake	610,342	19,000	166,469	4,978	793,318	24,394
Herring	36,825	1,167	73,707	2,053	172,732	4,464
Hickory shad	6,574	293	21,571	1,289	28,145	1,582
King whiting	5,340	819	7,567	1,204	20,219	3,190
Mackerel	12,616	2,554	11,600	2,900	26,916	6,108
Menhaden	20,194,712	71,466	64,331	754	20,577,078	74,700
Mullet	60	4	400	32	460	36
Perch, white					1,585	62
Pollock	1,240	52	300	15	4,540	127
Scup or porgy	182,225	10,934	531,619	28,819	1,558,760	71,739
Sea bass	13,447	807	20,244	1,386	130,095	10,829
Sea robin	43,740	866	19,500	466	63,640	1,340
Shad	3,361	842	30,839	7,649	36,423	9,044
Sharks	22,559	450	35,900	752	60,059	1,224
Skates and rays	12,600	286	11,600	356	31,300	824
Spanish mackerel	624	146	2,808	703	3,982	979
Spot	42,112	2,439	77,800	4,668	166,503	10,046
Squeteagues	1,831,953	148,001	5,777,282	462,177	8,343,800	709,667
Striped bass	140	42			1,542	393
Sturgeon	1,797	271	1,140	342	3,677	799
Sturgeon caviar			74	194	74	194
Sturgeon roe	158	457			238	697
Tautog	25,465	1,595	1,500	96	28,415	1,827
Tuna	34,004	1,366	30,900	1,445	64,904	2,811
Whiting	1,720,403	34,408	1,509,030	29,190	3,280,833	64,371
Other fish	275	14	50	3	589	20
Crabs, hard	2,562	154			2,562	154
Crabs, king					3,285,174	9,856
Squid	104,302	4,398	307,600	14,610	433,902	20,008
Turtles	8,015	160	4,500	90	12,515	250
Total	26,329,365	393,304	13,159,845	830,347	46,663,590	1,448,822

BY FYKE NETS AND BAG NETS.

Apparatus and species.	Atlantic.		Burlington.		Camden.		Cape May.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Fyke nets:								
Carp			302	$46				
Catfish	6,000	$600	1,406	85	850	$51	2,200	$176
Eels	1,250	125	1,651	185	785	93	5,000	400
Flounders	3,000	300	4,000	360				
Perch, white	10,000	1,080	5,000	600				
Perch, yellow							500	50
Striped bass	3,400	850	300	90	2,000	500		
Suckers	1,900	95	80	12				
Total	25,550	3,050	12,739	1,378	3,635	644	7,700	626
Bag nets:								
Flounders			7,800	624				
Perch, white	1,000	150	10,370	1,555				
Striped bass	500	150	10,950	3,320				
Total	1,500	300	29,120	5,499				

Yield of the fisheries of New Jersey in 1921, by counties, apparatus, and species—Con.

BY FYKE NETS AND BAG NETS—Continued.

Apparatus and species.	Cumberland.		Gloucester.		Hudson.		Monmouth.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Fyke nets:								
Alewives							1,500	$60
Bluefish							75	15
Carp	4,000	$600	4,950	$891				
Catfish	5,600	320	8,593	464				
Eels	350	35	2,452	291	4,000	$400	6,000	720
Flounders							3,900	312
Menhaden							3,750	75
Perch, white	500	50					2,353	353
Perch, yellow			125	19				
Shad							75	20
Spot							900	72
Squeteagues							2,100	168
Striped bass							2,850	512
Tautog							75	6
Tomcod							1,750	87
Crabs, hard							600	36
King crabs							28,000	560
Total	10,450	1,005	16,120	1,665	4,000	400	53,928	2,996

Apparatus and species.	Ocean.		Salem.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Fyke nets:						
Alewives	2,500	$75			4,000	$135
Bluefish					75	15
Carp					9,252	1,537
Catfish			13,954	$698	38,603	2,394
Eels			5,975	718	27,463	2,967
Flounders	44,340	3,587			55,240	4,559
Menhaden					3,750	75
Perch, white	4,800	720			22,653	2,803
Perch, yellow	13,200	1,979	375	56	14,200	2,104
Shad					75	20
Spot					900	72
Squeteagues					2,100	168
Striped bass	293	80			8,843	2,032
Suckers	100	8			2,080	115
Tautog					75	6
Tomcod					1,750	87
Crabs, hard					600	36
King crabs					28,000	560
Total	65,233	6,449	20,304	1,472	219,659	19,685
Bag nets:						
Flounders					7,800	624
Perch, white					11,370	1,705
Striped bass					11,450	3,470
Total					30,620	5,799

BY STOP NETS, DIP NETS, CAST NETS, OTTER TRAWLS, EEL POTS, LOBSTER POTS, AND SPEARS.

Apparatus and species.	Atlantic.		Bergen.		Burlington.		Camden.		Cape May.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Stop nets: Carp					23,050	$3,549	17,160	$3,089		
Dip nets: Crabs, soft	440	$193								
Otter trawls:										
Flounders	415,400	28,978							583,800	$40,171
Scallops	540	90								
Total	415,940	29,068							583,800	40,171
Eel pots: Eels, fresh			2,500	$375					10,200	1,020
Spears: Eels	10,000	1,000								

Yield of the fisheries of New Jersey in 1921, by counties, apparatus, and species—Con.

BY STOP NETS, DIP NETS, CAST NETS, OTTER TRAWLS, EEL POTS, LOBSTER POTS, AND SPEARS—Continued.

Apparatus and species.	Cumberland.		Gloucester.		Hudson.		Middlesex.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Stop nets:								
Carp	26,100	$3,420	39,925	$6,806				
Catfish	450	40						
Striped bass	400	80						
Total	26,950	3,540	39,925	6,806				
Dip nets: Crabs, hard	2,800	210						
Cast nets: Carp			3,250	585				
Otter trawls: Flounders	18,400	1,720						
Eel pots: Eels, fresh	40,000	2,000			6,000	$600	9,500	$950
Lobster pots: Lobster					5,000	1,000	500	150

Apparatus and species.	Monmouth.		Ocean.		Salem.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Stop nets:								
Carp					141,000	$22,740	247,235	$39,604
Catfish					2,153	107	2,603	147
Perch, yellow					1,935	290	1,935	290
Striped bass							400	80
Suckers					975	125	975	125
Total					146,063	23,262	253,148	40,246
Dip nets:								
Crabs, hard	8,333	$500	1,000	$60			12,133	770
Crabs, soft	14,560	5,464	200	75			15,200	5,732
Total	22,893	5,964	1,200	135			27,333	6,502
Cast nets:								
Carp					12,350	2,223	15,600	2,808
Catfish					1,320	66	1,320	66
Perch, yellow					195	29	195	29
Suckers					253	39	253	39
Total					14,118	2,357	17,368	2,942
Otter trawls:								
Flounders							1,017,600	70,869
Shrimp	20,000	400					20,000	400
Scallops							540	90
Total	20,000	400					1,038,140	71,359
Eel pots:								
Eels, fresh	112,010	11,668	31,556	3,155	8,000	960	219,766	20,728
Eels, smoked	4,680	1,497					4,680	1,497
Total	116,690	13,165	31,556	3,155	8,000	960	224,446	22,225
Lobster pots:								
Sea bass	2,000	120					2,000	120
Lobster	390,941	87,088	1,400	350			397,841	88,588
Crabs, hard	4,000	240					4,000	240
Total	396,941	87,448	1,400	350			403,841	88,948
Spears: Eels	11,250	1,125					21,250	2,125

Yield of the fisheries of New Jersey in 1921, by counties, apparatus, and species—Con.

BY HAND LINES AND TRAWL LINES.

Species.	Atlantic.		Cape May.		Cumberland.		Monmouth.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore			400	$8	600	$6		
Bluefish	256,400	$41,930	677,256	105,977	51,400	10,280	[illegible]58,580	$46,264
Bonito	17,900	1,078	168,537	10,373	59,600	2,980	1[illegible]1,551	8,531
Cod	318,000	14,860	100,400	7,920			143,400	7,282
Croaker	48,400	3,414	71,600	2,950	9,400	360	3,000	120
Flounders	8,150	745	65,150	4,565	24,600	1,430	22,250	1,600
Haddock	2,000	100	3,300	198			1,000	40
Hake	1,700	85	2,400	120			22,600	904
King whiting	300	45						
Scup or porgy	7,200	432	180,200	7,630	3,450	173	1,242	99
Sea bass	27,900	2,458	1,087,485	65,068	16,000	810	18,620	1,358
Sharks			400	8				
Skates			800	32			11,000	330
Squeteagues	37,328	4,899	65,800	5,122	35,900	1,831	6,250	500
Tautog	500	60	3,000	24			11,653	709
Tuna			6,800	132	1,500	18	10,160	398
Crabs, hard			4,800	800				
Turtles	1,200	84						
Total	726,978	70,190	2,438,328	210,427	202,450	17,888	651,306	68,135

Species.	Ocean.		Salem.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Albacore			600	$18	1,600	$32
Bluefish	27,400	$4,250	4,000	640	1,275,036	209,341
Bonito	229,500	13,518	5,000	250	622,088	36,730
Cod	45,500	3,185			607,300	33,247
Croaker	300	18	5,000	250	137,700	7,112
Flounders	43,130	3,090	5,650	395	168,930	11,825
Haddock					6,300	338
Hake	1,000	60			27,700	1,169
King whiting			50	8	350	53
Scup or porgy	15,850	922	2,850	142	210,792	9,398
Sea bass	11,000	619	2,630	131	1,163,635	70,444
Sharks					400	8
Skates					11,800	362
Spot			395	20	395	20
Squeteagues	95,250	6,820	5,000	400	245,528	19,572
Tautog					15,153	793
Tuna	4,000	120	370	14	22,830	682
Crabs, hard					4,800	300
Turtles					1,200	84
Total	472,930	32,602	31,545	2,268	4,523,537	401,510

BY DREDGES, TONGS, RAKES, HOES, ETC.

Apparatus and species.	Atlantic.		Burlington.		Cape May.		Cumberland.	
Dredges:	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Oysters, market, private	308,000	$64,300	91,000	$13,400	39,207	$7,612	9,912,280	$1,869,702
Oysters, seed, public	14,000	1,000			155,400	8,880	11,200,000	640,000
Oysters, seed, private			70,000	5,000				
Total	322,000	65,300	161,000	18,400	194,607	16,492	21,112,280	2,509,702
Tongs, rakes, hoes, etc.:								
Clams, hard	230,320	104,220	54,000	24,300	90,192	48,851	800	300
Clams, soft	11,000	1,000						
Oysters, market, public			14,000	2,200	42,000	6,000		
Oysters, market, private	222,075	40,307	63,000	9,400	1,400	300		
Oysters, seed, public	42,000	2,895	28,000	2,000			183,400	10,480
Oysters, seed, private	5,600	269	42,000	3,000				
Mussels	790,000	5,970					1,000	100
Terrapin	225	225						
Total	1,301,220	154,886	201,000	40,900	133,592	55,151	185,200	10,880

Yield of the fisheries of New Jersey in 1921, by counties, apparatus, and species—Con.

BY DREDGES, TONGS, RAKES, HOES, ETC.—Continued.

Apparatus and species.	Middlesex.		Monmouth.		Ocean.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Dredges:								
Crabs, hard			94,999	$5,700			94,999	$5,700
Oysters, market, public			10,500	1,550			10,500	1,550
Oysters, market, private			147,000	26,100	130,900	$19,520	[1]10,628,387	2,000,634
Oysters, seed, public	7,000	$1,000					11,376,400	650,880
Oysters, seed, private			15,400	1,760	152,600	10,720	238,000	17,480
Total	7,000	1,000	267,899	35,110	283,500	30,240	22,348,286	2,676,244
Tongs, rakes, hoes, etc.:								
Clams, hard	1,800	900	95,576	46,737	309,400	139,240	782,088	364,548
Clams, soft			128,000	19,200	4,500	450	143,500	20,650
Oysters, market, public					2,800	440	58,800	8,640
Oysters, market, private			13,293	2,500	49,700	7,165	349,468	59,672
Oysters, seed, public	7,000	500			2,100	150	262,500	16,025
Oysters, seed, private					25,900	1,780	73,500	5,049
Mussels							791,000	6,070
Winkles			7,800	159			7,800	159
Terrapin							225	225
Total	8,800	1,400	244,669	68,596	394,400	149,225	2,468,881	481,038

[1] In addition 1,543,059 pounds (220,435 bushels), valued at $232,850, were taken by New Jersey vessels in Delaware waters and are shown under the latter State.

INDUSTRIES.

Wholesale trade.—In 1921 there were 61 wholesale establishments in New Jersey, valued at $722,220, engaged in handling fresh fish, oysters, clams, and other fishery products. This number included 2 firms manufacturing scrap from king crabs, 1 firm manufacturing poultry grit from oyster shells, and 1 firm engaged in canning sturgeon caviar. The number of persons engaged was 480, who received $273,774 in wages, and the cash capital amounted to $230,100.

Menhaden industry.—In 1921 there were 3 menhaden factories operated in New Jersey, valued at $409,196, with a cash capital amounting to $78,000. There were 89 persons engaged in the factories, who received $24,485 in wages. The number of menhaden utilized in the factories was 33,600,000, or 20,160,000 pounds, valued at $109,000, and the products prepared included 7,238 tons of acidulated scrap, valued at $141,803, and 459,600 gallons of oil, valued at $107,340.

Statistics of the wholesale fishery trade and menhaden industry are given in the following tables:

Investment, persons engaged, and wages paid in the wholesale fishery trade of New Jersey in 1921, by counties.

Items.	Atlantic.		Cape May.		Cumberland and Salem.	
	Number.	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
Establishments	5	$20,900	7	$48,300	27	$200,233
Cash capital		11,000		14,100		146,000
Persons engaged	17		34		196	
Wages paid		5,600		3,200		123,610

Investment, persons engaged, and wages paid in the wholesale fishery trade of New Jersey, in 1921, by counties—Continued.

Items.	Essex and Hudson.		Monmouth.		Ocean.		Total.	
	Number.	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
Establishments	6	$270,535	4	$169,072	12	$13,180	61	$722,220
Cash capital		30,500		19,000		9,500		260,100
Persons engaged	134		71		28		480	
Wages paid		87,287		49,427		4,650		273,774

The menhaden industry of New Jersey in 1921.

Items.	Number.	Value.	Items.	Number.	Value.
Factories	3	$409,196	Gasoline vessels fishing	7	$99,800
Cash capital		78,000	Tonnage	134	
Wages paid factory employees		24,485	Outfit		9,600
Persons in factories	89		Purse seines	7	6,800
Persons on vessels	106				
Menhaden caught by vessels	[1] 16,275,442	45,526	Products:		
Menhaden caught in shore fisheries	33,897,437	72,691	Acidulated scrap...tons	7,238	141,803
Menhaden utilized in factories	33,600,000	109,000	Oil...gallons	459,600	107,340

[1] This includes 3,800,000 menhaden taken incidentally by fishing vessels.

FISHERIES OF PENNSYLVANIA.

The fisheries of Pennsylvania in 1921 gave employment to 591 persons, of whom 42 were on vessels fishing, 2 on vessels transporting fishery products, 105 in the shore or boat fisheries, and 442 on shore in the wholesale fishery trade and other fishery industries.

The investment in the fisheries and fishery industries amounted to $1,375,778, and included 4 fishing and transporting vessels, valued at $26,800, with a net tonnage of 103 tons, and outfits valued at $5,125; 45 boats, valued at $4,305; fishing apparatus, valued at $5,192; shore and accessory property, valued at $1,074,156; and cash capital amounting to $260,200.

The products of the fisheries amounted to 594,613 pounds, having a value to the fishermen of $44,621. The most important species taken were alewives, 20,085 pounds, valued at $405; carp, 9,712 pounds, valued at $1,511; scup, 142,000 pounds, valued at $7,100; sea bass, 135,000 pounds, valued at $12,500; squeteagues, "sea trout" or weakfish, 240,000 pounds, valued at $14,400; and suckers, 21,199 pounds, valued at $2,469.

Compared with 1904, there was a decrease in the number of persons engaged of 821, or 58.14 per cent, in the investment of $721,937, or 34.41 per cent, and in the products of 1,451,681 pounds, or 70.94 per cent, in quantity, and of $122,878, or 73.36 per cent, in value.

The following table gives the number of persons engaged, investment, and the quantity and value of the products of the fisheries of Pennsylvania in 1921:

Persons engaged, investment, and products of the fisheries of Pennsylvania in 1921, by counties.

Items.	Bucks.		Delaware.		Philadelphia.		Total.	
PERSONS ENGAGED.	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
On vessels fishing					42		42	
On vessels transporting			2				2	
In shore fisheries	85		20				105	
Shoresmen			12		430		442	
Total	85		34		472		591	
INVESTMENT.								
Vessels fishing:								
Gasoline					3	$26,000	3	$26,000
Tonnage					93		93	
Outfit						5,050		5,050
Vessels transporting:								
Sail			1	$800			1	800
Tonnage			10				10	
Outfit				75				75
Boats:								
Row	30	$990	7	215			37	1,205
Gasoline	1	1,000	7	2,100			8	3,100
Apparatus, vessel fisheries:								
Purse seine					1	1,000	1	1,000
Hand lines						250		250
Apparatus, shore fisheries:								
Haul seines	21	1,892	1	20			22	1,912
Gill nets	8	420	5	950			13	1,370
Stop nets	2	300	3	325			5	625
Fyke nets			25	35			25	35
Shore and accessory property		670		18,100		1,055,386		1,074,156
Cash capital				3,000		257,200		260,200
Total		5,272		25,620		1,344,886		1,375,778
PRODUCTS.	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Alewives	20,085	$405					20,085	$405
Bluefish					600	$108	600	108
Butterfish					200	6	200	6
Carp	6,212	881	3,500	$630			9,712	1,511
Catfish			2,125	128			2,125	128
Croaker					2,400	48	2,400	48
Eels			220	22			220	22
Flounders					200	10	200	10
Pigfish					2,000	80	2,000	80
Scup					142,000	7,100	142,000	7,100
Sea bass					135,000	12,500	135,000	12,500
Shad	14,827	4,662	4,045	1,172			18,872	5,834
Squeteague or weakfish					240,000	14,400	240,000	14,400
Suckers	20,199	2,349	1,000	120			21,199	2,469
Total	61,323	8,297	10,890	2,072	522,400	34,252	594,613	44,621

VESSEL AND SHORE FISHERIES.

The products of the vessel and shore fisheries of Pennsylvania are given in the appended table. The products taken by vessels amounted to 522,400 pounds, valued at $34,252, and by boats in the shore fisheries to 72,213 pounds, valued at $10,369.

Products of the vessel and shore fisheries of Pennsylvania, 1921.

Species.	Vessel fisheries.		Shore fisheries.		Total.	
	Pounds	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Alewives			20,085	$405	20,085	$405
Bluefish	600	$108			600	108
Butterfish	200	6			200	6
Carp			9,712	1,511	9,712	1,511
Catfish			2,125	128	2,125	128
Croaker	2,400	48			2,400	48
Eels			220	22	220	22
Flounders	200	10			200	10
Pigfish	2,000	80			2,000	80
Scup	142,000	7,100			142,000	7,100
Sea bass	135,000	12,500			135,000	12,500
Shad			18,872	5,834	18,872	5,834
Squeteagues or weakfish	240,000	14,400			240,000	14,400
Suckers			21,199	2,469	21,199	2,469
Total	522,400	34,252	72,213	10,369	594,613	44,621

FISHERIES BY APPARATUS.

The most important forms of fishing apparatus used in the fisheries of Pennsylvania in 1921 included purse seines, with a catch of 398,400 pounds, valued at $22,472, of which squeteague was the principal species taken; haul seines, with 58,770 pounds, valued at $7,503; and hand lines, with 124,000 pounds, valued at $11,780, consisting mostly of sea bass. The remainder of the catch was taken with gill nets, stop nets, and fyke nets. The catch taken with each form of fishing apparatus in the vessel and shore fisheries combined is given in the following table:

Yield of the fisheries of Pennsylvania in 1921, by counties, apparatus, and species.

Apparatus and species.	Bucks.		Delaware.		Philadelphia.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Haul seines:								
Alewives	20,085	$405					20,085	$405
Carp	4,677	642					4,677	642
Catfish			125	$8			125	8
Shad	12,684	3,979					12,684	3,979
Suckers	20,199	2,349	1,000	120			21,199	2,469
Total	57,645	7,375	1,125	128			58,770	7,503
Purse seines:								
Bluefish					600	$108	600	108
Butterfish					200	6	200	6
Croaker					2,400	48	2,400	48
Flounders					200	10	200	10
Scup					140,000	7,000	140,000	7,000
Sea bass					15,000	900	15,000	900
Squeteague or weakfish					240,000	14,400	240,000	14,400
Total					398,400	22,472	398,400	22,472
Gill nets: Shad	2,143	683	4,045	1,172			6,188	1,855
Stop nets: Carp	1,535	239	3,500	630			5,035	869
Fyke nets:								
Catfish			2,000	120			2,000	120
Eels			220	22			220	22
Total			2,220	142			2,220	142
Hand lines:								
Pigfish					2,000	80	2,000	80
Scup					2,000	100	2,000	100
Sea bass					120,000	11,600	120,000	11,600
Total					124,000	11,780	124,000	11,780
Grand total	61,323	8,297	10,890	2,072	522,400	34,252	594,613	44,621

INDUSTRIES.

Prepared products.—In 1921 there were 15 establishments in Philadelphia, Pa., engaged in preparing smoked fish and other products, having a value of $566,800, with cash capital amounting to $87,300, and employing 118 persons, to whom $119,919 were paid in wages. The quantity of smoked fish prepared was 1,185,328 pounds, valued at $215,436. Other products prepared amounted to $84,480 in value. Statistics of these products, by species, are given in the table below.

Wholesale trade.—In the wholesale fresh-fish trade of Philadelphia and Chester, Pa., in 1921, there were 52 establishments engaged, valued at $503,486, with a cash capital of $167,900, and employing 324 persons, to whom $357,787 were paid in wages.

Smoked and salted fish and other fishery products prepared in Philadelphia in 1921.

Items.	Number.	Value.	Items.	Pounds.	Value.
Establishments	15	$566,800	Smoked fish—Continued.		
Cash capital		87,300	Herring (Maine)	22,000	$2,640
Persons engaged	118		Herring (Nova Scotia)	494,646	62,687
Wages paid		119,919	Shad	9,600	3,840
			Sturgeon	4,800	6,000
Smoked fish:	*Pounds.*	*Value.*			
Alewives	36,300	$6,240	Total	1,185,328	215,436
Butterfish	14,000	3,080			
Ciscoes	460,582	101,974	Salted fish: Lake trout	3,600	1,080
Ciscoes ("tullibee")	5,900	1,475	Miscellaneous products [1]		83,400
Haddock	137,500	27,500			

[1] Includes lime and poultry grit from oyster shells.

FISHERIES OF DELAWARE.

The number of persons engaged in the fisheries of Delaware in 1921 was 976, of whom 279 were on vessels fishing, 2 on transporting vessels, 540 on boats in the shore or boat fisheries, and 155 on shore in the wholesale fishery trade and other fishery industries.

The investment in the fisheries and fishery industries amounted to $585,616 and included 29 fishing and transporting vessels, valued at $230,482, with a net tonnage of 760 tons and outfits valued at $23,561; 416 boats, valued at $39,035; fishing apparatus valued at $27,938; shore and accessory property valued at $153,400; and cash capital amounting to $108,500.

The products of the fisheries amounted to 25,023,193 pounds, having a value to the fishermen of $652,448. The most important species in value were alewives, 351,590 pounds, valued at $6,431; carp, 87,820 pounds, valued at $13,166; croaker, 418,873 pounds, valued at $18,682; menhaden, 18,082,000 pounds, valued at $67,970; shad, 86,836 pounds, valued at $16,312; squeteagues, "sea trout," or weakfish, 886,550 pounds, valued at $53,317; and oysters, 4,315,731 pounds, or 616,533 bushels, valued at $450,873.

Compared with 1904, there was a decrease in the number of persons engaged of 923, or 48.6 per cent, and also in the investment of $84,379, or 12.59 per cent, but an increase in the products of 19,414,904 pounds, or 346.18 per cent, in quantity and of $392,858, or 151.33 per cent, in value. This large increase in the products was due to the fact that a considerable catch of menhaden was taken in 1921 and none in 1904.

The number of persons engaged, investment, and products of the fisheries of Delaware in 1921 are given in detail in the following table:

Persons engaged, investment, and products of the fisheries of Delaware in 1921.

Items.	Kent.		New Castle.		Sussex.		Total.	
PERSONS ENGAGED.	Number.	Value.	Number.	Value.	Number.	Value.	Number.	Value.
On vessels fishing	127				152		279	
On vessels transporting					2		2	
In shore fisheries	177		84		279		540	
Shoresmen	19		6		130		155	
Total	323		90		563		976	
INVESTMENT.								
Vessels fishing:								
Steam					4	$165,382	4	$165,382
Tonnage					492		492	
Outfit						7,591		7,591
Gasoline	11	$36,400			1	2,500	12	38,900
Tonnage	127				8		135	
Outfit		8,150				900		9,050
Sail	12	23,700			1	2,500	13	26,200
Tonnage	115				18		133	
Outfit		6,500				420		6,920
Vessels transporting:								
Gasoline					1	600	1	600
Tonnage					7		7	
Sail			1	$500	2	1,500	3	2,000
Tonnage			5		16		21	
Outfit						100		100
Boats:								
Row	74	1,895	32	805	197	5,070	303	7,770
Gasoline	27	6,750	44	12,500	42	12,015	113	31,265
Apparatus, vessel fisheries:								
Purse seines					4	6,000	4	6,000
Dredges	46	1,055			4	90	50	1,145
Apparatus, shore fisheries:								
Gill nets	16	530	52	4,540	88	1,860	156	6,930
Pound nets			5	1,000			5	1,000
Haul seines	32	4,355	12	640	49	4,005	93	9,000
Fyke nets	64	158	292	671	75	800	431	1,629
Hand lines						25		25
Pots	25	25	51	51	205	205	281	281
Minor nets	20	240	16	645	5	3	41	888
Tongs	72	360			136	680	208	1,040
Shore and accessory property		6,000		19,500		127,900		153,400
Cash capital		2,500		5,000		101,000		108,500
Total		98,618		45,852		441,146		585,616
PRODUCTS.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives	62,990	$2,059			288,600	$4,372	351,590	$6,431
Bluefish					1,325	265	1,325	265
Carp	19,386	2,901	60,589	$9,089	7,845	1,176	87,820	13,166
Catfish	6,377	470	26,754	1,942	2,160	162	35,291	2,574
Croaker	141,848	7,591			277,025	11,091	418,873	18,682
Drum black					1,150	22	1,150	22
Eels	2,200	219	10,612	1,059	3,200	320	16,012	1,598
Flounders					34,429	1,798	34,429	2,198
Gizzard shad			7,320	292			7,320	292
Menhaden					18,082,000	67,970	18,082,000	67,970
Mullet	153	10			360	15	513	25
Perch, white	2,324	324	352	35	4,247	563	6,923	922
Perch, yellow			288	24	2,470	249	2,758	273
Pike	163	14			109	11	272	25
Sea bass					250	12	250	12
Shad	1,234	307	10,123	2,853	75,479	13,152	86,836	16,312
Spot					14,600	928	14,600	928
Squeteagues or weakfish	492,625	29,556	300	24	393,625	23,737	886,550	53,317
Striped bass	973	244			3,942	1,182	4,915	1,426
Sturgeon	520	78	11,570	1,735			12,090	1,813
Sturgeon roe	165	453	1,707	4,686			1,872	5,139
Suckers			983	118			983	118
Tautog					1,500	75	1,500	75
Crabs, soft					4,600	1,150	4,600	1,150
King crabs	500,000	1,500			130,000	390	630,000	1,890
Lobster					10,400	2,600	10,400	2,600
Clams, hard	3,400	1,700			640	640	4,040	2,340
Oysters, market, public	324,919	31,750			545,300	42,390	870,219	74,140
Oysters, market, private	1,942,563	293,975					1,942,563	293,975
Oysters, seed, public	1,376,949	75,558			126,000	7,200	1,502,949	82,758
Terrapin					300	300	300	300
Turtles	2,250	112					2,250	112
Total	4,881,039	448,821	130,598	21,857	20,011,556	181,770	25,023,193	652,448

VESSEL AND SHORE FISHERIES.

The products of the vessel and shore fisheries of Delaware are given in the following table. The products taken by vessels amounted to 21,462,331 pounds, valued at $456,518, and by boats in the shore fisheries to 3,560,862 pounds, valued at $195,930.

Products of the vessel and shore fisheries of Delaware in 1921.

Species.	Vessel fisheries.		Shore fisheries.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Alewives			351,590	$6,431	351,590	$6,431
Bluefish			1,325	265	1,325	265
Carp			87,820	13,166	87,820	13,166
Catfish			35,291	2,574	35,291	2,574
Croaker			418,873	18,682	418,873	18,682
Drum, black			1,150	22	1,150	22
Eels			16,012	1,598	16,012	1,598
Flounders			34,429	1,798	34,429	1,798
Gizzard shad			7,320	292	7,320	292
Menhaden	18,056,000	$67,710	26,000	260	18,082,000	67,970
Mullet			513	25	513	25
Perch, white			6,923	922	6,923	922
Perch, yellow			2,758	273	2,758	273
Pike			272	25	272	25
Sea bass			250	12	250	12
Shad			86,836	16,312	86,836	16,312
Spot			14,600	928	14,600	928
Squeteagues or weakfish			886,550	53,317	886,550	53,317
Striped bass			4,915	1,426	4,915	1,426
Sturgeon			12,090	1,813	12,090	1,813
Sturgeon roe			1,872	5,139	1,872	5,139
Suckers			983	118	983	118
Tautog			1,500	75	1,500	75
Crabs, soft			4,600	1,150	4,600	1,150
King crabs			630,000	1,890	630,000	1,890
Lobster			10,400	2,600	10,400	2,600
Clams, hard	3,400	1,700	640	640	4,040	2,340
Oysters, market, public	72,919	13,750	797,300	60,390	870,219	74,140
Oysters, market, private	[1] 1,942,563	293,975			[1] 1,942,563	293,975
Oysters, seed, public	1,387,449	79,383	115,500	3,375	1,502,949	82,758
Terrapin			300	300	300	300
Turtles			2,250	112	2,250	112
Total	21,462,331	456,518	3,560,862	195,930	25,023,193	652,448

[1] Includes 1,543,057 pounds (220,437 bushels) taken up by New Jersey owners.

FISHERIES BY APPARATUS.

The principal forms of fishing apparatus used in the fisheries of Delaware in 1921 included gill nets, with a catch of 275,840 pounds, valued at $30,406; purse seines, with 18,056,000 pounds, valued at $67,710, consisting entirely of menhaden; haul seines, with 1,578,466 pounds, valued at $81,882; and dredges, tongs, etc., with 4,949,771 pounds, valued at $455,103. The remainder of the catch was taken with pound nets, fyke nets, hand lines, pots, and minor nets. The catch taken with each form of fishing apparatus in the vessel and shore fisheries combined is given in the following table:

Yield of the fisheries of Delaware in 1921, by counties, apparatus, and species.

Apparatus and species.	Kent.		New Castle.		Sussex.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Gill nets:								
Alewives	11,230	$224			1,950	$39	13,180	$263
Carp			13,200	$1,980			13,200	1,980
Catfish	1,150	80	1,350	108			2,500	188
Croaker					76,550	3,062	76,550	3,062
Gizzard shad			7,320	292			7,320	292
Menhaden					26,000	260	26,000	260
Mullet	153	10					153	10
Perch, white	800	96					800	96
Pike	163	14					163	14
Shad	329	85	10,123	2,853	63,885	11,058	74,337	13,996
Spot					9,650	532	9,650	532
Squeteagues					36,275	2,236	36,275	2,236

Yield of the fisheries of Delaware in 1921, by counties, apparatus, and species—Continued

Apparatus and species.	Kent.		New Castle.		Sussex.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*
Gill nets—Continued.								
Striped bass					1,750	$525	1,750	$525
Sturgeon	520	$78	11,570	$1,735			12,090	1,813
Sturgeon roe	165	453	1,707	4,686			1,872	5,139
Total	14,510	1,040	45,270	11,654	216,060	17,712	275,840	30,406
Pound nets:								
Carp			1,760	264			1,760	264
Catfish			5,595	447			5,595	447
Eels			209	21			209	21
Perch, white			352	35			352	35
Perch, yellow			288	24			288	24
Squeteagues			300	24			300	24
Total			8,504	815			8,504	815
Haul seines:								
Alewives	51,760	1,835			276,650	4,133	328,410	5,968
Bluefish					1,325	265	1,325	265
Carp	7,131	1,063	14,929	2,240	5,995	899	28,055	4,202
Catfish	2,196	162	6,426	488	2,160	162	10,782	812
Croaker	141,848	7,591			189,375	7,585	331,223	15,176
Drum, black					1,150	22	1,150	22
Flounders					6,219	381	6,219	381
Mullet					360	15	360	15
Perch, white	1,524	228			3,017	416	4,541	644
Perch, yellow					220	24	220	24
Pike					109	11	109	11
Shad	905	222			11,594	2,094	12,499	2,316
Spot					4,950	396	4,950	396
Squeteagues	492,625	29,556			352,000	21,120	844,625	50,676
Striped bass	973	244			2,042	612	3,015	856
Suckers			983	118			983	118
Total	698,962	40,901	22,338	2,846	857,166	38,135	1,578,466	81,882
Purse seines: Menhaden					18,056,000	67,710	18,056,000	67,710
Fyke nets:								
Alewives					10,000	200	10,000	200
Carp	1,150	172	9,320	1,398	1,850	277	12,320	1,847
Catfish	1,908	147	12,420	822			14,328	969
Croaker					6,000	240	6,000	240
Eels	335	33	5,927	591			6,262	624
Flounders					27,960	1,402	27,960	1,402
Perch, white					1,230	147	1,230	147
Perch, yellow					2,250	225	2,250	225
Squeteagues					600	36	600	36
Striped bass					150	45	150	45
Turtles	2,250	112					2,250	112
Total	5,643	464	27,667	2,811	50,040	2,572	83,350	5,847
Hand lines:								
Croaker					5,100	204	5,100	204
Eels					200	20	200	20
Flounders					250	15	250	15
Sea bass					250	12	250	12
Squeteagues					4,750	345	4,750	345
Tautog					1,500	75	1,500	75
Terrapins					300	300	300	300
Total					12,350	971	12,350	971
Pots:								
Eels	1,865	186	4,476	447	3,000	300	9,341	933
Lobsters					10,400	2,600	10,400	2,600
Total	1,865	186	4,476	447	13,400	2,900	19,741	3,533
Minor nets:								
Carp	11,105	1,666	21,380	3,207			32,485	4,873
Catfish	1,123	81	963	77			2,086	158
Crabs, soft					4,600	1,150	4,600	1,150
Total	12,228	1,747	22,343	3,284	4,600	1,150	39,171	6,181

Yield of the fisheries of Delaware in 1921, by counties, apparatus, and species—Continued.

Apparatus and species.	Kent.		New Castle.		Sussex.		Total.	
	Pounds.	*Value.*	*Pounds.*	*Value.*	*Pounds.*	*Value.*	*Pounds.*[1]	*Value.*
Dredges, tongs, etc.:								
King crabs	500,000	$1,500			130,000	$390	630,000	$1,890
Clams, hard	3,400	1,700			640	640	4,040	2,340
Oysters, market, public	324,919	31,750			545,300	42,390	870,219	74,140
Oysters, market, private	[1]1,942,563	293,975					1,942,563	293,975
Oysters, seed, public	1,376,949	75,558			126,000	7,200	1,502,949	82,758
Total	4,147,831	404,483			801,940	50,620	4,949,771	455,103
Grand total	4,881,039	448,821	130,598	$21,857	20,011,556	181,770	25,023,193	652,448

[1] Includes 1,543,057 pounds (220,437 bushels) taken up by New Jersey owners.

INDUSTRIES.

Wholesale trade.—In the wholesale fishery trade of Delaware in 1921, there were 9 establishments, valued at $38,950, with a cash capital of $33,500, employing 112 persons, to whom $19,480 were paid in wages. Of these firms, 7 handled oysters, 1 handled fresh fish, and 1 manufactured scrap from king crabs. Statistics of the investment, persons engaged, and wages paid in the wholesale fishery trade of Delaware are given by counties in the appended table.

Menhaden industry.—There was one establishment in Delaware engaged in the menhaden industry. The statistics for this plant have been included with the statistics of the menhaden industry for New York, page 88.

Wholesale fishery trade of Delaware in 1921, by counties.

Items.	Kent and New Castle.		Sussex.		Total.	
	Number.	*Value.*	*Number.*	*Value.*	*Number.*	*Value.*
Establishments	4	$22,150	5	$16,800	9	$38,950
Cash capital		7,500		26,000		33,500
Persons engaged	25		87		112	
Wages paid		4,280		15,200		19,480

ARTIFICIAL PROPAGATION OF BROOK TROUT AND RAINBOW TROUT, WITH NOTES ON THREE OTHER SPECIES.[1]

Revised and enlarged by GLEN C. LEACH, *Assistant in Charge of Fish Culture.*

CONTENTS.

[1] Appendix VI to the Report of the U. S. Commissioner of Fisheries for 1923. B. F. Doc. No. 955. This document represents a revision and enlargement of the chapters on "The brook trout," "The rainbow trout," and "Minor trouts" from A Manual of Fish Culture, Based on the Methods of the United States Commission of Fish and Fisheries, with Chapters on the Cultivation of Oysters and Frogs, revised edition, published in 1900.

BROOK TROUT.

The propagation of the brook trout is conducted under widely differing conditions throughout the natural and acclimated range of the fish. While the general principles on which the work is based are essentially the same everywhere, the details connected therewith must necessarily be modified to meet the varying conditions of climate, water supply, location, and the purposes in view. The aim of this article is to outline only those general principles, as it is manifestly impossible to enter minutely into all the details that would apply in any given section of the country. The material for the description of the methods outlined has been drawn from wide personal experience and observation.

DESCRIPTION.

The brook trout or speckled trout (*Salvelinus fontinalis*) is one of the most beautiful, active, and widely distributed of the American trouts. It prefers clear, cold, rapid streams, and belongs to that group of trouts known as charrs, characterized by the presence of round crimson spots on the sides of the body. Other members of this class are the saibling or charr (*S. alpinus*) of Europe and (*S. stagnalis*) of Greenland; the red charr (*S. Marstoni*) of eastern Canada; the Sunapee trout (*S. aureolus*) found in parts of New Hampshire, Maine, and Vermont; the blueback trout (*S. oquassa*) of the Rangeley Lakes in Maine, and Dolly Varden, red-spotted, or bull trout (*S. bairdii*) of the Pacific States and Alaska. The lake trout (*Cristivomer namaycush*) also belongs in this group.

The general form of the brook trout's body varies considerably, sometimes being elongated and sometimes rather short, but the usual depth is about one-fourth or one-fifth of the length. The head is large and blunt, and is contained four and one-half times in the body length. The large terminal mouth is provided with teeth on the jaws, tongue, and palate bones, and also with a small patch on the vomer. The eye is placed high in the head; its diameter is about one-sixth the length of head. The gillrakers on the first arch number about 17, of which 11 are on the lower arm. The scales are very small and numerous; about 230 are in the lengthwise series and 35 above and 35 below the lateral line. The dorsal and anal rays are 10 and 9, respectively. The tail is square or slightly lunate in the adult; forked in the young.

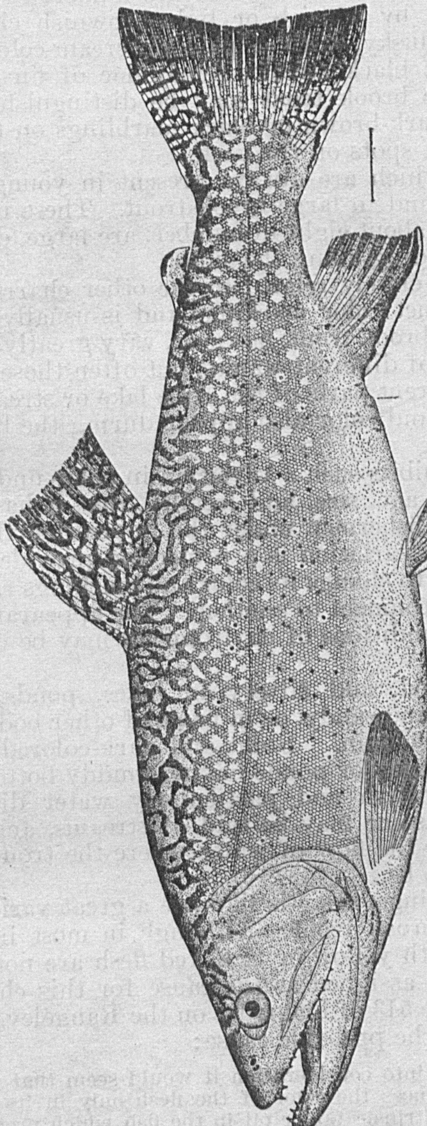


FIG. 1.—Brook trout (*Salvelinus fontinalis*).

There is considerable variation in the color of this trout, dependent on local conditions, sex, and age. The head, back, and sides of the body, dorsal and caudal fins are of a grayish or greenish color; the back, head, dorsal, and base of caudal are mottled with dark green or black. Along the middle of the side are numerous round, light-red spots surrounded by whitish or light-brownish circular areas. The lower fins are dusky, with a pale or cream-colored anterior border bounded by a black streak; remainder of fin often red in breeding males. The brook trout may be distinguished from the other charrs by the dark-brown or black marblings on the back and the general absence of spots on the back.

The parr marks, which are always present in young trouts and salmons, are often found in large brook trout. These marks, which in the brook trout are about eight in number, are large, dark, vertical blotches or bars extending along the sides.

The brook trout is closely related to the other charrs mentioned, but it has quite distinct color markings and is usually less slender in form. Individual brook trout, however, vary greatly in form and color; not only those of different waters, but often those of the same body of water or different parts of the same lake or stream. Modifications of both form and color also appear during the breeding season.

The brook trout exhibits such a variation in color under the varying conditions of sex, age, size, and locality, that it has been given many local names by fishermen under the impression that it was a distinct species. This variation is a protection provided by nature which permits the fish to change its color and markings rapidly when passing from one environment to another. The appearance of brook trout under various conditions of environment may be described, in general, as follows:

Slender, light-colored, and silvery in lakes, ponds, and swift streams that are clear and sandy, or in parts of other bodies of water where such conditions obtain. Stout and dark-colored in lakes or ponds or localities of lakes or ponds having muddy bottom and considerable vegetable growth and particularly water discolored by vegetable stain. The same may be said of streams, and it may be added that the swifter the flow of water where the trout occurs the slenderer it is likely to be.

As in external markings, there is likewise a great variation in the color of the flesh of brook trout. Although in most instances the flesh is white, trout with yellow or rich, red flesh are not rare. Several reasons have been assigned as the cause for this characteristic. W. C. Kendall, on page 543 of his paper on the Rangeley Lakes, Me.[2] gives the following as the probable cause:

After taking everything into consideration it would seem that the character or quantity of food influences the color of the flesh only in its fattening effects, and it is only the intrinsic fat or oil in the fish which produces the red flesh and delicious flavor of the red-meated trout. The oil or fat is naturally red as that of some other animals is naturally white or some other color, and

[2] The Rangeley Lakes, Me., with Special Reference to the Habits of the Fishes, Fish Culture, and Angling. By William Converse Kendall. Bulletin, U. S. Bureau of Fisheries, Vol. XXXV, 1915–16, pp. 485–594, Pls. XL–XLVI. Bureau of Fisheries Document No. 861, issued May 25, 1918. Washington.

it is the amount permeating the fish that gives the color its intensity. A well-fed, comparatively inactive adult trout will present a more intensive shade of the flesh than a fish of the same age living in running water, where its livelihood depends upon its activity, although it may be a well-conditioned, shapely fish. In the latter instance the food has been assimilated and utilized in the development of energy.

SIZE.

The size of the brook trout varies in different localities and probably is influenced by the abundance of natural food and the characteristics and range of the water in which it is found. A trout will not attain a very large size in a restricted environment no matter how much food it has. The average size, as taken from time to time in any given body of water, is remarkably uniform. It is generally true, and particularly as regards waters of small extent, that the size of the fish decreases in proportion to the numbers occupying a given body of water. Referring again to Kendall's Rangeley Lakes paper, we read on page 550:

> As previously stated, trout grow faster and larger in the larger bodies of water when food is plentiful than in smaller or more circumscribed places. Given plenty of room and plenty of food, it is a question to what size a trout might not attain. There are at least two natural conditions aside from those of environment just mentioned that probably affect trout. There is, doubtless, a natural size limit beyond which the trout could not go if it lived to be 200 years old; but even if there were no size limit, the species doubtless has a more or less definite life tenure that would in any case limit its growth.
>
> The comparatively recent development of the study of scales has shown that rarely, if ever, is a greater age than 10 years attained by European trout (*S. fario*), and probably not that; the lake trout of Scandinavia probably not over 12 years.
>
> Allowing, then, an average growth of 1 pound a year, as suggested by Mr. Page's experiment, the record fish would be only 12½ years old. It is quite probable that trout seldom live longer than 12 or 15 years.

The largest brook trout taken in American waters whose weight has been reliably authenticated was from Rangeley Lakes, Me., its weight being 12½ pounds, while from the Nepigon River, a Canadian tributary of Lake Superior, an example weighing 14½ pounds is recorded. From other streams brook trout weighing 10 and 11 pounds are recorded, but individuals of these sizes are by no means common.

The rate of growth also varies with the surrounding conditions, and is more rapid in water having a fairly uniform temperature throughout the year. The most favorable temperature for this fish is from 45 to 65° F. In the waters of the Rocky Mountain States where it has been successfully introduced, the brook trout grows rapidly and attains a large size. At present probably the largest examples are to be found in certain of the natural and artificial lakes of the lower altitudes of Colorado, though in the colder waters of the State, in altitudes ranging above 4,000 to 5,000 feet, it probably does not average more than 6 to 8 inches in length. Under favorable condititons the average growth is about as follows:

	Inches.
1 year old	4 to 5
2 years old	7 to 8
3 years old	10 to 12
4 years old	14 to 16

At 3 years the average weight should be about 1 pound. It is probable that fish under congenial artificial environment, receiving food regularly, will somewhat exceed this rate of growth. Because of the flavor and fine quality of its flesh the brook trout is highly esteemed as a table delicacy, and, as it is very game, it is much sought after by sportsmen. Those from clear, swift streams do not grow as large as those found in quiet and deeper waters but are superior in quality and appearance.

FOOD.

The brook trout has a voracious appetite and takes advantage of every opportunity to satisfy it. Some observers believe that brook trout do not feed during the spawning season. This may be true, in a measure, of wild fish, but fish that are kept under domestication and regularly cared for continue to feed throughout this period. In the wild state the species is no doubt largely carnivorous, its food consisting chiefly of Crustacea, Mollusca, and various forms of insects and worms. When pressed by hunger, it does not hesitate to devour its kind. Under domestication, however, it can readily be induced to eat mush made of various cereals. Kendall (loc. cit.) has the following to say regarding the feeding habits of the brook trout:

> The trout seems to avail itself of whatever animal life is available, and vegetable food is not always eschewed. A detailed list of what trout have been known to eat would be more astonishing than valuable. However, the general and principal food supply upon which the adult fish depends may be divided into two classes—fishes and insects.
>
> The trout of brooks subsist largely upon insects, particularly the aquatic larvæ of numerous species, such as caddis flies, Mayflies (*Chironomus*), and dragonflies, and also upon insects that fall upon the water or hover the water while depositing their eggs. The food of trout of larger streams, ponds, and lakes, of course, consists of the particular kinds that the waters afford, and these often differ materially from each other and seasonably in the same water. In all waters there is a seasonal supply of insects that varies with the season and locality; but where food in the form of fishes is available the insect food appears to be more or less neglected, particularly by the larger fish.
>
> The diet of the trout, however, varies not only with the season but with the age of the fish. The seasonal variation, however, may be one of convenience, but that of different stages of growth is influenced by suitability. The first food of trout fry consists largely of minute crustaceans and small insect larvæ, such as *Chironomus*, black fly, etc., and that of the fingerling of larger insect larvæ, worms, and small insects, which diet, however, is not exclusive and is controlled more or less by the habitat and environment.

COMMERCIAL IMPORTANCE.

While not to be compared in this respect with most of the fishes prominent in our market fisheries, there has been developed in recent years an important and apparently growing industry in connection with the brook trout. The comparative ease with which it may be brought under domestication, the constantly increasing demand in this country and elsewhere for the eyed eggs and fingerlings for the stocking of public and private waters, and the ready sale in many sections of the country for the adult fish at high prices as a table delicacy has induced a number of fish-culturists to undertake their artificial propagation on a commercial basis in New England, Pennsylvania, New York, and in many sections of the Western States. As the brook trout usually will spawn during the second year, many of the commercial breeders hold their fish through the first spawning period only and are able to dispose of both the eggs and parent fish at a profit.

RANGE AND SPAWNING SEASON.

The natural range of the brook trout in the United States is in the eastern section of the country. In Canada it occurs in many streams and tributary waters of the Great Lakes, the St. Lawrence River, and the Gulf of St. Lawrence, at least as far north as Hamilton Inlet on the Labrador coast. Its northern limit is not definitely known, but it extends southward in the Alleghenies to headwaters of streams in the mountains of Georgia and Alabama. It was also found naturally originally in the Great Lakes region of the United States as far west as Minnesota.

Owing to its hardy nature and ability to adapt itself to new surroundings, the species may be successfully transplanted into suitable streams, and it has become established in nonindigenous waters in Michigan, Wisconsin, Minnesota, many of the waters of the Rocky Mountains and the Pacific coast, in the Eastern States, and in creeks and rivers of the Allegheny Mountains. With the possible exception of the rainbow trout and steelhead it is the hardiest member of the salmon family and will make a brave struggle for existence even with adverse surroundings.

All streams can not be successfully stocked with this species. The flow must not be too sluggish nor the temperature of the water too high, although an unfavorable temperature, if not excessively high, is no serious obstacle where the current is swift enough to insure thorough aeration of the water or where the fish can run into spring-fed creeks flowing into the main stream. The ideal brook-trout stream receives numerous spring-fed tributaries throughout its course, so that its temperature does not exceed 65° F. in summer and by the same means is maintained at a relatively high temperature during the winter months. It has stretches of gravelly bottom, clear, shallow water, and a steady current. It should also contain large bowlders or projecting points of land at intervals for the formation of quiet eddies and deep pools.

Any stream having a summer temperature greater than 65° can hardly be considered suitable for brook trout unless it has large spring tributaries accessible to the fish during the heated period. Through the cutting away of the forests and the cultivation of the land many streams in the eastern part of the United States have become unsuited to brook trout. Wash from cultivated land during periods of heavy rainfall roils the streams and destroys much of the natural food contained in them. The rainfall on cultivated slopes drains rapidly into the adjacent streams, causing alternate periods of freshets, with turbid water, and drought. In wooded or uncultivated sections the rainfall is retained by the soil and returns to the streams in a uniform flow of cool, sparkling spring water, extending through periods of little rainfall. Streams flowing through open or cultivated areas are subject to high summer temperatures, influenced by the direct rays of the sun, and evaporation is increased proportionately. It may therefore be said that the best trout streams are to be found in wooded, hilly, or mountainous sections.

Remarkable results have been attained in introducing this fish into new waters in many sections of the country and in foreign lands, one of the most noteworthy instances being in connection with the Au Sable River in Michigan. This stream originally was the home of the grayling, a spring spawner. The utilization of the river by the lumber interests for the passage of logs at the time of the year when the grayling were spawning resulted in the destruction of the spawning beds and the consequent gradual disappearance of that species. The brook trout was suggested as the proper substitute because its spawning season is in the fall when the river is undisturbed. The work of stocking this river with brook trout was undertaken by the Michigan Fish Commission in 1885, during which year 20,000 fry were planted. This plant was followed from time to time by others, and the outcome of the attempt was so successful that during the spawning season of 1895 about 10,000 trout were captured on the spawning beds by means of a small seine and their eggs taken for artificial propagation. Many other Michigan streams where this fish was not indigenous have since been successfully stocked.

The most remarkable results of this work of acclimatization have been attained in the Black Hills and the Rocky Mountains. In these regions beautiful lakes and rivers hundreds of miles in extent, which formerly were either devoid of fish life or inhabited by coarse species of little value have been stocked so successfully with brook trout by the Bureau of Fisheries that they now constitute its chief source of supply for collections of wild eggs of that species.

In its native haunts, whether in lake or stream, the brook trout is always found in clear, cold spring water when it is accessible. When freshets occur, it pushes from lakes or rivers into the spring brooks of the upper waters, seeking out deep pools and eddies where it can lie concealed beneath the shelter of grassy banks or accumulations of drift and see without being seen. Throughout its range the brook trout spawns in autumn during the falling of the water temperature, the season beginning earlier in the north than in southern latitudes. In the Colorado region the first eggs are deposited in September and sometimes in August, while in New York and New England the season usually begins about the middle of October. Generally speaking, the spawning period does not last more than three or four weeks, though in some parts of the country, where the fish live in a copious flow of spring water subject to little change of temperature, it may cover three months or more.

As the spawning time approaches the fish seek suitable gravel beds for the deposition of their eggs. Those inhabiting lakes and ponds may find suitable nesting spots in those waters, or they may enter tributary streams, sometimes pushing long distances up to their headwaters. A favored nesting locality in a stream is at the head or the foot of a large pool, where the water ripples gently over gravel bars. The males usually precede the females, and they frequently have the beds well cleaned before the latter appear. The nests are formed by working out little depressions in the gravel and scrupulously clearing them of all sediment. In lakes or ponds such nests are made on gravelly shoals or bars where seeping water is present, either in the form of springs entering the pond or lakes or water seeping from the pond through a porous section of its bottom.

The fish usually pair on the nests, the males fighting viciously for the possession of the females. A few eggs are deposited at a time by a female and fertilized by the milt which the male simultaneously deposits. This process of spawning and impregnation by a pair of fishes is repeated many times until all the eggs have been deposited, and through the constant working of the fish on the beds the eggs become buried in the gravel. After a spawning bed is once occupied it is hard to drive the fish away, the female, especially, returning to it despite all hindrances. A female taken from her nest, marked, and placed in the water a mile downstream was found occupying the nest the following morning. The males remain on or near the beds for some time after the last females have spawned and left.

CHARACTER OF THE EGGS.

Brook trout eggs will average about one-sixth of an inch in diameter, but there is a great variation in the size of eggs taken from fish of different localities. Frequently lots are found of which little more than 300 eggs are required to make a fluid ounce, while other eggs are so small as to measure 700 to the ounce. Fish-culturists favor the larger eggs, as it is generally believed that they produce stronger and better fish than the smaller ones. The time necessary for developing the eggs is dependent on the temperature of the water, varying from about 125 days in water at 37° F. to about 50 days in water at 50° F.

PROPAGATION.

The first attempt to artificially propagate trout in America was made in Ohio in 1853 with marked success. Further satisfactory trials were made in 1855 and 1859 in Connecticut and New York, and in 1864 a hatchery was established in New York which carried on the work on a large scale. Somewhat later trout propagation was taken up by other State authorities and by the Federal Government, and it is now extensively conducted in many parts of the country.

WATER SUPPLY.

In selecting a location for a trout hatchery the first consideration is an ample supply of suitable water so situated with reference to the proposed hatchery that it can be brought completely under control. In this matter there is a rather wide range of choice. Perhaps the very best sources of water supply are deep-seated and well-protected springs, lakes of considerable depth, or spring-fed brooks.

In many instances spring water as it issues from the ground is quite unsuited to fish-cultural purposes, and before introducing it into the hatchery it should be exposed to the air for the correction of possible faults in aeration. Sometimes it may be possible to excavate a small, deep pool to form a reservoir, inclosing it to protect the water from sunlight, leaves, and débris of various kinds and to prevent small animals from entering it. Outside the spring house should be a ditch deep enough to convey all surface water away from the spring into a waste ditch. The inside of the reservoir should be protected by a foundation wall of loose masonry, the point above the water line being made substantial with mortar, building the house or cover above it, with a suitable overflow cut through the side of the masonry to provide an outlet for surplus water. The best results are obtained where the supply pipe leading from the spring to the hatchery is placed 2 feet or more below the surface of the spring and is continued underground at as great a depth as possible in order to insure a uniform temperature as it enters the hatchery. The most favorable temperature is 48° where the water leaves the ground, though no harm will result if it varies 3 or 4° either way. The entrance to the intake pipe should be covered with a wire screen inside the spring house.

If lake water is selected, the supply should be taken at a short distance below the outlet of the lake with rapids intervening if possible. The temperature of the water in lakes is influenced by the depth, and a deep lake, as a rule, affords water of more uniform temperature than a shallow one. Such water is generally quite even in volume and temperature. It is cold in winter and warms up slowly in the spring, assuring a slow normal development of the eggs, which is more conducive to the health and vigor of the resulting fry than rapid development.

A water supply obtained from a brook or stream is usually inferior to that from a spring or lake by reason of its susceptibility to floods, turbidity, and droughts, although a brook fed largely by springs may to some extent be free from these objections. In cold climates anchor ice at the intake is a serious cause of annoyance in connection with brook water. If the flow from a spring is not sufficient and lake water is not available, it would be advantageous, if possible, to have a combination of spring and river or brook water. Water from both sources should be brought to the hatchery in such a way as to permit of their use either separately or in combination, so that a temperature between the maximum of the spring and the minimum of exposed water may be maintained during cold weather. Under this arrangement the spring water may be utilized to force early hatching when desirable and the water from the exposed stream used for retarding development. This is a matter of importance in northern latitudes where the winters are long and cold and the waters locked with ice until late April or early May, conditions unfavorable for the distribution of fry. Farther south, where the waters remain open all or nearly all of the year, it is not such an essential factor.

Between these different sources of supply there is, of course, a great number of gradations. Water from boggy and stagnant ponds or marshes is objectionable, for although water of excellent quality, capable of bringing out the most vigorous of fish, may sometimes be had in such places, yet when not supplied by springs it is dependent for its freshness on rainfall, an unreliable source. Furthermore, bog water, particularly that from sphagnum bogs, is often excessively acid, and therefore deleterious to trout.

In some localities a meager flow of spring water may be successfully augmented by artesian wells. The suitability of such water for fish-cultural purposes should be determined in advance of extensive preparations, as water from such wells is frequently lacking in certain elements vital to fish life.

It is best to select a site for a hatching establishment in time of extreme drought, and if there is then an ample supply of pure sweet water the first requisite is fulfilled. It is also well to visit the place in time of flood, and during severe winter weather if in a cool climate, to learn what dangers must be guarded against. The volume of water necessary will depend upon its temperature, character as to aeration, the facilities existing for its aeration and repeated use, and the capacity of the proposed establishment. With water of the highest quality, low temperature, and adequate facilities for aeration, possibly 3 to 5 gallons per minute, or even less, will be sufficient for the incubation of 100,000 eggs. As the temperature rises or the facilities for aeration are curtailed a larger volume will be necessary. In the case of spring water having a temperature ranging between 48 and 52° F., aerated only by exposure in a pool and with no facilities in the hatching house for aeration, the amount necessary to incubate eggs in a trough of any given dimensions will be from 5 to 8 gallons per minute. As the number of eggs in a trough will vary from 40,000 to 50,000, or even more, no set rule can be applied. The proposition is different with relation to fry. A hatching trough 14 to 16 feet long and holding from 25,000 to 40,000 fry will require 6 to 8 gallons of water per minute. On the basis of 100,000 fish it may be figured that the following amounts of water will be required:

	Gallons.
Fry up to feeding stage	30
Fingerlings, 1 to 4 months old	50
Fingerlings, 4 to 6 months old	100
Fingerlings, 6 to 12 months old	200

These amounts are ample and probably even half as much would suffice if it were necessary to economize in the use of water.

If the water supply is drawn from a small brook or spring, it is necessary to measure the volume approximately, which is easily done. With a wide board 1 inch thick and having a smooth 1-inch hole bored through the middle, a tight dam is made across the stream so that all the water will have to flow through the hole in order to escape. If the water above the board rises just to the top of the hole, it indicates a volume of 2.3 gallons per minute. A rise of one half inch above the top of the hole indicates a volume of 3.5 gallons per minute; a rise of 2 inches, 5 gallons per minute; 13 inches, 12 gallons per minute. If two 1-inch holes are bored twice the volume will be indicated in each case, of course. The quantity of water flowing through holes of different sizes is in proportion to the squares of their diameters. Thus, a 2-inch hole permits the passage of four times as much water as a 1-inch hole. A tube whose length is three times its diameter will allow 29 per cent more water to pass than a hole of the same diameter through a thin plate or board.

THE HATCHERY SITE.

When a satisfactory supply of water has been found, a site that affords facilities for creating a head of water to provide the requisite fall into and through the troughs, security against inundation and severe freezing, and for general safety and accessibility must be selected for the hatchery. The extent of fall from the source of the water supply to the hatching house can hardly be too great. The minimum is as low as 3 inches, but only under circumstances in other respects extremely favorable will this answer the purpose, and then it is permissible only where there is an ample supply of aerated water, where the hatching troughs are less than standard in length, and where there is no danger of inundation. One disadvantage of a 3-inch fall is the impracticability of utilizing any form of aerating apparatus; another is the necessity of placing the troughs below the level of the hatchery floor. This makes the work of attending the fish and eggs very laborious. A fall of 1 foot will do fairly well if there is entire safety from inundation, as then the troughs may be placed on the floor, which is better than below it though still inconvenient, and some of the simpler aerating devices can be introduced. A fall of 3 feet is better, but a 10-foot fall is much better still as it permits the placing of the lowest hatching troughs 3 feet above the floor and leaves ample room for complete aeration. Everything depends upon the volume and character of the water, however, and upon its aeration before reaching the hatchery. In a small establishment there is no necessity for additional aeration in the building, and therefore a 3-foot fall is adequate.

Inspection of the site during flood season will suggest the safeguards necessary to provide against inundation. If located by the side of a brook, the building should not obtrude too much on the channel, and below it there should be ample outlet for everything that may come in the way of floods or freshets. Often much can be done to improve a poor site by clearing out and enlarging a natural watercourse. In a cold climate it is an excellent plan to have the building partly under ground for greater protection against cold. When spring water is used, there is rarely any trouble from the formation of ice in the troughs, even in a cold building, but in the latitude of the northern tier of States the water from lakes, rivers, or brooks is so cold in winter that if the air of the hatchery is allowed to remain much below the freezing point ice will form in the troughs and on the floor to such an extent as to be a serious annoyance. In very cold climates stoves are needed to warm the air sufficiently for the comfort of the attendants, but the building should be so located and constructed that it may be left without a fire for weeks without any dangerous accumulation of ice, and if the site does not permit of building the house partly under ground, the walls must be thoroughly constructed and well banked with earth, sawdust, or other material. In warmer climates no trouble will be experienced from that source. The type of building will, of course, be governed by the exigencies of each individual case. The location selected, extent and character of the fish-cultural work proposed, and the funds available, are all to be considered. The foregoing suggestions would apply to a small establishment in a more or less remote section and where strict economy in construction and operation are important.

DAMS.

The required head of water can often be obtained by throwing a dam across a stream and locating the hatchery near by. The dam will cause a small pond to form, serving the double purpose of aerating and settling the water. Unless the bed and the banks of the stream are of such character as to insure safety from under-mining or washing out it is not wise to attempt more than a 2-foot head in this way. With any bottom except one of solid ledge there is always danger, and washouts are very troublesome and difficult to control. Methods of dam construction and the materials used must depend on local conditions. Other conditions being equal, a concrete dam offers advantages in permanency and low cost of upkeep. In any case a spillway to care for flood waters and avoidance of the danger from washouts mentioned above are important considerations.

If there is a scarcity of water, or if it be desirable for aerating or other purposes to secure a considerable fall, it will be advisable to construct the dam on higher ground, some distance above the building site, where a low dam will suffice to turn the water into a conduit in which it may be carried to the hatchery at the desired level. A square conduit made of planks, carefully jointed and nailed, in nearly all cases is satisfactory and a small one will suffice for an ordinary establishment. A thorough coating of hot tar inside and out previous to use acts as a preventative of leaks and decay. Pipe is generally more desirable than the conduit, and galvanized iron is preferable to black. Perhaps the most durable and otherwise satisfactory material for a water supply conduit for a permanent establishment is wood stave pipe. Such pipe properly installed and constantly carrying its full capacity gives satisfactory service for a long period of time. It deteriorates when exposed and not full of water.

WATER-SUPPLY INTAKE.

If the water supply is to be taken from a stream, and a dam has been constructed to create the required head, the extension of the conduit through the dam is an important point to be observed. Unless this is done and the intake end of the conduit is properly screened and protected there is bound to be serious trouble from clogged or damaged pipes, resulting in the cutting off of the hatchery water supply.

A very satisfactory intake for meeting the conditions mentioned consists of a rectangular box of concrete construction of any desired dimensions to meet the requirements of the case. The upstream face of the dam forms one end of the box, and the shoreward side extends upstream parallel with the bank for 15 to 20 feet, or any required distance. The upstream end of the box is projected into the stream, and the wall forming the remaining side is so placed as to present an angle of 20° to the flow of the stream. In this position it serves effectively to deflect ice or other drift from the screen guarding the entrance to the intake.

Between the downstream end of the outside wall of the box and the dam is a space sufficiently large to permit the free passage of water to the intake. This space is protected by a screen consisting of a frame of 2 by 4 material of the proper size, in which is inserted a grating of ¾-inch galvanized pipe spaced 2 inches apart. Inside the inclosure thus formed, and midway between the walls, a deflecting partition extends upstream from the dam to a point some 3 to 5 feet from the upstream end of the inclosure. This aperture is guarded by a second screen placed at an angle of about 45°, the bars being spaced about 1 inch apart.

In operation water enters the intake box through the screen in the outside wall adjacent to the dam, reverses its flow, passes through the inner screen, around the head of the deflecting wall, and thence into the supply pipe. An intake box constructed in this manner and provided with a cement top, with the necessary openings and covers for access to the inner screen and pipe, may be entirely submerged during flood periods without interrupting the flow of water. To insure the greatest efficiency from the pipe line, the section entering the intake box should be several sizes larger than the main line. Thus, if an 8-inch pipe is used the pipe entering the intake box should be 12 or 14 inches and taper to 8 inches in the course of the first 8 or 10 feet of its length. The end of the pipe in the intake box should be submerged to a depth of at least 18 inches.

CAPACITY OF WATER PIPES.

The amount of water conveyed by pipes of various sizes is dependent on the head of water, length, kind, and quality of pipe used, and the manner in which connecting joints are made and the pipe is laid. Unavoidable imperfections in the work of installation of the water supply in a hatchery make it advisable to allow liberal safety factors in applying hydraulic formulas to the work. The "head" or "total head," as applied to the flow of water through pipes or other conduits, means the vertical distance from the level surface of the water at the source of supply to the center of the opening through which the discharge takes place freely in the open air. Theoretically and in practice it makes no difference, as regards the quantity of water discharged, whether the pipe is inclined downward or upward, provided the total head and the length of pipe remain the same.

The following table indicates approximately the velocity in feet per second and the supply delivered in imperial gallons[8] per minute for long pipe lines flowing full:

TABLE 1.—*Velocity in feet per second and supply in gallons per minute, long cylindrical pipes flowing full.*[a]

Diameter of pipe.	Head of water divided by length of pipe.							
	$\frac{1}{1000}$		$\frac{3}{1000}$		$\frac{5}{1000}$		$\frac{9}{1000}$	
	Velocity per second.	Supply per minute.	Velocity per second.	Supply per minute.	Velocity per second.	Supply per minute.	Velocity per second.	Supply per minute.
	Feet.	*Gallons.*	*Feet.*	*Gallons.*	*Feet.*	*Gallons.*	*Feet.*	*Gallons.*
2 inches	0.522	4.26	1.02	8.29	1.37	11.17	1.92	15.65
2½ inches	.600	7.64	1.16	14.76	1.56	19.85	2.18	27.75
3 inches	.670	12.30	1.29	23.64	1.73	31.73	2.41	44.29
4 inches	.798	26.03	1.52	49.63	2.04	66.46	2.83	92.51
5 inches	.911	46.48	1.73	88.14	2.31	117.80	3.21	163.69
6 inches	1.02	74.64	1.92	140.83	2.56	187.95	3.55	260.81
7 inches	1.11	111.09	2.09	209.22	2.79	278.90	3.87	386.57
8 inches	1.20	156.92	2.26	294.70	3.01	392.46	4.16	543.49
9 inches	1.29	212.71	2.41	398.58	3.21	530.36	4.44	733.83
10 inches	1.37	279.16	2.56	522.08	3.40	694.24	4.71	959.88

[a] Pocket-Book of Useful Formulæ and Memoranda for Civil and Mechanical Engineers. By Sir Guilford L. Molesworth. 23d edition. Page 285. E. and F. N. Spon. London.

[8] Imperial British gallon, 277.274 cubic inches; American gallon, 231 cubic inches.

TABLE 1.—*Velocity in feet per second and supply in gallons per minute, long cylindrical pipes flowing full*—Continued.

Diameter of pipe.	Head of water divided by length of pipe.							
	1/100		3/100		5/100		9/100	
	Velocity per second.	Supply per minute.	Velocity per second.	Supply per minute.	Velocity per second.	Supply per minute.	Velocity per second.	Supply per minute.
	Feet.	*Gallons.*	*Feet.*	*Gallons.*	*Feet.*	*Gallons.*	*Feet.*	*Gallons.*
2 inches	2.04	16.61	3.76	30.72	4.99	40.67	6.86	56.01
2½ inches	2.31	29.45	4.26	54.35	5.63	71.79	7.74	98.73
3 inches	2.56	46.09	4.71	86.39	6.22	114.15	8.54	153.85
4 inches	3.01	98.60	5.51	179.73	7.27	237.17	9.97	325.41
5 inches	3.40	173.70	6.22	317.08	8.2	418.02	11.24	572.99
6 inches	3.76	277.10	6.86	504.05	9.04	663.96	12.38	909.42
7 inches	4.09	408.45	7.50	749.83	9.82	981.68	13.44	1,343.7
8 inches	4.41	575.83	8.02	1,046.8	10.55	1,377.3	14.43	1,884.3
9 inches	4.71	777.50	8.54	1,411.6	11.24	1,856.4	15.35	2,538.6
10 inches	4.99	1,016.9	9.04	1,844.3	11.89	2,424.5	16.25	3,314.2

Diameter of pipe.	Head of water divided by length of pipe.							
	1/10		3/10		5/10		9/10	
	Velocity per second.	Supply per minute.	Velocity per second.	Supply per minute.	Velocity per second.	Supply per minute.	Velocity per second.	Supply per minute.
	Feet.	*Gallons.*	*Feet.*	*Gallons.*	*Feet.*	*Gallons.*	*Feet.*	*Gallons.*
2 inches	7.27	59.29	13.10	106.64	17.18	140.18	23.43	191.16
2½ inches	8.20	104.60	14.75	188.42	19.33	246.46	26.34	335.86
3 inches	9.04	165.99	16.25	298.28	21.28	390.73	28.99	532.18
4 inches	10.55	344.23	18.92	617.47	24.76	808.21	33.70	1,099.9
5 inches	11.89	606.13	21.28	1,085.4	27.81	1,419.8	37.87	1,931.1
6 inches	13.10	959.72	23.43	1,720.4	30.63	2,248.9	41.65	3,058.2
7 inches	14.22	1,421.2	25.41	2,539.4	33.21	3,319.2	45.13	4,510.7
8 inches	15.26	1,992.7	27.25	3,557.6	35.60	4,647.9	48.38	6,315.4
9 inches	16.25	2,684.5	28.99	4,789.7	37.87	6,256.8	51.44	8,499.2
10 inches	17.18	3,504.5	30.63	6,246.9	40.01	8,161.0	54.33	11,081.3

In using these tables divide the head of water by the length of pipe. Example: Required the flow of water in a 5-inch pipe 200 feet long under a 10-foot head. 10÷200=.05. Referring to the table, under 5/100, it is seen that under these conditions a 5-inch pipe affords a velocity of 8.2 feet per second and supplies 418.02 gallons per minute.

A square conduit conveys approximately 25 per cent more water than a cylindrical pipe of the same diameter under similar conditions. Excepting in very unusual circumstances, a pipe less than 3 inches in diameter should not be used. Avoid sharp bends and the use of fittings as far as possible in laying the pipe line, as they tend by friction to reduce the flow of water. Forty-five-degree fittings are better than 90° fittings, but bending the pipe is most satisfactory. Pipes up to 6 inches in diameter and sometimes larger usually can be bent after heating. Abrupt bends in large pipe will require flanged joints.

If the water completely fills the conduit, air will be shut out entirely, while if the conduit is larger the quality of the water may be improved by aeration before it reaches the hatchery. If wood stave pipe is used, however, it should carry its full capacity of water, as otherwise it deteriorates rapidly.

In installing a long pipe line the expense involved in carrying it at an even grade over depressions or through high places is frequently excessive, and it is usually better to follow the general contour of the land over which the pipe is laid. This method, however, has the disadvantage of reducing the flow of water through increasing the length of the pipe. There is also danger of "air pockets" forming at the highest points in such a line, greatly reducing or even entirely cutting off the flow of water. To guard against such a contingency, vent cocks should be placed at all such high points.

AERATION.

Fishes, like all animals, require an abundant amount of air—oxygen—for their well-being. Unlike land animals, however, they do not obtain their supply of oxygen directly from the atmosphere, but it is absorbed from the water passing over their gills, organs performing a function similar to that of the lungs of land animals. It is obvious, therefore, that water suitable for the maintenance of fishes must carry in solution a sufficient amount of gaseous oxygen to meet the requirements of the fishes in this respect. Water from springs, wells, or sometimes deep lakes is quite deficient in this vital requirement, or such water may contain an excess amount of air or gases inimical to fish life. The remedy in either instance is the same—intimate contact with the atmosphere. Water readily absorbs oxygen whenever it comes in contact with the atmosphere, and by the same process it readily gives off any surplus oxygen or other gases that it may contain. The necessity for ample aeration of the water to be used in a hatching house has already been mentioned as a consideration of first importance, and some of the devices by which it is accomplished have been alluded to.

Water from a brook or stream that has been torn to froth by dashing down a steep stream bed will be saturated with the life-giving oxygen, but such water, after supplying 16 to 48 feet of hatching trough space, will have lost a part of its oxygen and will need further aeration before it enters another series of troughs. As mentioned above, water from other sources may be entirely deficient in this respect, and it is therefore desirable to resort to all practicable means for the correction of such possible faults in the water supply.

If the hatchery site commands a fall of 5 feet or more, suitable aeration may be accomplished by a series of miniature riffles in the conduit outside the building. The broader and thinner the sheet of water provided the more thoroughly will it be exposed to the air. If it must fall through the air instead of flowing down the face of a perpendicular board, both surfaces of the sheet of water will be exposed to the air, thus doubling the effect. When circumstances permit, it is best to aerate in the conduit, which, as already suggested, should be made wide and open for that purpose.

If sufficient aeration can not be accomplished outside the building, much may still be done as the water enters. While an open water supply trough in the hatchery is somewhat unsightly perhaps, it has

FIG. 2.—St. Johnsbury (Vt.) station hatchery.

Fig. 3.—Hatching trough and trays of eggs.

advantages for aeration over a closed pipe. For a hatchery containing 20 hatching troughs a supply trough 10 inches wide by 10 inches deep, inside measurements, will carry sufficient water. As it enters this inside supply trough from the main conduit the water should have as great a fall as possible, and a number of riffles throughout its length will aid aeration further. The hatching troughs should, if possible, be set some 6 inches lower than and 3 to 4 inches distant from the supply trough. A satisfactory method of regulating the flow of water to the hatching troughs is by means of a 2-inch brass-faced molasses gate, set about 3 inches above the bottom of the supply trough. The horizontal screens and blocks on which the water falls as it leaves the supply trough, mentioned in connection with the propagation of rainbow trout, are recommended. The same results may be obtained by causing the water to pass through a pan (a 6-quart size is satisfactory) with a perforated bottom before entering the hatching trough or through a series of such pans in a rack one above the other, spaced a few inches apart. In cases where the water from a hatching trough is used again in troughs at a lower level one of these or a similar device is desirable.

In most instances, temperature and other conditions being equal, the more perfect the aeration the smaller the volume of water required, and, conversely, the greater the volume the less aeration is needed. In any event exposure to the atmosphere under the conditions mentioned can not result harmfully, and it may be very beneficial to water from any source intended for fish-cultural purposes. The use of all practicable means of aeration is recommended.

HATCHERY EQUIPMENT.

The troughs and other equipment used in the incubation of trout eggs vary considerably as to dimensions. All of the various kinds in general use have meritorious features, and in many instances they were designed to meet peculiar local requirements. The general principle in each case remains the same. The eggs are placed on trays or in baskets which are installed in the troughs and supplied with a free circulation of water.

The standard trough used at stations of the Bureau of Fisheries is 14 feet long, 14 inches wide, and 8 inches deep inside. It is constructed of white pine, cedar, or cypress, from 1 to 2 inches thick (usually 1⅜ inches) and is coated inside with asphaltum. Hatching troughs are usually arranged in pairs with aisles between, and, when desirable, the water may be passed through two or more series of troughs standing on different levels.

Each hatching trough is usually divided by galvanized iron dams into compartments large enough to accommodate the particular type of egg tray or basket in use. The dams are arranged in such a manner as to cause the water to flow over the dam at the head of the compartment, under the succeeding dam, then up through the trays or basket of eggs, and so on throughout the length of the trough. By placing the trays or baskets alternately, the first against the upper dam, the succeeding one close to the lower, and so on, all of the water is forced up through the eggs and utilized instead of passing around them.

The trays more generally used consist of frames 16 inches long by 14 inches wide, made of pine strips 1 inch by ¼ inch. To these frames galvanized wire cloth of an oblong mesh is fastened. The cloth is usually woven 8 threads to the inch, with a mesh seven-eighths inch long, galvanized after weaving, although it is gauged to retain the eggs and permit the newly hatched fry to fall through.

While the basket method was devised to meet adverse conditions at some of the Federal fish hatcheries and at such stations is considered to have meritorious features commending it for general adoption, many fish-culturists prefer the tray system, while still others use from choice the Clark hatching box, which insures a good water circulation. Perhaps the most compact and economical method is found in the Williamson trough, which has compartments divided by galvanized iron partitions as described in this article. From 8 to 14 trays are placed in each compartment, according to the depth of the trough. The flow of water is always up through the stack of eggs, which are held down in the compartment by a crossbar or binder. To facilitate their removal from the trough, a strap made of 28-gauge galvanized iron and having wooden handles on each end is placed around the stack of trays. This also serves to hold the trays together and prevents the escape of the fry, which would occur if the trays were lifted out singly. The troughs described in the section on rainbow trout, with trays 28 inches long, may be very successfully used in brook-trout culture. The eggs on such trays are always under the immediate observation of the fish-culturist, and dead eggs are easily discernible.[4]

FIELD OPERATIONS.[5]

While a very large percentage of the brook-trout eggs handled in fish culture is obtained from domesticated fish, the bureau still operates a number of profitable field stations where eggs are obtained from wild fish. Where natural spawning on a sufficiently large scale to make the gathering of wild eggs profitable occurs within reasonable distance of a hatchery, it is customary to establish temporary stations in the immediate vicinity of the spawning grounds. After taking and developing the eggs to a point where they will bear transportation they are shipped to the central station to be hatched. In certain instances green eggs may be shipped for a considerable distance without serious loss, though whenever practicable it is desirable to develop them to the eyed stage before subjecting them to a long journey. Brook trout work of this character is extensively conducted in Colorado, Utah, Wyoming, and Vermont.

If lakes or ponds constitute the spawning grounds, their bottoms must be cleared for seining operations. Where the lakes are artificial and retaining dams have been built, the water usually may be drawn and the fish collected easily. However, this process may involve the carrying away of most of the natural food contained in the

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[4] Artificial Propagation of Whitefish, Lake Trout, and Grayling. By G. C. Leach, assistant in charge of fish culture. Appendix III to the Report of U. S. Commissioner of Fisheries for 1923. Bureau of Fisheries Document 949.

[5] Notes on the capture of wild brook trout and collection of their eggs were contributed by A. H. Dinsmore, superintendent of the St. Johnsbury (Vt.) station of the Bureau of Fisheries.

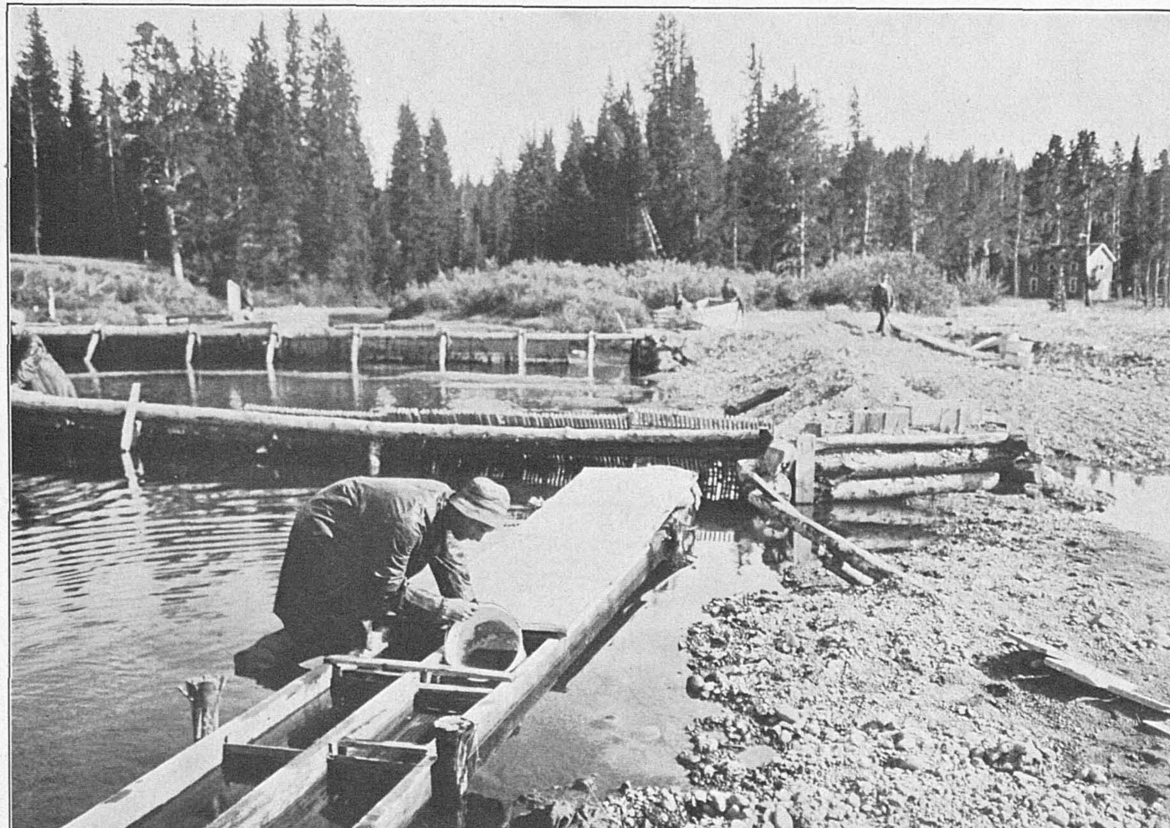

FIG. 4.—Racks and traps.

ponds, making artificial feeding necessary for the maintenance of the stock.

The capture of the brood fish is greatly facilitated where they enter tributary streams at or before the spawning season. Such migrations are very common in lakes and ponds having reasonably large inlets whose sources are at some distance, especially if they are subject to frequent increase in flow from rains. Such conditions often are met in the east and north. Here the fish may leave their common habitat as soon as high summer temperatures prevail or when the streams are affected by heavy showers or protracted rains. A larger movement usually will occur during periods of heavy rains in the fall, immediately before or a few weeks in advance of the spawning season. As it is not desirable to retain the brood fish in close quarters longer than is absolutely necessary, the tributary streams may be kept closed by racks during the early summer, thus preventing their ascent until near the approach of the spawning season. At that time traps are installed in the streams in which the fish are known to spawn.

TRAPS.

The general principles of trap construction for the capture of trout and salmon are identical, though the details, which are simpler in the case of trout because of the smaller sizes of the streams operated, must necessarily vary in each individual instance. The successful operation of a trap depends largely upon the ingenuity of the builder in so locating it that the fish will lead in rapidly and not escape easily through the entrance.

The simplest form of trap is built in the stream. It consists of a framework of poles or timbers supported by stakes driven in the bed or, if the foundation is of such coarse rocks as to preclude flood shifting, by means of three-legged horses weighted with stones. To these frames 1-inch square pickets are nailed sufficiently close together to prevent the passage of any fish it is desired to retain. Before nailing the pickets should be driven as deeply into the stream bed as its character will permit and must project 2 feet or more above high-water mark, so that the fish can not leap them. To form the entrance or lead, a rack is run from either bank diagonally upstream to a point in mid channel to form a **V**, with an opening at its apex large enough to permit the fish to enter. A rack of similar material crossing the stream in a straight line a short distance above the lead racks completes the pound. If the stream is large, however, the capture of the fish can be facilitated by running side racks from either lead rack at a point well above the apex of the **V** to the cross rack above, thus forming a pound in the shape of a reentering polygon. For greater convenience in sorting and handling the fish several retaining pens of similar material are frequently built above the rack.

A trout trap which has been successfully operated at stations of the Bureau of Fisheries for many years is built in the lower section of a retaining raceway through which the normal flow of the stream is diverted. From this raceway trap at the point where the water is returned to the stream the main channel is closed by a rack which extends to a point somewhat lower downstream on the opposite side to give greater rack surface. It is well to operate a somewhat coarser rack than that required to stop the small trout at a suitable point above where floating leaves and other débris may be stopped and removed, thus reducing the liability of the trap racks to dam up and undermine. The location selected for the trap is very important. Other conditions being favorable, it should be placed as near the mouth of the stream as the character of the banks will permit with the V-shaped entrance lead toward deepening water.

The fish run most freely on dark, rainy nights when the stream is rising, but during the spawning season ripe fish will enter night after night in times of normal stream flow. The majority of the fish are usually taken while one or two heavy rains are bringing the streams to flood stage. At such times it is necessary that the attendant have an assistant to keep the racks free from débris, as the fish often enter the trap as fast as one person can readily transfer them with a large dip net from trap to pens. Not infrequently as many as 1,000 to 3,000 fish are taken in a night. If ample rains are lacking at the height of the spawning season and the water is very low, only a few fish will ascend to the traps, and the egg collections will be relatively small unless the fish can be taken by seining the lower stretches of the stream. An abundance of rain late in the season will have little influence in bringing spawning fish to the traps.

A comfortable cabin in close proximity to the traps is a necessity, as the constant care of the racks and the work of guarding the fish against predacious animals and malicious persons often subject the attendants to great hardships during inclement weather.

TAKING THE SPAWN.

When the fish are running briskly, no attempt is made to separate them, but as soon as the run slackens they are carefully assorted and segregated in pens according to their degrees of ripeness. This saves much time and possible injury to the fish through constant handling for the purpose of ascertaining their spawning condition. A percentage is kept of the ripe fish taken from each pen so that the proper time for handling those in the various inclosures may be determined. It is sometimes necessary to examine every day or every other day the fish that appear to be nearly ripe and others from once to twice a week.

Eggs are not ripe enough to be taken until they flow readily under very slight pressure. In some instances a fish may by muscular contraction retain its eggs for a few seconds, deceiving the spawn taker for the moment, but if the eggs are ripe they will begin to flow as soon as the muscles relax.

The eggs are taken in pans or other metal vessels which have been thinly coated with asphaltum to prevent rust or in receptacles made of pressed fiber, the advantage of the latter being that they do not require painting and do not transmit cold as readily as the metal vessels. Just before the eggs are taken the vessel is dipped into cold water and drained.

The spawn taker holds the fish as firmly and gently as possible at such an angle as will cause the ripe eggs to flow naturally toward the vent. With the thumb and forefinger he then gently presses out the eggs, beginning the pressure just forward of the vent. The hand is then moved forward toward the head of the fish, and further gentle pressure is applied as necessary to assist the natural flow of eggs until all that will come freely from the fish are obtained. Pressure should never be applied forward of the ventral fins, as even slight pressure applied over the vital organs is very apt to result in injury to the fish. The above seems to be the logical and rational method of spawn taking, as the egs nearest the vent are taken first, leaving a clear passage for those that follow.

As the eggs fall into the dampened vessel milt is immediately applied, being obtained by the manipulation of the male fish in a similar manner. The next step is to add enough water to cover the eggs and agitate the vessel sufficiently to thoroughly mix eggs and milt, or a feather may be used to effect the mixing prior to the introduction of water. The excess milt is then almost immediately discarded by adding and pouring off water until it becomes clear, when the vessel is half filled with clean water and is protected from temperature changes by placing it in running water or inside of a larger vessel of water. It is then left entirely unmolested until the adhering stage has passed and the eggs separate, the time required for separation being from 30 to 60 minutes, according to the temperature. Some spawn takers consider it advisable to delay washing the eggs until after separation occurs, while others use no water at all until that stage is reached. In general practice, however, the method herein described is most satisfactory. If the eggs remain in the vessel long after separation, the water must be changed frequently.

The work of spawn taking should be done only by thoroughly experienced persons. While the test of efficiency along this line is frequently based on the percentage of fertile eggs obtained, the numbers of fish stripped and not injured is a point of equal importance. Proper methods of spawn taking carefully applied will result in no injury to the adult fish, either females or males; but unless the spawn taker understands something of the anatomy of the fish and exercises the utmost care serious, if not fatal, injuries are very likely to be inflicted. Some of the more common mistakes made by spawn takers in handling fish during the egg-taking process are mentioned below:

Grasping the fish by the tail and holding it head downward while it struggles violently, or similar handling in a dip net. Such treatment is very apt to result in rupture of the delicate ova-containing membrane, causing the eggs to fall into the abdominal cavity, from which they can not be extruded. An injury of this nature may result in barrenness or even death. The proper method of removing a fish from the water is described under the section on rainbow trout.

After stripping a fish spawn takers sometimes throw it from a distance into the retaining inclosure or pond. This procedure is so obviously wrong that it should need no comment. Perhaps the most common cause of injury in spawntaking is the practice of certain spawntakers of squeezing the fish several times, beginning well forward near the gill opening, until blood and fecal matter are extruded, in order that every egg may be secured. This is sure to result in expressing some immature eggs that are incapable of more than imperfect fertilization, and it is very liable to injure the ovaries or other organs of the fish. The eggs in the ovaries of a trout do not all ripen at the same time. Those in the posterior end mature first, and it is good practice in all cases to take only such eggs as come freely from the fish by very gentle pressure, which should extend very little, if at all, forward of the ventral fins. In some instances it may be desirable to retain the fish for a second stripping a few days later.

Eggs taken in close proximity to a regularly established hatchery may, of course, be transferred there immediately for development, but when secured at distant field stations it is necessary to hold them at the point of collection until they reach the eyed stage, as green trout eggs are so tender that they rarely can be subjected with impunity to the rough treatment incidental to a long journey.

As a rule, an eyeing station consists of a small building equipped with a number of troughs patterned after the standard hatching trough described elsewhere. A gravity water supply should be provided and, where it is available, spring water of a volume not seriously affected by the falling temperature of late autumn is selected for this partial development work, as such a supply insures the rapid advancement of the eggs, making it possible to ship them to the main hatchery before the beginning of winter.

The troughs and equipment should be standard size. Trays 14 by 16 or 14 by 28 inches, as described, are satisfactory. In cases where the eggs are to be incubated and the fry held in a limited space until ready for planting, trays covered with wire cloth 14 to 16 meshes to the inch, as described on page 28, are useful.

As manv as eight trays may be stacked in a trough compartment, one compartment being reserved for the reception of trays from the other compartments when the eggs are picked over and cleaned. As the trays of eggs are picked over one by one they are transferred to the empty space in the trough, and each compartment emptied becomes in turn the depositing place for another stack of trays until all occupy new space. Four small blocks one-half inch in thickness are tacked to the rough bottom in the corners of each compartment on which the trays rest, thus permitting a flow of water underneath.

When the eggs are brought in from the stripping place, they are measured in a tin cup or glass graduate, the capacity of which has been established by count, and are then placed on the trays. As each tray is filled it is gently settled in place in one of the compartments. When there is an ample amount of water, as great a quantity is admitted into each trough as will flow through the eggs without disturbing them, but in case of a limited supply the eggs may be carried to the eyed stage in good condition with a flow of not over 2½ gallons per minute to a trough of 200,000.

During the early stages of incubation the eggs should be handled as little as possible, but in order to prevent the development of fungus it will be necessary to pick them over at intervals, removing all white eggs and those that are known to be dead. The lengths of these intervals can be determined only by close observation, as the necessity for frequent picking will be governed largely by the varying conditions of the water supply. However, they should be carefully gone over at least once a week. One attendant at a field station can care for a million eggs unless the percentage of fertilization is excessively low.

Trout eggs are extremely sensitive to shock during the period extending from two to four days after they have been laid down in the hatchery up to the time when the eyes of the developing embryo are discernible to the unaided eye, and any movement of the trays of eggs at this stage is liable to result in heavy loss. The exact length of this period is dependent on the water temperature. It is known to fish-culturists as the "tender stage," and until it is past it is advisable to leave the eggs undisturbed so far as possible. If it becomes necessary to remove dead eggs to prevent the spread of fungus, as indicated above, it should be done with the utmost care.

PACKING THE EGGS FOR SHIPMENT.

At the proper stage of development the eggs may be transported for long distances without material loss if skillfully packed. Cases of a great variety of shapes and sizes with an equal variation in the styles of trays and the methods of insulation have been used. The essential requirements for the successful transportation of trout eggs are, (1) a package so insulated that it will preserve a uniformly low temperature on the eggs; (2) protection from undue jars or shocks; (3) the maintenance to the end of the journey of a reasonable amount of moisture. Any package that will accomplish all of these things may be considered fairly satisfactory, although as such shipments are usually sent by express the weight of the package also becomes an important item. In this way the so-called bulk method of packing trout eggs is more economical than the use of trays, and for shipments involving not more than 48 hours' time it may be satisfactorily applied in most cases to the transfer of eyed eggs from the collecting fields to the main hatcheries. For journeys of longer duration the mode of packing described on page 25 is preferable.

As regards the bulk method, the size of the case will depend upon the number of eggs to be shipped. The case consists of one or more inner boxes for eggs and an outer box of sufficient size to hold them and allow 4 inches of space all around for packing. The inner boxes are made of one-half-inch lumber with the bottoms left partially open to permit the surplus water to drain off and to allow for swelling of the lumber when wet. An egg box 12 by 15 inches and 4 inches deep will carry from 80,000 to 100,000 eggs, the actual number depending on their size. Three of these boxes packed in a single case, containing approximately 300,000 eggs, will weigh about 125 pounds.

While a great variety of materials, including leaves, straw, sawdust, shavings, etc., have been used as an insulating medium in packing fish eggs for shipment, probably nothing superior to sphagnum moss for the purpose has been found. When saturated with water, it retains the moisture for a long time and is thus valuable for use on the egg trays or boxes. When dry, it packs closely around the egg trays and is a most excellent nonconductor of heat or cold. Further, it has not the tendency to "heat" that certain other materials possess.

Brook-trout eggs are in condition to bear transportation as soon as the eyes of the embryo are visible. Before packing the eggs for shipment they are thoroughly washed. This is accomplished by removing them from the trays to a tub of water and introducing a stream of water among them with sufficient force to slightly agitate them for several minutes. This treatment not only removes all sediment from the eggs, but it causes all infertile eggs to change color, thereby facilitating their removal. Unless this is done a considerable number of infertile eggs is likely to be included in the shipment, as such eggs will frequently retain the color and general appearance of good eggs for a long period. The same results may be attained by passing a feather brush among them. After washing, the eggs are again placed in a tub of water, the temperature of which is very gradually reduced several degrees.

The bottom of an egg box is covered to a depth of one-half inch with sphagnum moss freshly wrung from ice water. A mosquito netting large enough to fold in from the sides and ends, entirely covering the eggs, is laid over the moss. The water is drained from the eggs and the required number placed in the box. In folding the netting over them it is drawn in a little from the sides and ends of the box and a thin layer of moss is tucked around to prevent the eggs from coming in contact with the wood. The box is next filled with moss, so that when closed by the cover the eggs will be retained in place should the case receive rough handling en route. If more than one box is used they are stacked and cleated one above another and only one cover is used, the bottoms of the upper boxes forming the covers of the ones below. Dry moss to a depth of 4 inches is placed on the bottom of the outer case, the stack of egg boxes installed, and the remaining spaces tamped tightly with dry moss to keep the stack in place and to provide the necessary insulation against temperature changes. For short distances no ice is necessary, provided the eggs, moss, and netting used in the inner boxes are near the freezing point when the packing is done. If the weather will permit, the egg boxes may advantageously be left in a freezing temperature until the moss stiffens slightly before placing them in the outer case or a quantity of snow or grated ice may be sprinkled over them. In most instances an ice hopper is desirable, and this is made to occupy the 4-inch space immediately over the egg boxes, forming the cover of the upper box of eggs. Where ice in any form is used in the package ample drainage through the bottom of the box must be provided.

Brook-trout eggs have been shipped successfully to many foreign countries. For shipments of this nature, where the eggs will be in transit for an unusually long period and will require replenishing of the ice chambers and possibly the removal of dead eggs, a more elaborate case is necessary. A so-called refrigerator case has been used with good results in making foreign shipments.[6] A case similar to this in some respects but more compact and of less weight has recently been designed by G. C. Leach, assistant in charge of the division of fish culture, United States Bureau of Fisheries, and has been successfully used in European shipments. Figure 17, page 53.

[6] Artificial Propagation of the Salmons of the Pacific Coast. By Henry O'Malley. Appendix II to the Report of the U. S. Commissioner of Fisheries for 1919. Bureau of Fisheries Document No. 879, pp. 26–28.

This case is 2 feet 4 inches square by 1 foot 7 inches deep, outside measure. It has double walls and bottom made of 1-inch lumber, and the 2-inch space between is filled with dry sphagnum moss or granulated cork, closely tamped. Two cleats are fastened to the bottom to give free vent to the iron drain tube, which extends through the insulation to the egg compartment as shown. The case has handles for convenience in moving and is closed by a hinged cover. The inside walls and bottom are lined with galvanized sheet iron to exclude moisture from the insulating medium as far as possible. After the lining is in place, two cleats 1 inch in thickness and 2½ inches wide are fastened to each inner wall of the case, eight in all, as shown in the cut. These cleats extend from the bottom to within 4 inches of the top and to them is fastened galvanized iron wire screen of ¼-inch mesh, thus forming a space about 2½ inches wide extending from the bottom of the case to within 4 inches of the top between the galvanized iron lining and the wire mesh, which is filled with chopped ice when the case is in use. Thin strips of wood are tacked over the wire mesh at the points of contact with the cleats. These serve to hold the wire mesh in place and facilitate the placing or the removal of the egg trays.

The remaining space in the center of the case is devoted to the egg trays. These are frames 14 inches square, made of five-eighth by three-eighth inch strips halved together at the corners and covered with linen scrim firmly stretched and securely tacked to the frames. The space provided will accommodate 15 such trays, leaving a space of 4 inches above for an ice tray. This is of galvanized iron 21 inches square by 4 meshes deep and occupies the entire space above the ice chambers and egg trays. The bottom of this tray has a double row of one-eighth inch perforations along each side, permitting drainage from melting ice down through the ice chambers and not over the egg trays. To the bottom of the egg tray compartment are fastened half-inch cleats, which hold the egg trays that distance from the bottom. The trays are intended to carry eggs in a double layer, and the case has a capacity for between 150,000 and 160,000 brook trout eggs, or more, according to their size.

TRANSPORTATION OF GREEN EGGS.

While the transportation of green trout eggs can not be recommended, it is sometimes necessary, and with great care it can be accomplished successfully provided the shipping destination is not more than 48 hours distant. The eggs should not be packed until they are thoroughly water-hardened, which will be within a few hours after stripping if they are maintained at a temperature of 48 to 55° F. Moderate success has been attained in shipping young eggs on trays, but ordinary fruit jars are probably best adapted to the purpose, and this is the form of container in general use. The jars are first filled with water and the eggs are poured in gently in sufficient quantity to replace about three-fourths of it. They are then sealed and packed in dry moss to guard against changes in temperature.

A satisfactory method of shipping green brook-trout eggs has been developed at the Rocky Mountain trout stations of the bureau. This method involves the use of a case of suitable size, with the usual provision for insulation and ice-hopper. The trays are divided into compartments or pockets 2 to 4 inches deep into which the eggs, wrapped in cheesecloth or mosquito bar, are placed. The dimensions of this type of case used at the Leadville (Colo.) station are 15½ by 22 by 13¾ inches deep, outside measure. Each case contains four trays 8¼ by 19½ inches and 2½ inches deep. These are divided by cross partitions into three pockets 6 by 7⅝ inches, with an ice hopper 11 by 19½ inches and 2½ inches deep. Such a case will carry from 100,000 to 150,000 eggs.

The superintendent of the Springville (Utah) station has described a method of packing the green eggs as follows:

> In putting the eggs on the hatching trays at the field station a 2-quart dipper is filled with water and over it is laid a piece of mosquito netting or cheesecloth about 18 inches square. Into this a measured lot of eggs—enough to fill one pocket in the shipping tray, between 20 and 30 ounces—is poured. The cloth is then lifted by the four corners and deposited, with the eggs, on the hatching tray. Here they remain until the time for shipment arrives. In shipping, wet moss is first placed on the bottom of each pocket, the shipping tray is submerged in water, and the eggs are lifted from the hatching tray as described and deposited thereon, a light layer of moss being placed on top. If desirable, the eggs may be shipped as soon as "water hardening" is completed.

INCUBATION OF THE EGGS.

When eggs are received from a collecting station or other source, their temperature is compared with that of the water in the hatchery, and before installing them in the troughs any wide difference is equalized by slowly adding and pouring off the hatchery water in small amounts. A quantity of the eggs, sufficient to register at the 32-ounce mark, is poured into a graduate full of water. The eggs are settled together by shaking the graduate, and enough are added to make up the deficiency thus caused. One such measure is placed on each tray, and any remainder is put into another tray to comprise a broken lot. As soon as it is convenient to count 32 fluid ounces of the eggs and ascertain the number contained in each tray, those in the broken lot are drawn upon and counted into the separate trays until the count of each is the even number decided upon for a tray unit. Owing to variation in the size of the eggs this may be any number from 10,000 to 15,000.

The incubation of the eggs beyond the eyed stage does not differ materially from the eying process. While the equipment at different stations varies somewhat to meet local conditions, the general principles of the work are the same. From this time on the care of the eggs consists in removing the dead ones and keeping the good ones free of silt, which is dislodged by raising the tray slightly and settling it back into place. In the event that the eggs become very dirty they may be removed from the trays or baskets, cleaned as described on page 24, and then returned to the trays. The fry are hatched in the troughs in which the eggs are incubated and are retained there until ready for distribution. The original number of eggs in each receptacle is maintained by the systematic daily addition of eggs from the broken lots to make up for any losses that may occur.

CARE OF THE FRY.

With the approach of the hatching period great care must be taken to guard against the clogging of outlet screens by accumulations of eggshells. As the eggs hatch the fry drop through the trays to the bottom of the troughs and remain there during the sac stage, which varies in length from 25 days in water with a temperature of 50° to 50 days in a water temperature of 33° to 35°. As the young fish develop they will show a tendency to congregate near the head of the trough. To guard against suffocation of the fry, the troughs should be subdivided into compartments by the insertion of screens. The use of baskets for the retention of the fry also obviates this difficulty.

PLANTING THE FRY.

When the weight of the yolk sac has diminished sufficiently to permit the fish to rise in the water, they begin taking food, and under normal conditions are feeding freely by the time the sac has entirely disappeared. When very young fry are transferred to open waters, where there is natural food only, the planting should be done 8 or 10 days before the sac is entirely absorbed, for if delayed till after the sac disappears many will die before they become accustomed to finding food in their new environment. Very good results may be expected from the planting of fry if they are properly handled and carefully deposited in small spring-fed tributaries not frequented by larger fish.

Brook-trout fry are usually transported in ordinary round-shouldered milk cans of 10 gallons' capacity, the number of fish per can depending entirely upon the temperature of the water in which they have been held, the distance they are to be carried, and the facilities for taking care of them en route, such as opportunities for changing the water, supplying fresh ice, etc. From the fact that water absorbs air more rapidly at a low temperature it can readily be seen that more fish can be transported per can when the water is cold. However, trout may not be subjected to great and sudden changes with safety, and it is not wise to lower the temperature in the transportation cans more than 10° below that of the water in which they have been carried in the hatchery. In making trips of from 5 to 10 hours' duration between 2,500 and 3,000 fry may be carried in each can if the temperature of the water is not above 50°, but where they are to be on the road more than one day it is not safe to carry more than 1,500 per can.

The distribution work of the Bureau of Fisheries is accomplished mainly by means of cars especially built for the purpose and equipped with pumps for forcing air currents through the cans in which the fish are carried. Small shipments, however, are made by a special messenger in a baggage car, the railway companies usually offering every available opportunity for securing fresh supplies of water and ice. In the case of public plants, the fish upon arrival at the railway point nearest their destination are transported to the stream where they are to be planted and liberated in small lots in different places where there is shallow water and a good bottom or in small spring-fed tributaries when possible. Where deliveries of fish are to be made to individuals or organizations on formal application, the applicant is expected to meet the shipment at the railroad station and effect the necessary arrangements for their final planting. The demand for fingerling fish for stocking streams far exceeds the available supply.

The methods outlined on page 47 for handling fry may be applied advantageously to brook trout, and where it is necessary to economize, either in space or in the flow of water, the fry may be carried through the sac stage on trays stacked one above another in the trough compartments as is done with the eggs. In employing this method it is customary to transfer the eggs from the hatching trays to trays similar in size but covered with wire cloth 16 meshes to the inch just prior to the time of hatching. The more open mesh is desirable during the incubation period, as it gives a freer circulation of water, but the smaller mesh must be used to hold the fry successfully. This method of carrying fry is practiced extensively in fish-cultural operations addressed to such important commercial species as the Pacific-coast salmons and the lake trout of the Great Lakes.

REARING AND FEEDING.

If the fry are to be reared for breeding, one week before the food sac is absorbed they should be changed from the trays to a large pan and removed to the rearing troughs. Gravel may be used in these troughs, but in general practice it is undesirable, as the unconsumed food works down into it and, becoming fungussed there, causes a great spread of disease and increases the labor of caring for the fish.

Trout fry are ready to be fed regularly when they rise to minute particles of food thrown upon the water. The time and frequency of feeding young fish, the kind of food, and the manner of feeding them are of the utmost importance. A difference of opinion exists among fish-culturists as to how often young trout should be fed, but the majority is in favor of feeding them from five to six times a day until they are a few weeks old and after that giving them larger quantities of food at less frequent intervals. Only such an amount as the fish will eat readily at one time should be spread upon the surface of the water with a feather until they are accustomed to taking it.

While various foods have been fed more or less successfully, it is believed that beef heart and beef liver give better results than any artificial food, and their preparation is very simple. A less expensive and very satisfactory substitute is beef melts or spleen. The meat is first ground fine by running it through a meat chopper several times, using a plate with perforations five sixty-fourths of an inch in diameter, a little water is added, and the meat beaten to give it the proper consistency. An egg beater is used by some fish-culturists in preparing the food. The finely ground meat is placed in a deep pan, with sufficient water to bring it to the proper consistency, and then thoroughly mixed with the egg beater. This removes practically all the small particles of connective tissue and muscle which ordinarly pass through the finest plate of the meat chopper and cause trouble by clogging the screens and fouling the troughs.

The introduction of beef liver into the troughs causes a milky discoloration of the water. This may be overcome, however, by washing the prepared material before giving it to the fish. The washing process is accomplished by introducing a stream of water into the vessel containing the meat, which is screened to prevent loss of the food, and allowing the milky substance to escape with the overflow. This treatment does not in any way lessen the nutritive value of the food.

At this stage the young fish have such a precarious hold upon life that too much attention can not be given to their care. Not more than 20,000 can be held with success in a feeding or rearing trough, and a constant circulation of water through the troughs must be kept up to prevent disease, while the fish should be properly thinned out in order to prevent loss by suffocation when they increase in size. About 3 to 5 gallons of water per minute are sufficient for 20,000 fry, although this quantity must be increased as the fish grow stronger and are able to breast a heavier current.

In the spring when the water begins to grow warm the fish require more room than the feeding troughs afford and it is necessary to transfer them to other troughs or ponds. At some of the Federal hatcheries the young trout are held in troughs or nursery ponds until they attain a length of 3 or 4 inches before they are distributed. It has been demonstrated that raceways arranged as described on page 31 possess many advantages over troughs for the rearing of such fish. Among the most successful rearing ponds are those from 5 to 8 feet wide and not more than 100 feet in length, modeled after the ponds described on page 37. A water supply of about 200 gallons per minute and having a temperature of between 48 and 55° is desirable. Ponds of such shape and dimensions may be constructed with natural earth sides from the top of the bank to the water's edge and of cement from the water level to the bottom. The bottoms, with the exception of a feeding area of cement near the outlet, are of gravel. A rearing pond 5 by 20 feet, having a gravel bottom and a flow of not less than 50 gallons of water per minute, will accommodate from 10,000 to 20,000 fry till midsummer, when the number must be reduced to not more than 5,000. A raceway 4 feet wide and 100 feet long, with a strong current, will carry 100,000 fry, and as the fish develop the number can be reduced and the surplus distributed in other waters or shipped.

At this stage they are usually fed at regular intervals three times a day, and, as they do not take food readily during the first few days, a great deal of patience is necessary in their treatment and care must be taken to see that no unconsumed portions are allowed to remain at the bottom of the pond and pollute the water. At this time the food should be given in small amounts, and considerable time should be taken to see that it is properly administered. Three-fourths of an hour is not too long for feeding 5,000 fry. The time occupied in feeding should be diminished and the amount of food increased according to the judgment of the fish-culturist as the fish grow older, but their appetites should never be completely satisfied.

By early winter all fish reserved for brood stock should have attained a length of from 3 to 5 inches. If they have been held in troughs or small ponds, arrangements should be made for their transfer to more commodious quarters. A breeding pond 20 feet by 75 feet will accommodate 10,000 yearlings, 5,000 2-year-olds, and about 3,000 from 3 to 5 years old, though much better results will be attained with half this number. The water supply should be from 100 to 150 gallons per minute. For adult fish the pond may be any size from 1 acre up to 20 acres or more, provided it has a very large water supply entering at one end and flowing through its longest dimension to an outlet. A 20-acre pond should have a flow of 5,000 to 10,000 gallons of water per minute for best results. A raceway or channel should be arranged where the water enters the pond, with a trap to catch the spawning fish as they try to ascend the stream.

Less care is required in the preparation of food for adult trout. It may be given to them in pieces half an inch in diameter, may consist of almost any kind of raw meat or fish, and the flesh may be mixed with cooked mush made of a low grade of flour. Meat meal and fish meal in combination with meat and flour also have been used successfully.

DISTRIBUTION OF FINGERLINGS.

Fish which have attained a length of 1 inch are termed "fingerlings No. 1"; those which are 1½ inches long are designated as "fingerlings No. 1½", and so on. Small fingerlings are distributed from the eastern hatcheries in May and June and at a later period in the west. Larger fingerlings are sent out in the autumn. Assignments of fingerling fish are necessarily much smaller than assignments of fry. In shipping fingerlings No. 1 to No. 2 the number carried in a can ranges from 500 to 1,000, the actual number varying with weather conditions and the length of the trip to be made. Not over 200 No. 3 fingerlings can be safely carried in a 10-gallon can, even under the most favorable conditions.

EGGS FROM COMMERCIAL HATCHERIES.

The collections of brook-trout spawn from wild fish, even when supplemented by eggs taken from brood fish under domestication, are totally inadequate to meet the present demand for eggs of that species, and but for the supply resulting from the raising of trout for the market by commercial fish-culturists the production of this fish would be curtailed considerably. The business of growing trout for the market was undertaken in this country more than half a century ago, but within the past 20 years it has developed so rapidly that it is now an industry of considerable importance.

The main object of the private hatchery usually is the production of adult trout. The eggs, which, as a rule, are stripped from the fish just prior to marketing, are a secondary consideration. As New York and Boston are the best markets for the fish, it is natural that the most successful commercial hatcheries in the east should be located within easy reach of those cities.

The methods followed by private plants in handling eggs and fry during the early stages of development do not differ materially from those employed at the Federal and State hatcheries. As the end in view is not the same, however, there is necessarily some variation in the treatment of the fish beyond the fry stage.

At some of the commercial establishments ponds more or less irregular in size and shape are used for rearing, but, as a rule, the growing fish are held in long narrow raceways, some of them half

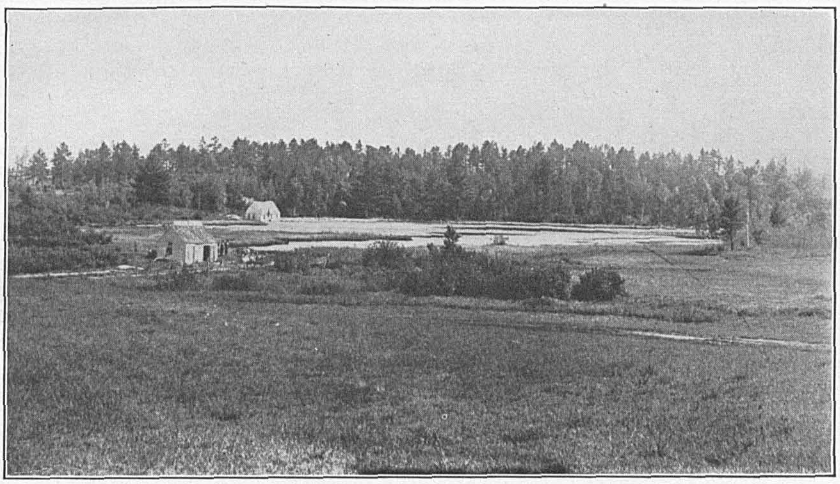

FIG. 6.—Commercial trout farm, West Buxton, Me.

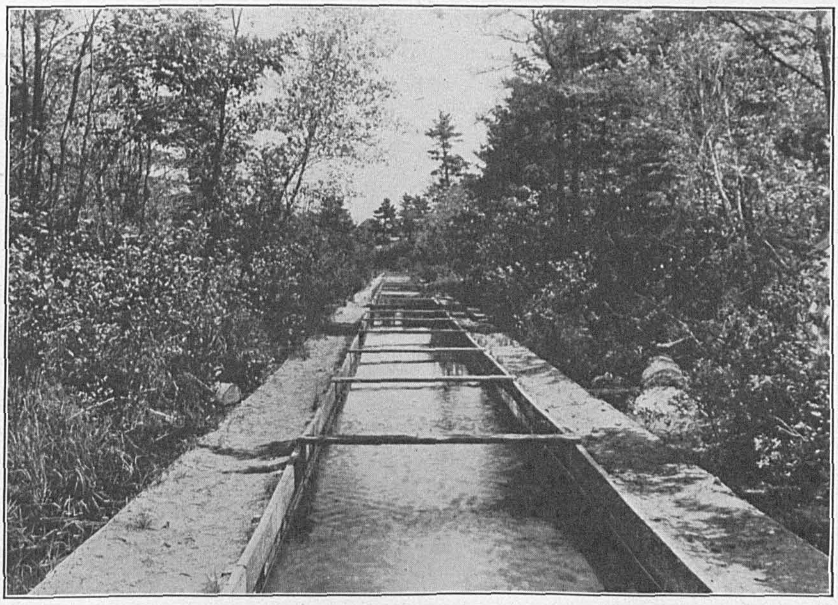

FIG. 7.—Section of a raceway, commercial trout farm, West Buxton, Me.

a mile or more in length, though never more than 8 feet wide and with a water depth rarely exceeding 2 feet. Where there is an abundant supply of water a strong current flows through the raceways, sometimes broken at short intervals by partition boards extending half way from the surface of the water to the bottom, with openings somewhat narrower than the raceway. The refuse swept downstream by the current and the actions of the fish is deposited in the eddies formed above these riffles and may be removed easily. If the fish are uniform in size, no screens are placed between the compartments formed by the partitions, but if different sizes are carried in the same race screens form the partitions. Usually the upper sections of the raceways are screened for retaining the fry and the lower sections are used for holding the larger fish. As soon as the fry in the hatching troughs begin to take food freely they are transferred to the raceways and fed systematically.

While such packing-house products as the livers, hearts, melts, and lungs of cattle, hogs, or sheep form the principal food, quantities of small waste fish, especially small herrings, are utilized at hatcheries located in the vicinity of the New England coast fisheries.

The trout market demands fish known as "thirds," "quarters," and "fifths," designations for fish running, respectively, 3, 4, and 5 to the pound. Many of the fish attain these sizes by the time they are 20 months old, at which age they produce their first eggs. After taking the spawn the fish are again placed in the raceways or in special ponds or pools and fed all they will eat until they are in proper condition for marketing, when they command 50 to 60 cents per pound, net.

Some commercial fish culturists raise fish especially for an egg supply, holding them in ponds until they weigh from 2 to 3 pounds. Such fish yield eggs of better quality than are usually obtained from fish spawning for the first time, especially if a certain amount of natural food is available in the ponds in which they are kept.

The eggs produced in 1922 by commercial establishments were sold at from $1 to $1.50 per thousand, depending upon their quality and the number contracted for. As a rule, eggs are purchased subject to their condition upon receipt, and it is generally stipulated that they shall be shipped as soon as they have reached the stage when infertile eggs can be removed. Consignments of eggs that are very near the point of hatching upon arrival at their destination are likely to suffer heavy loss both in the egg and in the fry stage.

RAINBOW TROUT.[7]

The following discussion relates to the rainbow trout, which has received the attention of fish-culturists throughout the country. The earliest work along this line was concerned with the rainbow trout of the McCloud River and later was extended to include the trout of the Klamath River basin. Subsequently eggs of the steelhead from the Rogue River in Oregon and certain streams in Washington were shipped east, and in many instances the fish resulting therefrom have been distributed in public waters under the name of

[7] The notes for the section on Rainbow Trout were contributed almost entirely by George A. Seagle, superintendent of the Wytheville (Va.) station of the Bureau of Fisheries from 1880 to 1922, who has very ably described the methods employed at that station in the artificial propagation of this species.

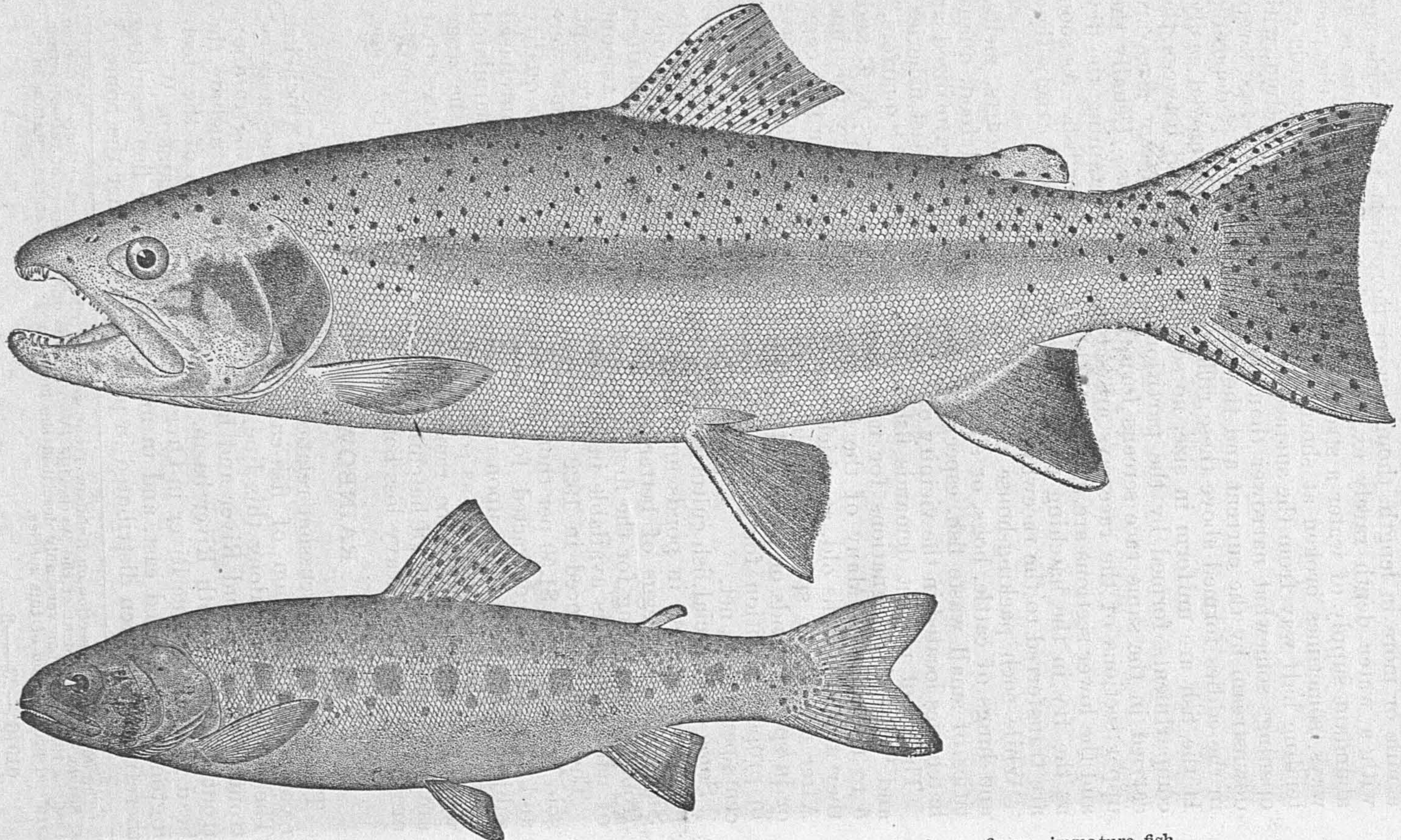

FIG. 8.—Rainbow trout (*Salmo shasta*). Upper figure, adult male; lower figure, immature fish.

rainbow or have been included in brood stocks at the various hatcheries, Federal, State, and commercial. The technical name, *Salmo shasta*, is used since it appears to be the name of the trout of the McCloud River, from which the original stocks were derived.

DESCRIPTION.

The body of the rainbow trout (*Salmo shasta*) is comparatively short and deep and is more elongate in males than in females. The average depth is contained about three and four-fifths times in the body length. The short head, which is obtusely ridged above, is about one-fourth the total length. The mouth is smaller than in other species of Salmo, the maxillary reaching scarcely beyond the eye, which is rather large and is contained five times in the side of the head. The caudal fin is distinctly but not strongly forked. On the vomer are two irregular series of teeth. The dorsal rays number 11 and the anal 10. In the typical species there are about 135 scales in the lateral series, with 20 rows above and 20 below the lateral line. In the several subspecies the number of rows of scales along the side is from 120 to 180. The color is variable, depending on sex, age, and character of water. Typical adult fish are bluish above, silvery on the sides, profusely and irregularly dark spotted on the back and sides, the spots extending to the vertical fins, with a red lateral band and blotches and a nearly plain belly. The sea-run fish are nearly plain silvery. The chief distinguishing color characteristics of the varieties are in the number and position of the spots.

RANGE AND VARIATION.

The rainbow trout is not indigenous to eastern waters. The natural home of *Salmo shasta* is in certain tributaries of the Sacramento River, and originally it was particularly abundant in the McCloud River, Calif. Other species of the rainbow trout (*S. gilberti*, etc.) occur in the upper San Joaquin River and its tributaries. *S. gilberti* appears to be very similar to *S. shasta.*

The rainbow trout is subject to considerable variation in form and color in different parts of its range. *Salmo shasta* has smaller scales than *S. irideus*, a species of steelhead trout inhabiting coastwise streams, and appears to be distinct from the Klamath River trout, which are probably either *S. irideus* or *S. newberri*. *S. shasta* has more than 145 scales in the lateral series, *S. irideus* has less than 135, while *S. newberri* has about the same number as the lowest count of *S. shasta.* The proper classification of the so-called rainbow and steelhead series has been the cause of much discussion among ichthyologists,[8] but it has no place here.

TRANSPLANTING.

The rainbow trout was introduced into eastern waters by the United States Fish Commission in 1880, but specimens of it, or its spawn, probably had been brought east by State commissions or private enterprise prior to that time. Previous to this date the State of New York had established a brood stock of trout from eggs taken in tributaries of the Sacramento River. They were known as California mountain trout (*Salmo irideus*). In certain streams of the East

[8] What are Rainbow Trout and Steelhead Trout? By W. C. Kendall. Transactions of the American Fisheries Society, 1920.

repeated plants of rainbow trout have failed to give results, the fish apparently seeking an outlet to the sea. Whether unsuitable conditions in the streams are responsible for this failure or whether it is due to some extent to a possible cross with the anadromous steelhead is a matter for conjecture.

The theory has been held that this species would serve for stocking streams formerly inhabited by the brook trout (*Salvelinus fontinalis*), in which the latter no longer thrives owing to the clearing of the land at the sources of the streams, which has changed conditions in and along the waters, so that they are not agreeable to the brook trout's wild nature. It has been believed generally that the rainbow trout is adapted to warmer and deeper waters and therefore is suited to many of the now depleted streams which flow from the mountains through the cultivated lands of the valleys. This theory is disputed by Meehan, Bean, and other fish-culturists, however.

Rainbow trout, particularly the smaller sizes, differ from brook trout and other predacious fishes in that they feed principally upon worms, larvæ, Crustacea, and the like, and do not take readily to minnows as food. They should be planted in spring or early summer, when their natural food is abundant, as they will then grow more rapidly and become accustomed to life in the stream, and when worms, larvæ, etc., are no longer to be found their experience and size will enable them to take a minnow or anything that may present itself in the shape of food.

SIZE AND GROWTH.

The size of the rainbow trout depends upon its surroundings, the volume and temperature of the water, and the amount of food it contains. The average weight of those caught from streams in the East is probably less than a pound, but some weighing 6¾ pounds have been taken. In the Ozark region of Missouri they are caught weighing 5 to 10 pounds. In some of the cold mountain streams of Colorado their average weight is not more than 6 or 8 ounces, but in lakes in the same State, where the water becomes moderately warm in summer and food is plentiful, they reach 12 or 13 pounds and a length of 25 to 28 inches. In the Au Sable River, in Michigan, they attain a weight of 5 to 7 pounds. In their native streams of California they are often caught ranging from 3 to 10 pounds, but average from 1 to 2 pounds. The largest specimen ever produced in the ponds at Wytheville and fed artificially weighed 6½ pounds, but many others in the same ponds weighed from 1 to 3 pounds. It is possible that *Salmo shasta* might be more successful in the southern range of the rainbow trouts, and that "steelhead" rainbows might thrive better in the northern range.

Under favorable artificial circumstances rainbow trout hatched January 1 should absorb the yolk sac in about 30 days in a mean water temperature of 55° F. At this time feeding begins, and if properly cared for and supplied with a sufficient amount of suitable food the young trout should attain the following sizes: 1 year old, 8 to 10 inches; 2 years old, 12 to 14 inches; 3 years old, 16 to 18 inches. In the open waters of natural lakes and streams their sizes probably would average about 2 inches less per year. They grow until they are 8 or 10 years old, the rate diminishing with age. Some grow much faster than others under the same circumstances, but the rate of growth is largely a question of food, temperature of water, and extent of the range. In water at 55°, with plenty of food, fish 1 or 2 years old will double their size several times in a single season, while in water at 40° with limited food the growth is scarcely perceptible.

The rainbow, like the brook trout, will live in water with a comparatively high temperature if it is plentiful and running with a strong current, but sluggish and shallow water, even with a temperature of 70° F., is dangerous for brook trout. Rainbow trout will live in warmer water than brook trout and are found in swift, rapid streams at 85° F., especially where there is some shade, but in ponds that temperature is dangerous even with shade and a good current. In its natural condition this trout is usually found in water varying from 38° F. in winter to 70° F in summer, and in selecting a site for a trout hatchery spring water with a temperature of 42° to 58° is required.

The rainbow trout is a superior game fish, a vigorous biter, and fights bravely for liberty, though in the east it is somewhat inferior to the brook trout in these respects.

PROPAGATION.

WATER SUPPLY.

The best water supply for a trout hatchery is that taken from a well-protected and deep-seated spring. The fall between the spring and the hatchery should be sufficient to permit the hatching troughs to be placed about 30 inches above the hatchery floor and to aerate the water as it enters the trough. Water obtained from a spring-fed stream or lake is apt to vary considerably in temperature and to carry much sediment and other foreign matter. While an open supply trough in the hatchery is somewhat unsightly and cumbersome, it seems to produce better results than a closed pipe. For a hatchery with 20 troughs a supply trough 10 inches wide and 10 inches deep, inside measurements, will carry sufficient water. A 2-inch molasses gate with a brass face set about 3 inches above the bottom of the supply trough is the best means of regulating the flow of water to the hatchery troughs. The water should have a drop of from 10 to 12 inches as it enters the hatchery supply trough from the main conduit, and it should be further aerated as it enters the hatching troughs. For this reason the supply trough should be set about 6 inches above the top of the hatching troughs with a space of 3 or 4 inches from the ends. When local conditions will not permit such means of aeration, the water supply must be aerated as thoroughly as possible by some other means.

The main water supply at the Wytheville (Va.) hatchery is obtained from a spring such as is described above. After heavy rains the water becomes very turbid and much discolored from the yellow clay soil characteristic of the locality. At times the water supply carries sufficient sediment to smother both eggs and newly hatched fry. While this condition is not permanent, it causes much labor and a considerable loss of eggs and fish.

As the water level from the spring is about 12 feet above the water level in the hatchery supply trough, it was a comparatively easy matter to construct a settling tank and filter. The settling tank was built near the spring. Water is conducted from the spring to the head of the tank through a 6-inch pipe controlled by a gate valve. It enters an end compartment in the tank 4 feet wide and 20 feet long, from which it flows into a second compartment 10 feet wide and 70 feet long, returning through a similar compartment and discharging into a compartment 5 feet wide and 70 feet long. Near the lower end of this compartment is a sand filter bed 20 feet long. The water passes down through the gravel and sand and is conducted to the discharge chamber through five lines of 3-inch tile. These drains are about 12 inches in length, with broken joints about $\frac{1}{8}$ inch apart, and they extend into bulkheads in either end of the compartment. The hatchery supply pipe is extended into this compartment and receives only water that has passed down through the filter bed, and since there is a fall of approximately 12 feet between the filter and the hatchery supply trough, this pipe carries a satisfactory head.

Arrangements are provided for cleaning the sand and gravel used as a filtering medium. To reach the filter bed, the water passes over a cement bulkhead built across the compartment. Near the bottom of this bulkhead is a 6-inch valve whereby the water is admitted for cleaning the filter. The water used for cleaning passes up through the sand bed and discharges through a gate valve in the lower end into the waste ditch. While the water is passing up through the filter bed a rake, made by driving spikes into a 2-inch plank, is moved back and forth, by means of a sprocket and chain, over the surface of the sand. This rake is manipulated easily by one man operating a crank on the outside. This action loosens the sediment contained in the sand and the flow of water carries it into the waste ditch. About 10 minutes' work is required, twice each day, to keep the filter in perfect working order.

To assist the percipitation of sediment and to relieve the sand filter an alum dropping device was installed between the spring and the settling tank. The alum solution is lifted by means of a hand pump to an elevated tank of 60 gallons' capacity; after remaining in this tank for 24 hours it is drawn off by means of a valve into a tank at a lower elevation. This gives a clear solution for use in the water supply. From the second tank the solution passes through a brass pipe to a copper-lined closet tank, in the bottom of which a $\frac{1}{2}$-inch sight-feed oil dropper is fitted. The float in the closet tank maintains a uniform level therein, and the solution is constantly discharged through the oil dropper into the water supply pipe. A constant rate of flow through the oil dropper is maintained—60 gallons per 24 hours—but the strength of the solution varies in proportion to the turbidity of the water. In extreme cases a mixture of 1 part of alum to 50,000 parts of water will supply the hatchery with practically clear water. From this mixture the solution is reduced to as low as 1 part of alum to 120,000 parts of water. As a rule, 4 pounds of sulphate of alumina per 24 hours, applied as described above, to each 20 gallons of water per minute used in the hatchery is sufficient to clarify the muddiest water. The untreated water carries in solution sufficient alkali to react completely with the small amount of sulphate of alumina used, leaving a sufficient amount of alkaline nitrate to prevent any "after coagulation" in the filtered water. It is doubtful if any of the alum is carried into the hatching troughs. Experiments conducted in Washington demonstrated that neither the eggs nor young

FIG. 9.—Wytheville (Va.) station hatchery.

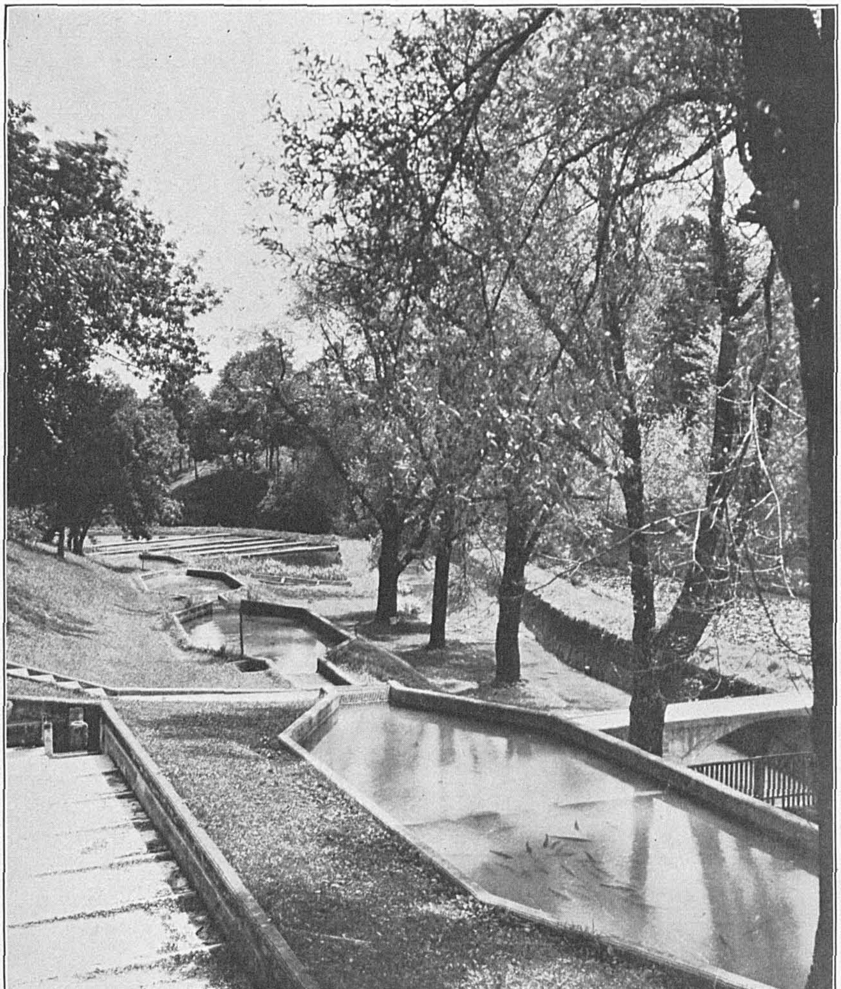

FIG. 10.—Spawning ponds, Wytheville (Va.) station.

fish of the rainbow trout were affected by an alum solution below a strength of 1 part of alum to 8,000 parts of water. Rainbow trout 2 inches long were held in a 1 to 20,000 solution for a period of two weeks without apparent harm.

SPAWNING PONDS.

In constructing ponds one of the first considerations is to place the fish absolutely under control, that they may be handled without delay or inconvenience. The ponds at Wytheville formerly were constructed of wood, but when they were rebuilt recently concrete was used. They are 15 by 50 feet and 3 feet 4 inches to 3 feet 6 inches deep, shaped as shown in Figure 11, page 38, and have proven very satisfactory. The length of the pônds may be increased up to 100 feet without impairing their efficiency, though the width should not exceed 12 to 15 feet. Much depends upon the volume of water available, but ponds more than 100 feet in length are difficult to clean and care for. Excellent water circulation is obtained in all parts, there being no corners in which refuse can lodge. From the outlet the bottom has a gradual rise of 6 inches in its entire length, making it practically self-cleaning. Most of the refuse will pass off, and any remaining can be disposed of readily by lowering the water level for a short period and then flushing the pond with fresh water. This method obviates the necessity of handling the fish, an important point, especially at the approach of the spawning season.

A guard rack made of thin narrow slats is arranged on an incline of about 45°, as shown at *A*, Figure 11. If the water is to be used again in ponds below, a "receiver" is built underneath the bottom of the pond, at the lower end, between the foot of the guard rack and the dam boards, and the floor of the pond immediately over the receiver is cut away and fitted with a grating. This allows all waste to fall through into the receiver. From there it is washed through the sluiceway by opening the gate valve. The sluiceway, *D*, is of 8-inch terra-cotta pipe and connects with a 12-inch drain of the same material.

The pond is provided with a spawning race about 14 inches deep, 4 feet wide, and 25 feet long, placed at the upper end of the pond, as shown in Figure 11. Three division boards (shown at *E*), about 12 feet long and of suitable width to come within 1 or 2 inches of the surface of the water when the pond is filled, are firmly fixed at the bottom. The object of these boards is to form four entrances to the raceway, so that one or two pugnacious fish can not command the approach and keep back spawning fish inclined to enter. There is a dam across the raceway about 4 inches high for the purpose of bringing the water to that depth in the lower end, so that when trout enter the raceway they will find sufficient water in which to swim freely and not be inclined through fear to return to the pond.

At the approach of the spawning season the water level of the pond is raised to within 6 inches of the top of the dam in the raceway, which will give the fish in entering the raceway a jump of 7 inches, allowing 1 inch for the depth of water on the dam in the raceway. This distance has been found the most satisfactory, as under such conditions only spawning fish will ascend. If a jump

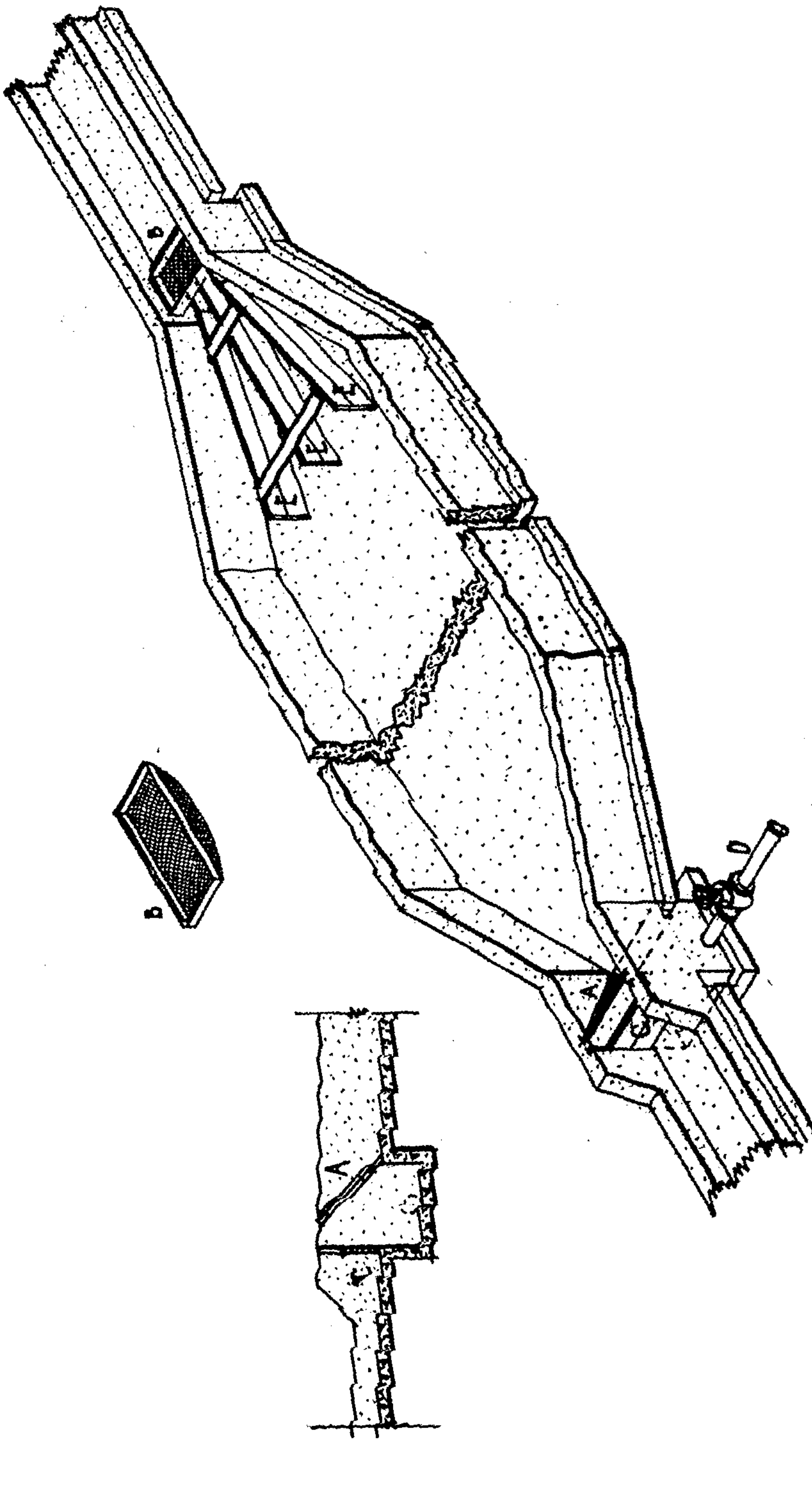

FIG. 11.—Spawning pond. *A*, retaining screen; *B*, catch screen; *C*, dam boards; *D*, drain; *E*, boards forming entrance to spawning race.

of less than 7 inches is provided, other fish can enter the raceway without much exertion and will ascend and disturb the breeding fish, which, when spawning, should be kept strictly by themselves.

There is no rule regarding the supply of water that applies to a spawning pond at all times and in all places. It is necessarily governed by the temperature of the water, size and shape of the pond, size of the fish to be supported, the amount of shade, and other factors. For a pond such as has been described, where water is plentiful, at least 200 gallons per minute should be provided, with not less than 75 gallons per minute as a minimum, even where the temperature is from 50 to 55° and all other conditions are favorable. While the former amount is not absolutely necessary for the support of the fish, it insures the pond being kept clean and the fish are more inclined to enter the raceway at spawning time. In order to maintain an even temperature of water, earth is banked against the sides and ends of the pond, the embankments being made broad enough on top to permit ample footway around the ponds. Such a pond can accommodate from 800 to 1,000 breeding fish. Fish must not be crowded, and in estimating the capacity of a pond several factors must be considered, such as the size of the fish, volume and temperature of water, and shade. In stocking the spawning pond a good proportion is two females to one male. The brood stock must be selected carefully each year, and only sound and perfect fish retained.

All pond bottoms should be cleaned frequently to prevent the accumulation of undesirable matter. A method recently devised permits the cleaning of ponds without subjecting the fish to the usual more or less protracted period of turbid water while the cleaning is in progress. About 10 feet from the intake end of the pond a cement bulkhead about 18 inches high extends into the pond from either side, leaving an opening in the center 4 feet wide. Each open end of this bulkhead is provided with slots in which boards may be inserted to complete the dam as required. In cleaning the water level is reduced and the section of the pond above the bulkhead thoroughly cleaned. The fish are then driven, by means of a seine, through the opening to the cleaned section and dam boards are inserted as described. The outlet valve is then opened and the remaining portion of the pond cleaned.

TAKING THE SPAWN.

The spawning season varies with the locality and the temperature of the water. It is usually from two to four weeks later in streams than in ponds where the fish are confined in spring water. At Wytheville the spawning fish may be found in the ponds any time after October 1; the season is well started by October 20, and generally closes about January 25, the height of the season being between November 1 and December 15. At the Neosho (Mo.) station the season usually begins about November 1 and extends to the 1st of March; at Manchester, Iowa, it occurs between November 15 and March 15. In California the season extends from February to May; in Montana from April 15 to June 1; and in Colorado from May to July.

The natural nests of these fish are made on gravelly bottoms and are round or elongated depressions about the size of a dinner plate.

The work of preparing the nest is performed chiefly by the male fish; upon completion the male and the female enter it together and by a rolling spasmodic tremor they deposit eggs and milt, which are brought together and mixed by agitation of the water. For a short period after they have been deposited the eggs are slightly adhesive, and during this time they absorb the impregnated water. When filled they fall apart and settle down between the gravel and stones of the nest, where they lie protected until hatched.

Under domestication the fish rarely will deposit their eggs of their own accord unless conditions are favorable. Swift, well-aerated water of suitable temperature, gravelly bottom, and a male consort seem to be necessary, although instances have been recorded where female rainbow trout have deposited their eggs on the cement bottom of the stock pond without a male fish in attendance. On the other hand, adult fish in an aquarium have been observed to make nests and apparently attempt to spawn, failing in the effort and later dying with the eggs still retained. Instances have been reported, also, where fish (rainbow trout and landlocked salmon) have been taken from native waters several months after the spawning season, apparently still retaining their full quota of eggs in the ovaries. In every case the eggs were hard and "glassy," though as far as could be observed the fish had suffered no ill-effects as a result of their unnatural condition. Under any circumstances, however, retention of the eggs beyond the spawning period is, of course, unnatural and undesirable. In practical fish-cultural operations easy access to a suitable spawning race will invariably permit the fish to spawn or to indicate that they are ready to spawn. Overlong retention of eggs undoubtedly results in "glassy" eggs, probably caused by their coming in contact with a serious ovarian exudation present in the fish under these conditions, and may also result in serious permanent injury or even death to the fish. Eggs that absorb this fluid become hard and incapable of fecundation. Similarly, freshly extruded eggs if immersed in water which lacks the male element of fecundation for even a short period become hard and "glassy."

When spawning ponds are provided with suitable raceways, the fish will ascend from the ponds into them in search of a place to nest and may then be taken out and stripped of their spawn. To remove the fish from the raceway, a square net (*B*, fig. 11) is dropped in on cleats bolted against the side walls in the approach, the dam in the mouth of the raceway is raised, and the fish driven back into the net. The net is then lifted out of the water, and if it contains too many fish to handle conveniently a landing net is used to take out part of them before the square net is moved. The ripe fish are then placed in tubs or other vessels provided for the purpose, but care should be taken not to put too many in the tub at one time, as they will become restless or sick before they can be stripped of their spawn. While being held in this way the water in the vessel should be renewed frequently.

There are two methods of taking and impregnating the spawn of fishes—the "wet" and the "dry" methods. By the wet method the eggs are taken in a pan containing sufficient water to cover them and allow them to mix freely with the milt, which is added immediately. After the contents of the pan has been stirred for a few

FIG. 12.—Taking the spawn.

seconds with the hand or a feather, the eggs are set aside and left undisturbed during fertilization. The dry or "Russian" method is now in general use; the eggs and milt are taken in a moist pan, and it makes little difference which is taken first, but one should immediately follow the other, and the contents of the pan is mixed thoroughly. In freezing weather it is advisable to use two pans, one set in the other, with water in the bottom pan to prevent the eggs from being chilled.

After the eggs and milt have had time for contact and before the eggs begin to adhere to the bottom of the pan, water is added to a depth of about an inch, the eggs being kept in gentle motion by turning the pan to prevent adhesion. After 2 or 3 minutes the milt is poured off and clear water is put in the pan, in which the eggs are allowed to remain until they separate, which will be in from 15 to 45 minutes. When eggs are held in a deep vessel capable of holding several layers of eggs, those at or near the top will harden in the time indicated above, but those in the lower layers will remain soft for a much longer period. Most fish-culturists consider the temperature of the water a factor in this connection and believe that the hardening process is hastened by higher temperatures. This theory is not held by others, and as far as is known no really authentic data on the subject have been recorded. A vessel was devised at the Wytheville (Va.) station especially for holding the eggs during this period of water hardening. It consists of a 6-quart tin bucket in which is fastened, about 1 inch above the bottom, a circular piece of perforated tin. A funnel-shaped spout, soldered to the outside of the pail, admits water between the bottom of the bucket and the perforated tin. About 4 quarts of eggs are placed in each bucket, and a small flow of water, about 1 gallon per minute, is supplied.

In taking spawn the manipulation of the fish without injury is a very delicate and exacting task, full knowledge of which can be acquired only by experience, as it is difficult to squeeze the spawn from the fish without injuring or even killing it. In taking hold of the fish in the spawning tub the operator catches it by the head with the right hand, the back of the hand being down and the nose of the fish well in the palm, with the fingers extending under and along each side of the fish in the direction of the tail. At the same time the fish is grasped between the dorsal and caudal fins with the left hand, the back of the hand being up. A fish caught in this way can be brought out of the water easily, and when held gently but firmly against the body will struggle only for a moment. The operator leans forward slightly, bringing the vent of the fish over the spawning pan and holding the head of the fish higher than the tail, its body at an angle of about 45°. The fish should be held well down in the pan, which is usually of 2-quart capacity, so that the eggs will not drop more than 2 inches. Some operators turn the abdomen of the fish upward with the tail bent backward. This method is not recommended, however, since the bending of the tail may cause serious injury and the eggs are subjected to a greater drop into the pan. A large fish may be held with its head under the right arm.

When the struggle is over, the hand is passed down the abdomen of the fish until a point midway between the pectoral and ventral fins is reached, then with the thumb and the index finger the abdomen is pressed gently, and at the same time the hand is slipped toward the vent. If the eggs are ready to be taken, they will come freely and easily. If they do not come freely after the first pressure, the hand is moved toward the head of the fish and a very gentle pressure is applied to assist the natural flow of eggs until all that will come readily are obtained. Pressure should never be applied forward of the ventral fin, as even slight pressure over the vital organs is very apt to result in injury.

By this method all of the eggs that have fallen from the ovaries and are ready to be expressed will fall into the abdomen near the vent, so that it will not be necessary to press the fish again over its vital parts, the eggs having left that portion of the body. An experienced operator can tell almost at a glance whether or not a fish is in spawning condition as soon as it is lifted from the water. By grasping the fish as described, holding the head highest, if ripe eggs are in the ovaries they may be observed to roll slightly toward the vent. If this movement can not be detected, the right hand may be passed lightly down the abdomen, and if the egg mass is soft and yielding to the light touch the eggs will flow freely from the vent with but slight pressure. Examination of a large number of specimens has proven beyond doubt that serious injury, resulting in barrenness or death, is very likely to result from improper handling of fish at spawning time.

Recent studies[9] tend to correct the long accepted belief that the mature eggs of trout and certain other salmonoid fishes fall loosely into the abdominal cavity and from there are extruded. As a matter of fact the ovaries of the Salmonidæ are inclosed in a delicate membrane, and the eggs are conveyed to the genital pore through an open membranous trough. The ova do not fall naturally into the abdominal cavity, and it seems probable that they can not be extruded if they are inadvertently displaced into it, and their presence there can not be advantageous to the fish.

Careless fish-cultural methods are responsible for displacing the eggs. Some of these are dipping the fish head first into a dip net, causing it to flop about, and grasping the fish by the tail and holding its head until its struggles cease. The dip net should always be large enough to permit the fish to lie extended. If the fish is ripe or partly ripe, the mass of eggs may be seen to sag toward the head, and inevitably any free eggs settle in the forward end of the abdominal cavity outside of the ova-containing membrane. It is after the stripping process has begun, however, that the danger of displacement is greatest, and particularly after some eggs have been expressed and the tenseness of the supporting abdominal wall is relaxed. Displacement is largely responsible for failure to secure all of the ripe eggs, and even though the fish may emit retained eggs later it is impossible for it to rid itself of displaced eggs.

Another disadvantage from which the fish may suffer is rupture of the membranes and injury to the ovaries from forcible pressure, so that the eggs falling into the abdominal cavity are not secured.

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[9] Peritoneal Membranes, Ovaries, and Oviducts of Salmonoid Fishes and Their Significance in Fish-cultural Practices. By William Converse Kendall. Bulletin, U. S. Bureau of Fisheries, Vol. XXXVIII, 1919–20. Bureau of Fisheries Document No. 901. Some Previously Unrecognized Anatomical Facts and Their Relation to Fish-cultural Practices. By William Converse Kendall. Transactions, American Fisheries Society, 1920.

When injured in this way, the ovary may not recover its natural function and may become sterile. If, however, simple precautions are observed, no injury to the fish will result. As an illustration it may be mentioned that fish have been kept for 14 years and their full quota of eggs extracted each season during the egg-producing term, which is normally from 10 to 12 years. The male fish is to be treated very much in the same manner as the female, except that the milt must not be forced out, as only that which flows freely is of value.

After stripping, the fish are not returned to the spawning pond, but spent females are placed in one pond and males in another. The males are very pugnacious at this season and sometimes fight for an hour or more at a time until they are entirely exhausted; they run at each other with open mouths, lock their jaws together, and in that position sink to the bottom of the pond, where they lie for a short time, each holding the other in his grasp until rested, when they rise and resume the combat. As their teeth are abnormally long, they scar each other and even bite pieces of skin and flesh from the sides of their antagonists.

From 15 to 25 per cent of the females yield eggs the second year, about 60 per cent the third year, and from 80 to 90 per cent each season thereafter. From 10 to 15 per cent of the fully matured females are barren each season. At one time it was thought that the same individuals were barren each year, but experience has shown that such is not the case, as fish that were barren one season have been held over in a separate pond until the following year when a large proportion, if not all, produced eggs. The sterility may be the result of injuries received during the progress of spawning. The males are good breeders when 2 years old.

PRODUCTION OF EGGS.

The number of eggs produced by a fish depends upon its size and age. The maximum from one 2-year-old fish, weighing from 6 to 12 ounces, is from 500 to 800; from one 6-year-old, weighing from 2 to 4 pounds, it is 2,500 to 3,000. The average of fish from 3 to 6 years old is 1,200 to 1,500. The eggs vary in size from 4½ to 5 eggs to the linear inch, and from 300 to 360 per fluid ounce, according to the age of the fish, though in some localities larger eggs, averaging not more than 220 to 240 per fluid ounce, are not uncommon. They are of a rich cream color when first taken, changing to a pink or flesh tint before hatching. Eggs from wild fish are of a pink or salmon color, and as a rule average somewhat smaller than those from domesticated fish.

HATCHING TROUGHS AND TRAYS.

The eggs are incubated on trays placed in troughs of wood, metal, or concrete and of various shapes and sizes. Standard troughs are 14 feet long, 14 inches wide, and 8½ inches deep, inside measure. They are set in pairs, as shown in Figure 13, page 44. Six inches from the lower or outlet end inside is a guard screen of perforated zinc or wire mesh, fastened on a frame exactly fitted across the trough. Zinc with perforations one-sixteenth of an inch in diameter for very young fry, and larger ones as the fish increase in size, is preferable to wire cloth.

The screen is arranged to slide vertically between beveled cleats, so that it may be cleaned more readily. An iron standpipe of suitable length to give the desired water level in the trough is screwed into the discharge pipe from the inside of the trough. Each trough should be provided with two of these standpipes of different lengths, mak-

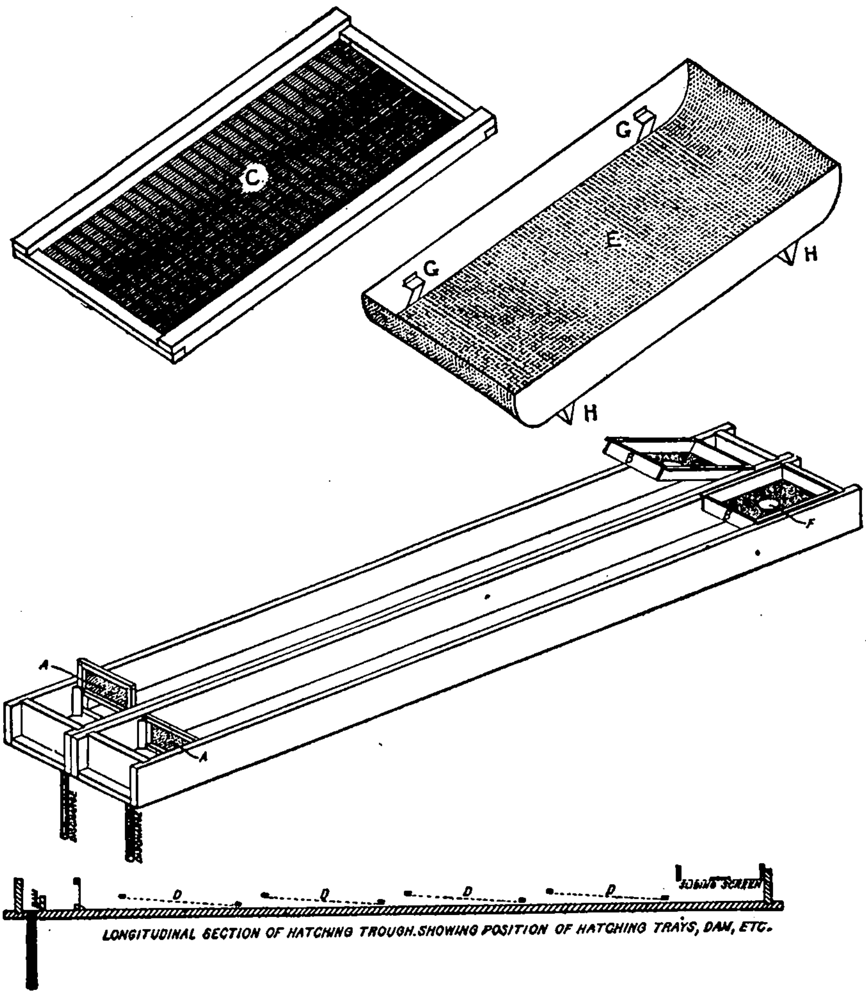

FIG. 13.—Hatching troughs, guard screen, and egg trays. *A*, guard screen; *B*, horizontal sliding screen; *C*, hatching tray; *D*, position of hatching trays; *E*, tin tray for use in muddy water; *F*, block for water to fall on; *G*, brackets; *H*, feet.

ing it possible to reduce the water level in the trough when desired for reasons which will be discussed in subsequent pages.

In the upper end of the trough a horizontal screen made of perforated tin, shown at *B* (fig. 13) is used. This is so constructed that it can be slipped forward or raised up (as shown in the illustration) when the fry are fed or the troughs cleaned. The water falling upon a small wooden block in the center of the screen is thoroughly aerated before entering the trough. This arrangement possesses many advantages over the old method, where the screens were vertical, or nearly so, as it permits fish to ascend to the head of the trough and receive the water as it falls from the screen, which is very beneficial. Its use not only keeps the fry clean even in muddy water, but also reduces the loss of fry from suffocation in the early stages, caused by their banking around the vertical screens, and obviates the necessity for trough covers to prevent jumping, as trout rarely jump where the horizontal screen has been adopted.

The horizontal screen and deflector are exceptionally valuable where the water supply is somewhat limited, and when used with the spreaders hereafter described the fish may be held under ideal conditions. The bureau's latest troughs have a pocket at the head, followed by a screen on a frame 6 inches from the upper end. Three-fourths of an inch below this is a dam board made of three-fourth-inch material extending from the top of the trough to within one-half inch of the bottom; a similar screen and dam board is placed in the middle of the trough. This system causes the current of water to pass close to the trough bottom, and a greater number of fish may be held in a trough divided in this way than otherwise. The tin spreaders, however, give the same effect; some fish-culturists are careless and do not use these until there has been a loss of fish. The young fish like to fight the current of water as it comes under the dam boards or spreaders, and it gives them exercise and good appetites.

The hatching trays, *C* (fig. 13), are convenient to handle and adjust in the troughs when made about twice as long as wide; that is, 28 by 13½ inches. The sides of the frame are made of good pine lumber, dressed, 1¼ by ⅞ inch. The ends are dressed ½ by 1 inch and are cut into the sides to form a smooth surface on the bottom for the wire cloth. The wire used on the trays is woven with eight threads to the inch, with a mesh seven-eighths inch long, and should be well galvanized after it is woven in order to prevent rusting at the laps. The inside of the troughs, the egg trays, and all other equipment used in the trough are given a coating of asphaltum, thinned with turpentine, prior to use and each successive season thereafter. This acts not only as a preventative of rust and decay, but aids materially in keeping the trough and fittings in a sanitary condition.

Four hatching trays are placed in each trough and secured by keys or wedges and should be from 1 to 2 inches lower at the end next to the head of the trough, as shown at *D*, *D*, *D*, *D* (fig. 13). When so placed, a tray will hold from 14,000 to 16,000 eggs of average size. Muddy water during the hatching season necessitates the use of a perforated tin tray 32 inches long and 13¾ inches wide, with perforations one-tenth of an inch in diameter in the bottom (shown at *E*, fig. 13). This rests on feet inside the trough, 1 inch above the bottom. The hatching tray containing the eggs is placed inside and rests on brackets shown at *G*. As they hatch the fish fall from the hatching tray upon the perforated bottom of the tin tray and by their movements work the sediment through so that they are left on a clean bottom and are in no danger of smothering. The tin trays are useful, also, in counting fish or for holding small lots of different species in the same trough. Where supplementary trays are not used the fry fall directly into the troughs.

A trough 14 feet long will carry 56,000 eggs safely on four hatching trays in a single row, 14,000 eggs to the tray, but if it is necessary to make more room a double row of trays may be put in, one tray resting on top of the other. Thus the trough could contain 112,000 eggs as its full capacity. By inclining the trays as described above a trough will carry this number up to the time of hatching.

When the hatching stage arrives, two trays of 14,000 eggs each are as many as should be left in one trough. With this number, by using the horizontal sliding screen in the upper end and several spreaders in the body of the trough at intervals of 2 or 3 feet, there is but little danger of the alevins congregating and smothering in any part of the trough. If it is necessary to hatch a much larger number of fry in one trough, the sliding screen should be so arranged that the water will fall well up toward or nearly against the end of the trough. This is done by raising the screen and turning it back against the supply trough. When danger from smothering has passed, the screen is again laid flat.

The spreaders are tin strips about 4 inches wide and 2 inches longer than the width of the trough, and when placed in the trough they are bowed toward the upper end, their excess length giving this effect. Three " feet " made of six penny finished nails are soldered to the bottom, giving the spreader a half-inch clearance above the bottom of the trough while the top extends just above the water level. The current created by this device near the bottom of the trough prevents the fry from congregating—a natural tendency—and serves to keep them well spread on the bottom.

The amount of water required for hatching and rearing depends upon its temperature and the manner in which it is applied. It should receive as much aeration as possible before entering the troughs or ponds containing eggs or fish. At the Wytheville (Va.) station each molasses gate in the supply trough furnishes water for two hatching troughs so placed that the water from the trough nearest the supply falls about 8 inches as it enters the trough below. In cleaning the higher troughs it is important that the plugs near the outlet end be removed in order that any refuse may pass directly into the drainage pipes. Under this arrangement eggs or fish in the lower troughs develop and thrive equally with those receiving water directly from the supply trough.

The volume of water at a mean temperature of 53° F. generally used in the troughs at this station, with their capacity for eggs and young fish of varying sizes, is indicated in the following statement. The figures given are for two troughs set end to end and supplied with water from one gate as described above:

Capacity of troughs:	Gallons per minute.
112,000 eggs	3½–4
56,000 fry, up to feeding stage	5
40,000 fingerlings, No. 1 to 1½	5
30,000 fingerlings, No. 1½ to 2	7
20,000 fingerlings, No. 2 to 2½	8
10,000 fingerlings, No. 2½ to 3	8
6,000 fingerlings, No. 3 to 4	8

FIG. 14.—Care of eggs and fry.

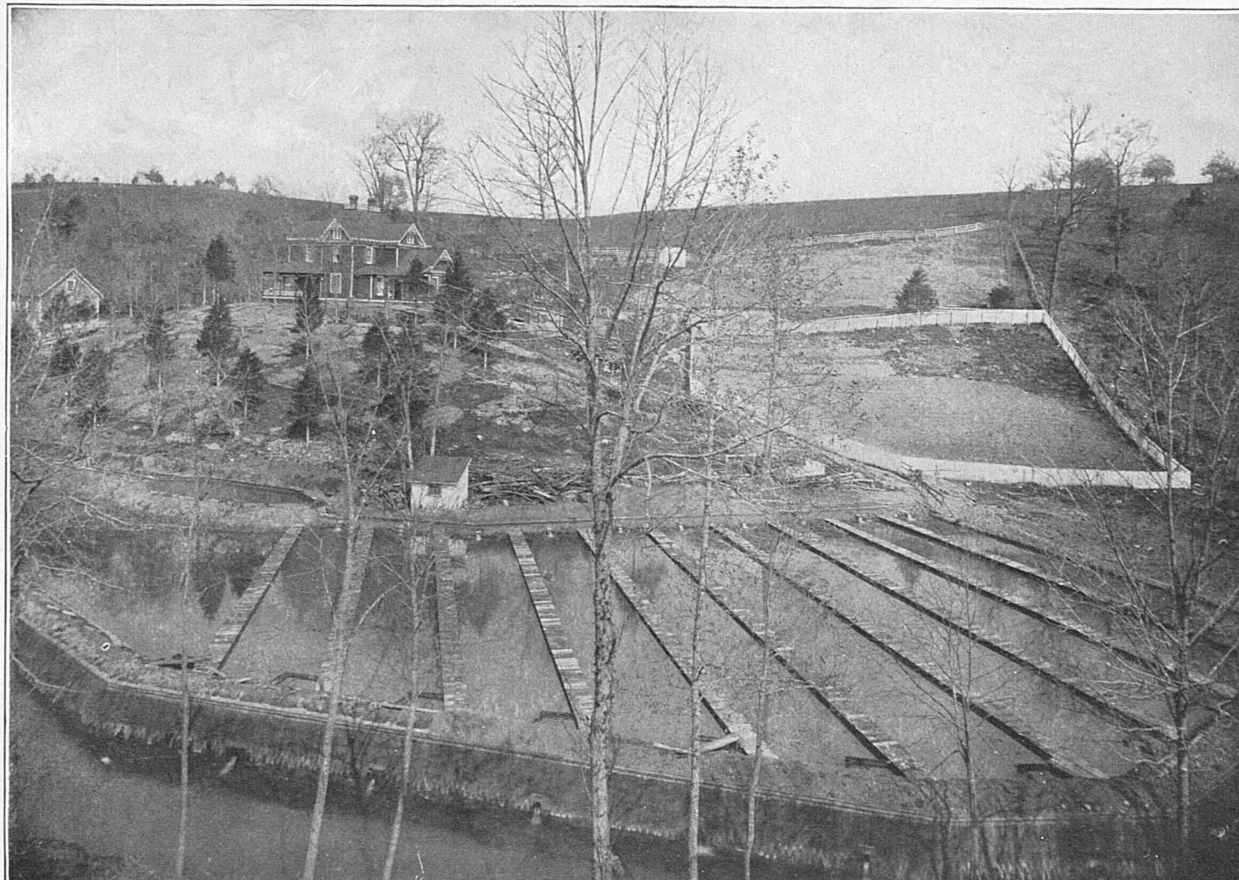

FIG. 15.—Rearing ponds, Wytheville (Va.) station.

The riffle ponds, 50 feet long by 5 feet wide (fig. 16, p. 48), carrying 40,000 No. 1 fingerling fish, receive from 20 to 40 gallons of water per minute. Yearlings and older fish in the brood or rearing ponds receive from 200 to 500 gallons of water per minute. A strong current of water is desirable in both the troughs and ponds, as it necessitates constant activity on the part of the fish, producing stronger fish than can be obtained in more sluggish water. The volume of water given here for fingerlings No. 1 and larger may be reduced without material disadvantage if the water temperature does not exceed 54°, but where water is plentiful and there is no need to economize in its use the amounts given can be used advantageously. In rearing ponds more water is required, as the circulation is not so good, and the outdoor exposure causes the temperature of the water to rise.

CARE OF EGGS AND FRY.

After the eggs are placed on the trays the only attention necessary until hatching begins is to keep them clean; dead eggs, which may be known by their turning white, must be picked out at least once each day. After the eyespot is plainly visible it is well to run a feather through the eggs for the purpose of changing their position on the trays and to disclose any dead eggs or foreign matter that may be hidden underneath. The greatest care should be exercised in handling the eggs at any time to avoid injuring them, especially from the first or second day after collection until the eyespots appear, and then only when absolutely necessary. During this period the eggs are very delicate and they should not be disturbed except to carefully remove the dead ones. This may be accomplished with wooden or metallic tweezers. A moderate amount of sediment has no harmful effect, since it covers one side of the eggs only. In cases where sediment is deposited on the eggs in sufficient quantity to solidify the mass and thus impair water circulation, the tray may be shaken gently, keeping the eggs well submerged during the operation.

In a water temperature of 53° the eyespots appear in about 13 days and at this time the eggs should be feathered carefully. In water of this temperature hatching occurs in from 35 to 38 days. A higher temperature shortens the incubation period, while a lower temperature lengthens it. As a rule, the best results are obtained in temperatures from 48 to 54°. A lower temperature prolongs the incubation period unduly, while higher temperature encourages the growth of fungus.

After the fry hatch they require but little attention until the umbilical sac is absorbed and the time for feeding arrives. They are examined daily and the dead fish and decayed matter removed from the troughs, which must be kept perfectly clean to keep the fish in healthy condition. As the fish grow they should be thinned out in the troughs from time to time as their size may require. When they first begin to feed, 20,000 to 25,000 fish per trough are not too many, but when they have attained a length of 1½ inches the number should be reduced to not more than 15,000, while from 3,000 to 4,000 three-inch fish are as many as one trough will accommodate advantageously. It is advisable to give them as much room as is practicable and to provide exercise for them several hours each day by lowering the water level in the troughs to a depth of about 1 inch. The extra overflow pipe previously mentioned is used for this purpose.

REARING PONDS.

Ponds for rearing trout from fry to fingerlings should be from 4 to 8 feet wide and of any desired length up to 60 feet, which, for convenience in drawing off the water and feeding the fish, is about the extreme limit. Between the advanced fry and No. 1½ fingerling stages it is of the utmost importance that the fish have several hours of exercise each day. This can be provided for best by having the bottom of the pond perfectly level across its width but with a slope of about three-fourths of an inch to each 5 or 6 feet from the head of the pond to the foot, with riffles 1 inch high at intervals (fig. 16, p. 48). There should be a sufficient water supply to allow the riffles to work effectively, and this will be evident from the formation of water beads and air bubbles immediately beneath them. When the water is drawn down to exercise the fish, it should be about 1¼ inches deep above the riffle and one-half of an inch deep below the riffle. It is very important that the pond have ample screen surface, otherwise the water will dam and destroy the effectiveness of the riffles. The screen may be placed vertically or inclined, and where it is possible a horizontal screen from 10 to 12 inches wide should be placed level with the bottom of the pond in front of the vertical or inclined screen, with a pit underneath for the reception of excrement. This insures an even depth of water in the pond and affords an effective means of ridding it of waste matter, which must be flushed out of the pit every few days to guard against pollution. Under such an arrangement the water supply enters the pond at the shallow end and discharges at the opposite end at a point several inches below the bottom of the pond. A successful means of preventing the fish from entering the supply pipe is shown in Figure 16, page 48.

STOCKING THE RIFFLE POND.

A pond 60 feet long and 5 feet wide will safely carry from 30,000 to 40,000 fish of No. 1 to No. 3 fingerling size. Larger ponds may be stocked with a proportionately larger number of fish. One-fourth of the pond area should be shaded with a frame made of 1 by 2½-inch strips over which 2-inch poultry wire is stretched and then covered with tarred roofing paper. This makes a cheap and satisfactory cover, and with proper care it will last through several seasons.

Young fish in a riffle pond may be easily trained to take food. Simply break up the material into small particles and allow it to enter the pond with the water. As it passes over the riffles the fish will seize it, and after having been fed a few times in this way the food may be given to them by the usual method when the pond is filled with water.

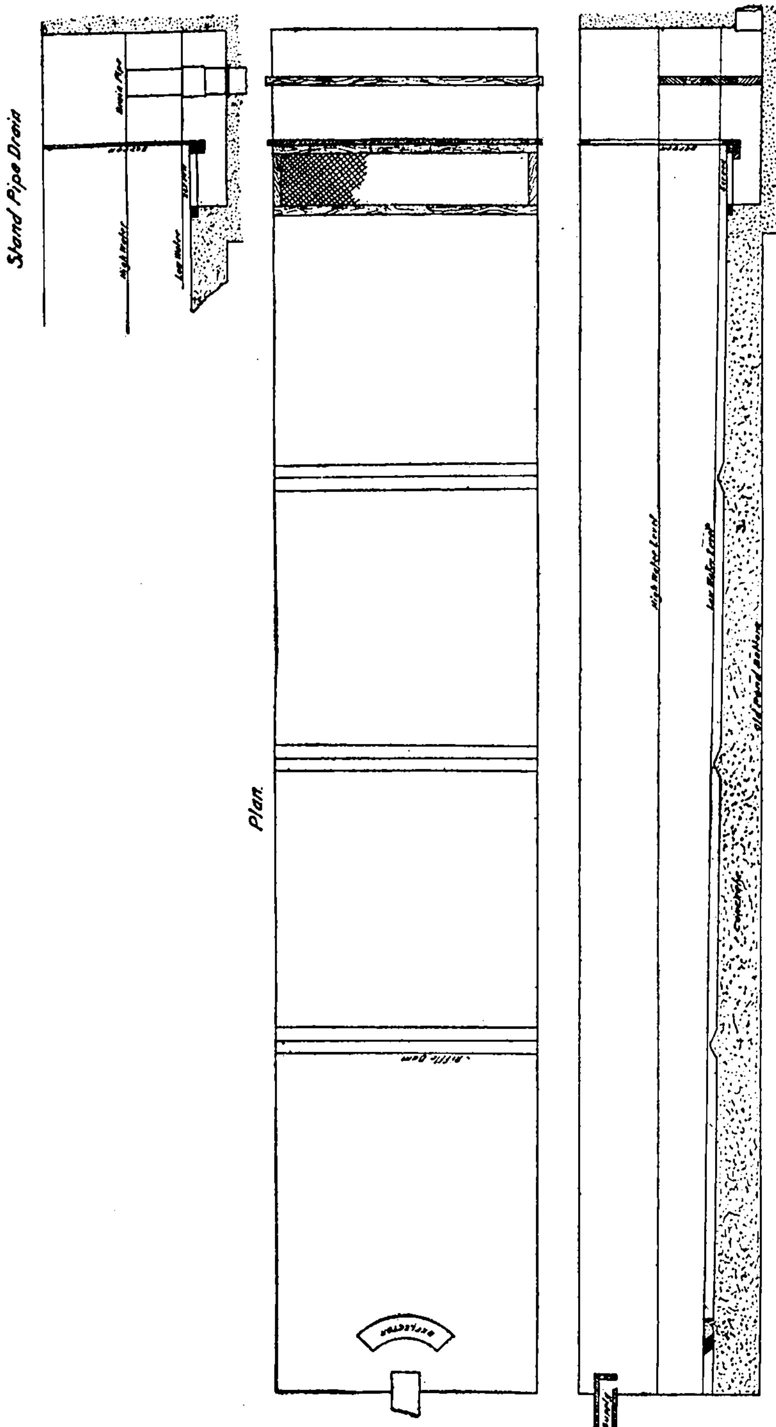

FIG. 16.—Plan of Seagle riffle rearing pond for trout.

FOOD.

Beef or sheep heart ground or chopped to a pulp seems to be the most satisfactory artificial food for young trout. Second to this in value is sheep liver, which is drier and more granular than beef liver, and it can be used to good advantage for the first two or three months or until the fish are large enough to thrive on a mixed diet. European fish-culturists have achieved at least partial success in producing a natural or living food, such as insect larvæ and small crustaceans, for artifically reared trout,[10] but nothing better than the meats mentioned has been found.

The proper method of feeding young fry should be understood thoroughly, as the losses resulting from improper feeding are frequently great. If there is undue haste, the water becomes polluted or the food is so distributed that some fish do not receive their share. Polluted water is very injurious to the young fish, sometimes causing inflammation of the gills and other ailments, which often result in heavy mortality. It may also produce undersized fish.

The fry are ready to take food as soon as the sac is absorbed, the time required for this depending upon the rate of growth, which is governed by the temperature of the water. In a uniform temperature of 53° they will take food in about 30 days after hatching, and the time to begin feeding may be closely estimated by observing the movements of the fish.

It is preferable to feed artificially reared rainbow trout on meat entirely if it is plentiful and cheap; otherwise a combination of liver and mush will give satisfaction. The mush is made by stirring wheat shorts or middlings in boiling water and cooking it until the mixture becomes thick. After the mush is thoroughly cool the finely ground heart or liver is added, the proportion usually being 20 to 25 per cent mush to 75 or 80 per cent meat. In some localities rye shorts are obtainable in better grades than wheat shorts and at a lower price, and the rye seems to be quite satisfactory as food for the young fish. Enough of the mush for several feedings may be made at one time, as it keeps well in a cool place, but the meat should not be added at one time, but only as needed.

Before the sac is entirely absorbed the school of fry at the bottom of the trough will begin to break up and scatter through the water, rising higher from the bottom each day until they can balance themselves gracefully in a horizontal position, all of them heading against the current and swimming well up in the water. By dropping small bits of cork or prepared food on the surface of the water it can be determined if they are ready for food. If they strike at the pieces as the current carries them down, it is evident that they are hungry.

The food is prepared by chopping it very fine and mixing it with water, in order that it may be distributed evenly. It should be given to the fish by dipping a feather into the food and gently

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[10] Fresh-water Crustacea as Food for Young Fishes. By William C. Kendall. Appendix I, Report U. S. Commissioner of Fisheries, 1922. Bureau of Fisheries Document No. 914, 1921.

skimming it over the surface of the water. After the fish have grown to be 1¼ to 1½ inches long, they begin to take food that settles on the bottom of the trough, and it may then be given with a spoon. The young fry are fed five times a day, the food being given slowly and sparingly. After they learn to take their food from the bottom of the trough it is necessary to feed them only three times a day, but the amount given at each meal must be increased. Fish that are being fed artificially should not be carried in troughs that overflow into other troughs containing eggs or newly hatched fry, as particles of food will pass through the screen and cause trouble.

When the fish are first fed, the meat is prepared very carefully. The liver is usually "skinned" and all fat and connecting tissue removed from the heart. It is then passed through the finest plate of a meat chopper several times. These machines are provided with plates having holes from one-twelfth to one-half inch in diameter, so that the meat can be prepared fine or coarse, according to the size of the fish to be fed. At the bureau's stations the Enterprise food chopper No. 42, driven by a two or three horsepower gasoline engine, is employed.

The practice of throwing food into the pond by handfuls is entirely wrong, as it causes the fish to rush together violently, with open mouths, struggling to get a bite of food. They often hurt each other and injure one another's eyes, sometimes even plucking them from their sockets. This is probably one of the main causes of blindness among pond-fed fish.

The most approved method of feeding is to walk along the entire length of the pond to the upper end and then scatter a handful of food along the surface of the water so that it will fall to pieces. The fish quickly learn to follow and take up the food and then return to watch for the next handful. The operation is repeated until sufficient food has been given. This method of feeding induces all the fish to head in the same direction while eating, thus reducing the danger of injury.

The proper amount of food for a given number of trout depends upon their size, the temperature of the water, and to some extent on the kinds of food used. More food is required when the water temperature is comparatively high than when it is low. With water from 50 to 60° F. and food consisting of meat and wheat or rye mush, as described, the following daily ration for 1,000 fish will be found to be approximately right: Fingerlings, 3 to 5 inches long, 2 to 3 pounds per day; yearlings, 8 to 12 inches long, 4 to 8 pounds per day; adults, 8 pounds per day.

As the fish increase in size the amount of food should be increased proportionately and the number of feedings per day reduced until at the yearling stage they should receive food only in the morning and evening at regular hours. Some fish-culturists find one feeding per day satisfactory for year-old and older fish. In the table below are indicated the kind and amount of food per month per 1,000 rainbow trout of different sizes at some of the bureau's stations.

TABLE 2.—*Kind of food fed and amount required for 1,000 rainbow trout of various sizes.*

Station.	Size of fish.	Kinds of food.					Mean water temperature.
		Beef heart.	Beef liver.	Sheep liver.	Mush.	Fresh fish.	
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*°F.*
Wytheville, Va	Fingerlings No. 3		34		21		52
	Fingerlings No. 6	12	26		33		
	Adults	27	60		120		
Neosho, Mo	Fingerlings No. 3			105	157		58
	Adults			130	150		
Springville, Utah	Yearlings	31			25	26	53
	Adults	27			183	860	

PREPARING EGGS FOR SHIPMENT.

Trout eggs are in condition to bear transportation when they have developed sufficiently to show the eyespots but are not too old to reach their destination before the time for hatching. Allowance is made for changes in temperature on the road that would cause them to hatch too soon. Best results are obtained by selecting eggs after they have reached the "tender" stage, or when the eyespots are first discernible by holding the egg up to the light. Twenty-four hours in advance of shipment the eggs selected are transferred from the trays to pans or buckets. They are thoroughly washed with a stream of water of sufficient force to cause some agitation among them or by stirring them with a feather brush. This treatment not only removes all sediment from the eggs but causes all infertile eggs, which up to this time may have retained the color of good ones, to turn white and thus facilitates their removal. Unless this is done infertile eggs are very likely to get into the shipment. The eggs are then accurately weighed or measured (1 ounce may be weighed and counted or the eggs for one tray counted and then weighed), and the total number needed may be estimated from the result thus obtained.

To facilitate the work of packing the trays are sometimes placed in a trough in which there is no current of water and the eggs poured on them from the graduate or measure. The trays are then shaken gently to settle the eggs evenly into place. If trough room is not available, a tub of water may be used. All trays and moss should be soaked in cold water for several hours previous to use, and when dry moss is used it is well to expose it to frost. If this is not practicable, shaved ice may be sprinkled through it. It is also desirable that the packing be done in a room with a low temperature.

PACKING EGGS FOR SHIPMENT.

The method of packing trout eggs on deep trays with a cushion of wet sphagnum moss over each tray is no longer practiced to any great extent with rainbow trout. The egg tray now in use has a cheesecloth or linen scrim bottom, it is about three-sixteenths of an inch thick, has a depth varying with the diameter of the eggs to be shipped, and has such other dimensions as may be required. For shipping 50,000 eggs 25 trays are used; for 100,000 eggs 33 trays, and so on, each tray being proportioned to contain its quota of eggs, reckoning 25 eggs to a square inch of tray surface one layer deep in the shallow trays, as shown in Figure 17 on this page.

After the trays have been filled with eggs they are placed one on top of another in stacks of from five to eight trays, and in order to keep the eggs moist a tray of the same dimensions but three-fourths

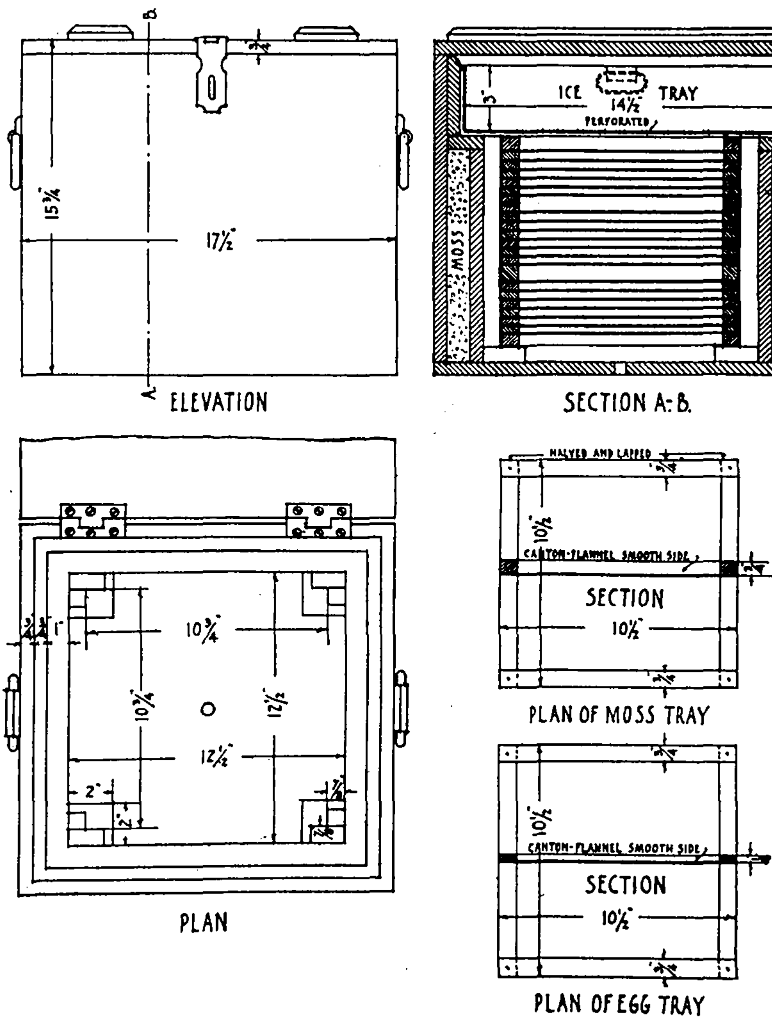

FIG. 17.—Plan of Seagle egg-shipping case.

of an inch deep is packed with wet moss and fastened on top of the stack with strong wrapping twine. First, a tray of moss is placed in the bottom of the shipping case, serving as a foundation for the trays containing eggs, then the stack of egg trays is placed on top of this and another tray of moss is set on top of the stack.

The outside shipping case has double side walls, with 1¼-inch compressed cork insulation between, extending up as far as the ice chamber, which occupies about 4 inches at the top of the case. Inside of the case, around the sides, and at the bottom of the stack of trays, is a one-half-inch air space, the air entering through four holes bored through the walls, one on either side near the bottom, one at the front, and one at the back under the ice pan. The case is provided with strong iron handles, and the lid is put on with four hinge hasps with drop fastenings, these being more satisfactory than common hinges.

The trays of eggs are held in place by V-shaped grooves formed by nailing cleats of suitable size in the corners of the case and are supported by four small blocks nailed to the bottom in the corners. Covering the bottom of the case and extending up 1 inch on all sides is a lining of tin, and through the center of the bottom is the drain tube. The ice pan, of galvanized iron and about 4 inches deep, fits the inside of the case. Its bottom is perforated to correspond with the inside dimensions of the egg trays, so that water from the melting ice contained in the pan must pass downward through the trays of eggs and escape through the tube at the bottom of the case.

After arranging the stacks of egg trays in the case the ice pan is set in position over them, filled with broken ice, and covered with a piece of oilcloth. A cushion or pillow of dry sphagnum moss is fitted into the space between the ice and the lid of the case; the lid is then closed and the eggs are ready for shipment.

DISTRIBUTING AND PLANTING FRY AND FINGERLINGS.

Rainbow trout from the bureau's hatcheries are distributed to applicants either as advanced fry immediately preceding the feeding stage or as fingerlings, after two or three months of artificial feeding. They may, however, be planted successfully at any time after the absorption of the yolk sac in waters where conditions are favorable. In the Southern States the best time for planting is the middle of March. In the more Northern States the springfed streams and open lakes are usually in condition to receive plants of fish in April. In any locality where the new green of the meadows and woods indicates the advent of spring the young fish may be safely planted. In their natural habitat the rainbows spawn during the early spring, and the young have absorbed the sac and are ready for food late in May or by June. Practically all of the fish hatched during the winter months at stations of the bureau are held and fed until weather conditions are favorable.

In making deliveries of fish to applicants, the ordinary 10-gallon milk can of the commercial dairyman is used. The number of fish that may be carried safely, per can, is dependent on the size of the fish, temperature of water, and the distance to be covered. In well-aerated water of a temperature ranging between 48 and 55°, the following numbers may be carried safely in a 10-gallon milk can:

Advanced fry, at feeding stage	2,500
Fingerlings No. 1	1,000
Fingerlings No. 1½	600
Fingerlings No. 2	300
Fingerlings No. 2½	150
Fingerlings No. 3	100

Too frequently plants of fish in public waters fail to give the best results because of careless and improper methods used in making the plants. The Bureau of Fisheries delivers fish to applicants free of charge at the railroad station designated in the application. It devolves on the applicant to see that the fish thus furnished are carefully and properly planted in the waters for which they are assigned. Many times the fish are taken to the place most easily accessible and the entire lot poured into water where there is but slight chance of their escaping large fish or finding congenial surroundings. The most suitable planting places in streams are to be found near the headwaters or in small tributaries. The fish should be scattered over as wide a stretch of stream as possible, in quiet, shaded, shallow backwaters and eddies. Deep pools where large fish are apt to be lurking should be avoided; also quick water, where the little fellows could not maintain themselves or find the food that is essential to their well-being. In stocking lakes or ponds the best places for planting are to be found in the small tributaries, as described above. Whenever possible avoid planting directly in the lake, but if it is impossible to do otherwise, select the shallow weedy margins or other places affording the greatest protection from enemies. Such places are the first to warm in the spring and they are sure to produce the greatest amount of natural food for young trout.

BLACK-SPOTTED, LOCH LEVEN, AND BROWN TROUT.

The methods employed in taking and fertilizing the eggs, the incubation thereof, and the care of the fry, fingerlings, and adult fish in the artificial propagation of the various trouts are practically interchangeable, and for this reason it is unnecessary to dwell again on the fish-cultural processes. In the following pages the three species of trout mentioned above are briefly described. Of these only the black-spotted trout (*Salmo lewisi*) of the Yellowstone National Park is artificially propagated to any extent by the Bureau of Fisheries.

The brown trout is not propagated by the bureau, and the Loch Leven trout is handled only incidentally at one or two of the Rocky Mountain trout stations. Propagation of the latter two species was discontinued because evidence was obtained from various sources to the effect that almost without exception these fishes offered nothing of advantage to the natural fish of the regions where they were introduced, and in many cases their introduction proved to be a serious detriment to the more valuable native species.

BLACK-SPOTTED TROUT (SALMO LEWISI).

Several varieties of the black-spotted trout have at various times been artificially propagated. In the past the more important operations were conducted at the Leadville (Colo.) station of the bureau and dealt with the black-spotted trout (probably *Salmo pleuriticus*) of the Grand Mesa Lakes, in Delta County, Colo. The Manual of Fish Culture[11] mentions the work of the Leadville station and that

[11] A Manual of Fish Culture, Based on the Methods of the U. S. Commission of Fish and Fisheries, revised edition, p. 181. Washington, 1900.

of the California Fish and Game Commission addressed to *S. henshawi* of Lake Tahoe. The same publication makes the following reference to the spawning season and incubation period of the eggs:

In the vicinity of Leadville the spawning season extends from May 1 to July 15. The eggs are hatched in the same troughs and under the same conditions as those of the brook and rainbow trouts. In water ranging from 42 to 60° and averaging about 52° F., the eyespots appear in 20 days and hatching ensues in 30 to 45 days.

At the present time artificial propagation of this trout is confined to the fish of the Yellowstone National Park (*Salmo lewisi*), and a limited amount of work is done at the Springville (Utah) station, where a small brood stock is maintained. Some information relative to the spawning season and incubation period of the eggs at these points is given in the following table:

TABLE 3.—*Spawning season of black-spotted trout (Salmo lewisi), showing egg production and period of incubation.*

Station.	Spawning season.	Average number of eggs per fish.	Number of eggs per ounce.	Minimum egg production.		Incubation period.		Fry.
				Weight of fish.	Number of eggs.	Eyespots appear.	Incubation completed.	Yolk sac absorbed.
Yellowstone Lake, Wyo.	June 10 to July 20.	950	350	2 pounds..	1,600	14 days at 47° F.	22 days at 47° F.	15 days at 47° F.
Springville, Utah.	May 27 to June 30.	2,000	320	....	....	....	23 days at 54° F.	

Smith and Kendall [12] have the following to say regarding the black-spotted trout in Yellowstone National Park waters:

In its numerous varietal, subspecific, or specific forms the redthroat, cutthroat, or black-spotted trout is of extensive distribution on the Pacific slope. In the park a form designated as *Salmo lewisi* is found naturally in both upper Snake and upper Missouri waters, having doubtless gained access to the latter from the Snake River by the way of Two Ocean Pass, and it is not unlikely that an interchange of individuals still takes place. Yellowstone Lake and Yellowstone River from its source to many miles beyond the park are inhabited by it. The abundance of trout above the falls is remarkable. At almost any time as one passes along fish are seen breaking water.

The size attained by trout in park waters, as elsewhere, varies much with locality and conditions. Fish of over 4 pounds have been reported.

In some waters this trout is highly esteemed as a game fish and can be taken in all sorts of ways—spoon, phantom, natural bait, artificial fly, etc. Mary Trowbridge Townsend (loc. cit.) writes of it in the Firehole River:

The father of the Pacific trout, the black-spotted "cutthroat," with the scarlet splotch on his lower jaw, was most in evidence, with long, symmetrical body, and graduated black spots on his burnished sides. He is a brave, dashing fighter, often leaping salmon-like many times from the water before he can be brought to creel. We found him feeding on the open riffs or rising on the clear surface of some sunlit pool.

[12] Fishes of the Yellowstone National Park, With Description of the Park Waters and Notes on Fishing. By Hugh M. Smith and William C. Kendall. Appendix III to the Report of the U. S. Commissioner of Fisheries for 1921. Bureau of Fisheries Document 940, p. 18.

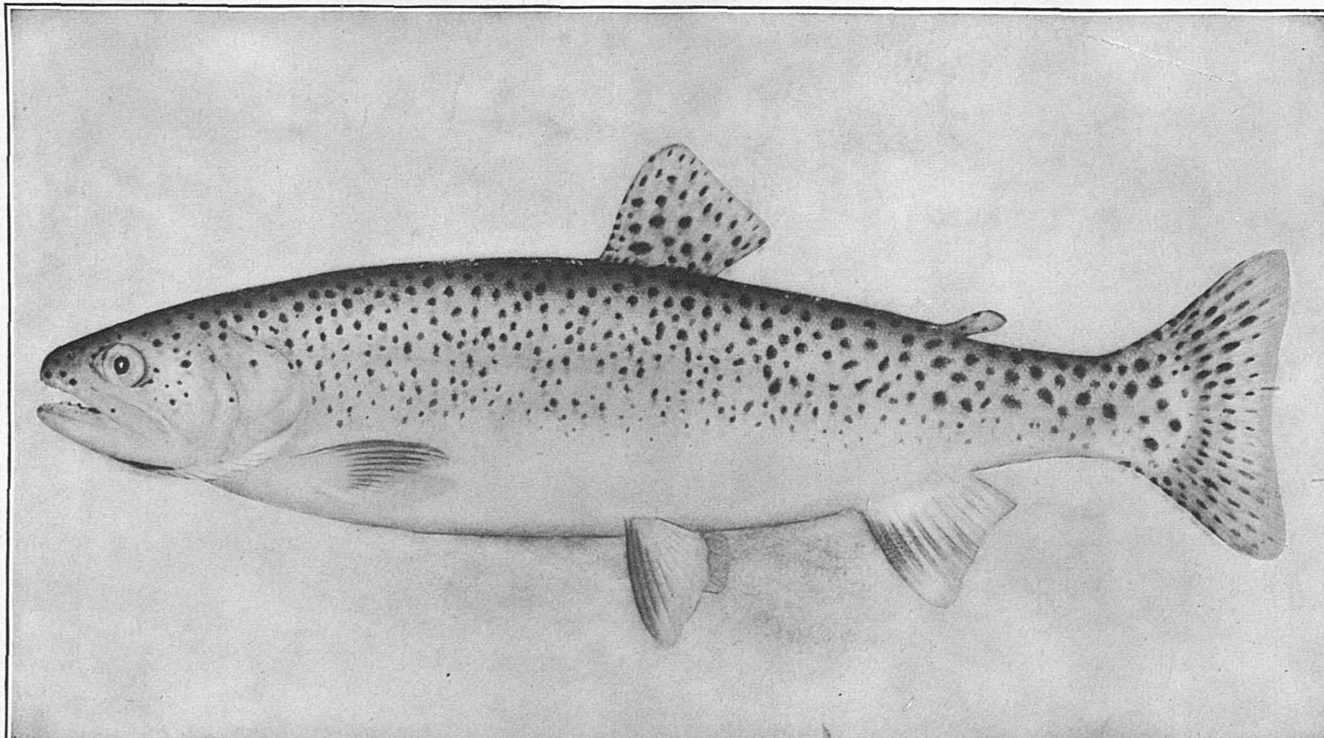

FIG. 18.—Black-spotted or cutthroat trout (*Salmo lewisi*).

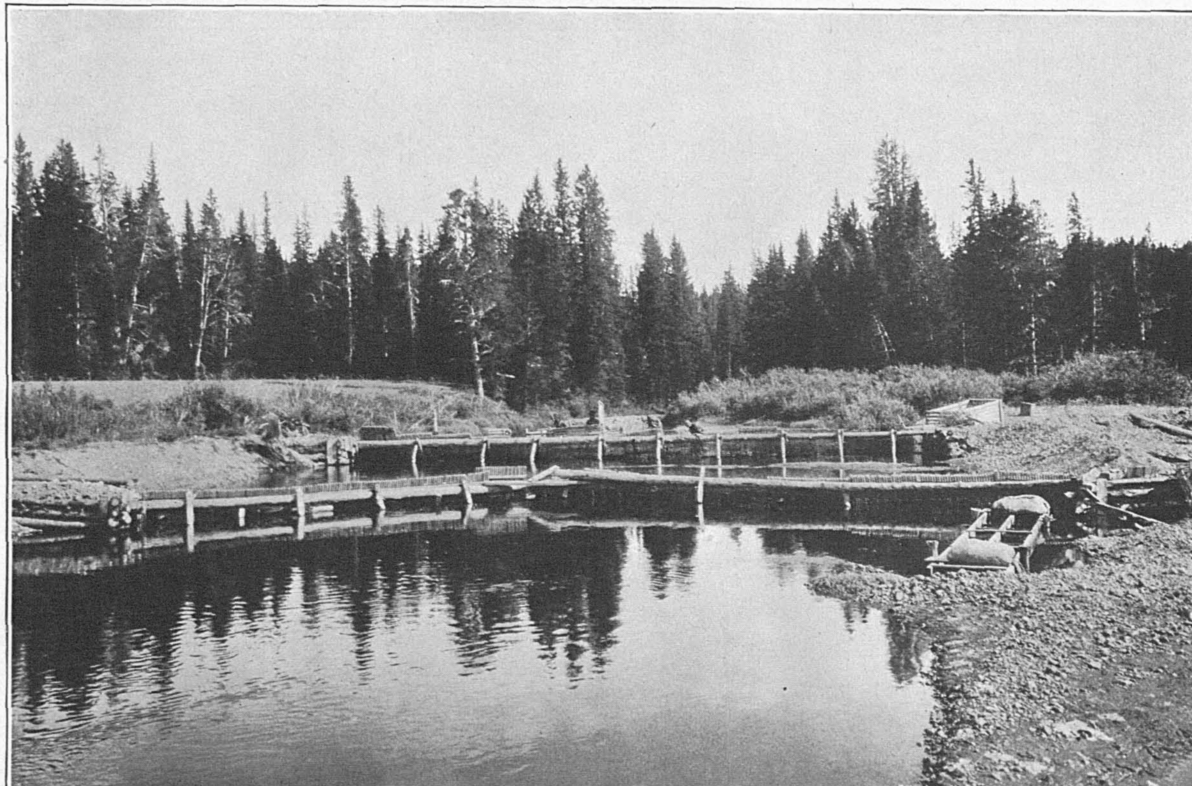

FIG. 19.—Trap for the capture of spawning black-spotted trout, Yellowstone National Park.

FIG. 20.—Collecting the eggs of black-spotted trout, Yellowstone National Park.

Ralph E. Clark wrote (loc. cit.) that "the dark, silver-gray trout of the West seem to favor flies more in harmony with their own coloring," and mentioned the gray hackle, brown hackle, coachman, grizzly king, Seth Green, black gnat, and white moth:

The junction of Yellowstone and Lamar Rivers is noted for fine fishing. If you find the waters high, swift, and roily, you will probably try your flies in vain. Put on a spinner or a little spoon and watch the fish rise to it, almost touch it, and then go away. They are after live bait and won't touch anything else. The grasshoppers are abundant. Catch a few, bait your hook carefully, and let it float down with the current. A large trout will rise to it, and if you are not very careful he will steal it away from you.

VARIETIES AND DESCRIPTION.

It has been said that there are two varieties of native trout in the park, the larger ones of the Yellowstone, with bright yellow bellies, and the smaller kind more silvery in appearance and exhibiting much greater activity and game qualities, of which Tower Creek fish are examples. Also trout of Yellowstone Lake seem to differ from those of Heart and Henry Lakes in having more distinct and rather less numerous black spots. However, in this respect very much individual variation is shown. It has also been suggested that the silvery color is a juvenile characteristic, while the "yellow bellies" are older fish. Who knows?

This is the principal fish artificially propagated by the Bureau of Fisheries at the hatcheries on Yellowstone Lake and Soda Butte Creek. From 3,000,000 to 20,000,000 eggs are taken annually. After the local park waters are liberally stocked the remaining young are supplied to suitable waters in the adjoining States. The park, however, should have and does have first claim on the hatchery output.

Jordan and Evermann[18] give the following description of the fish and other information concerning it:

The Yellowstone or Lewis trout (*Salmo lewisi*) inhabits the Snake River Basin above Shoshone Falls and the headwaters of the Missouri. It is abundant throughout this whole region in all accessible waters and is particularly numerous in Yellowstone Lake. As already stated the trout of Yellowstone Lake certainly came into the Missouri Basin by way of Two-Ocean Pass from the upper Snake River Basin. One of the present writers has caught them in the very act of going over Two-Ocean Pass from Pacific into Atlantic drainage. The trout on the two sides of the pass can not be separated and constitute a single species.

The cutthroat trout (*Salmo clarkii*) * * * is found in all the coastwise streams and lakes from northern California to British Columbia and possibly in southeastern Alaska. In the Columbia River Basin it is found as far up the Snake River as Shoshone Falls and in the headwaters of the Pend d'Oreille. In the waters about Puget Sound it is very abundant, as it is, in fact, throughout most of its range. It is known variously as cutthroat trout, black-spotted trout, Columbia River trout, and by many other local names.

In the earlier books this species was identified with the Mykiss of Kamchatka and was called *Salmo mykiss* or *Salmo purpuratus*, but recent investigations have shown that it is not identical with the Kamchatkan species, and that there is a wide region between Kamchatka and southeast Alaska in which no trout are found.

The cutthroat trout and all of this series spawn in the spring and early summer. Those in the streams seek the shallow waters of the smaller creeks, while those of the lakes come to the shallow waters near shore or upon the bars; in many cases they ascend tributary streams. * * *. The cut-

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[18] American Food and Game Fishes. Pp. 176 and 179. By David Starr Jordan and Barton Warren Evermann. Doubleday, Page & Co., New York, 1902.

throat trout and its different derived forms vary greatly in the sizes at which they reach maturity, the chief factors being, of course, the size of the body of water they inhabit and the amount of the food supply.

Those species or individuals dwelling in lakes of considerable size, where the water is of such temperature and depth as to insure an ample food supply, will reach a large size, while those in a restricted environment, where both the water and food are limited, will be small directly in proportion to these environing restrictions. The trout of the Klamath Lakes, for example, reach a weight of at least 17 pounds, while in Fish Lake in Idaho mature trout do not exceed 8 to 9½ inches in total length, or one-fourth pound in weight. In small creeks in the Sawtooth Mountains and elsewhere they reach maturity at a length of 5 or 6 inches and are often spoken of as brook trout under the impression that they are a species different from the larger ones found in the lakes and larger streams, but as all sorts of gradations between these extreme forms may be found in the intervening and connecting waters the differences have not even subspecific significance.

The various forms of cutthroat trout vary greatly in game qualities. Even the same species in different waters, in different parts of its habitat, or at different seasons will vary greatly in this regard. In general, however, it is perhaps a fair statement to say that the cutthroat trout are regarded by anglers as being inferior in gameness to the eastern brook trout. But while this is true it must not by any means be inferred that it is without game qualities, for it is really a fish which possesses those qualities in a very high degree. Its vigor and voraciousness are determined largely, of course, by the character of the stream or lake in which it lives. The individuals which dwell in cold streams about cascades and seething rapids will show marvellous strength and will make a fight which is rarely equalled by its eastern cousin, while in warmer waters and larger streams and lakes they may be very sluggish and show but little fight. Yet this is by no means always true. In the Klamath Lakes, where the trout grow very large and where they are often very loggy, one is occasionally hooked which tries to the utmost the skill of the angler to prevent his tackle from being smashed and at the same time save the fish. An instance is on record of a most enthusiastic and skilful angler who required one hour and three-quarters to bring to rest a 9¾-pound fish in Pelican Bay, Upper Klamath Lake. * * *. The typical cutthroat trout (*Salmo clarkii*) may be described as follows:

Head 4; depth 4; D 10; A 10; cœca 43; scales small, in 150 to 170 cross series. Body elongate, compressed; head rather short; mouth moderate, the maxillary not reaching far beyond the eye; vomerine teeth as usual set in an irregular zigzag series; teeth on the hyoid bone normally present, but often obsolete in old examples; dorsal fin rather low; caudal fin slightly forked (more so in the young). Color, silvery olivaceous, often dark steel color; back, upper part of side and caudal peduncle profusely covered with rounded black spots of varying sizes and shapes, these spots often on the head and sometimes extending on the belly; dorsal, adipose, and caudal fins covered with similar spots about as large as the nostril; inner edge of the mandible with a deep red blotch, which is a diagnostic mark; middle of side usually with a diffuse pale rosy wash, this sometimes quite bright and extending on to side of head; under parts silvery white. The red blotches or washing on the membrane joining the dentary bones of the lower jaw are usually constant, probably always present in the adult, and constitute a most important character. This species has been called *Salmo mykiss* in various publications by the writers and others, but the true *Salmo mykiss* is allied to *Salmo gairdnerii* and has never been taken outside of Kamchatka.

GROWTH AND EGG PRODUCTION.

The superintendent of the Bozeman (Mont.) hatchery gives the following information regarding the growth and egg-production of the black-spotted trout of the Yellowstone National Park waters:

Even with domesticated trout on the hatchery grounds, fed and reared in the same ponds and with the same opportunity for growth, there is a very wide range of development. In the case of wild fish we have reason to believe that this development presents even a greater range owing to food conditions, range, and number of fish in proportion to the previously named conditions. From observations in connection with the Yellowstone Park operations we believe that the following figures are approximately correct:

Age.	Length (inches).	Egg production.
Yearlings	3-5	....
Two-year-old	5-8	....
Three-year-old	8-12	500-800
Four-year-old	11-15	800-1,200
Thereafter	13-18	1,000-1,600

On several occasions when we kept count of the fish spawned the average production was found to run from 900 to 1,000 eggs per spawned fish. There are very few undersized spawning fish as compared with brook trout, where we find them producing spawn at 7 and 8 inches, and occasionally when even smaller. It is believed that very few females spawn under 3 years of age in the Yellowstone watershed. The season is short, due to both latitude and high altitude, hence the rate of growth is somewhat slower than in many sections more favored climatically.

PARASITES.

This is an excellent food fish when fresh from cool waters, but the trout from some parts of the Yellowstone Lake, Upper Yellowstone River, and Heart Lake are generally reputed to be infested with a parasitic worm. In his book pertaining to the fish of the park, General Chittenden says:

> The trout of Yellowstone Lake are to a slight degree infected with a parasitic disease that renders them unfit for eating. Many efforts have been made to discover the cause of this condition and a suitable remedy for it, but so far without success. An explanation sometimes advanced is that the excessive number of these fish and the absence of sufficient food reduce the vitality and they become easy prey to parasites which a more vigorous constitution would throw off. Later investigations have shown that reports of the prevalence of this condition were much exaggerated.

The parasite referred to is a tapeworm, of which only the larval or intermediate form occurs in the trout, the host of the adult being an entirely different animal, as is the case with all tapeworms of this kind. Briefly, its life cycle has been found to be as follows: Starting with the egg in the water it develops into a ciliated embryo. This passes into the fish, probably by way of the mouth, and becomes established and assumes the form usually observed. The fish is eaten by the pelican, and in the intestinal tract of that bird the parasite attains its adult and reproductive stage and its round of life is there completed. The eggs pass into the water and a new generation is begun.

General Chittenden's statement that the parasite renders the fish unfit for food involves a matter of prejudice rather than actual unfitness for food or danger to the consumer. Cooking destroys the vitality of the worm, and it may be said that this particular worm is not harmful to man. Probably no one would knowingly eat an infected fish, but if he should there would be absolutely no danger in doing so. Beyond doubt the presence of this parasite is greatly exaggerated, as General Crittenden says, and lean, cadaverous, unsightly trout, the condition of which is commonly attributed to parasitism, are often fish which are run down from breeding, although they may carry some parasites. There is scarcely a fish that swims that is not more or less infected by some sort of parasitic worm, and in this respect the Yellowstone fish do not appear to be worse than the fish of many other lakes in the country.

LOCH LEVEN TROUT (SALMO LEVENENSIS).

The Loch Leven trout[14] of Great Britain was introduced into the United States from Scotland in 1885 and subsequent years. It is somewhat closely related to the European brown trout (*Salmo fario*), and has been artificially crossed with that species in the United States, so that it is sometimes difficult to find the purebred Loch Levens in fish-cultural establishments at home.

DESCRIPTION.

The body of the Loch Leven is more slender and elongate than that of the brown trout, its greatest depth contained four and one-fourth to four and one-half times in the total length without caudal. Caudal

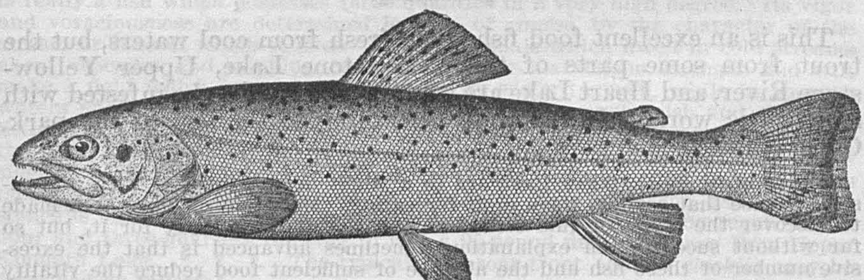

FIG. 21.—Loch Leven trout (*Salmo levenensis*).

peduncle slender, its least depth three-eighths of the greatest depth of the body and equal to length of snout and eye combined. The head is rather short and conical, its length two-ninths to one-fifth of the total length without caudal. The snout is one-fourth or slightly more than one-fourth as long as the head. The interorbital space is somewhat convex, its width equal to three-fifths of the length of postorbital part of head. The eye is of moderate size, its long diameter contained five and one-half to six times in the length of the head and equaling about twice the greatest width of the maxilla. The maxilla reaches to or slightly beyond the posterior margin of the eye. Teeth rather strong, those in the intermalillary and mandible the largest, triangular head of vomer with two or three in a transverse series at its base, teeth on the shaft of the vomer usually in a single, partially zigzag, persistent series. Mandable without a hook and but little produced even in breeding males.

Anterior end of dorsal base distant from tip of snout about as far as posterior end from base of caudal; the dorsal fin higher than long, its base one-eighth of total length without caudal, its longest ray equal to longest ray of anal fin. The anal fin is much higher

[14] Food and Game Fishes of New York. By Tarleton H. Bean. In the Seventh Report of the New York Forest, Fish, and Game Commission, 1901 (1902), p. 336. Albany.

than long, its distance from the base of the ventral equaling length of the head. The anterior end of the base of the ventral is nearly under the middle of the dorsal, the fin being as long as the postorbital part of the head. Pectoral equals length of head without the snout. Adipose fin very small, its width one-half its length, which is about equal to eye. The caudal when fully extended is square or truncate; in natural position it is somewhat emarginate. The outer rays are about one-seventh of the total length of the fish including the caudal.

Upper parts brownish or greenish olive, or sometimes with a reddish tinge; sides silvery with a varying number of X-shaped black spots, or sometimes rounded brown spots or rounded black spots which may be ocellated; occasionally red spots are seen on the sides, and the adipose fin may have several bright orange spots, or it may show a red edge and several dark spots; sides of the head with round black spots; dorsal and adiposed fins usually with numerous small brown spots; tip of pectoral blackish; anal and caudal fins unspotted, but the caudal sometimes has an orange margin and the anal a white edge with black at its base; a similar edge may sometimes be observed on the ventral.

RANGE, SIZE, AND FOOD.

The Loch Leven trout is a nonmigratory species, inhabiting Loch Leven and other lakes of southern Scotland and the north of England. Its range in Great Britain and on the continent of Europe has been greatly extended by fish-cultural operations, and the fish is now fairly well known in the United States, though mixed to some extent with the brown trout, as remarked above. Examples weighing 18 pounds have been recorded, but the average weight at 6 years of age is about 7 pounds, though some individuals of that age may reach 10 pounds. The natural food of this species includes fresh-water mollusks (snails, *Buccinum*, etc.), crustaceans, worms, and small fish. In captivity it is reared on liver, horse flesh, chopped clams, and various other meats.

As a food fish the Loch Leven is highly esteemed because of the red color and delicate flavor of its flesh when obtained from suitable waters. In some localities the flesh often becomes white from lack of proper food or from other causes.

The spawning season begins late in September or early in October and continues until December. In Michigan it corresponds with that of the brook trout. The egg varies from about one-fifth to one-fourth of an inch in diameter. A trout weighing 2 pounds contained 1,994 eggs, the weight of which was one-half pound.

The Loch Leven will take the artificial fly as readily as the brown trout and the brook trout. Its great size and strength add to its attractions for the angler.

Smith and Kendall[15] make the following comments on the Loch Leven trout as it occurs in waters of Yellowstone National Park:

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[15] Fishes of the Yellowstone National Park. With Description of the Park Waters and Notes on Fishing. By Hugh M. Smith and William C. Kendall. Appendix III to Report of U. S. Commissioner of Fisheries for 1921. Bureau of Fisheries Document 904, p. 22.

This trout originated in Loch Leven, the lake made famous by Scott's poem, "The Lady of the Lake." Typically it was peculiar to this loch, where it seldom, if ever, attained much over 1 pound in weight. The claim has been made that it is merely an ontogenetic development of the common brown trout, and that when transferred to other waters its progeny can not always be distinguished from the common brown trout. On the other hand, information derived from persons familiar with Loch Leven indicates that both this trout and the brown trout exist in the same lake, and that in that body of water they can always be distinguished.

It is not impossible that confusion has arisen by brown trout from that lake having been propagated under the supposition that they were Loch Leven trout. There are parallel instances of such mistaken identity in this country in respect to other species, and so-called Loch Leven trout have been propagated for a long time in this country. In the early years the progeny of Loch Leven eggs could easily be distinguished from brown trout hatched at the same time, especially when they had attained a few inches in length. Recently, however, there is reason to suspect that many of the so-called Loch Leven plants have been brown trout.

PROPAGATION.

The Bureau of Fisheries makes no special effort to artificially propagate the Loch Leven trout for reasons stated elsewhere. At two of the hatcheries—Leadville, Colo., and Spearfish, S. Dak.—very limited numbers of eggs are handled each year. At the former point the egg collections are obtained from the Arkansas River, and such work is incidental to the more important brook trout egg collections annually undertaken in the same region. At the latter station a small brood stock of the species is maintained, numbering 82 female fish sexually mature at the end of the fiscal year 1922. The distribution of the output in each case is limited to local waters.

The information regarding the spawning season, incubation period of the eggs, etc., contained in the following table, is taken from the reports of the superintendents of the stations:

TABLE 4.—*Spawning season of Loch Leven trout, egg production, and period of incubation.*

Station.	Spawning season.	Average number of eggs per fish.	Number of eggs per ounce.	Maximum egg production.		Incubation period.		Fry.
				Weight of fish.	Number of eggs.	Eyespots appear.	Incubation completed.	Yolk sac absorbed.
Spearfish, S. Dak.	Oct. 10 to Dec. 10.	920	300	....	....	25 days at 41° F.	112 days at 39° F.	35 days at 39° F.
Leadville, Colo.	Oct. 8 to Dec. 31.	1,500	260	6 pounds..	3,000	22 days at 43° F.	150 days at 33° F.	60 days at 34° F.

The superintendent at Spearfish (S. Dak.) station comments further on the Loch Leven trout, as follows:

The Loch Leven trout has proven to be the hardiest trout in the Black Hills, for, while the numbers planted each year have been small as compared with plants of brook and black-spotted trouts, the numbers taken by fishermen would seem to exceed those of both the other species. Very few black-spotted trout were ever taken in this section.

BROWN TROUT (SALMO FARIO).[16]

The fish better known in this country as brown trout was first introduced under the name of von Behr trout, after the man through whose instrumentality the eggs were obtained from Germany. It was later called German brown trout and finally just brown trout, also having many other local names. In Germany it is the Bachforelle (brook trout), but it is not exclusively a brook trout any more than the eastern brook trout of the United States (*Salvelinus fontinalis*) is such.

RANGE, SIZE, AND FOOD.

The brown trout also inhabits lakes, in some of which it reaches a large size, even 50 pounds, if the British *Salmo ferox* is the same species. Day, in his "British and Irish Salmonidae," 1887, gives the habitat of this trout as the colder and temperate portions of the Northern Hemisphere, descending into Asia as far south as the Hindu Kush, but not normally present in any portion of Hindustan.

This trout has been introduced into many United States waters, in some of which it has thrived. It is a good game fish, but Hen-

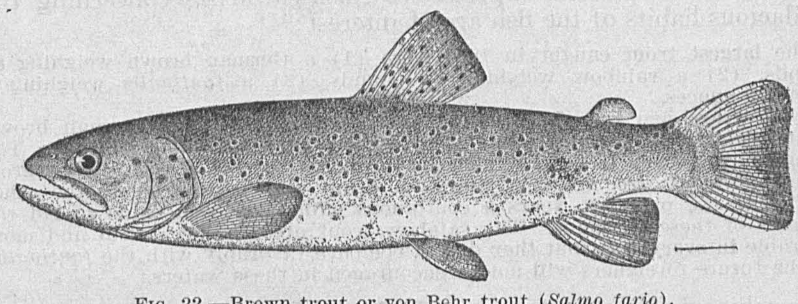

FIG. 22.—Brown trout or von Behr trout (*Salmo fario*).

shall says it is not as gamy in this country as the eastern trout (*Salmo fontinalis*). It will endure warmer water than *S. fontinalis* and may be suited to depleted trout streams which, owing to change of conditions, are unsuited to the brook trout. Day says:

> The food which trout consume is of various descriptions. One of about 1½ pounds weight, taken in June, 1882, in the Tweed, was found to contain 11 small trout and 1 minnow. They do not object to little fish, as the minnow, loach, sticklebacks, etc., water rats, young birds, frogs, snails, slugs, worms, leeches, maggots, flies, beetles, moths, water spiders, and even a lizard (Field, October, 1885). They will swallow one of their own kind two-thirds as large as themselves. In Mr. Buckland's museum was an example, the stomach of which was distended by 2,470 eggs of apparently the salmon.

BREEDING HABITS AND PROPAGATION.

Regarding their breeding habits, Day continues:

> Trout commence breeding in their second year or prior to their attaining 24 months of age, and often later in the season than their parents. The males are more forward than the females, but at this early period of their

[16] Fishes and Fishing in Sunapee Lake. By William Converse Kendall. Report of the Commissioner of Fisheries for 1912. Bureau of Fisheries Document 783, p. 45.

lives the probabilities of the ova being healthy and fertile are less than in somewhat older examples. At first the number of males appears to be in excess of the females, but the mortality among them is greater than those of the other sex, until at 3 or 4 years of age the proportion may be expected to be about the same, and subsequently the females predominate. The number of eggs produced by each female trout has been roughly estimated at 800 for every pound's weight of fish, which computation has been observed at the Howietoun breeding ponds to be fairly accurate. * * *. The period at which these fish breed varies in different rivers and districts, extending from October until February, and even, although rarely, to March. * * *. Although trout generally migrate into the smaller contiguous brooks to breed, large ones are more frequently found forming redds in the broader streams than are smaller fish; but it is by no means rare to find large examples having taken possession of pools in burns. The trout's redd or nest is a mound of gravel which would fill one or even two wheelbarrows, and when by probably causing a shallow may assist in aerating the water. The eggs themselves lie loose among the gravel at from 1 to 2 feet below the surface.

From the foregoing account of the brown trout it would not seem to be a very desirable acquisition in waters where the indigenous fish fauna is wholly satisfactory.

In connection with the foregoing comment on the probable undesirability of the brown trout in American waters the following extracts from opinions expressed by fish-culturists concerning the predacious habits of the fish are of interest:[17]

The largest trout caught in 1894 were (1) a German brown weighing 8½ pounds, (2) a rainbow weighing 3½ pounds, (3) a *fontinalis* weighing 2 pounds 9 ounces.

Some years ago the club planted as an experiment some German brown trout (*Salmo fario*) and a few of the rainbow variety (*Salmo irideus*). The former have proven to be very undesirable tenants of the stream. They grow to an enormous size, are very coarse, and are very destructive to the other fish. For the past two years a continuous effort has been made to rid the streams of these Germans. The rainbow trout are more beautiful and more desirable in every way, but they do not compare favorably with the *fontinalis*. In the future foreigners will not be encouraged in these waters.

Speaking before the American Fisheries Society at Grand Rapids, Mich., in 1906, Dr. Tarleton H. Bean, at that time fish-culturist for the State of New York, said:[18]

The State propagates the brown trout to a much less extent than formerly, and its present policy is that it should never be planted in any waters containing brook trout. An expert angler friend of mine told me he got 10 brown trout to 1 brook trout in the Beaverkill River. The cause of that is unquestionably (at least in the minds of the anglers, and it seems reasonable) that the brown trout destroy the brook trout. If they do not they at any rate destroy the food of the brook trout, which amounts to the same thing. There is now a continual desire on the part of the New York commissioner to refuse applications for brown trout, and he does refuse them for waters already containing brook trout. They are suitable for some waters, undoubtedly waters which contain no other trout, and they have done very well there.

The following is extracted from a letter written November 2, 1905, by State Fish Commissioner W. E. Meehan, of Pennsylvania.

We have had a great deal of trouble, and much disaster has followed the planting of brown trout in some of our brook-trout streams.

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[17] From a book of the Castalia Trout Club, Castalia, Ohio. By Frank C. Hubbard. Published in 1905.

[18] Transactions of the American Fisheries Society, 1906.

In a letter written January 7, 1921, John W. Titcomb, at that time fish-culturist of the New York Conservation Commission, stated:

I personally feel a pang of regret every time I see a German trout introduced into a new field to compete with the *fontinalis*.

DESCRIPTION.

The following description of the brown trout is taken from "Food and Game Fishes of New York," by Tarleton H. Bean, in the seventh report of the Forest, Fish, and Game Commission of the State of New York, 1901:

The body of this trout is comparatively short and stout, its greatest depth being contained about four times in the length without the caudal. The caudal peduncle is short and deep, its depth equal to two-fifths of the length of the head. The length of the head in adults is one-fourth of the total length without caudal or slightly less. The diameter of the eye is about one-fifth the length of the head, and less than length of snout. The dorsal fin is placed nearer to the tip of the snout than to the root of the tail; the longest ray of this fin equals the distance from eye to the end of the opercle. The ventral is under the posterior part of the dorsal; its length is about one-half that of the head. The adipose is placed over the end of the anal base; it is long and expanded at the end. The caudal is emarginate in young examples, but nearly truncate in specimens 10 inches long. The pectoral is nearly one-sixth of the length without the caudal. In the male the jaws are produced, and very old ones have a hook. The maxilla extends to the hind margin of the eye. The triangular head of the vomer has a transverse series of teeth, and the shaft of the bone bears two opposite or alternating series of strong persistent teeth. * * *.

On the head, body, and dorsal fin usually numerous red and black spots, the latter circular or X-shaped and some of them with a pale border; yellowish margin usually present on the front of the dorsal and anal and the outer part of the ventral. The dark spots are few in number below the lateral line. The ground color of the body is brownish or brownish-black, varying with food and locality.

Names.—In European countries in which this species is native it bears the name of trout or brook trout or the equivalents of these terms. In Germany it is *bachforelle;* in Italy, *trota;* in France, *truite.* In the United States it is known as the brown trout and von Behr trout, the latter in honor of Herr von Behr, president of the Deutscher Fischerie Verein, who has been very active in the acclimation of the fish in America.

Distribution.—The brown trout is widely distributed in continental Europe and inhabits lakes as well as streams, especially in Norway and Sweden. Tributaries of the White Sea, the Baltic, the Black Sea, and the Caspian contain this species. In Great Britain it lives in lakes and streams and has reached a high state of perfection; in Germany and Austria, however, the trout is a characteristic fish, and our supply has been drawn principally from the former country. Moreau found it at an elevation of 7,000 feet in the Pyrenees, and a color variety is native to northern Algeria in about 37° north latitude. In the United States the brown trout has been successfully reared in Colorado at an elevation of nearly 2 miles above sea level; it is now well established in New York, Pennsylvania, Maryland, Missouri, Michigan, Wisconsin, Nebraska, Colorado, and several other States. This trout has proved to be well adapted to the region east of the Rocky Mountains, which has no native black-spotted species, though the western streams and lakes contain many forms in a high state of development.

Size.—Under favorable conditions the brown trout has been credited with a weight of 22 pounds and a length of 35 inches. In New Zealand rivers, where it was introduced with unusual success, it now approximates equal size; but in most localities 10 pounds is about the limit of weight and 5 or 6 pounds is a good average, while in some regions the length seldom exceeds 1 foot, and the weight ranges from ½ pound to 1 pound. In the United States a wild specimen 7 years old weighed about 11 pounds. In a well in Scotland an individual aged 15 years measured only about 1 foot in length. These illustrations will serve to show how much the growth of a brown trout is affected by its surroundings and food supply. The species has been known to become sexually mature when 2 years old and 8 inches long.

Habits.—The brown trout thrives in clear, cold, rapid streams and at the mouths of streams tributary to lakes. In its movements it is swift, and it leaps over obstructions like the salmon. It feeds usually in the morning and evening, is more active during evening and night, and often lies quietly in deep pools or in the shadow of overhanging bushes and trees for hours at a time. It feeds on insects and their larvæ, worms, mollusks, and small fishes, and, like its relative, the rainbow trout, it is fond of the eggs of fishes. In Europe it is described as rising eagerly to the surface in pursuit of gnats, and it is said to grow most rapidly when fed on insects.

Reproduction.—Spawning begins in October and continues through December and sometimes into January. The eggs are from one-sixth to one-fifth of an inch in diameter and yellowish or reddish in color; they are deposited at intervals during a period of many days in crevices between stones, under projecting roots of trees, and sometimes in nests excavated by spawning fishes. The parents cover the eggs to some extent with gravel. The hatching period varies according to temperature from 40 to 70 days. Females aged 3 years furnish on the average about 350 eggs each, but individuals of this age have yielded as many as 700, and even at the age of 2 years some females produce from 400 to 500. When they are 4 to 5 years old, the number of eggs has reached 1,500 to 2,000. The young thrive in water with a temperature of about 50° F. Sterility in the females is common, and breeding females have been observed to cease reproduction when 8 years old.

Qualities.—The brown trout is in its prime from May to the last of September. Its flesh is very digestible and nutritious and deeper red than that of the salmon when suitable food is furnished. The flavor and color, however, vary with food and locality. Insect food produces the most rapid growth and best condition. This species has been so long known as one of the noblest of the game fishes, and its adaptability for capture with artificial flies because of its feeding habits is so well understood that I need not dwell on these familiar details.

DISEASES COMMON TO TROUT UNDER DOMESTICATION AND THEIR TREATMENT.

Trout in artificial environment are subject to various ailments, and little definite knowledge is available as to the causes or prevention of such ailments. The more simple and obvious preventive measures are (1) the utmost cleanliness in and about the hatchery, troughs, and ponds, and all equipment used in connection therewith; (2) careful handling of eggs, fry, fingerlings, and adult fish at all times; (3) a carefully selected diet of materials free from contamination of any kind; (4) an abundant flow of uncontaminated water through all ponds and troughs.

Most of the diseases to which trout fingerlings and adults are susceptible may be traced to some form of parasitic animal. Where these parasites attack the fish externally a number of methods of treatment, all more or less effective, have been prescribed. One of the most simple of these consists in immersing the affected fish in a solution of salt or cider vinegar. More recently certain chemicals, including copper sulphate and potassium of permanganate,[19] have been used with success. In certain instances bicarbonate of soda, applied with a brush to the affected parts of adult fish, has proven efficacious.

Parasites occurring in the intestines or other internal organs are less responsive to treatment, and internal medication of fish of any

[19] A New Bacterial Disease of Fresh-Water Fishes. By H. S. Davis. Bulletin of the Bureau of Fisheries, Vol. XXXVIII, 1921–22. Bureau of Fisheries Document 924.

size or age is hardly practicable, and hope of eradication must lie along other lines. Sanitary conditions in and about the hatchery are undoubtedly important in this connection, and it has been suggested that some of these diseases may be carried in the eggs of fish that are "carriers" of disease. Eggs taken from such trout would seem almost certain to have mixed with them matter from the intestinal tract that would contain these organisms. It is possible that these might survive and develop in such a manner as to infect the fry.

The Twelfth Annual Report of the New York Conservation Commission for 1922 contains a description of some of the parasitic diseases common to trout under domestication, and the following notes on the subject are extracted therefrom:[20]

Hatchery diseases.—All fish hatcheries suffer annual losses of fish from disease. The combating of these maladies and the keeping of the losses from them within bounds presents one of the most serious problems of fish culture. There is wide variation between hatcheries as to trouble with disease. Some are practically free from epidemics, in others disease conditions are so severe as to restrict the kinds of fish which can be reared in them. The most obvious difference between hatcheries is the water supply, and it was decided to make a study of that feature as throwing valuable light on the water conditions most favorable to fish life. Such information is needed for the setting up of standards for the permissible pollution of streams.

Ground covered.—Recurrence of an epidemic of "whirling sickness" among the brook trout fry at Bath hatchery was reported early in the season, and the whole problem at that hatchery was given intensive study. Later the other hatcheries were examined for this and other diseases. Most diseases found were given some study, but special efforts were directed toward the particular disease above mentioned.

OCTOMITIASIS.

"Whirling sickness" or "gill trouble."—This disease is of long standing and practically universal. It attacks all kinds of trout and may cause heavy mortality. It is caused by a minute parasite of the intestine (*Octomitus salmonis*). The symptoms of what appears to be this disease have been described and the causative organism, or one closely allied to it, has been figured, but the two seem heretofore not to have been connected.

Symptoms of the disease.—Apparently this disease is confined to the intestines, and no external lesions have been thus far observed. Badly infected trout fingerlings have a characteristic behavior which aids in diagnosing the disease. Balance seems easily lost, and the fish turn over repeatedly with a "whirling" or "corkscrew" motion in the water. Too weak to make headway against the current, numbers of them are found in the corners at the foot of the trough or nosing along the sides near the surface. They lie on their backs with gills distended and in feverish action. The walls of the intestines themselves become translucent, whitish or yellowish in color. They are filled with a watery fluid, in which the active organisms swim about. * * *.

Distribution.—Probably this disease exists in wild fish, but under natural conditions causes little harm or inconvenience. In the crowded condition of a fish hatchery the disease seems to be aggravated and may assume the proportions of a deadly epidemic. It was found in all our trout-rearing hatcheries, but was not serious in all. Until more is known of the disease this difference can not be explained with certainty. Adverse conditions in the water supply may well contribute to the intensification of the malady. Thus, water low in dissolved oxygen, or high in deleterious substances, might lower the degree of resistance of the fish to the disease. Further study of this relation is needed.

Transmission.—*Octomitus salmonis* in ordinary form probably can not long exist outside of the intestinal tract of the fish. It can not readily be de-

[20] Diseases of Fish in State Hatcheries. By Emmeline Moore. Twelfth Annual Report of the New York Conservation Commission for 1922 (1923), p. 66. Albany.

tected in fish that have been dead for more than a few hours. It forms cysts and in this form may survive outside the fish for long periods. It seems probable that the disease is transmitted by such cysts in the excrement, which, if eaten by other fish, might become active and infect the new hosts. It is evident that hatchery water should be protected from infection by keeping it free from fish when this is possible. It was thought that it might be derived from frogs, but, though these animals are plentifully infested by a somewhat similar form, this particular one was not found in them.

COSTIASIS.

Occurrence.—Costiasis, a disease rapidly fatal under hatchery conditions to many species of fish and to which trout are particularly susceptible, appeared at one of our hatcheries early in June. Early recognition enabled remedial measures to be taken promptly and it was stamped out. Delay would have doubtless cost us hundreds of thousands of young trout. This disease was also found in other hatcheries.

Symptoms.—Fish die suddenly at any point in the trough. Loss of appetite and a frayed, slimy, and grayish appearance of the fins are the most readily recognized symptoms. Viewed against a piece of glass the attacked fin shows a clear area where the outer surface of the skin is sloughing away. Unfortunately, when these symptoms become evident to the unaided eye, the disease is far advanced.

Costia necatrix.—Costiasis is caused by a small protozoan parasite (*Costia necatrix*) which destroys the cells of the skin and other membranes. Once established it rapidly covers the entire body of the fish. In the final stage the gills are attacked and the fish dies of suffocation. *Costia* attach themselves under the edges of the epithelial cells and multiply with great rapidity. An exudation of slime issues from the diseased skin, marking the affected areas.

Transmission.—Costia appear to have a free swimming stage, during which they may pass from fish to fish. They also form resistant cysts, both on the fish and on the bottom of the troughs. It has been suggested that the use of fresh-water fish as food for hatchery trout may result in the introduction of the disease. Further study is necessary.

Remedy.—Remedial measures suggested in the literature on the subject have been tried out with success. The process consists in placing the fish in a 2½ per cent solution of salt in water (21 pounds of table salt to 100 gallons of water). Fish are left in this bath from 10 to 15 minutes, or a less time if distressed. This kills the attached and free-swimming forms. Four treatments at intervals of three days are required to kill the young as they emerge from the cysts. Best results are obtained by adding sufficient salt to the water in the trough in which the infected fish are. This treatment must be applied to both fish, infected troughs, and utensils. Additional work on these measures and the life history of the caustive organism is needed.

GYRODACTYLIASIS.

Fin disease.—Two of our hatcheries were infected with fin disease, or Gyrodactyliasis. This disease is probably widespread, frequently epidemic in hatcheries among fish of all species and all ages. Trout, particularly the brook trout, are especially susceptible. It is caused by a flatworm or fluke (*Gyrodactylus*), so called from its resemblance to a gyrating finger as it protrudes from the layer of slime over the affected skin. The animal itself is equipped with an anchor disk, by which it attaches itself to the fish, and a sucking organ for feeding.

Symptoms.—Affected surfaces are covered with a bluish gray slime, most conspicuous on the fins. This copious production of slime may cause confusion between this disease and Costiasis. Fins are apt to be most severely affected; in advanced stages they become frayed so that the rays project as spines, or may be reduced to mere stubs. The disease is not always fatal. At times open sores are produced at the bases of the fins, a condition which causes death in a short time. With a microscope diagnosis is simple and certain, as slime scraped from affected parts will contain adults, young, or both forms of the parasite. The worm itself is transparent and exceedingly active, moving backward or forward, looping along like an inch worm, or gyrating.

Remedial measures.—No cure for this disease has yet been found. External application of some solution is indicated. Salt solutions are not efficacious; thorough sanitation may be of assistance. Diseased fish should be isolated or destroyed; infected troughs and implements sterilized. Experiments with curative measures are in progress.

At the Neosho (Mo.) station of the bureau a 1 to 15 solution (approximately) of cider vinegar has been found effective in treating this trouble. The solution is prepared in a tub or any suitable vessel; the affected fish are removed from the trough with a dip net, immersed in the solution for a period not to exceed 8 to 10 seconds, and are returned immediately to fresh running water. The fish should be watched closely while in the solution and not retained in it beyond the point where they manifest undue distress by turning on their sides. Because of the variation in the strength of cider vinegar a 1 to 15 solution will not always give the best result. It would be well, therefore, for the practical fish-culturist to note the effect of his solution on a limited number of fish before treating the entire lot.

Trout eggs and fry, as well as fingerling and adult trout, are subject to disease. Perhaps the more common affections are the so-called "white spot disease" and the "blue sac," some notes on which are appended. The discussion pertaining to the white spot disease is quoted from a report on the subject by Dr. Franz Schrader, while the discussion of the blue sac is taken from a memorandum by Dr. Adrian Thomas.

WHITE SPOT DISEASE.

This trouble manifests itself by the appearance of an opaque or white area in some part of the embryo, very generally the yolk. There the gradually expanding milky white area is very noticeable in its semitransparent surroundings, and the affected eggs are easily recognized, even in the early stages of the disease. Any stage of development up to the complete absorption of the yolk sac may show the infection, and its appearance has come to be recognized as certain death to the affected specimen. Although by no means confined to the eggs, it is in the eggs of salmonoid fishes that it is most conspicuous and most easily observed.

The hypotheses of fish-culturists as to the cause or causes of white spot are more or less indefinite. Weakness of the parent fish, water temperatures, rough handling, holding of the adult fish under unfavorable conditions during the spawn-taking period, are some of the more common causes ascribed. In connection with the last one mentioned the belief is held by some experienced fish-culturists that the transfer of spawning fish from one pond to another just prior to the spawning period may be conducive to white spot, and that such contemplated transfers of adult fish should be made well in advance of spawning or not until after that function has been accomplished.

More serious attempts to clear up the nature of the white spot were made by Bataillon (1894) and Hofer (1892). The former was concerned with what was apparently an epidemic of the disease and obtained pure cultures of several bacteria from the dying eggs, one of which proved pathogenic from cold-blooded animals. Hofer also attributed the disease to bacterial agency, although he was unable to obtain pure cultures and found Bataillon's account too indefinite to render a comparison of the organisms concerned of much use. He was inclined, however, to believe that infection occurred through the agency of unclean packing material or the water from contaminated ice, since he observed disease only in eggs that had undergone shipment. Shipment might also weaken the eggs so that they would be more susceptible to bacterial invasion than untransported ova. According to him both single isolated eggs, as well as the entire contents of hatching troughs, may be affected.

It must be recognized at the outset that any disturbance that will cause a refraction of light at any location in the homogeneous transparant yolk will give rise to an opacity or white spot at that place. It is therefore entirely possible and even probable that the disease may have more than one cause, and that its progress is variable. Certainly the ordinary occurrence is not epidemic in character, differing thus from Bataillon's case and some encountered by Hofer.

General morphological features.—The yolk of trout fry that have just started the absorption of the sac presents a characteristic appearance under normal conditions. Beneath the enveloping layer of cells are located the embryonic blood vessels and what might be called an absorption area. The latter harbors periblast cells more or less irregularly distributed and surrounds the yolk, which is structureless and homogeneous under ordinary magnification, and takes a dense stain.

In yolk affected by white spot the diseased region showed uneven extent of the absorption area. Various stages of disintegration characterized such pictures, tracts of transformed yolk and yolk spheres of various sizes penetrating into the still unaffected material. Blood vessels follow the advancing disintegration, so that they are often found in the center of the yolk, whereas under normal conditions at such a stage of development they are entirely at the surface. Location of the white spot in the yolk sac is variable, but in a general way the following may give some idea of the distribution. The diseased specimens were Loch Leven fry from Saratoga, Wyo. (early stage of sac absorption), 42 being examined.

Diseased area close to liver	9
Touching or surrounding oil globule	8
Close to both liver and oil globule	12
Near heart	3
Posterior tip of yolk	10
	42

In no case was the spot located entirely in the interior of the yolk; that is, it always came in contact with the yolk enveloping cell layer at some point.

The question of bacterial agency.—In some cases bacteria are certainly involved. Examples were furnished by rainbow-trout eggs from Cape Vincent, N. Y. (stage shortly before hatching), which had been shipped there from Wytheville, Va., some weeks previously. Microscopic examination showed at least two kinds of bacteria present in the disintegrating yolk, and these were found side by side in the individual cases or also in seemingly pure cultures. The affected yolk had broken up as usual, and the bacteria were clustered most thickly around the yolk spheres. Similar conditions were observed in the few cases of the disease present in brook-trout eggs from a hatchery at Taunton, Mass.

But this serves to show only that bacteria may be involved in the progress of the disease—not that they are to be considered as causative agents. The random distribution of diseased eggs among healthy eggs is a fair proof in itself that the infection is not contagious or, better, that normal and healthy eggs are not attacked by the bacteria. There must, then, be a predisposition in some eggs that renders them liable to infection. It is of some note to observe that eggs with high mortality rates had generally (not always) undergone shipment from a more or less distant station. Naturally they had, therefore, undergone a certain amount of rough handling, and this made it very possible that the primary cause of the disease was to be found in some injury thus sustained by means of which the bacteria gained access to the yolk. To gain some data on this point, 200 brook trout in the fry stage (yolk sac at early stage of absorption; fry, 18 mm.) were isolated and the yolk sac of each pricked to a slight depth with a sharp needle. In a few cases the fishes were injured in the operation, and in still others the wound caused partial loss of the yolk. In what may be called successful operations the wound caused no loss of yolk and appeared only as a very small white area at the surface of the latter, the fishes showing no immediate ill-effects on liberation. One hundred uninjured fry were kept under similar conditions for control purposes. After 10 days a little more than 25 per cent of the operated fishes had entirely recovered and showed no signs of the injury, and somewhat less than 50 per cent showed a growth of the artificially produced white opaque area. A third of the latter died in the course of these 10 days. Development of fungus eliminated a greater part of the remaining 25 per cent. Of the control 2 per cent died during this period, neither they nor the survivors showing a definite development of white spot. Twelve of the fishes experimented upon that showed a growing white spot were examined and all showed severe bacterial infection. Several kinds of bacteria were involved, one of which seemed identical with one of the forms observed in natural infections. However, all of them were apparently effective in the destruction of the yolk. Similar infections were also observed in the eggs of landlocked salmon which had been subjected to the same treatment.

The difficulty of making exact bacteriological tests is apparent, since the injection of any pure cultures into healthy eggs will also cause the wound that opens a pathway for the general bacterial fauna in the water. The use of sterile water in the hatching operations of such experimental eggs would, of course, solve this difficulty, but practical difficulties in the use of such water have heretofore made these tests impossible.

Sufficient data is furnished by the observations and experiments set forth, however, to indicate that bacteria are not to be regarded as primary agents in the common form of white spot. That various bacteria are instrumental in the disintegration of the yolk is not to be doubted, but the yolk must be regarded only in the light of so much inert organic matter which, once deprived of its protective covering, is open to the attack of all saprophytic and holophytic bacteria. It is a rupture of the yoke envelope that furnishes the primary cause, and only the growth and spread of the spot is due to the bacteria.

Periblast activity.—The white spot cases involving bacteria furnish only one group, a group which, peculiarly enough, does not seem as large in numbers as that which is now to be discussed. In these cases the most careful microscopic scrutiny revealed no indication of bacteria, although the disintegration phenomena do not differ materially. The most remarkable feature is furnished by the periblastic cells. They are found throughout the disintegrating region, augmented in number as compared with normal eggs and embryos, but extremely active, judging from their lengthened form. It may be repeated that diseased eggs are generally found side by side with healthy ones. The affection is therefore not transmissible to normal eggs, and periblastic action just as much as bacterial infection must have the ground prepared for it by another factor, which is therefore the primary agent. Eggs showing such periblastic activity were obtained from Hartsville, Mass.; Saratoga, Wyo.; La Crosse, Wis.; and St. Johnsbury, Vt. Those from the two last-named points had undergone railroad transportation. The Saratoga occurrence was attributed by the superintendent of that hatchery to chilling of the freshly stripped eggs, something which might also have taken place in the case of the Hartsville eggs (the weather was cold at the time of egg taking), although no definite data was obtainable. It was of some significance that the eggs from La Crosse showed cases of bacterial infection, other cases wherein periblasts alone were active, and, finally, a few cases that showed bacteria and periblasts side by side in the disintegrating yolk. If mechanical disturbance was instrumental in introducing bacteria, and if it consisted in actual rupture of the yolk envelope, it could not have been responsible for the periblastic activity. In other words, since the bacteria involved were undoubtedly present at La Crosse, a rupture should give access to bacteria in one case as well as in another. Mechanical injury without rupture of the envelope—that is, shock or concussion—is then left as a possibility. An attempt was made to duplicate the conditions produced through concussion by dropping a wooden box containing 200 landlocked salmon eggs from a height of 3 feet. Two hundred normal eggs were kept for control. At the end of 10 days 10 of the former lot showed indications of white spot, while 6 showed it in the control, a difference of 2 per cent. This is certainly not significant enough to admit of any conclusions, save that eggs at that stage of development (immediately before hatching) are extremely resistant to concussion. A repetition of the experiment with younger eggs is therefore necessary, especially in view of the fact that experience has proved the early stages more susceptible to injury of any kind.

Unfortunately no experiments could be conducted in connection with the possible effect of chilling and freezing the eggs. The temperature factor is liable to be very important in clearing up the periblastic activity, and there should be little difficulty in the future in working out the relations.

The necessity of more experimental data is thus plainly apparent. Sufficient evidence is available, however, to point to physical injury of some kind as the causative agency of the common occurrence of white spot. It seems more or less of a truism to recommend more careful handling of fish eggs, but such a recommendation points only toward the greatest possible elimination of distance shipments at present. Although so crude at the first glance, the "bulk" method of shipping eggs may possibly be more safe than the careful tray method, simply because it confines scratching of the eggs to the outer layers, keeping the inner ones intact. On the trays, however, each egg is carefully placed on cloth, which, of course, exposes it to friction with rough places in the latter and also stray bits of packing material. Careful statistical scrutiny of shipping records should decide this, however, since no reliance can be placed on individual shipments, wherein the amount of rough handling is so exceedingly variable.

Summary.—(1) Both bacteria and periblastic activity are instrumental in the progress of white spot as it commonly occurs. (2) Neither of these features can be considered as the primary cause, however, since either can occur only in "predisposed" eggs. (3) "Predisposed" eggs are those which have been subject to physical injury of some kind.

BLUE SAC DISEASE.

This disease is otherwise known as *Hydrocele embryonalis* or yolk-sac dropsy. Dr. Bruno Hofer, in his "Handbuch der Fischkrankheiten," treats of this affection, and in doing so says that many breeders agree that it is probably due to shock or pressure to the eggs, though nothing appears to be certain concerning the etiology.

The disease appears sporadically, the first symptoms being an enlarged sac, which after a time becomes so weighty that the fry are unable to rise to the surface. After a few days the sac usually bursts, resulting in the death of the fry in a few hours.

The sac appears to contain a serous fluid, which surrounds the yolk and at times assumes a bluish tinge, hence the name blue sac. The disease seldom appears after the yolk sac has been nearly absorbed but usually attacks the fish during the first week after hatching.

Hofer seems to think that the disease is caused by rough handling of the eggs, whereby they receive shocks or jars or are injured by too much pressure during stripping. He also mentions the probability of the disease being caused by the taking of eggs from brood fish that are too young, and says that precaution should be taken against the taking of eggs from very young females; also that care should be exercised in handling and packing for transportation, and that eggs prepared for shipment should be packed in an abundance of soft insulating material, such as moss, etc.

It has been suggested that improper fertilization may be responsible for the disease. Improper fertilization may not be exactly the correct term, but it is well known that any injury to eggs or sperm will produce monstrosities or diseased offspring.

Up to this point no definite cause of or remedy for the disease is known, though several possible causes and their prevention have been mentioned.

L. von Betegh has made a study of the disease. Its sporadic occurrence led him to believe it infectious, and he attempted to isolate the specific organism causing the malady.

In the serous fluid of the yolk sac he found a diplobacillus in pure culture. This organism he proposed to name *Diplobacillus liquefaciens piscium.* Von Betegh concluded that the organism he found may be regarded as the specific cause of the disease. Though he states that further experiments will later be reported on, it does not seem that the mere presence of this diplobacillus is evidence that it causes the disease, yet it is not improbable that it does.

We must look for all diseases of young fish to arise from one of two causes, namely, infection or injury to the eggs. It is highly probable that this disease may be prevented in a hatchery if the hatching apparatus is kept perfectly clean, all fish suspected of disease are immediately removed and destroyed, and care is exercised in handling the eggs and fish. The stripping of eggs from very young brood stock should also be avoided.

George A. Seagle, former superintendent of the bureau's Wytheville (Va.) hatchery, speaks of the diseases occurring among the rainbow trout at that station, as follows:

The diseases most frequently occurring among rainbow-trout fry under domestication are an inflammation of the gills and a slimy skin affection. The causes of these diseases are not well known, but improper food, water pollution, or insanitary conditions of any kind are among the most probable. By closely watching the movements of the fish the symptoms can usually be detected before an alarming stage is reached.

When the gills are affected, the fish as a rule swim high in the water in an uneasy restless manner, as if gasping for breath. As soon as such a condition is detected the gills should be examined for inflammation or swelling. In the case of a skin disease the fish ordinarily indicate its presence by rubbing on the bottom of the trough or against any convenient surface. They dive with a quick twisting motion against the trough bottom. If the disease is not promptly checked it will soon reach a stage where nothing can be done.

One of the best remedies known for both these disorders is salt, which is sprinkled through the ponds or troughs after the water has been drawn low, about half a pint of salt being used to each gallon of water. In extreme cases the fish are always treated in the troughs, and in addition to the salt a half pint of apple vinegar is allowed to each gallon of water. These are the proportions for large fish; for lots which are small and weak the proportion of both salt and vinegar must be reduced. The fish are closely watched and allowed to remain in the solution only until they begin to turn on their sides, showing plainly that they have stood all they can endure. Fresh water is then turned on freely and distributed among the fish with the hand. As the fresh water fills the trough a slimy white scum rises and floats on the surface of the water.

Fungus, "blue-swelling," and other affections sometimes occur, but the most serious diseases of fry are those just described.

During the dry weather of summer fry and fingerling fish are frequently affected by external parasites, which usually make their appearance immediately after a rain following a drought. They first attack the tail and fins of the fish, sometimes forming a fringe around the outer fin edges, and after consuming the slimy coating within reach they move up toward the body of the fish, leaving nothing behind them apparently except the bony sinews of the fins. Under such conditions the fish soon weaken and die, when the parasites leave them for other victims.

Under the microscope the parasites appear to be small white worms, almost transparent, about 0.4 mm. or one-sixtieth-inch long and larger at one end than the other. The mouth is at the small end, and at the other are claw-like tentacles with which they fasten themselves to the fish. They appear to be continuously feeding upon the slimy coating of the fish, stretching themselves at full length and then drawing up until they resemble tiny rice grains. Their presence is indicated by the following symptoms: The color of the fish changes to a dark bluish-black; the fish swim high, dart around restlessly, and in the last stages turn their tails to the current or seek quiet corners and remain there until they die.

At some of the bureau's stations where it has been found necessary to treat fish for parasites from one to three times each season it is customary to turn the fish from two adjoining troughs into one. The empty trough is then thoroughly cleaned, wiped with a cloth or sponge saturated with vinegar, and allowed to fill with water. If proper care is exercised in making the solution and the fish are handled carefully, this remedy will be found to work perfectly. The salt treatment alone merely causes the parasites to abandon the fish for a short time; it does not kill them, and they will resume their attack when the water supply again becomes normal.

A very serious disease is sometimes encountered with adult rainbow trout. Very dark spots, ranging in number from 2 or 3 up to 20 or 30 and in size from one-fourth inch to 1 inch in diameter, appear on different parts of the body; a light spot about the size of a green pea forms on the head immediately over the brain. The fish refuse food and become restless; they jump and dart around as though frightened, settling back on their tails; they hide among the plants, seek shallow water in the corners of the pond, and finally sink to the bottom, dying within 24 hours after the appearance of the first symptom.

This disease was first encountered among a lot of von Behr (brown) trout that had been delivered at the bureau's Wytheville (Va.) station on November 29, 1895. The first symptom was noted six days after their arrival, and by December 12, one week later, 455 of them had died. During its first stages the fish were in the nursery, and the water in which they were being held passed through an empty pond into a second one containing about a thousand large rainbow trout that had spawned recently. On the morning of December 23 the disease was apparent among the rainbow trout, and by 4 o'clock of that day 56 had died. The water in the pond was drawn down promptly to about 300 gallons, and 150 pounds of common salt was sprinkled through it. After holding the fish in this brine for 15 minutes fresh water was turned on freely and good results were at once noticeable. The fish became quiet and improved steadily, making a second application unnecessary. The final outcome of the experiment was that the mortality among the rainbow trout amounted to only 30 per cent, whereas the death rate on the untreated von Behr fingerlings exceeded 71 per cent.

Foul ponds cause disease, and when fish become affected from that cause they must be removed at once to a clean pond and given a salt and clay bath, applying it in the following manner: While the salt bath previously described is being given, from 2 to 3 bushels of clay are placed in the reservior or supply trough, and when fresh water is turned on after the salting the pond is flushed for about 30 minutes with roily water from the clay, and after the clay water has passed an increased supply of water is maintained for 10 days or more.

Adult fish which have been bruised or scarred or have become emaciated are very liable to develop fungus. If the trouble originates from an injury, it can often be cured before it spreads to the sound flesh, but after the growth has spread like a slimy web over the entire body of the fish the case is hopeless. During the spawning season fish are especially susceptible to fungus, and they must be handled very carefully to avoid bruising or scarring in any way. If fungus makes its appearance, the affected fish should be caught and the diseased part treated with salt and with the vinegar solution. It should then be placed in a separate pond or tank with the view of giving it further treatment a day or two later. Any fish that are affected over the entire body should be removed from the pond at once and killed.

Thyroid tumor is not an uncommon ailment among artificially reared trout. It affects the gills and may be encouraged by a generally run-down condition of the fish or by insanitary conditions in and about the ponds and troughs. As preventives of disease, plenty of fresh water, scrupulous cleanliness, and the utmost care in handling eggs, fry, or adults are all-important factors. Many of the ailments to which the eggs under incubation and the fry in the early stages of development are subject—" white spot," " blue sac," etc.—may be traced, as a rule, to careless and improper methods of taking the spawn or handling the eggs during the incubation period. Sand sprinkled generously on trough or pond bottoms will facilitate the removal of the coating of slimy substance that frequently forms, and a small amount of salt occasionally mixed with the food is beneficial.

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PROGRESS IN BIOLOGICAL INQUIRIES, 1923.

REPORT OF THE DIVISION OF SCIENTIFIC INQUIRY FOR THE FISCAL YEAR 1923.[1]

By WILLIS H. RICH, *Assistant in Charge of Scientific Inquiry.*

(With the collaboration of investigators.)

CONTENTS.

INTRODUCTION.

The work of the division of scientific inquiry consists primarily in the investigation of the biology of those species of fish and shellfish that form the basis of the fishery industries. In common with much scientific work the service of this division is, in the main, one step removed from direct contact with the business man. The biological

[1] Appendix VII to the Report of the U. S. Commissioner of Fisheries for 1923. B. F. Doc. No. 956.

facts pertaining to the fisheries, which are discovered through scientific investigation, are essential for the reason that adequate measures of conservation must be based on a knowledge of the biology of the fish. The actual administration of measures of conservation, however, devolves upon other governmental and State agencies, and it is these agencies that directly perform the very necessary service of conserving the various fishery resources. Without scientific investigation, however, this direct service could not be properly conducted.

The utilization of the fishery resources of the United States has gradually increased since the Colonies were first established, and the past decade or two has witnessed a remarkable growth in many of our fishery industries. Certain fishery resources have shown more or less marked signs of depletion for years; more of these resources are showing evidences of depletion each year; and, with the increased exploitation, which we can observe and which will in all probability continue, we can only look forward to the depletion of resources at present apparently unaffected and to the more serious affection of those already showing evidences of depletion. Such exhaustion does not necessarily become obvious to everyone while the process is going on, and it is only through careful scientific investigation that it may be determined before it has reached a dangerous stage. The work to be done is of a distinctly practical nature, but must be interpreted and conducted by means of biological and oceanographical knowledge. Such investigations were never so essential to the preservation of our fishery resources as they are to-day.

The depletion of a fishery resource is not always the result of overfishing, although this usually is an important factor and in some instances apparently is the only one. Other factors of greater or less importance are the pollution of coastal and inland waters and the obstruction of streams by dams or other similar structures. Without regulation it is to be expected that the amount of pollution and the number of dams will tend to increase along with our increasing population and industrialization. Efforts to combat the various factors tending to deplete a fishery resource have been confined mainly to artificial propagation and to various legal restrictions affecting the seasons in which, and the means whereby, the fish may be taken, the discharge or treatment of pollutants, and the construction of fishways over dams or of screens in irrigation ditches.

It is the primary function of the division of scientific inquiry to determine, if possible, when depletion is taking place—or, still better, to determine when the condition of a fishery resource is such that depletion is likely to occur—and then to devise and propose means whereby such depletion may be prevented. Both of these are biological problems and, to be adequately solved, require a reasonably complete knowledge of the biology of the species in question. The more complete our biological information, the more perfect can be made the work of artificial propagation, and the better may the legal regulations be adjusted to the normal life of the various species of fishes so as to permit of the fullest possible exploitation of the resource without endangering the continuation of the supply.

It is with these things in mind that the scientific activities of the bureau are being directed more and more into studies pertaining to the biology, or life history, of the various fish and shellfish of commercial importance. In years past the bureau has sponsored much scientific work of the highest order but not bearing directly upon problems connected with the conservation of our important fisheries. Valuable as this work in "pure science" is, it is felt at the present time, and in view of the limited funds available, that precedence must be given to investigations relating to fishes of economic importance. Happily, these practical investigations yield a considerable measure of results of interest and value from the viewpoint of "pure science," just as research in "pure science" has so frequently an ultimate, though often unexpected, practical application.

The general plans for the scientific investigation of our fisheries are being made on as broad a foundation as possible. The fundamental problem is to determine the factors affecting the abundance of any given species. One of the most important of these factors obviously is the abundance of food. The food of all fish and shellfish is, either directly or indirectly, those minute forms of animals and plants found floating in both fresh and salt waters and collectively known as plankton. The abundance of plankton, however, is directly determined by various physical factors, such as temperature, light, salinity, etc., and in the ocean the abundance of both fish and plankton in any given locality is dependent in great measure upon the oceanic currents in which drift the plankton and the eggs and young of many fishes. It is evident that the abundance of fish is determined to a considerable extent by various physical factors acting, in part indirectly, through the medium of the plankton. A comprehensive plan for the biological investigation of the fisheries must therefore include a study of these physical conditions, a study of the plankton, and finally a study of the fish and fisheries themselves. By this means we may hope eventually to understand the ultimate and proximal causes of fluctuations in the abundance of any given species, and this is the end of practical importance for which economic fishery investigations should be designed. All of these lines of inquiry are being given consideration, although emphasis is naturally placed on those investigations dealing most immediately with the fishes.

During the past year many important investigations heretofore begun were continued and some new ones were inaugurated. Outlines of the various studies that have been conducted will be found in the following pages.

The division has suffered a serious loss through the resignation of Dr. R. E. Coker, who had been in charge of the division since 1915. Doctor Coker had been connected with the bureau since 1902 and was thoroughly familiar with the various problems pertaining to the fisheries. The administration of the division has been aided greatly during the year by the advice and help that he has freely given.

INVESTIGATIONS OF FISH AND FISHERIES.

ATLANTIC COAST.

FISHES OF THE GULF OF MAINE.

For a number of years the bureau, in cooperation with the Museum of Comparative Zoology of Harvard University, has been conducting an oceanographic and biological survey of the Gulf of Maine.

Special attention has been given to the fishes and the floating plants and animals (plankton) that compose the food of the fishes, as well as to the physical and chemical condition and the circulation of the waters of the gulf. Several reports on special phases of the survey have been published, but not until recently did the body of data warrant undertaking a general account of the fish fauna. During the past year such an account has been completed by Dr. H. B. Bigelow and is now in course of publication.

The aim has been to prepare a handbook for the ready identification of the fish occurring in the Gulf of Maine, and to present a concise statement of what is known of the distribution of each, their relative abundance, and the more significant facts in their life histories. The descriptions have been made as simple as is compatible with scientific accuracy, and are limited chiefly to such external features as may suffice for identification in the field. As a further aid to identification, keys to all species have been provided. The area covered by the report includes the oceanic bight from Nantucket and Cape Cod on the west to Cape Sable on the east, thus including the shore lines of northern Massachusetts, New Hampshire, Maine, and parts of New Brunswick and Nova Scotia. The Gulf of Maine has a natural seaward rim formed by Nantucket Shoals, Georges Bank, and Browns Bank, but the 150-fathom contour has been taken as an arbitrary boundary because this includes all the species apt to be caught by commercial fishermen.

STUDIES IN FISH MIGRATIONS—TAGGING OPERATIONS.

As a part of a plan to investigate the biology of the important food fishes of the cod family (Gadidæ), an extensive experiment in tagging these fishes off the coast of New England had been inaugurated. The tagging is intended primarily to throw light on the movements of the various species of fish between the different fishing banks and between the banks and the shore. The bureau's steamer *Halcyon* is being used for this work and has been outfitted with appropriate fishing gear. The vessel left Gloucester for the first tagging cruise on the 16th of April and the first tags were attached on Nantucket Shoals. By June 30, 2,396 fish had been tagged. It is planned to attach a total of not less than 10,000 tags during the season. Cod, pollock, and haddock have been tagged, but by far the greater number has been cod. Some few returns have been obtained, but at this early date not even tentative conclusions can be given. The work has been conducted mainly by William C. Schroeder, with the advice and aid of Dr. H. B. Bigelow and Willis H. Rich.

The tags used are small and made of a noncorrosive metal so that they will withstand the action of sea water, as it is expected that returns will be obtained over a number of years. Each tag bears a serial number and the initials U. S. B. F. As the fish are caught a tag is attached, a record is made of its length, and the fish is then released. A reward of 25 cents is being offered for each tag returned, together with information as to when and where it was obtained.

In addition to the tagging experiment there are being collected material and data that will be used in other phases of the study of the fishes, such as the rate of growth, spawning habits, and age at maturity.

CHESAPEAKE BAY.

Work on a report on the fish and fisheries of Chesapeake Bay has been continued during the year by S. F. Hildebrand and W. C. Schroeder. Gratifying progress has been made. A large collection of fishes is on hand, and much of it has been worked over and identifications made. Many of the more important species are represented by large series of specimens, and from these considerable information is being derived as to the life histories, rate of growth, etc. Important data bearing on the extent and nature of the commercial fisheries have been collected and are being put into shape suitable for publication.

SALMONIDÆ AND SMELTS.

In the fall of 1922 work on the completion of important studies on the Salmonidæ and smelts of the Atlantic coast and coastal fresh waters was undertaken by Dr. William C. Kendall, a former assistant of the bureau. The greater part of this work involved the assembling and arranging of notes and the study and tabulation of data of several years' accumulation. Most of the time was devoted to the smelt problem, with the result that work on it is somewhat further advanced than that on the Salmonidæ. The question of the relationship of trouts (Salmonidæ) was also taken up from time to time. The problem is a complicated one and requires careful examination of many specimens from various localities and the tabulation of statistical measurements and counts. The studies so far indicate that many of the supposed rainbow trout of the Northwestern States are steelheads.

The smelts of the region referred to for years have afforded, and still afford locally, a valuable fishery in themselves as well as a valuable food supply for other important fishes, but they are suffering gradual depletion. These studies have been undertaken with a view to developing information that may be utilized in the conservation of the species. In a popular account that has been completed during the past year regard has been given to geographical distribution, habits, breeding, food, rate of growth, sizes attained, mortality, enemies, history of the fisheries, methods of the fisheries (both commercial and angling), and to legislation and protection. A more technical account has been begun. To throw light on the life history of the smelts, the scales are being studied and many proportional measurements made to determine the relationship between the marine and fresh-water forms. The relationship of the fresh-water smelts from various localities has also been given consideration, and studies of their evolution, embryology, and anatomy, and classification as to families, genera, and species, have been made.

LARVAL FISHES OF THE WOODS HOLE REGION.

A study of the larval fishes of the Woods Hole region has been begun by Marie D. P. Fish, and a considerable quantity of interesting material has been collected. The study of larval fishes has been greatly neglected, very little information on the subject being available. With the increased attention that is being given to biological studies of the various fishes, this sort of knowledge becomes of increasing importance. Attention is being devoted to the collection and classification of larval fishes and also to certain features in their life history, especially their food and feeding habits, distribution, and growth. A large collection made over a number of years by the late Vinal N. Edwards is available for study. The seasonal variation in abundance of 36 species has been studied during the year.

FISHES OF KEY WEST.

At the Key West station Isaac Ginsberg, the director, made an effort further to build up the collection of a representative series of fishes of that vicinity that was started several years ago. Many specimens were added to the collection and progress was made in the identification and labeling of the specimens. Data concerning the occurrence, seasonal distribution, and abundance of the local fishes also were collected.

INTERNATIONAL COMMITTEE ON MARINE FISHERY INVESTIGATIONS.

Two meetings were held during the year—the first in Washington on November 10, 1922, and the second in Toronto on May 4, 1923. It is gratifying to record that at the second meeting the newly elected member from France was present. The purpose of the committee is to secure coordination of the various investigations pertaining to marine fisheries conducted by the several member countries. Among the more important topics discussed are the following:

Statistics of the deep-sea fisheries.—Information was given to the effect that the collection of the Canadian statistics is becoming more thorough. In the opinion of the committee it is desirable that each country represented should publish an annual statement of the total yield of the bank fisheries of the western Atlantic, and that the representatives of the several countries undertake to exchange the data for such annual statement.

Tagging of fish.—Interest was expressed by the committee in the tagging of codfish, pollock, and haddock, which is being undertaken by the bureau on the banks off the coast of New England.

Drift bottle experiments.—It was reported that a preliminary statement covering the more important results of the experiments of 1922 had been prepared and that the account in its final form would be furnished the various countries represented for publication if desired. A plan for the season of 1923 was presented, which involved the putting out of drift bottles along 14 lines covering the coast from the Strait of Belle Isle to Vineyard Sound.

Oceanographic investigations by the ice patrol service.—Appreciation was expressed of the work accomplished by the ice patrol service. In the opinion of the committee this work should be extended considerably in the future.

Mackerel investigation.—The committee went on record as considering it most desirable in the near future to initiate a comprehensive investigation of the mackerel.

At the close of the year the committee consisted of the following members: For Newfoundland, D. James Davies; for France, E. LeDanois; for Canada, W. A. Found, Dr. J. P. McMurrich, and Dr. A. S. Huntsman; for the United States, Dr. H. F. Moore, Dr. H. B. Bigelow, and W. H. Rich.

INTERIOR WATERS.

COREGONINÆ OF THE GREAT LAKES.

The investigations on the Coregoninæ, or whitefishes, of the Great Lakes have been continued; the field work was completed early in the fiscal year, and the attention of the investigators has for some months been directed toward the examination and comparison of collections and the compilation of data to be included in the final report. Dr. Walter Koelz is engaged in work on the systematic relations and natural history of the various species, while John Van Oosten is working on age determinations from the scales, the rate of growth, and allied problems. The problems involved in this investigation are difficult and will require considerable time for solution, but the progress made is regarded as most encouraging.

The studies on the systematic relationships and natural history of the Coregoninæ were continued on Lake Superior and Lake Nipigon. In Lake Superior an additional form was discovered and data on the distribution of the coregonine fauna in the eastern section of the lake were collected. In Lake Nipigon seven species were found, all but one of them with representatives in the Great Lakes, and some ecological data were secured. The preparation of the report on the whitefishes and lake herrings of the Great Lakes is well advanced.

Much additional material pertaining to the study of the life histories has been collected and our knowledge of the species materially advanced. Important information as to rate of growth, age at sexual maturity, average length of life, maximum age attained, and average length and weight at any year have been obtained. Where possible the variations in rate of growth in different localities are noted with a view to the planting of fry from hatcheries to the greatest advantage.

By obtaining two large representative collections of the lake herring taken from the same locality at the same season of different years, it has been possible to answer with confidence certain critical questions relative to the scale method of age determination as applied to the whitefish.

During the year a report on experiments carried out on whitefish of known age and life history was completed and is now in press. This report presents evidence to show that the correspondence between the known age of the fish and the number of annuli, or yearly rings, observed on the scales is exact and holds for old fish as well as for the young.

Much aid has been given to these investigations by the University of Michigan, particularly by Dr. Jacob Reighard, and also by the State department of conservation. A fine spirit of cooperation is manifested, which will materially aid and advance the work.

MISSISSIPPI RIVER FISHES.

The investigation of the fishes of the Mississippi Basin has been continued by members of the scientific staff at the Fairport laboratory under supervision of the director, R. L. Barney. The work has been confined largely to the hackleback sturgeon, rock sturgeon, and sheepshead. A considerable amount of material on the growth, food, sexual cycle, habits, etc., of both the rock and hackleback sturgeons has been collected. There is evidence in both of these species that sexual maturity is not reached as early as in the case of the "scaled" fishes, and that, unlike these fishes, the reproductive cycle is not an annual one. If these observations are corroborated by future work it will explain to a considerable extent the ease with which the sturgeon fishery has been depleted. A large collection of dermal plates of both species of sturgeon has been made, together with data on weight, length, and the condition of the sex organs.

The study of the natural history of the sheepshead has included observations on their habits in Lake Pokegama, Minn., and the collection of otoliths and scales (to be used in age determination), with records of length, weight, and sexual condition. These data have been supplemented by other data of similar character obtained from fishes taken at Fairport, Iowa.

Some observations have been made on the habits and natural history of the channel catfish.

Tagging experiments have been conducted at several localities in the Mississippi Basin for the purpose of obtaining information as to the migrations of several of the more important fishes. Over 150 small hackleback sturgeon were tagged and liberated in the Mississippi River. A great many sheepshead were tagged and liberated at Lake Pokegama and at Fairport, Iowa. In cooperation with the Louisiana State Conservation Commission some 300 small paddlefish were tagged at Lucas, La. These fish were seined from a large borrow pit outside the river levee, tagged, and transported to the river. The fish were all of small size, presumably of the year, none being longer than 12 inches. In Lake Pepin, a wide section of the Mississippi River between Minnesota and Wisconsin, 1,660 fish were tagged and liberated. These tagged fish were distributed among the various species as follows: Wall-eyed pike, 728; saugers, 771; sheepshead, 16; carp, 42; buffalo, 103. At the close of the fiscal year comparatively few of the tagged fish had been recovered and no significant results had been obtained. It is hoped and expected that future returns will be sufficient to give the information desired.

DESTRUCTION OF TROUT BY PELICANS IN YELLOWSTONE NATIONAL PARK.

During the summer of 1922 the bureau, in cooperation with the National Park Service, began an investigation of the pelicans in the Yellowstone National Park to determine their destructiveness in relation to the trout, the supply of which the bureau helps to maintain by artificial propagation. The services of Dr. H. B. Ward, of the University of Illinois, were secured for this work. The results of this investigation indicate that the pelican is a highly specialized predatory bird, and that its breeding period in the park is so precisely synchronized with that of the trout that its depredations effect maximum losses.

The pelican colony on Yellowstone Lake in 1922 was found to number between 500 and 600 birds, from which about 200 young resulted. For the six weeks of their sojourn on the lake they subsist almost entirely upon the black-spotted trout, the toll taken by each pelican during the season amounting to about 350 fish, and involving, besides, a large loss in trout eggs through the destruction of the breeding fish.

The pelican represents a strange and interesting ancient type of bird life and it is not desired to exterminate it in the Yellowstone Park, where it is of much interest to tourists. Measures have been recommended, however, for the regulation of its numbers through the destruction, by proper authorities, of a percentage of the eggs deposited on the breeding grounds in the park. The recommendations are now under consideration by the Bureau of Fisheries and the National Park Service.

It was originally suggested that attention be directed rather definitely to the problem presented by the parasites of the pelicans and of the trout in Yellowstone Lake. Some data were secured on this point, but the general problem of the destructiveness of the birds with respect to the trout was considered to be of such immediate importance that the question of parasites was temporarily relegated to the background and was not made the subject of special attention.

PACIFIC COAST AND ALASKA.

ALASKA SALMON.

Especial attention was given during the summer and fall of 1922 to a study of the salmon in the Alaska Peninsula fisheries reservation. The work was conducted by Dr. C. H. Gilbert, of Stanford University, and Willis H. Rich, assisted by W. P. Studdert. During June and July 4,000 red salmon were tagged with numbered aluminum tags in an effort to learn something of their migrations. The results of this experiment were striking and gave information of the greatest value. A report was prepared by Doctor Gilbert and has been published.

The tags were attached at four localities near the end of the Alaska Peninsula, where several large canneries are located. Of the 4,000 tags attached, 861 were put on at Unga Island, 200 in Morzhovoi Bay, 2,300 in Ikatan Bay, and 639 in the vicinity of Port Moller. A total of 709, or 18 per cent, was reported recaptured either in the vicinity where tagged or at more distant points.

Of the 639 fish tagged near Port Moller 174 were recaptured, all of them close to the point where they had been liberated after tagging. It is evident that the Port Moller fishery is sustained largely, if not entirely, by local runs.

The general trend of the migration of the fish tagged in the vicinity of Unga Island was to the westward. Furthermore, they proceeded directly to Morzhovoi and Ikatan bays without entering on their way the minor red salmon streams to be found along the southern side of the peninsula. A few of these fish moved eastward along the south shore of the peninsula, one being captured at the mouth of the Ozernoi River and four on the eastern shore of Cook Inlet. Other captures were reported from Bristol Bay.

The results obtained in Ikatan and Morzhovoi Bays indicated an extensive movement of salmon back and forth between these two bays. A purely haphazard movement of the fish seemed to be indicated. It was made abundantly clear that Ikatan and Morzhovoi Bays form parts of the same fishing grounds and deal with the same schools of fish, which pass back and forth from one to the other. No conclusive evidence was obtained, however, that any considerable proportion of the commercial run frequents either the local spawning grounds tributary to these bays or other local spawning grounds on the south side of the Alaska Peninsula.

A most important feature of the Ikatan, Morzhovoi, and Shumagin tagging experiments consisted in the considerable number of marked salmon that passed into Bering Sea and were recaptured in the Port Moller district and on the various fishing grounds of Bristol Bay, including those off the mouths of the Ugashik, Egegik, Naknek, Kvichak, and Nushagak Rivers. These amply demonstrate a movement throughout the season from the North Pacific into Bering Sea, and indicate that a considerable contingent of the red salmon that form the great run on the northern shores of the Alaska Peninsula have their feeding grounds in the North Pacific and enter Bering Sea only when on their final spawning migration. It is felt that this is one of the most important contributions ever made to our knowledge of the oceanic migrations of fishes.

The investigation of the salmon run in the Karluk River was continued. The count of red salmon entering the stream was much below that of 1921, and an investigation of the spawning ground made by Doctor Gilbert and Mr. Rich showed a corresponding scarcity of spawning fish.

SALMON OF PACIFIC COAST STATES.

Progress has been made in the investigation of the life histories of the salmon of the Pacific coast. Very satisfactory results were obtained during the year from one of the extensive salmon-marking experiments in progress on the Columbia River. During the spring of 1920 the bureau and the Oregon Fish Commission, in cooperation, marked 100,000 young sockeye salmon (*Oncorhynchus nerka*) at the Herman Creek hatchery of the Oregon commission. These fish were reared from eggs brought from the Yes Bay hatchery of the bureau in 1918 and had been hatched at the Bonneville hatchery of the Oregon commission and reared at the Herman Creek hatchery. The marking was under the supervision of Willis H. Rich, of the bureau, and consisted in the removal of the adipose and both of the ventral fins.

A considerable number of these fish, grown to maturity, were recovered this year in the Columbia River, and scales and data from approximately 1,200 were obtained by H. B. Holmes, temporary assistant. Mr. Holmes was greatly aided in this work by the Oregon Fish Commission, which offered a reward of $1 for the return of the scars from each fish accompanied by the necessary data and scales.

These returns are far the most satisfactory that have ever been obtained from the marking experiments that have been conducted on the Columbia River during the past six years. It is especially interesting that the results obtained this year are quite comparable with those obtained in 1918 from a similar experiment begun in 1916, and the estimated per cent of the total number of returned fish is very similar. The results this year further support those obtained in 1918 in that the adult fish were distinctly different from the typical Columbia River fish of the same species, locally known as bluebacks, and resembled the parent fish of Yes Bay. This resemblance is not only external but involves also the quality of the flesh, that of the Yes Bay fish being inferior to that of the Columbia River blueback. This confirms the earlier conclusion that heredity is more important than environment in determining the general appearance and quality of the flesh of salmon.

An investigation of the spawning grounds of the blueback salmon of the Columbia River was made by Harlan B. Holmes during the fall of 1922.

Up to the present there have been no accurate data as to where this species of salmon now spawns in the Columbia Basin. All of the well-known areas formerly used have been rendered inaccessible by the construction of dams and irrigation ditches. Notable among these old spawning grounds are the large lakes of the Yakima Basin of Washington, the Payette Lakes of Idaho, and Wallowa Lake of Oregon, all of which are now closed to salmon. The especially large run of bluebacks in the Columbia River during the season of 1922 made this year a very favorable one for the study of the present spawning grounds. The results of the investigation show that a run of these fish passes up the Salmon River in Idaho at least as far as Sunbeam Dam, about 12 miles east of Stanley. The series of lakes known as the Red Fish Lakes are above this point and were visited for evidence of spawning fish. No direct evidence that the fish got above this dam was obtained, but it is not at all impossible that many of the fish were on their way to the spawning streams visited but at the time were in the lakes or at points in the river that were not visited. The evidence that there is still a run of bluebacks in the Red Fish Lakes seems sufficient to justify providing a certain passageway over the dam for the returning fish in future years. The present fishway over Sunbeam Dam is considered inefficient.

INVESTIGATIONS OF SHELLFISH AND TERRAPIN.

OYSTERS.

Investigations relating to oyster culture were conducted during the fiscal year by J. S. Gutsell and H. F. Prytherch, scientific assistants, aided during the summer months by J. G. Scott. Dr. P. S. Galtsoff also carried on some special oyster investigations. As in recent years, the "setting" problems of Long Island Sound and Great South Bay, Long Island, received chief attention.

In the summer of 1921 there had been an oyster "set" of exceeding abundance in Great South Bay. Before the summer was over it was nearly all dead. The work of that summer and fall and of the following spring showed that where the spat had attached well above the bottom, as on "pound" stakes and boat bottoms, good growth and no excessive mortality had occurred. The discovery that H_2S was being generated by decomposing organic material over a large part of the bottom seemed to account for the loss of bottom set and the survival of that which was elevated. It was hoped that in 1922 definite evidence might be obtained for or against this hypothesis and especially that the degree of elevation required for the survival of the set might be determined and a way opened for improvement in commercial practice to meet the special needs of this area. Unfortunately, however, complete failure of the oyster set made it impractical to add to our knowledge in regard to the minimum or optimum elevation for growth and survival, but data of value for the determination of the correlation of temperature and oyster spawning and setting were obtained. Later, at Milford, Conn., it was found that the presence of very minute amounts of H_2S causes spat to stop feeding, and from this it follows that the presence of the gas is, at the very least, highly disadvantageous.

The work in the New Haven-Bridgeport area of Long Island Sound, where once an important supply of northern "seed" oysters was produced and where the sets have become alarmingly reduced, consisted in the collection of data regarding temperatures; spawning of oysters; the occurrence, distribution, and development of larvæ and spat; and the effects on spat of various chemicals known to be important pollutants. Data concerning the age and growth of spat also were collected. The investigations revealed the fact that the set of oysters was much above the average following a season in which the oysters in harbors and inshore areas of the Sound spawned comparatively early.

Oyster larvæ were found in the Housatonic River for the first time in the five seasons during which these investigations were carried on. For a number of years there had been no oysters in this river until a planting was made in the spring of 1922. The set was comparatively good, but a very large proportion was destroyed by starfish and drills, and to a considerable but uncertain extent by other adverse factors. The set of oysters at the mouth of the Housatonic River occurred during a time of lessened trade-waste pollution due to decreased manufacture and when water conditions presumably were temporarily much better than usual. Because it was believed that improved water conditions may have had a great influence on the set, it seemed desirable that a survey be made at this time for comparison with conditions obtaining during periods of greater industrial activity. In October, therefore, in cooperation with the Bureau of Chemistry, an investigation was made of water conditions in the Housatonic River and New Haven Harbor with regard to trade-waste pollution with heavy metals, and also with regard to oxygen content and alkalinity. From this work it appeared that conditions were chemically decidedly worse in the optically clean Housatonic River than in the obviously fouled New Haven Harbor. This was most notably true with regard to copper, but also held for zinc and dissolved oxygen.

In the experiments with pollutants a copper salt was found most destructive. A solution of copper chloride containing 10 parts per 1,000,000 of copper gave complete mortality of oyster spat under conditions in which other metallic salts gave less mortality and the control experiments nearly complete survival.

An inquiry into the relationship between spawning and water temperatures has been carried on for a number of years. At this stage of the investigation the evidence indicates that fairly satisfactory temperature conditions, viz, the attainment of 70° F., or higher, by late July or early August, and the maintenance of about this temperature for the few weeks required for spawning and setting, are generally to be expected not only in estuaries but also in inshore areas in the sound. Therefore, until conditions in the estuaries can be greatly improved, in so far as pollution is concerned, the general planting of inshore lots with oysters (where this will not result in loss from storms, etc.) is to be urged as the most hopeful method in sight for the improvement of oyster sets in the sound.

In September there came to the attention of Dr. P. S. Galtsoff, in the course of his hydrographic surveys, the matter of the death of large numbers of "set," especially in the neighborhood of New Haven. He found that in addition to those being killed by the drill, many were dying from some unknown cause. Attempts, by histological methods, to connect this mortality with some parasite were unsuccessful. When, in October, he again visited this region he found that although the drill was still active the mortality from the unknown cause or causes had ceased.

CLAMS AND CRABS OF ALASKA.

In connection with the administration of fishery reservations in Alaska, an investigation of the clams and crabs has been undertaken. The utilization of these shellfish has only just begun in Alaska, and while there is no immediate danger of depletion it is desired to obtain all the information that may be needed later to properly control the utilization of the resource. For this work the bureau has obtained the services of Dr. F. W. Weymouth, of Stanford University, who has made extensive studies of the life histories of both clams and crabs in California and British Columbia. Some preliminary work has been done in the way of compiling information as to the present state of the industry and active field work will be begun soon after the close of the present fiscal year.

FRESH-WATER MUSSELS.

Investigations of the factors affecting the survival and growth of juvenile mussels conducted at Fairport and at Lake Pepin have been characterized by important results, which have appeared sufficiently favorable to warrant the establishment of a small rearing system at Fairport. This system consists of 140 metal troughs fed by a gravity supply of water, twice sedimented in ponds before reaching the troughs. The elasticity of this system, and its apparent efficiency, mark it as a distinct step toward the conservation of fresh-water mussels. One of the main features of the system is the exclusion of light from the troughs. Experiments have proved that the dark trough, probably because it simulates natural conditions on the bottom of mussel-bearing streams, will produce about 25 times as many mussels as the open trough.

Similar noteworthy results have been produced experimentally at Lake Pepin, Minn., by the use of a totally different apparatus. There a floating basket with wooden floor approximately 8 feet below the surface was used. A second smaller basket, in which the infected fish are held until the mussel embryos are liberated, was suspended within the larger inclosure. This style of pen and bottom was used in an effort to avoid losses caused by enemy organisms living on the lake bottom. Its value is evidenced this year by the fact that on the bottom of one experimental float 10 feet square more than 23,700 young mussels, all at least half an inch long, and many longer, were recovered. These mussels spent their parasitic life on wall-eyed pike and saugers and represent an 84.6 per cent survival of the glochidia, constituting the total experimental infection. The production of these juveniles averaged 237 per square foot of bottom surface. The mortality of mussels after having reached this length is approximately nil.

The results of these experiments stand as an indication of the possible usefulness of controlled methods over the present method of artificial propagation in which infected fish are liberated in natural bodies of water to drop the juvenile mussels on bottoms, where it is unlikely that more than a 2 or 3 per cent survival results. These results are particularly significant if, based on the apparatus used, artificial mussel propagation may be carried on more effectively than formerly with results more tangible, cheaper, and less limited by natural physical, chemical, and biological factors.

During the year two undescribed parasites of fresh-water mussels, ciliates of the genus Conchophthirius have been observed. One of these has no particular significance as it is apparently harmless. The other, however, evidently is the cause of the mortality of large numbers of larval mussels while they are still held in the marsupia of the adults. Mussels seriously infected have been taken in Lake Pepin and from the ponds at Fairport.

Statistical and biological surveys of mussel beds have been carried on during the year at Lake Pepin and at Lake Pokegama, Minn. Artificial culture of mussels by the inoculation of the host fishes has been carried on for several years in both bodies of water. At Lake Pepin there has also been in operation for some time a five-year alternate sectional closure of the lake to commercial mussel fisheries. The surveys, therefore, especially in the case of Lake Pepin, have provided important data regarding the benefits derived from artificial mussel culture and the advantages to be expected from protective closure of streams. The survey of Lake Pepin indicates, though not conclusively, that the important commercial mucket (*Lampsilis luteola*) has increased in the lake. This apparently is due to the artificial culture of this species that has been carried on by the bureau since 1913. The noncommercial species and other commercial species that have not been propagated apparently have decreased during the same period of time.

The presence in the lake of a large number of mussels under 10 years old further corroborates the value of the work. The returns from this survey are the best indication of the value of artificial mussel culture so far obtained. The protective closure, as inaugurated in 1918 through the cooperation of the States of Minnesota and Wisconsin, is unquestionably a desirable aid in perpetuating the mussel fisheries of the country.

Physiological and anatomical studies of the mussel embryo and its development, and experimental efforts at metamorphosis induced without the normal stage of parasitism on fishes, were conducted by Dr. Edgar Allen at the fisheries biological station, Fairport, Iowa. Obeservations were made on a number of mussels, but particularly on the species *Anodonta imbecillis* and *Strophitus edentulus*.

Dr. L. B. Arey continued his investigations of (1) the history and structure of the normal cyst of fish tissue surrounding the mussel glochidium, its relations to the surrounding host tissues, mutual adjustments, nutritive relations, etc.; (2) the morphological study of the glochidia of a large number of fresh-water mussels; (3) the nutrition of the encysted glochidium; and (4) the histological changes in tissues of the host due to an immunity reaction of the fish to inoculation with glochidia.

Dr. E. P. Churchill, jr., during the summer of 1922 was engaged in a continuation of his study of the food and feeding of fresh-water mussels. His attention was confined chiefly to feeding reactions and requirements of juvenile mussels.

Activities looking toward adequate protection for the commercial mussels in order that the industry might be perpetuated have been of a cooperative and advisory character. During the year, as a result of endeavors along this line, the fish and game authorities of the States of Minnesota, Iowa, Wisconsin, and Illinois have cooperated to close to commercial fishing for a period of five years alternate sections of the Mississippi River between Brownsville, Minn., and Keokuk, Iowa.

TERRAPIN.

A series of cultural and breeding experiments with the diamond-back terrapin was continued at Beaufort, N. C., by Charles Hatsel, the acting director of the station. Careful records were kept of the reactions obtained by varying methods of feeding, size of range, etc., and special experiments in selective breeding were begun. Further attention has been given to the determination of the cause or causes of a bacterial disease among young winter-fed terrapin and to methods of combating the disease.

Terrapin from a wild brood stock have been grown in confinement under various conditions for the purpose of determining the environment under which the best results may be obtained. It has been found that at least one year's growth can be gained by placing young terrapin in a hothouse, keeping them warm, and feeding them regularly for the first winter of their lives. Winter feeding for older terrapin has not proved to be of much value. The young that received this winter treatment the first year have also invariably reached sexual maturity and produced eggs one year earlier than those of the same age that were permitted to hibernate. Diseases among the winter-fed stock, however, are more prevalent than they are among the hibernating terrapins and constitute a problem that requires further study. Several experiments have been conducted in the past and others are now under way looking toward the successful control of these diseases. Fortunately, diseases among terrapin of one or more years of age are very rare.

The offspring of wild stock have been reared to sexual maturity in captivity in four years. Several lots of young, hatched from eggs laid by terrapins reared in the pounds at the Beaufort station, are now being held, and their rate of growth is compared from time to time with that of terrapins of the same age hatched from eggs of the wild brood stock. To date the rate of growth in the offspring of the "domestic" stock invariably has exceeded that of the "wild" stock, indicating that as early as the second generation after confinement these animals are becoming adapted to the changed environment. Certain lots have been separated for selective breeding. The terrapins in these lots were selected for rapid growth, size, and general healthy and vigorous appearance. The third generation of domestic terrapins probably will result during the next breeding season from this series of experiments. The results attained show beyond a doubt that it is entirely practical to grow diamond-back terrapins in confinement for commercial purposes, and, indeed, this appears to be the only hope of maintaining a supply of this animal, which is nearing extinction.

ECOLOGICAL AND OCEANOGRAPHIC STUDIES.

CONTROL OF MOSQUITOES BY MEANS OF FISH.

Investigations of fishes in relation to mosquito control were conducted at Augusta, Ga., during the mosquito-breeding season of 1922 by Samuel F. Hildebrand, ichthyologist, working in cooperation with the United States Public Health Service. Particular attention was devoted to a study of the relationship that various plants bear to mosquito control by the use of fish. A single plant—the duckweed Spirodela—was found to prevent mosquito production in a measure. All other plants used in the experiments appeared to favor mosquito breeding. The extent to which plants favored mosquito breeding and to what extent they formed " barriers " between the fish and the wiggle-tails was arrived at through the creation of fishless areas in ponds supporting various types of vegetation in which mosquitoes were permitted to breed unmolested for a time. Later such areas were restocked and the results were checked.

Extensive studies of sex ratios in Gambusia (the most important of the fishes used for mosquito control) were made, from which it was determined that the males are proportionately fewest in August, when among the specimens examined only 1 male occurred among about 8 females. In October the males had become much more numerous and the proportion was about 1 male to 2 females. The conclusion is that the male is the weaker sex, and in August, just before the early young of the season become sexually mature, so many of the males have died or have been destroyed by enemies that the disparity is very great. In October, when many of the young of the previous spring and summer have become sexually mature, the young males greatly increase the proportionate number of that sex. Microscopic studies of the sexual organs of a limited number of young fish showed a sex ratio of about 1 to 1.

It is well known that in the northern part of its range Gambusia spawns only during the summer, but it had previously been noticed that gravid females may be taken at Key West at all seasons of the year. Consequently the director of the Key West station, Mr. Ginsberg, was requested to confine females in the aquarium and make careful observations relative to the period and frequency of spawning. These observations show that at Key West Gambusia spawn the year round at more or less regular intervals of four weeks.

Extensive experiments relative to the proper handling of Gambusia in confinement and shipment were conducted. It was shown that a larger proportion of the fish survived when approximately 3 inches of water was placed in a vessel of a given diameter than if 8 to 10 inches of water were used in the same container.

During the year Mr. Hildebrand visited several localities in the South in an advisory capacity, offering suggestions for the best use of top minnows for the control of malaria and for the propagation of these fish for distribution.

OCEANOGRAPHIC WORK.

During the fiscal year 1923 laboratory work on the collections made in the hydrographic and biological survey of Chesapeake Bay was inaugurated, the field work in the main having been completed early in June, 1922. The special collections have been segregated and assigned for study by specialists in the National Museum and biologists in various parts of the United States and Canada, and a comprehensive report on the fish and fisheries of the region is well advanced. The data relating to the physical and chemical features have been compiled, and a report on this phase of the investigation is also well under way.

In this investigation the bureau has received cooperation and assistance from the United States Geological Survey in the determination of the salinities of the water, and from these results most of the densities have been calculated. The Geological Survey has also furnished important information concerning the average amount of fresh water that drains into Chesapeake Bay, and this, together with valuable information prepared by the United States Coast and Geodetic Survey as to the total area, areas of cross sections, and volume of sea water entering the bay, will have an important bearing on the study of the movements of the water and the organisms contained in the water. The United States Weather Bureau has cooperated by furnishing information on the daily precipitation during the last few years in drainage basins that feed Chesapeake Bay. These important data have been found very valuable in the study of the variations in position of the water layers of different density in the bay.

The survey of Chesapeake Bay was begun in 1912 by Lewis Radcliffe and William W. Welsh primarily for the study of the Clupeidæ. The work was later extended to include the general fauna and flora of the bay, with the exception of the birds and the higher plants. Dr. R. P. Cowles, of Johns Hopkins University, undertook the supervision of the work and personally conducted numerous cruises on the bay during 1920 to 1922. William C. Schroeder made extensive collections of fishes and obtained many data on the commercial status of the fisheries of the region. The fisheries steamer *Fish Hawk* was used in making the survey.

To supply fundamental data for the elucidation of oyster-cultural problems, especially the failure of the set, Dr. Paul S. Galtsoff, naturalist on the fisheries steamer *Albatross*, has been conducting a hydrographic and microbiologic survey of Long Island Sound and adjacent waters. The program included a series of Richter and Negretti-zambra reversing thermometer readings and Eckman current-meter readings, salinity and dissolved oxygen titrations, colorometric hydrogen-ion determinations, color and transparency determiniations, qualitative and quantitative plankton studies, and quantitative bacteriological tests. Fourteen cruises were made with the fisheries steamer *Fish Hawk*, and observations were taken at 299 stations.

Although at the end of the fiscal year the work was not completed, Doctor Galtsoff was able to make an interesting progress report. The Sound receives salt water through both ends, but by far the most, probably nine-tenths or more, enters through the east end known as the "race." The entering sea water is diluted by the discharge from numerous rivers, particularly on the north shore, so that there is a marked decrease in salinity from the race to the head of the Sound. There is also a seasonal variation. From July to November the salinity rose and thereafter it gradually decreased. Highly polluted water enters from East River and from many industrialized and sewage-polluted streams and harbors. Accordingly, at the head of the Sound the bacterial content was high, up to 4,000 per cubic centimeter, and in certain harbors very high, indeed, up to 20,000 per cubic centimeter. However, so great is the dilution in the Sound that within 2 or 3 miles off the mouths of the worst polluted harbors the bacterial content was reduced to 100 per cubic centimeter or less. Corresponding with the evidences of pollution afforded by the bacterial examinations, the dissolved oxygen content was low at the head of the Sound and in the harbors but fairly high a short distance away from these polluted areas.

Being less affected by ocean conditions, the waters of the western part of the Sound show much higher summer temperatures than were found at the mouth. An increase also occurs in inshore waters. The hydrogen-ion studies revealed comparatively little variation from place to place, day to day, or season to season. Except for the one river, the pH values for the Sound and estuaries ranged only from 8 to 8.3. In the Housatonic River, which receives an extreme amount of acid pollution, values of 7.6 and 7.8 were recorded. Much of this information is of great interest in the study of the oyster-cultural problems of the region. When the examination of the material is completed and the work of another year added, a fine basis for the study of specific problems will have been laid.

STUDIES OF MARINE PLANKTON IN RELATION TO THE FISHERIES.

During the past year an investigation of the seasonal variation in the plankton of the Woods Hole region was carried on by Dr. Charles J. Fish, assisted by Marie D. P. Fish. The purpose of the work was to make an exhaustive investigation of the plankton, the seasonal variation of the various species, their interrelationships, and the general factors governing their distribution. As planktonic organisms form the sole food of the pelagic larval fish and are important factors, both directly and indirectly, in the diet of the adults, the results of the present investigation will serve as a basis for a future study of the factors governing the seasonal variation of both the fry and the adult fishes.

Examinations of collections taken daily were made throughout the year, together with records of temperature, salinity, and other physical governing factors. The seasonal variation of 291 species of plankton organisms, of which 36 were larval fish, were recorded. It was found that salinity has little or no effect on the plankton of the immediate region. No fresh-water streams of any size enter

Great Harbor, the salinity averaging about 31.5 throughout the year. Water temperature is the dominant factor in governing the seasonal distribution and the breeding periods of all local pelagic animals. It also determines whether oceanic species entering the region shall perish at once or live long enough to become an important factor in the local fauna.

As in the case of the bottom-living animals, the plankton of this region is made up of a complex of faunas. The region about Woods Hole forms the northern limit of many southern species, the southern limit of many northern species, and a pocket where oceanic animals blown in by strong southerly winds are deposited. The arm of Cape Cod forms a permanent northern barrier for the southern coastal plankton, but only a summer barrier for northern pelagic animals. A distinct periodicity in the occurrence of all common animals of the region is clearly noticeable. The succession of species remains the same each year, the only variation being in the time of their appearance and disappearance. The planktonic animals of the region, with one exception, may be placed in two general groups—the summer community and the winter community. The coelenterates form the exception; for the most part these have a long spring period of maximum frequency and another short one in the fall.

Three general conditions affect the appearance of the pelagic animals—winds, tides, and the food supply. Salinity forms barriers in some localities, but not at Woods Hole. Once introduced into the region, the organisms remain until the temperature becomes unfavorable or the food supply is exhausted; then they must leave or perish. Food is also an important factor in causing the disappearance of a species during a period of favorable physical conditions.

Temperature governs the breeding seasons of the plankton and benthonic animals of this region. The temperature prevailing at the time of the extrusion of the eggs is not often the important factor, for the eggs are usually thrown off as soon as ripe provided the conditions are not too unfavorable. After being deposited in the waters the existing temperature plays a controlling part in determining whether the incubation period will be long or short. The determination of an early or late breeding season depends on the temperature at some previous date when a warming or cooling of the water started the development of the sex products. These facts must be considered when interpreting the appearance of certain larvæ in the plankton.

The distribution of the plankton of the western Atlantic coast is little understood, and the number of animals new to the region taken during the past year indicates that most of the eastern Atlantic coast pelagic species will probably be found here also.

A full report of the work of the year, compiled with complete records of plankton collections by the late Vinal N. Edwards covering the years 1893-1907, inclusive, is nearly completed.

ECOLOGY OF FRESH-WATER LAKES.

Cooperation with the Wisconsin Geological and Natural History Survey in important investigations of the fundamental conditions of fish life in lakes has been continued. These studies are directed by Dr. E. A. Birge, president of the University of Wisconsin, and the work was executed by Chancey Juday and Dr. H. W. Rickett, assisted by students from the university. The aquatic plants, the plankton, bottom fauna, and mussels of Green Lake were studied during the past year, with reference to quantity and distribution, and a report on the aquatic plants has been completed and will appear in Volume XXI of the Transactions of the Wisconsin Academy of Sciences, Arts, and Letters. Arrangements have been made for the continuance of these investigations during the fiscal year 1924.

FOULING OF SHIPS' BOTTOMS.

In September, 1922, in cooperation with the Navy Department, the bureau began an investigation of the marine growths on the bottoms of ships to determine, if possible, the conditions governing the amount and character of such growths and the possible seasonal and regional factors affecting them. The work was undertaken with a view of securing further data on the problems of preventing the attachment of the fouling organisms to ships' bottoms, as well as to determine the proper docking intervals for ships in various kinds of service. J. Paul Visscher, of Johns Hopkins University, was placed in charge of the work. Through the Navy Department he has been kept in touch with the docking of vessels in the navy yards of the Atlantic coast and has made examinations of more than 70 vessels in dry dock.

While the results so far obtained are not entirely conclusive, sufficient data have been collected to indicate that the color of the paint used is an important factor in determining the extent of fouling. In the tests made with submerged plates painted, respectively, white, black, yellow, red, green, and blue, it was found that there was much more fouling on the dark plates than on those of lighter colors. These results apparently are explained by the fact that at the time of attachment of the larvæ to the plates the organisms are negatively phototropic; that is, they tend to go away from the source of light. It would seem, therefore, that there is an important and specific relation between light and the nature and extent of the fouling of ships' bottoms.

The investigation has also indicated rather conclusively that fouling in the North Atlantic waters is caused, in the order of their importance, by barnacles, hydroids, algae, bryozoa, ascidians, and by numerous other growths of much less importance, and that most of the organisms attach while the ships are in harbor. It has been shown that vessels in commission, which never stay more than six or seven days in any port and travel between ports a considerable distance apart, do not foul seriously, at least during the period from August to March in the North Atlantic Ocean. On the other hand, it is found that vessels that lie at anchor continuously in any one port for the five or six winter months become heavily coated with hydroids but not with barnacles.

INVESTIGATIONS PERTAINING TO FISH-CULTURAL OPERATIONS.

PATHOLOGY OF FISHES.

Studies have been continued by Dr. H. S. Davis, pathologist, on *Octomitus salmonis*, an intestinal parasite of trout. In the course of these investigations visits were made to a number of hatcheries in different parts of the country. The parasite has been found to be widely distributed and probably occurs at most of the bureau's trout hatcheries. It is strictly an intestinal parasite, usually being most abundant at the anterior end, but may be found throughout the entire length of the intestine. It occurs in two quite distinct forms that evidently represent different stages in the life cycle.

The most common form of *Octomitus* is the flagellate stage that lives in the lumen of the intestine and under certain conditions may be present in large numbers. In addition there is also an intracellular stage that is quite different in appearance and occurs in the epithelial lining of the pyloric cæca and the anterior end of the intestine. This stage first makes its appearance as a small rounded body lying in a vacuole in an epithelial cell. It grows rapidly, producing hypertrophy of the infected cell, which eventually is destroyed. After a time the parasite undergoes schizogony and the resulting schizonts invade other epithelial cells and repeat the process. On the other hand, some of the schizonts, instead of again undergoing schizogony, after a short period of growth become metamorphosed into the free-swimming flagellate. Usually both intracellular and flagellated forms are found in the same host, but under some conditions, which are not well understood, one form may greatly predominate. This is especially true of the intracellular stage, which may become very abundant without any corresponding increase in the flagellated form.

The effect of the parasite on the host varies greatly and is apparently largely dependent on local conditions. Under ordinary circumstances the injurious effects appear to be confined to the fingerlings, older fish being affected little if at all. In the young trout the parasite is often present in great numbers, the flagellates usually being more abundant than the intracellular stages. The flagellates do not ordinarily cause a severe mortality, but may seriously interfere with the proper nutrition of the host. The fish become greatly emaciated and instead of growing steadily may even lose weight for a number of weeks. The disease usually is more pronounced in the spring and apparently is associated with a slight rise in the temperature of the hatchery water. In some instances, for reasons not well understood, the intracellular stages may become very abundant, producing an inflammation of the intestine that often terminates fatally. There can be little doubt that many, if not most, of the epidemics among young fish, which occasionally break out in trout hatcheries in early spring, are due to this cause. The intracellular stages are also the cause of an excessive mortality that sometimes occurs when fish are being transported from the hatcheries. Usually there is little loss for the first 24 hours, but if the fish are held in cans for a much longer time the mortality is sometimes very high. It has been found that for some reason the intracellular stages multiply very rapidly when the fish are placed in cans, producing a fatal enteritis.

Since Octomitus is so widely distributed and occurs in the brood fish as well as fingerlings it will doubtless be very difficult, if not impossible, to eradicate it in the hatcheries. It is believed, however, that the parasite can be controlled and its injurious effects reduced to a minimum. Although it has been found in wild fish, there is no evidence that it is very abundant or produces serious injury to the host under natural conditions. However, the unnatural conditions under which the fish are necessarily kept at the hatcheries appear to furnish an ideal opportunity for the development of the parasite, and consequently it has come to be one of the most serious pests with which the fish-culturist has to deal. Overcrowding undoubtedly is one of the conditions that favor its rapid development, and wherever the fish have been given more room there has been a noticeable improvement in their condition. It is believed that improvement in the food would also help in alleviating the injurious effects of Octomitus, and experiments have been planned with this object in view.

It has been found recently that excessive mortality, which often occurs during distribution, can be greatly reduced by keeping the fish at a much lower temperature than formerly. In fact, fish from the White Sulphur Springs (W. Va.) station, which in previous years had shown the greatest mortality, were carried at a temperature of 40° F. with very little loss.

A preliminary paper dealing with this parasite was published in the Journal of Parasitology for March, 1923.

For a number of years the Neosho station has experienced great difficulty with brood fish. The number of eggs produced often was below normal and of such poor quality that a considerable percentage failed to develop. This was most noticeable among the black bass, especially the smallmouth. Many of these fish failed to spawn, and in some of the ponds practically no fry were produced. This station was visited by the pathologist in May, and it was found that the trouble is, in all probability, due to a cestode, *Proteocephalus ambloplitis*. The plerocercoid larvæ of this tapeworm were found in large numbers in the ovaries of the smallmouth bass, while the ova had failed to develop normally. The larvæ occurred throughout the connective tissues of the viscera, but were much more abundant in the ovaries than in the other organs, and in a number of fish examined were so numerous as to effectually prevent the development of the ova. The same parasite was found in the largemouth bass, rock bass, and blue-gill sunfish, but was not as abundant in these fish as in the smallmouth. Evidently the ponds furnish exceptionally favorable conditions for the development of the parasite, which has seriously curtailed the output of the Neosho station.

A small percentage of the halibut taken on the Pacific coast are referred to as "wormy," from the fact that the flesh contains many long, white, wormlike structures that render the fish unsalable. These so-called worms are in reality hypertrophied muscle fibers that are infected with an undescribed species of myxosporidian. These parasites live only within the muscle fibers that become greatly enlarged and eventually filled with a glistening whitish mass of spores, which accounts for its wormlike appearance. A description of the parasite and its effect on the fish has been prepared for publication. This condition should not be confused with the so-called mushy halibut, which is apparently due to a small bacterialike organism that develops in the connective tissue surrounding the muscle fibers. The investigations on mushy halibut are being continued and will be reported on later.

An outbreak, in the bureau's aquarium, of the disease caused by Ichthyophthirius, provided a favorable opportunity for studies on the life history of the parasite and methods of control. These investigations were carried on by H. F. Prytherch, scientific assistant, who found that alum sulphate possesses certain advantages over chemicals previously used in the treatment of the disease. A brief bulletin on the disease is being prepared.

An outbreak of a "gas bubble" disease in developing trout at La Crosse, Wis., was investigated by the Fairport station. The disease was found to be characterized by the diffusion of yolk through the surrounding tissues and in some cases by the formation of a bubble of gas in the yolk. Since it was known that there was an excess of carbon dioxide dissolved in the water, it was suspected that this was the primary cause of the trouble. This diagnosis was borne out by the fact that elimination of the gas before the water entered the troughs caused a disappearance of the abnormal condition although the fish affected failed to recover.

At the invitation of the Minnesota State Game and Fish Commission an investigation was made of the mortality of pike perch at Cut Foot Sioux, Minn. The fish found dead had apparently been trapped some weeks before for the collection of eggs and, owing to improper handling, had been scratched and bruised, resulting in a fatal infection with Saprolegnia.

In June a severe mortality of crappie and sunfish in Lake Pokegama, Minn., was investigated by R. L. Barney, director, and H. O. Hesen, superintendent, of the Fairport station. The cause of the mortality was diagnosed as a heavy infestation of the gills by the worm Dactylogyrus with a secondary bacterial infection that usually killed the fish. This mortality at Pokegama is of particular interest in view of its regular annual occurrence in May and June for the past 15 years. Its original appearance seems to have been connected with the lowering of the water level of the lake by the blowing out of a dam, which resulted in cutting off a broad connection with Snake River. The mortality affects several species of fish, but the crappies and sunfish suffer most severely.

During June a heavy mortality of gizzard shad occurred in lakes in the suburbs of Des Moines, Iowa, and at the invitation of the State game warden an investigation was made by the Fairport station. The disease was characterized by inflation of the pectoral fins, and the study of sectioned material led to the conclusion that it was due to bacterial infection, probably by a gas-forming organism.

At the request of Representative Sweet, of Iowa, an investigation of conditions in the Iowa River was made by C. N. Blystad, of the Fairport station. A serious mortality of fishes occurred in this river during the late fall and early winter, and although fish were not dying at the time of the investigation it was possible to gather sufficient data to warrant a definite conclusion as to the cause. It was found that the mortality was due to large amounts of chemical and organic wastes allowed to pass into the stream from a sugar factory located on the river.

PHYSIOLOGY AND NUTRITION OF FISHES.

Prof. A. S. Pearse, of the University of Wisconsin, and his graduate students continued their studies on the physiology and nutrition of fishes, assisted to a limited extent by the bureau. These studies include investigations on the amount of natural food consumed, the chemical composition, the functions of the swim bladder, and the digestive enzymes of fishes. In the investigations on the chemical changes in trout and perch during growth the protein, fat, water, and ash have been determined for fish of various ages taken at intervals throughout the year. The composition of fed and starved pumpkinseeds (sunfish) has also been determined and compared with individuals caught fresh from Lake Mendota.

Studies on the function of the swim bladder have demonstrated that it is primarily a hydrostatic organ that has secondarily taken on respiratory functions. The effects of temperature and pressure on the gaseous content of the organ have been thoroughly investigated.

A study of the digestive enzymes of fish has been begun and promises to yield results of great value. Up to the present the work has been confined to pickerel, carp, and perch, but it is planned to broaden the scope of the investigation in the future.

Professor Pearse and his students have also started investigations directed at certain fundamental problems relating to the metabolism of cold-blooded vertebrates that promise to be of exceptional interest. It is planned to use turtles for these investigations, and special attention will be paid to the relation of various rations to the rate of growth; the relation of temperature to pulse, respiration, and hibernation; the basal metabolism; the amount of food required per day; the chemical composition of turtles at various seasons and ages; and the degree of activity at various temperatures.

During the latter part of the fiscal year a series of experiments for developing a more satisfactory diet for trout was inaugurated at the Manchester (Iowa) station. For many years there has been little change in the character of the food used at trout hatcheries, although in the light of the more recent knowledge of animal nutrition that has attracted much attention in late years it is evident that the standard rations are deficient in certain essential food requirements. They are especially lacking in salts and vitamines, and it is not impossible that many of the difficulties experienced at the hatcheries are in reality primarily due to an inadequate diet. For this reason it was thought advisable to undertake an extensive series of feeding experiments in the hope that it would be possible to work out a more satisfactory ration than those in use at present. Milton C. James, scientific assistant, has been assigned to this work, which was just getting under way at the end of the fiscal year.

EXPERIMENTAL WORK IN FISH CULTURE.

A number of investigations relating to the development and improvement of methods of artificial culture of some important food fishes have been conducted at the Fairport biological station. Observations on the culture of buffalofish seem to indicate that the fish will not lend itself to cultivation on a commercial scale on account of the large acreage necessary for it to attain an optimum growth. Efforts to artificially propagate the paddlefish have not yet succeeded owing to the fact that the young fish placed in one of the ponds several years ago have not yet reached the age of sexual maturity. They will continue to be held, however, in anticipation that at some future time they may ripen and spawn. This species is of particular value commercially, and its perpetuation is a matter of concern in view of the great decrease in its numbers in recent years. Experiments in the culture of the channel catfish have been continued. Considerable light has been thrown on the natural history and essential factors for success in the pond culture of this species, and several ponds have been set aside for a practical demonstration of these experiments. At the close of the fiscal year quite a number of nests were observed, and it seems quite possible that the pond culture of this fish may be taken up on a practical basis next year. An effort at the pond culture of the hackleback sturgeon was made at the Fairport station and a large mass of data was collected, on which it is hoped to base recommendations for protective legislation for the species. The fishery for this species is of value and one that is carried on intensively because of the high prices paid for both the flesh and the eggs.

Observations on the production of the "farm pond" at Fairport have been continued with significant results. The purpose of the study of this pond production has been to obtain useful data regarding the possible value of small ponds on farms or large estates. With this end in view the pond has been handled just as one would be managed in practice; that is, the fish have not been fed but have depended on the natural "fish food," the small animals and plants that normally form the diet of food fishes and that are naturally produced in the pond.

Year.	Net production per acre.		Production of edible fish per acre.		Year.	Net production per acre.		Production of edible fish per acre.	
	Pounds.	*Ounces.*	*Pounds.*	*Ounces.*		*Pounds.*	*Ounces.*	*Pounds.*	*Ounces.*
1919	203	14	94	1	1921	374	11	92	10
1920	333	8	54	0	1922	440	14	101	11

The production of the pond has been obtained by computing the difference between the weight of the fish at the time of their introduction into the pond in spring and the weight of the same fish and their offspring as occasionally caught out during the summer or when removed from the pond at the autumn inventory. This method of computation gives the increased weight of fish in the pond due to the "turnover" of small plants and animals. The fish used (the bluegill) feeds primarily on insect larvæ, cladocerans, copepods, and plants. This annual net "turnover" of food organisms of the pond into fish flesh is here tabulated. The table includes also the weight of the fish of edible size taken from the pond.

The annual production of fish of edible size in 1919 and 1920 was based on the weight of fish removed from the pond by hook and line during the summer. In 1921 and 1922 line fishing was not carried on in the pond and the data on the production of edible-sized fish were collected when the fall inventory was made. The use of the fall measurements for this computation necessarily tends to hold down the total possible "turnover" and the total possible production of fish of edible size. The computation, however, as made for 1921 and 1922, can not be far from accurate, though the total net "turnover[7] and the production of food fish would probably have been somewhat greater had the larger fish been removed at intervals during the summers of those years.

The effort in manipulating the stock of this pond has been to so control the number of fish of different ages in it that an association might result that would give continual maximum production of fish of edible size year after year. The tendency of the manipulation for the last three years has been to decrease the number of fish constituting the spring plant, so that the small fish produced by them during the current year might not make up an undue proportion of the total annual production of fish flesh. It has been observed that too great a production of young fish in a given year prevents many of the half-grown fish from attaining edible size through too serious competition for the available food.

THE BIOLOGICAL LABORATORIES.

The biological laboratory at Woods Hole, Mass., was reopened during the summer of 1922 under the direction of Dr. R. E. Coker, then assistant in charge of the division of scientific inquiry. The laboratory was again opened in June, 1923, and was made available during the summer for investigators working on fishery problems. Doctor Coker was secured as director for the season. The policy of extending the use of the laboratory to the Marine Biological Laboratory of Woods Hole with the understanding that no charge be made by that institution for the use of the facilities provided the bureau has been continued. The laboratory has been used throughout the year by Dr. P. S. Galtsoff, naturalist of the *Albatross*, who has conducted here the laboratory work connected with the hydrographic and biological survey of Long Island Sound. Dr. Charles J. Fish and Marie D. P. Fish have also made use of the laboratory facilities in the work they have been doing on the study of the plankton and larval fishes of the Woods Hole region.

On account of the inadequate salary provision, the Beaufort Biological Laboratory has continued without a scientific director, and, with the exception of the diamond-back terrapin experiments, has remained inactive so far as the investigation of fishery problems is concerned. The facilities of the laboratory were used by several investigators during the season, among whom were Dr. L. F. Shackell, of the University of Utah; Dr. H. V. Wilson, of the University of North Carolina; and Dr. Bert Cunningham, of Trinity College, Durham, N. C. The Navy Department also made use of the laboratory in continuing its investigations on the fouling of ships' bottoms, and in October a conference was held there by the naval officers and investigators concerned. This bureau was represented at the conference by J. Paul Visscher, whose work on the fouling of ships' bottoms is referred to elsewhere in this report. The acting director has supervised the necessary repairs to buildings, sea wall, and grounds, and has carried out instructions for the conduct of the terrapin experiments, which have been intrusted largely to his care for several years past.

The work at the Key West biological station for the fiscal year has been, for the most part, of a preliminary nature. Owing to the lack of equipment and a laboratory building, together with an insufficient personnel, little in the way of scientific work could be accomplished. Early in the year Isaac Ginsberg was appointed director of the station. His attention has been given mainly to directing much needed work in improving the grounds and the condition of the buildings, although some time has been found in which to add to the collection of Key West fishes. Observations have been made also on the natural history of the top minnow, Gambusia, in connection with the important work of distributing these fish for the purpose of controlling mosquito breeding. The station is greatly in need of a fully equipped laboratory building in which the investigation of problems relating to the important fisheries of the Gulf of Mexico and the southern Atlantic States may be carried on. At present the only space available for this work is a small room in the power house, which is also used for storing the collections and as an office.

The biological laboratory at Fairport, Iowa, has been operated during the entire year. The work has been devoted in the main to mussel and fish culture and to investigations on the natural history of some of the more important food fishes. This has been discussed in more detail in other parts of this report. The director has participated, in an advisory capacity, in various conferences with State legislative bodies with a view to the enactment of legislation for the protection of mussels. The laboratory has also been called upon frequently to render aid and advice to clubs, individuals, and State fisheries organizations in the handling of fish, in planning, building, and stocking ponds, and in pointing out the needs, care, and possible improvement of the fisheries of certain sections. Members of the staff conducted a statistical survey of the fisheries of the Illinois River for the year 1921, and a report was submitted early in the fall of 1922. The work was done in cooperation with the Illinois State Natural History Survey, the United States Public Health Service, and the Chicago Drainage District. It is the intention of the investigators to try to discover the effects of pollution and of reclamation of submerged lands along the Illinois River upon public health and recreation, agriculture, and the aquatic resources of the river. The study of the relation of the Hemiptera to the pond culture of fishes was continued by Dr. C. B. Wilson.

During the year two of the station's investigators, Dr. A. D. Howard and Barry J. Anson, resigned. The superintendent, H. L. Canfield, was transferred to the Mississippi River rescue station in August, 1922, and his place was filled by H. O. Hesen, jr.

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A NEW MYXOSPORIDIAN PARASITE, THE CAUSE OF "WORMY" HALIBUT.[1]

By H. S. Davis, *Fish Pathologist, U. S. Bureau of Fisheries.*

The extensive halibut fishery of the Pacific coast is subject to a material annual loss owing to the fact that in a considerable percentage of the fish the flesh is abnormal and unsalable. In the great majority of the abnormal fish the flesh is soft and "mushy" and readily falls apart when cut, but in a small percentage it has a very different appearance. Instead of being soft the muscles are hard and firm as in normal fish but contain large numbers of white, wormlike structures, whence the name "wormy" halibut. A comparison of the flesh of "mushy" and "wormy" fish has convinced the writer that they are caused by very different organisms, the "wormy" condition evidently being due to an undescribed myxosporidian parasite for which the name *Unicapsula muscularis* n. gen. et n. sp. is proposed.

The appearance of the flesh in the "wormy" fish is well described by Thompson (1916), as follows: "There is no external evidence of the infection by the parasite which causes 'worminess.' A cut through the trunk muscles parallel to the grain exposes the parasites as silvery threads lying among the muscle fibers. These threads lie with the fibers in a regular way and extend from septum to septum of the myomeres but not through them. The muscles of the head are apparently less liable to infection than those of the trunk, and usually none are to be seen in the head of even a heavily infected specimen. The density of the infection varies somewhat in different individuals."

The writer has had no opportunity to examine halibut on the Pacific coast, but the appearance of the flesh of an infected fish that was sent to Washington in cold storage agreed in every respect with Thompson's description. In this fish the white opaque "worms" were very common and presented a sharp contrast to the smaller translucent fibers that made up the great bulk of the muscles. A closer examination confirmed Thompson's observation that the "worms" are simply hypertrophied muscle fibers filled with a whitish granular mass. This granular material, which is composed of the spores of a myxosporidian, is surrounded by a relatively thin, transparent envelope made up of muscle fibrils embedded in sarcoplasm and surrounded by the sarcolemma. The diameter of the infected fibers in material preserved in formalin was about 0.6 to 0.8

[1] Appendix VIII to the Report of the U. S. Commissioner of Fisheries for 1923. B. F. Doc. 957.

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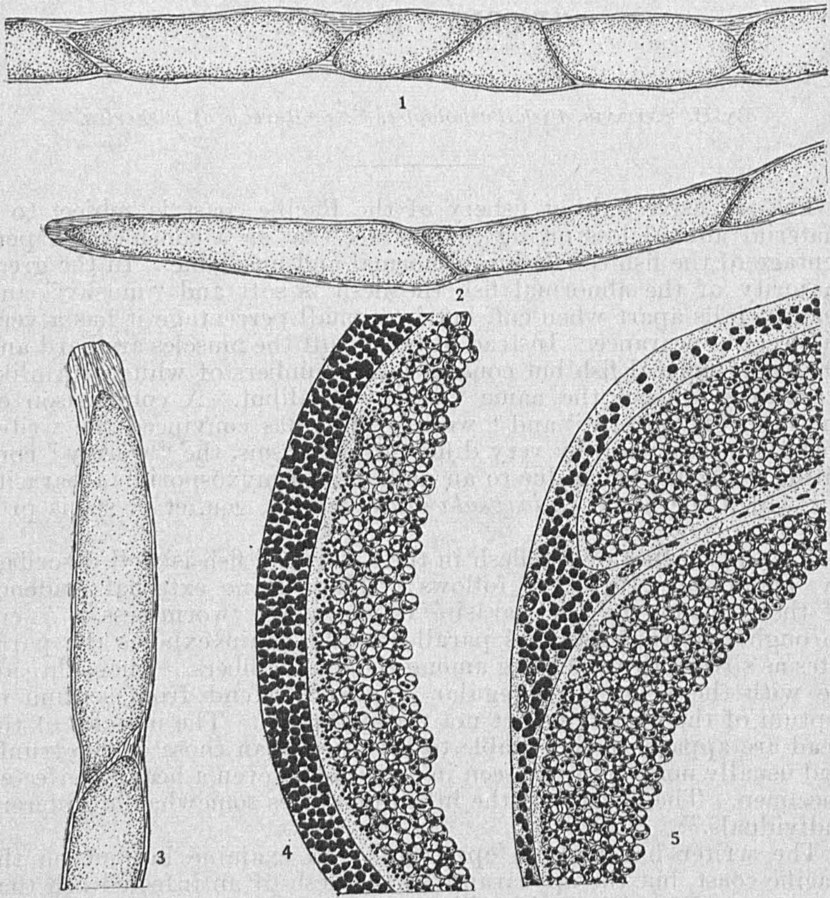
mm., while that of the uninfected fibers was about 0.2 to 0.4 mm. These measurements are somewhat greater than those given by Thompson. Possibly the discrepancy may be due to a difference in the size of the fish, that examined by the writer having a total length of about 5 feet.



FIGS. 1, 2, AND 3.—Portion of muscle fibers showing the arrangement of the parasites within the fibers. ×20.
FIG. 4.—Cross section of a small portion of an infected muscle fiber. The cut ends of the fibrils are shaded black. Within the fibrillar layer can be seen a portion of the trophozoite surrounded by a distinct ectoplasmic layer. ×575.
FIG. 5.—Cross section of a portion of an infected fiber showing the overlapping ends of two trophozoites. This is a somewhat later stage than Figure 4, and the fibrils are beginning to degenerate. ×575.

When examined under the microscope, the infected fibers were seen to contain a number of elongated trophozoites arranged in a single row within the fiber but usually overlapping more or less at the ends (figs. 1 to 3). In every case the parasites extended practically the entire length of the fiber. This condition was also noticed by Thompson, who suspected they were trophozoites of a sporozoan but was unable to definitely determine their nature.

It is a remarkable fact that the trophozoites never extend to the sarcolemma, there being always a thin layer of sarcoplasm and muscle fibrils between the two. This is well shown in Figures 4 to 6, where the peripheral layer of fibrils and sarcoplasm can be distinctly seen. As shown in the figures the trophozoites vary considerably in size, some being several times the length of others. The length of those measured varied from 2 to 6 mm. The size of the mature trophozoite appears to be dependent on the number present in a fiber, since the diameter of the fibers containing fully developed trophozoites is remarkably uniform. There may be as many as six trophozoites, or possibly even more, in a fiber. In all cases observed by the writer they were arranged in a single row extending from one end of the fiber to the other, but in Thompson's figures several trophozoites are shown lying side by side.

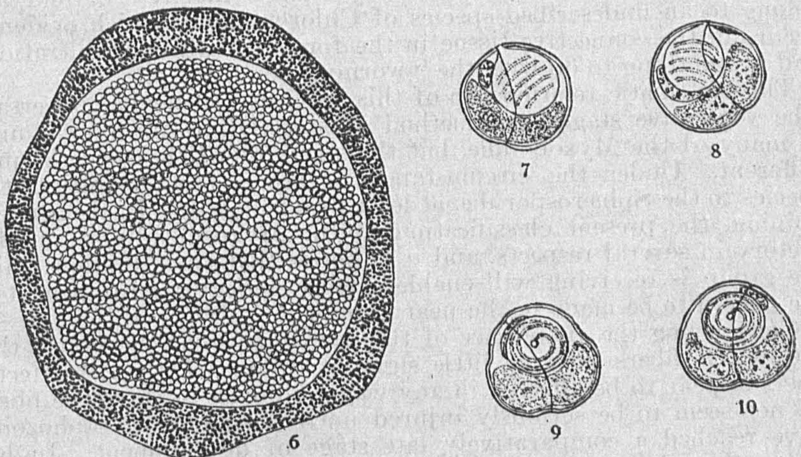


FIG. 6.—Cross section of an infected fiber showing the trophozoite filled with spores and surrounded on all sides by a portion of the muscle fiber. ×190.
FIGS. 7 AND 8.—Spores viewed from the side. ×2,500.
FIGS. 9 AND 10.—Polar views of spores. ×2,500.

Only sporulating trophozoites were found in the fish examined by the writer, the spores forming the whitish, granular mass previously referred to. Surrounding the spores is a thin but distinct layer of ectoplasm (figs. 4 and 5). Just within the ectoplasm can be seen numerous free nuclei and pansporoblasts in different stages of development. Evidently, as in many other myxosporidia that form cysts in the tissues, the development of the spores takes place in a comparatively narrow zone just within the ectoplasm.

The spores (figs. 7 to 10) are subspherical, asymmetrical, and contain but one capsule. The shell is thin and the sutural line indistinct. There is usually a slight indentation along the sutural line on the postcapsular side. The shell valves are very unequal in size, that containing the capsule being much larger than the other, which is evidently degenerate. The capsule is relatively large and appears spherical in shape except when viewed from the side, when a short neck can be distinguished connecting it with the shell (figs. 7 and 8).

The coiled filament is indistinct but can usually be made out by careful focusing. The nucleus of the capsulogenous cell can often be distinguished attached to one side of the capsule. The sporoplasm is finely granular and fills practically all of the spore not occupied by the capsule. Two nuclei are present, and the sporoplasm is often more or less distinctly divided into two parts of approximately the same size, each containing a nucleus. There is no evidence of the presence of an iodophile vacuole. The diameter of the spore is about 6μ, that of the capsule 3μ.

The spore was seen and figured by Thompson (1916). His Figure 8 is evidently that of a mature spore, the large eosinophile body being the capsule. Thompson also found a spore shaped like a "four-pointed star with four polar capsules," which he thought might have some relation to the "wormy" condition of the flesh. These spores are not uncommon in both "wormy" and "mushy" halibut and belong to an undescribed species of Chloromyxum, which evidently occurs in the connective tissue in the form of "diffuse infiltration" and has nothing to do with the "wormy" condition.

The systematic relationship of this species is somewhat uncertain. The vegetative stages and method of sporulation are very similar to many of the Myxobolidæ, but the structure of the spore is quite different. Under the circumstances it seems best to assign this species to the Sphærosporidæ, at least provisionally. In the writer's opinion, the present classification of the Myxosporidia is unsatisfactory in several respects, and it is hoped that the attention which the group is receiving will enable a more logical rearrangement of the genera to be made in the near future.

Considering the abundance of the parasites, it is remarkable that the muscle fibers show so little signs of injury. Only the infected fibers appear to be affected in any way, and even in these the fibrils do not seem to be seriously injured until the inclosed trophozoites have reached a comparatively late stage of development. In late stages there is a noticeable tendency for the fibrils to swell up and undergo a hyaline degeneration (fig. 5), but no fibers have been observed in which the fibrils were entirely destroyed. According to Thélohan (1895) and Keysselitz (1908), a somewhat similar hyaline degeneration is produced by *Myxobolus pfeifferi* in the muscles of the barbel.

Since the spores are formed only within the muscle fibers and apparently remain there indefinitely, it is obvious that they can only be released by the death or injury of the host. From our knowledge of the life cycle of other Myxosporidia we may assume that the spores are taken into the digestive tract of the halibut with the food and germinate in the intestine. The minute amœboid sporoplasm then makes its way into the blood vessels and is carried to the muscles, where it leaves the capillaries and enters the muscle fibers. The large number of infected fibers indicates that, in all probability, there is a multiplicative stage before the young trophozoites enter the fibers. After entering the fibers the trophozoites evidently divide several times, for in no other way can we explain the presence of several trophozoites in each fiber.

It is interesting to note that although a number of Myxosporidia are known to occur in the muscles of various species of fish the great majority is found only in the connective tissues. Only a very few species ever enter the muscle fibers, and even in these forms the principal seat of infection is the connective tissues. The present species appears, therefore, to be unique among the Myxosporidia, since so far as known it develops only within the muscle fibers and never in the surrounding connective tissues. In this respect it resembles the Sarcosporidia and lends additional interest to Darling's theory that these muscle parasites are simply aberrant Cnidosporidia.

For convenience a brief description of the genus Unicapsula nov. gen. is appended:

Spores rounded; asymmetrical, without processes of any kind, only one large rounded capsule present; valve of shell containing capsule much larger than the other; tissue parasites, polysporous.

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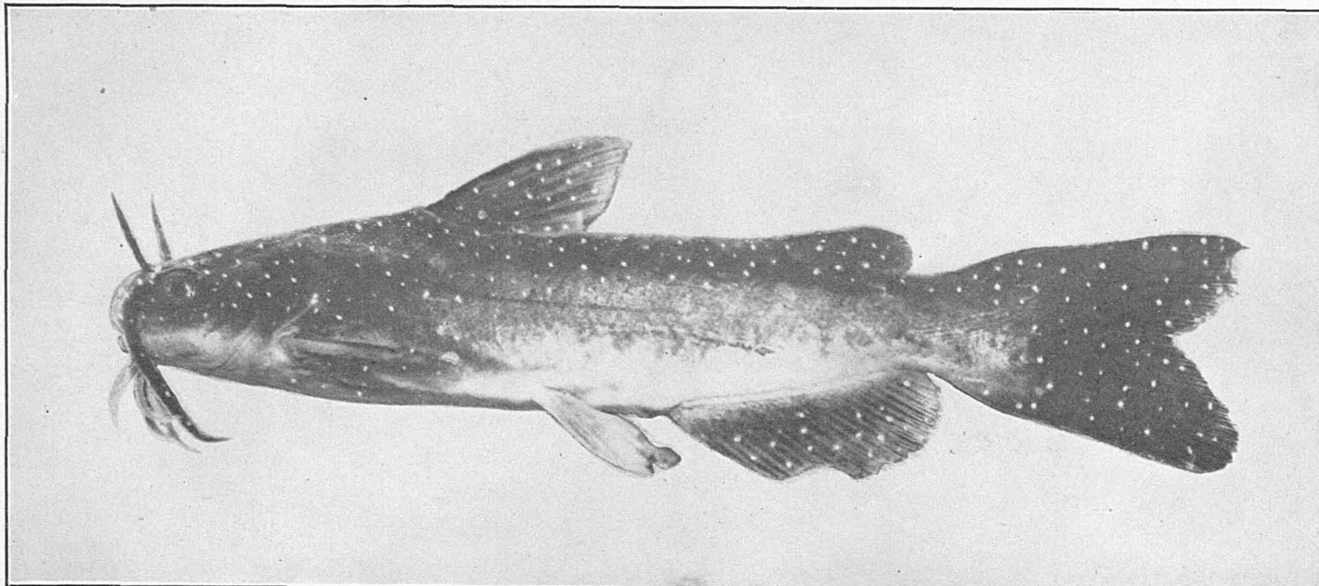

FIG. 1.—Catfish infected with the parasite *Ichthyophtherius multifiliis*

THE ICHTHYOPHTHIRIUS DISEASE OF FISHES AND METHODS OF CONTROL.[1]

By HERBERT F. PRYTHERCH, *Scientific Assistant, U. S. Bureau of Fisheries.*[2]

CONTENTS.

INTRODUCTION.

The unusual occurrence of the parasitic ciliate, *Ichthyophthirius multifiliis* (Fouquet), on fish in the Washington aquarium during the cold winter months led to a series of experiments to determine more efficient methods of combating the disease. Catfish, bass, bream, and sunfish that were brought in from Maryland waters and the Potomac River in the late fall were found, after a week's confinement in the aquaria, to be heavily infected with the parasite. The steadily lowering temperature did not halt the disease, but only served to render its treatment more difficult.

OCCURRENCE OF THE DISEASE.

The parasitic protozoan Ichthyophythirius is found on fish in their natural environment as well as on fish in aquaria and artificial ponds. In nature fish seldom are killed by the disease, as the possibility of heavy infection by the young parasites is greatly reduced by the large expanse of water and the movements of the fish.

Serious epidemics have occurred from time to time in France, Holland, and Germany, and in various sections of the United States. The disease was first recorded in 1869 in the Zoological Garden in Hamburg, Germany, and in France in 1876, where careful observations were made and the name *Ichthyophthirius multifiliis* proposed by Fouquet. In America the parasite is prevalent in small ponds, reservoirs, and aquaria, where it spreads rapidly, causing a heavy mortality of most of our common fresh-water fishes.

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[1] Appendix IX to the Report of the U. S. Commissioner of Fisheries for 1923. B. F. Doc. No. 959.

[2] The author is particularly indebted to Dr. H. S. Davis, fish pathologist of the Bureau of Fisheries, for criticism in reviewing the manuscript and for suggestions during the course of the work.

SYMPTOMS OF THE DISEASE.

The first symptoms of the presence of Ichthyophthirius are the queer actions of the fish and the appearance of small, whitish-gray, sharply defined pimples sticking out over the surface of the body. When the fish are first infected they rub themselves continually against the bottom and sides of the tank in an attempt to brush off the young parasite. In a short time they will be seen to hang listlessly in the water with drooping fins, or gasping at the surface due to the impaired condition of the gills. All parts of the body, head, sides, fins, and especially the mouth and gills, may be heavily infected by these organisms.

As the parasite grows it becomes visible as a raised light-colored spot on the fish, and if these are numerous the adjacent ones may touch each other and unite to form a large spot, giving the skin a mottled appearance. As the disease spreads the raised spots often occur by the hundreds and thousands, covering the entire external surface of the fish. Fish that become heavily infected soon stop eating, and in the last stages of the disease they are covered with a heavy slime and red blotches or "scalded" areas. Fungus soon develops on the raw parts of the fins and body, and the fish live but a short time.

DESCRIPTION OF THE PARASITE.

The adult parasite may be identified by gently scraping off one of the "spots" from the fish and carefully examining it under the microscope. It may be necessary to separate the animal from the tissue surrounding, in which it is generally found in active rotating movement. The adult parasites range in size from one-half to slightly less than 1 millimeter in diameter. The body is round or elongate oval in shape when it is inactive, but will assume almost any form when in motion. Covering the outer surfaces are numerous short threadlike cilia arranged regularly in rows, which serve to propel the animal through the water. The protoplasm of the body contains numerous opaque granules, a large crescent-shaped nucleus, a small oval opening or mouth, and many fine contractile vacuoles. (See fig. 7.) In warm water the animal soon surrounds itself with a semitransparent membrane or cyst and there undergoes many successive divisions, forming thousands of young parasites.

LIFE HISTORY OF THE PARASITE.

In order intelligently to combat the disease, a thorough knowledge of the life history is necessary. The young parasite is a microscopic, free-swimming form, which revolves rapidly through the water in search of a host. Upon coming in contact with a fish it endeavors to burrow into the epidermis, especially in the gills, fins, and unscaled regions. At this time the fish is irritated the most and tries hardest to brush it off. If the young parasite is unable to find a host, it will die within a few days, as it seems incapable of taking food from the water. Fish that have been previously infected are covered with a layer of slime, which offers an unusually favorable medium for attachment for the young parasites. When once embedded in the skin of the fish, the parasite begins to grow rapidly with the nourishment it absorbs from the tissues and is soon a visible white spot on the outside of the fish. The small white body increases in size and in warm water (65 to 75° F.) will leave the fish in two to five days as an adult free-swimming form.

Upon leaving the fish it drops to the bottom, and after swimming around for a short time forms a cyst. Generally the cyst remains on the bottom, though in some cases it may be brought to the surface by suspended matter and air bubbles that collect around it. Within the wall of the cyst multiplication takes place, resulting in the for-

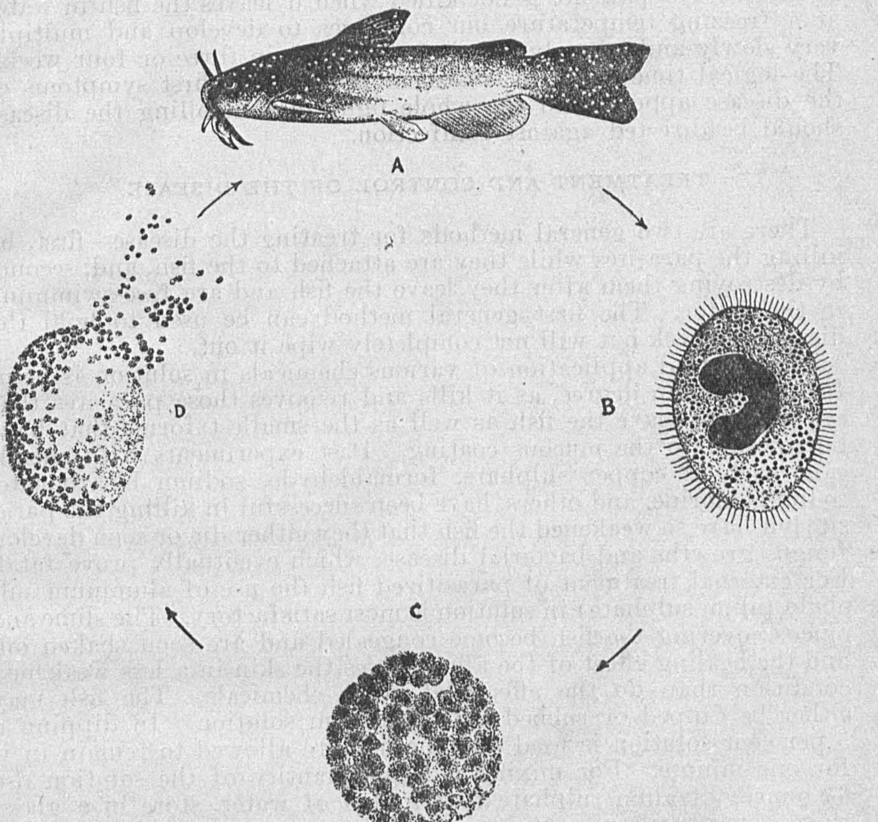

FIG. 2.—Life cycle of the parasite. A, adult parasites on catfish; B, parasite after leaving fish as a free-swimming form and settling to the bottom; C, division of adult into many smaller individuals after formation of a cyst; D, bursting of cyst, releasing hundreds of minute parasites, which in turn reinfect the fish.

mation of large numbers of minute individuals that are invisible to the naked eye and about 30 µ (.03 millimeter) long. When reproduction is completed, the wall of the cyst bursts open (see fig. 5), releasing thousands of young parasites, which immediately go in search of a host.

The parasites that drop from the fish are of various sizes, some being much larger than others. A corresponding variation is noticed in the numbers of young formed within a cyst, which range from approximately 500 to 2,200 minute individuals. This is the usual method of reproduction, though the parasite may undergo one or two stages of division while embedded on the host or as a free-swimming form after leaving the fish. The rapidity with which the parasite goes through its life cycle depends on the temperature of the water, the kind of fish infected, the region in which it becomes embedded, and the metabolic activity of its host.

Under general conditions the parasite will remain on the fish for five or six days in warm water of 65° F. or higher, and, on the other hand, in water of 35 to 40° F. it may not leave the fish for a month or more. The parasite is not killed when it leaves the fish in water at a freezing temperature but continues to develop and multiply very slowly and is ready to reinfect the fish in three or four weeks. The logical time to begin treatment is when the first symptoms of the disease appear, and the whole fight in controlling the disease should be directed against reinfection.

TREATMENT AND CONTROL OF THE DISEASE.

There are two general methods for treating the disease—first, by killing the parasites while they are attached to the fish, and, second, by destroying them after they leave the fish and are free-swimming in the water. The first general method can be used to hold the disease in check but will not completely wipe it out.

The external application of various chemicals in solution is helpful to a certain degree, as it kills and removes those parasites that are about to leave the fish as well as the smallest forms that have burrowed into the mucous coating. Past experiments with chemicals, such as copper sulphate, formaldehyde, sodium bicarbonate, sodium chloride, and others, have been successful in killing the parasite but have so weakened the fish that they either die or soon develop fungus growths and bacterial disease, which eventually prove fatal. For external treatment of parasitized fish the use of aluminum sulphate (alum sulphate) in solution is most satisfactory. The slime and mucus covering the fish become congealed and are soon shaken off, and the healing effect of the alum leaves the skin in a less weakened condition than do the effects of other chemicals. The fish may either be dipped or rubbed with the alum solution. In dipping a 5 per cent solution is used and the fish are allowed to remain in it for one minute. For mixing a large quantity of the solution use 6½ ounces of alum sulphate to 1 gallon of water, store in a glass, wood, or porcelain container and change every five days. For rubbing or brushing the fish a 3 per cent solution is used, or 4 ounces of alum sulphate to 1 gallon of water. The fish are laid in a shallow pan with about half an inch of the solution in the bottom of it, and the affected parts are gently rubbed with saturated cheesecloth or a brush. These chemical applications have been used successfully on carp, catfish, bass, sunfish, goldfish, Fundulus, bream, and trout, but were only helpful as a means of holding the disease in check by killing those parasites that were about to leave the fish. Alum sulphate has also given excellent results in the treatment of Saprolegnia when applied in a 3 per cent solution to the diseased parts of the fish.

The second general method for combating the parasite is the most practical and should be put into effect in every possible case. It

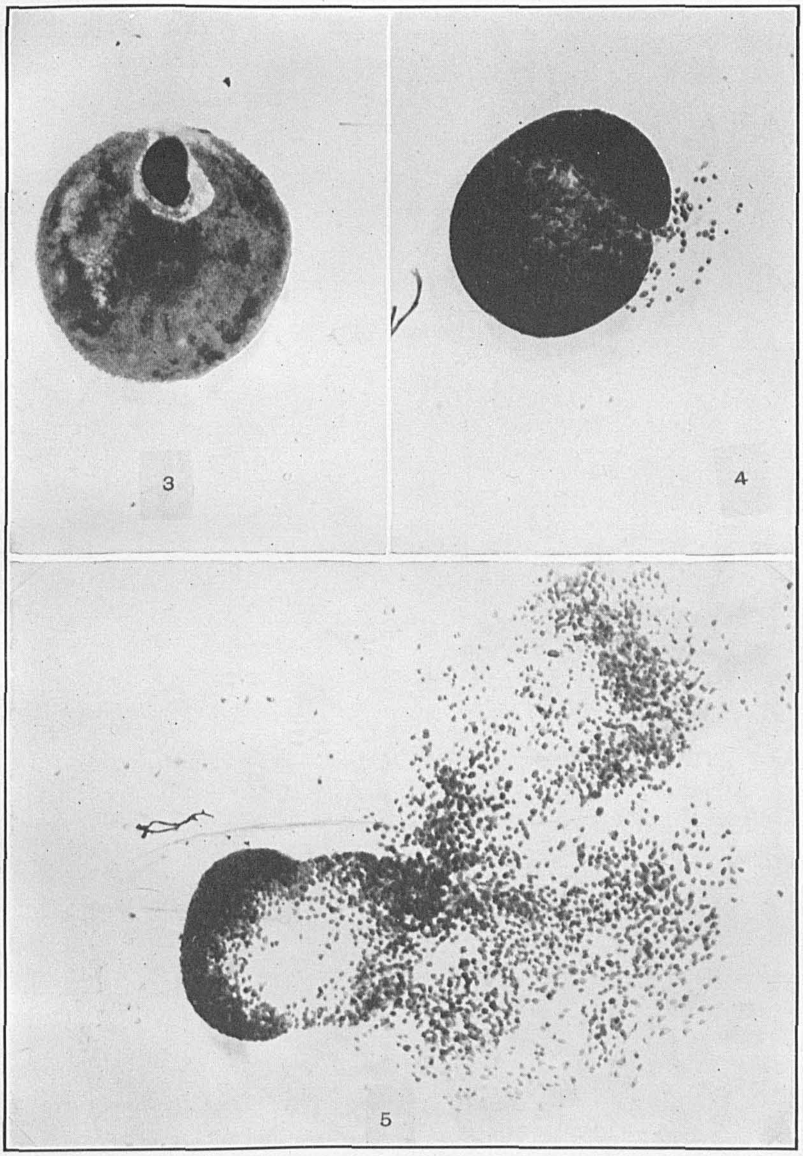

FIG. 3.—Adult parasite as it appears by transmitted light. Highly magnified.
FIG. 4.—*Cyst filled with minute young parasites about to burst open. Highly magnified.*
FIG. 5.—Bursting of cyst and escape of large numbers of young parasites. Highly magnified.

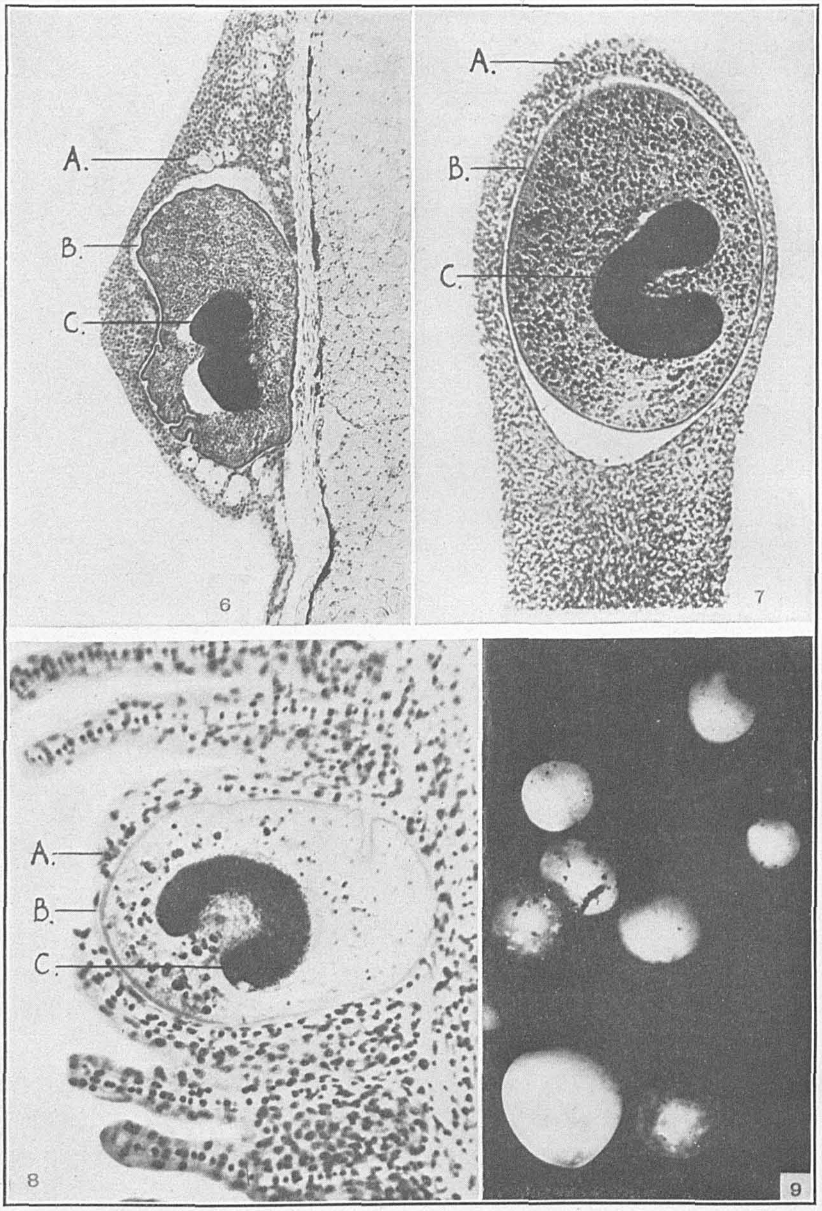

FIG. 6.—Cross section of skin and external muscles of small catfish, showing the parasite lying beneath the epithelium. A, epithelial layer; B, outer cell wall of parasite; C, nucleus of parasite. Highly magnified.
FIG. 7.—Portion of the gill of a buffalofish, showing large parasite within the epithelium. Symbols the same as in fig. 6. Highly magnified.
FIG. 8.—Section through a portion of the gill filament, showing embedded parasite. Symbols same as in fig. 6. Highly magnified.
FIG. 9.—Several parasites after removal from a fish, viewed by reflected light. Magnified 30 diameters.
(Material for photographs in figs. 6, 7, and 8 was furnished by Dr. H. S. Davis.)

consists in removing or destroying the large adult parasites after they have dropped off the fish. This may be accomplished by placing the fish in swiftly running water, which carries away the parasites before they have time to multiply and reinfect the fish. Long troughs or cylindrical tanks can be easily equipped for this purpose. The inside of the receptacle used should be coated with asphalt paint, so that the surface will be smooth and not likely to prevent the parasites from being washed away. The intake must be constructed in such a way as to maintain a steady flow of water throughout the length of the trough. At the overflow the water must be drained off from the bottom as well as the top in order to insure removal of the parasites whether they sink or are carried to the surface of the water. In the case of cylindrical tanks (see fig. 10) the rotation of the water causes the parasites to settle at the center of the tank, where they are immediately carried away. The treat-

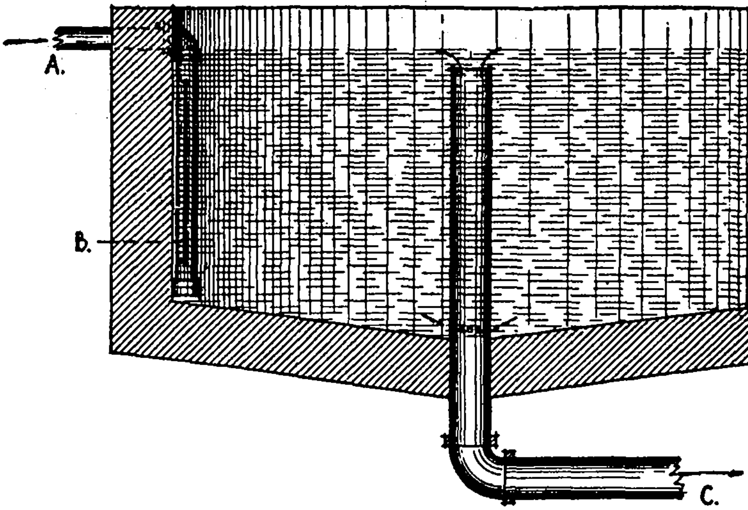

FIG. 10.—Apparatus for the removal of parasites by a continuous flow of water. A, intake; B, water-spreader for inducing rotary circulation; C, drain from surface and bottom outlets.

ment may be made even more positive by scrubbing the trough or tank every day with a strong salt solution after removing the fish. In warm weather infected fish may be cured by this method in 7 to 10 days, and further epidemics can be prevented by quarantining newly brought in stock in this way. Successful treatment in any case depends upon combating the disease when the first symptoms are noticed and continuing it until all the parasites have had a chance to drop from the fish.

In some instances swiftly flowing brooks or small streams might be utilized by fencing off a suitable section and placing the fish in it until cured. Fish in aquaria can be cured of the parasite, first, by removing all sand and dirt so as to have the bottom of the tank clean; second, by using about five large tadpoles to each square foot of bottom surface; third, by siphoning off each day all waste material that settles at the bottom; and, fourth, by adding a level tablespoon of salt to each gallon of water about every other day. Goldfish and tadpoles will eat the parasites and by so doing prevent a rapid spread of the disease.

Nets and siphons used around infected fish should be sterilized each time they are used in a strong brine solution lest the parasites be transferred to other tanks.

ECONOMIC IMPORTANCE.

The parasite Ichthyophthirius has proven fatal to catfish, sunfish, smallmouth black bass, goldfish, buffalofish, trout, bowfin, carp, tench, bream, crappie, white bass, pike perch, pickerel, pike, and whitefish, as well as to many tropical aquarium fishes. Other fresh-water species, such as perch, largemouth black bass, roach, sturgeon, gar pike, and eels seldom are killed by the disease or affected to any noticeable degree.

At fish farms, aquariums, and hatcheries the disease has often caused a considerable loss of valuable brood stock and fry, the damage in many instances amounting to hundreds of dollars. Fishes that are imprisoned in pools and ponds by the receding of flood waters become infected with this disease and others under the crowded conditions and warm temperatures. The practice of rescuing these fish and transferring them to other ponds and aquaria is likely to result in serious epidemics unless the fish are quarantined and kept under observation for a short time.

OYSTER-CULTURAL PROBLEMS OF CONNECTICUT.

By J. S. Gutsell, *Scientific Assistant, U. S. Bureau of Fisheries.*

That the situation in the northern oyster fields is a serious one has been evident for a number of years. In the Long Island Sound region, upon the seed production of which so much of the northern oyster industry has depended, where cultural methods had early and great development, and where oyster growing long ago became one of the big, highly organized industries, the "sets" or annual crops of young oysters have become light and irregular and production has greatly fallen off. Even the most successful growers have had to curtail their forces and equipment and reorganize on a reduced scale. If loss in volume had not in some measure been counteracted by an increase in price, many, if not all, of the concerns would have been put out of business.

From the early days of the industry up to the end of the last century, "sets" in the oyster areas along the north shore of the Sound were generally heavy and almost unfailing. At first the seed oysters obtained from these "sets" were used for planting various inshore growing or conditioning areas, particularly bays, harbors, etc., in the region. Later such plantings were extended more and more into the Sound, and finally into the deep-water, offshore areas, the use of which has made this region famous. As its reputation for vitality and growing qualities became established, Connecticut "seed" came into great demand wherever in the north there existed areas adapted to growing or conditioning oysters but where the locally produced supply was insufficient or unsatisfactory. Thus a special stimulus was given to the production of seed.

Gradually another set of factors helped to strengthen this situation and increase such demand. In the early days of almost pristine purity of the waters, the oysters of Connecticut bore an excellent reputation for edibility and were readily and profitably marketable. The principal supply and all the more highly prized varieties came from harbors, small stream-fed bays, and the lower reaches of rivers. As industrial and sewage pollution increased in these estuaries, however, the quality of the oysters deteriorated. Growing became more and more difficult. In time production was almost limited to the Sound. The Sound oysters, never having had the reputation possessed by the harbor and river oysters, suffered less in quality than the latter but failed fully to take their place in the markets. This situation, combined with the reputation of the Sound oysters as seed, helped to make the oyster industry of Connecticut more and more one of "seed" production.

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[1] Appendix X to the Report of the U. S. Commissioner of Fisheries for 1923. B. F. Doc. No. 960.

An examination of the following table will show that after 1900 "sets" in this region became generally light or scattering until 1911, when an excellent "set" was obtained, and that thereafter there was only one important "set"—that of 1914. Such was the situation in the Connecticut oyster-growing region when the bureau's investigations were begun in the spring of 1917. This state of affairs, which has continued up to the present time with slight modifications, was, of course, particularly menacing to an industry so largely one of seed production. What was the explanation of this lack of set, and what could be done to restore it? Intelligently to answer either of these questions, even in part, there is required an understanding of the development or life history of the oyster, particularly the early life history, and a due appreciation of the factors, local and general, that affect its development and distribution.

Table showing the extent of oyster sets in Connecticut waters from 1885 to 1923, inclusive.[1]

Year.	Set.	Year.	Set.	Year.	Set.
1885	Good.	1898	None.[2]	1911	Good.
1886	Unknown.	1899	Excellent.	1912	None.
1887	Excellent.	1900	Fair.	1913	Do.
1888	Light.	1901	Light.	1914	Fair.
1889	Do.	1902	Poor.	1915	None.
1890	Excellent.	1903	Very poor.	1916	Do.
1891	Very good.	1904	Excellent.	1917	Do.
1892	Do.	1905	Scattering.	1918	Fair.
1893	Fair.	1906	Very poor.	1919	None.
1894	Very good.	1907	Do.	1920	Poor.
1895	Do.	1908	Scattering.	1921	Do.
1896	Good.	1909	Poor.	1922	Light.
1897	Uneven.	1910	Do.	1923	Poor.

[1] Compiled chiefly from reports of various oyster houses, and since 1917 from personal observations.
[2] It is reported that there was a good set in this year, but that it was destroyed by storms.

In its final stage the oyster is a sessile bivalve, fixed to one spot and taking from the water only such minute food as comes within the reach of the current produced by means of the wave action of its infinitely numerous cilia. In the younger stages its life is quite different.

As Brooks[2] discovered many years ago, the sexes of the oysters of the Atlantic coast of the United States (*Ostrea elongata* Solander) are contained in different individuals—not combined in one, as is the case with the European oyster, *Ostrea edulis*. The female oyster produces many millions of minute eggs or female reproductive cells; the male, countless millions of still more minute actively swimming sperms. With the warming of the water in the spring the oyster feeds more and more actively, and the development of the sexual products takes place. Finally, when these are matured, eggs and sperms are cast into the water under the influence of an increase in water temperature. If eggs and sperms are cast at the same time from oysters near one another, the sperms find the eggs and development of the oyster begins. If neighboring oysters do not spawn at the same time, union of male and female cells fails to occur and whatever spawn is cast is wasted.

[2] Brooks, W. K., "Development of the American oyster." Report of the Commissioners of Fisheries of Maryland, January, 1880 (for 1879), pp. 85–87. Annapolis.

From the fertilized egg the oyster develops rapidly into a swimming embryo containing its own nourishing material, and from that, within a day or so, depending upon the temperature, it develops into another, more vigorously swimming stage—the microscopic, actively feeding larva with a double or two-valve shell somewhat like that of a clam. This stage continues much longer than the previous one.

Although the larva's habit of occasionally settling to the bottom tends, to a limited degree, to check the influence of the tide, during these early stages the oyster is practically at its mercy. Aside from this settling habit only the back-and-forth or reciprocal action of the tide and whatever collecting or stationary effect it may produce by means of eddies prevent the larvæ from being carried hopelessly about and broadcasted, as it were, in the most wasteful and destructive manner. Finally, a very small proportion of the oysters complete the larval stage, "set" by attachment to firm, hard objects such as oyster shells, and attain the spat or first sessile stage.

Experience and the science known as ecology teach us that for any proper understanding of the life of any organism—plant or animal—we must study it in relation to its environment—organic and inorganic, dynamic and passive. The environment of the oyster, obviously, is an aquatic one, but not all aquatic environments are suitable for it. Fresh-water areas are, of course, ruled out, and so are those of full ocean saltness. Between these two extremes are the moderately salty or brackish areas. It is in such areas, which embrace so many sounds, bays, harbors, and estuaries of all sorts, that the oyster finds its proper environment; but here, again, qualifications must be made. Food organisms must be sufficiently plentiful, enemies not too abundant, the bottom neither too soft nor too shifting, the chemical content of the water such that no serious poisonous effect will be produced, and the water temperatures those to which the oyster may easily adapt itself.

That both salinity and temperature are important factors in Long Island Sound oyster cultivation is apparent from consideration of the situation. The Sound is almost the northern range limit of the oyster along the Atlantic coast of the United States. Being a very large body of water with a tremendous tidal flow from the ocean, its salinity is reduced comparatively little by the generally small if rather numerous rivers that flow into it. It therefore approaches the range limit both as to salinity and temperature. Although the salinity of the Sound is rather high for the development of oysters of the very best "meat," it by no means shows an unfavorable effect on reproduction. Summer temperatures, however, have a very important bearing in this regard.

It has long been known that water temperature is an important factor in oyster spawning, a fact which the work of the bureau's investigators has served to emphasize. This does not mean that any hard and fast rule can be laid down for the relationship between water temperature and spawning, nor does it follow that temperature is the only influence involved, but it is an observed fact that oyster spawning can be held back by low temperature and induced or "forced" by an increase in water temperature. Under natural conditions the really vigorous and extensive spawnings almost, if not quite always, are coincident with a marked rise in temperature.

Although, as before stated, no exact rule as to the effect of temperature on the spawning of oysters can be formulated, something of the relationship between the two can be given. At temperatures below 70° such spawning as occurs is almost invariably of the slow, little at a time, or dribbling sort, but under certain circumstances ripe oysters, previously deterred from spawning by low water temperatures, will spawn vigorously when a rise comes, even if this rise stops somewhat short of attaining 70°. In general, however, spawning at temperatures appreciably below 70° is of the dribbling sort, which does not produce heavy sets. If temperatures approaching 70° have been maintained sufficiently long to insure seasonal sexual maturity, but not long enough to allow the dribbling of most of the spawn, an increase to 70°, if maintained for a day or two, will produce active concerted spawning. Under similar circumstances an increase in temperature markedly above 70° will cause extremely vigorous and almost universal spawning. In northern waters abundant larvæ and "heavy" sets are produced only by these vigorous concerted spawnings.

The accompanying maps (figs. 1 and 2) make clear the historic fact that the great natural oyster areas of Connecticut were harbors, lower reaches of rivers emptying into the Sound, and sections in the Sound just off the mouths of these estuaries and so situated as to be affected by the flow from them. These were the great self-maintaining areas and the natural producers of seed oysters. As they became depleted and were turned over in greater or less measure to private enterprise they, with some extensions in the Sound, became the great private seed-producing grounds.

The principal reason for this condition is to be found in the early and high warming of the water in the estuaries. This warming produced concerted and vigorous spawning, which in turn produced vast numbers of embryos and then larvæ. Coming at an early date it gave excellent opportunity for the larvæ to develop and set and for the set to make a good growth and pass through the more delicate early stages before the September storms set in. These sets were not confined to the estuaries themselves but extended naturally some distance into the Sound. By planting shells for the larvæ to set on, oyster-culturists increased these Sound setting areas.

Under private culture, as long as conditions in the harbors and rivers made oyster growing or conditioning profitable, fairly large beds were maintained. As conditions became worse, fewer and fewer oysters were planted on the private harbor or river grounds, and those grounds that were still public became depleted. With the general passing of harbor and river production came the general failure of "sets." With the failure of "sets" came such an extended depletion of Sound areas that the chance of good "sets" from the spawning of Sound oysters was reduced. Obviously, if the Connecticut oyster industry is to be kept going, either effective estuarial spawning beds must be maintained or oyster planting in the Sound must be of such a type that reasonably good sets may occur at reasonably frequent intervals.[3]

[3] This consideration of the question takes no notice of the possible success of "artificial" set production, but even if this were developed, it is questionable how much it would benefit Connecticut with its best oyster areas so largely destroyed.

In general,[4] conditions became so bad that the planting of oysters in harbors and rivers was no longer profitable except as to such set as might be produced; so bad, in fact, that it was difficult even to maintain oyster beds in these places, and the chance of set production was very poor. Indeed, water collected in 1918 at various

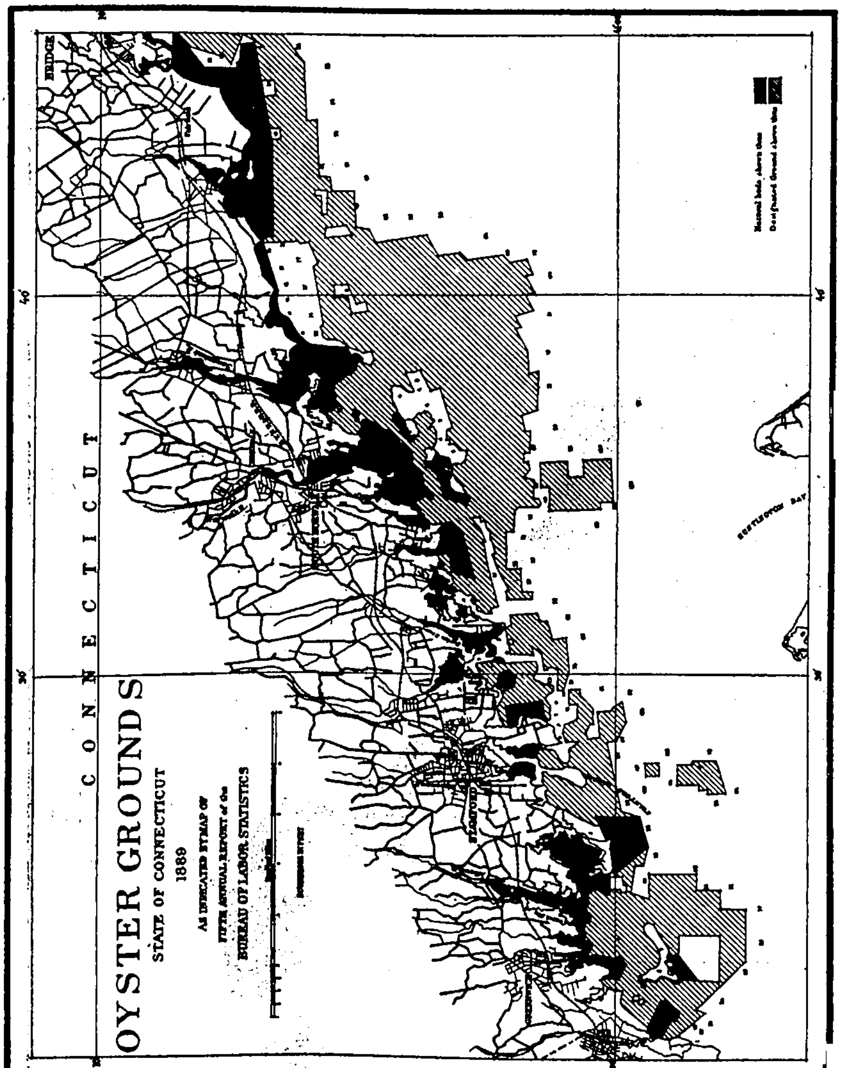

Fig. 1.

locations in one of the more highly industralized harbors was found by Dr. E. P. Churchill, formerly in charge of the bureau's oyster investigations, to be quickly fatal to oyster larvæ even when diluted one-half with unpolluted water. This means that to get any ap-

[4] New Haven is the principal exception, but even there much trouble is experienced.

preciable relief either conditions in the estuaries would have to be greatly improved or attention turned to the Sound.[5]

Improvement in harbors and estuaries is very greatly to be desired, and their restoration to conditions really favorable to oyster culture would be a wonderful boon to the oyster industry. Not

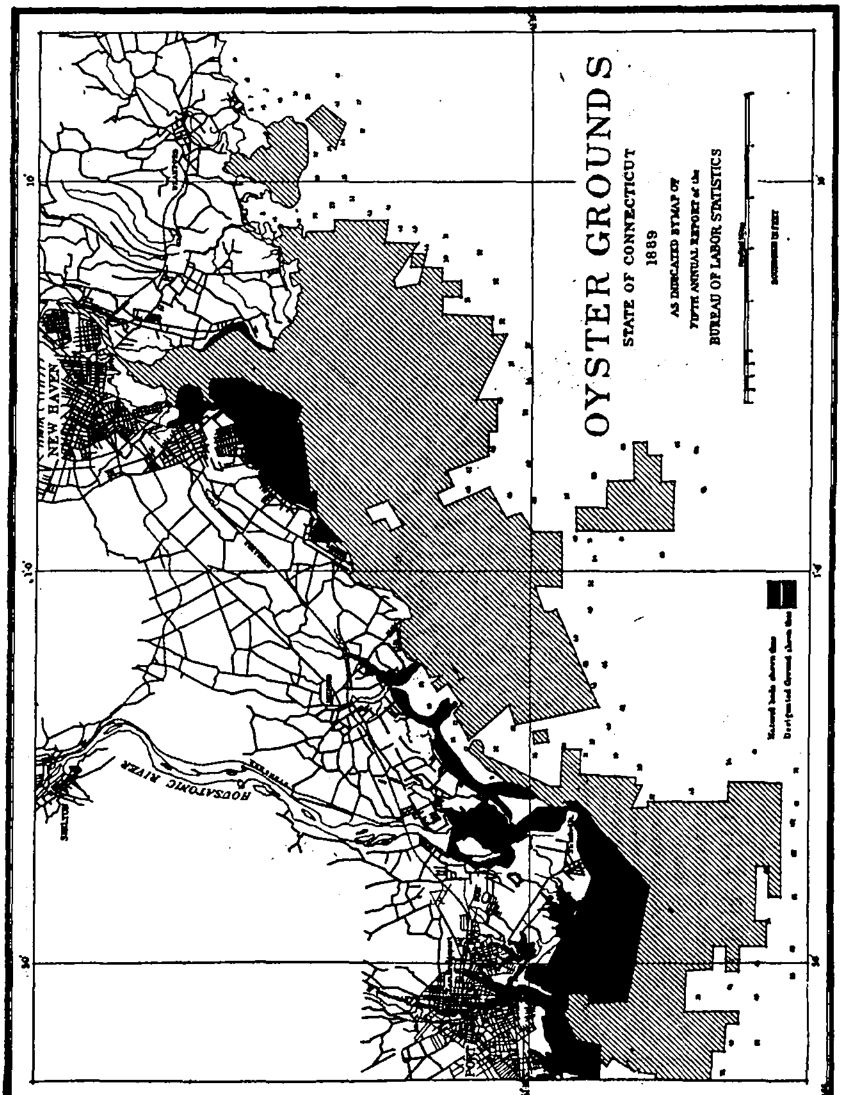

FIG. 2.

only would seed production be improved, but the finest of the growing and conditioning areas would be returned to productivity, the oyster business of the State increased, and the country's total of high-class market oysters augmented to a marked degree.

[5] See footnote 3 on p. 4.

The chief factor to be corrected in order to bring this about is trade-waste pollution. Domestic sewage pollution is, of course, undesirable, and when sufficiently great it makes necessary the transfer of oysters to pure water for cleansing. Where such pollution is excessive, it may produce such a degree of depletion of dissolved oxygen as to be harmful or even deadly to oysters or other aquatic forms. If rapid sedimentation from contact of the sewage with salt water ("salting out") occurs over an oyster bed, much damage may be wrought. Moreover, in these days of the automobile, even if trade wastes in the sense of discarded by-products of manufacture be kept from the municipal sewers, many poisonous petroleum products are inevitably present in untreated sewage. Therefore, from the standpoint of oyster production as well as from that of health, municipal sewage discharge into oyster waters should be prevented or properly controlled. However, as before stated, the principal factor to be corrected in this highly industrialized region is trade-waste pollution. Many of these trade wastes are actively poisonous to oysters or other edible forms, or to the organisms on which they feed. The prevention of the discharge of harmful trade wastes is the great problem to be solved in the restoration of the most valuable of Connecticut's oyster waters.

In order to shed light on some of the specific improvements needed, the bureau's investigators tested the effect of various important industrial pollutants[6] on oyster larvæ and spat. Doctor Churchill, in 1920, used various solutions of metallic salts, which, in strengths of 10 parts of copper, 20 parts of zinc, and 45 parts of lead per million parts of water, were quickly fatal to small oyster larvæ. He also found various dyes to be highly poisonous. More recently the author conducted experiments with salts of these heavy metals and with a few other substances to test their effect on embryos, larvæ, and spat. The results of these experiments were tested by means of "controls," in which embryos, larvæ, or spat were kept under the same conditions except that pure water, lacking the chemicals, was used. Where experiments were prolonged the water was changed from the same source, both for the controls and for the poisoning experiments, with a renewal of the chemicals for the latter. Except where otherwise indicated there was approximately 100 per cent survival in the controls. This consistent high survival shows that the loss in the poisoning experiments was due to the addition of the chemicals.

Although spat, because of their ability to remain tightly closed for hours and probably days at a time, are difficult to poison quickly, yet they are satisfactory subjects for most tests because of the ease with which they may be kept alive. In the tests of the effect of metallic salts upon spat, the copper salts have consistently proved most deadly. A copper-salt solution containing 1 part of metal per million was fatal in 5 days to 70 per cent of the spat exposed to it. A solution of slightly less than 2 parts per million was fatal in four days to all spat exposed to it. Solutions of zinc and lead salts of 10 parts of the metal per million exhibited no greater toxicity than did solutions of 1 and 2 parts of the copper per million. With

[6] Determined by the investigations of J. W. Sale, now chemist in charge, Water and Beverage Laboratory, Bureau of Chemistry, U. S. Department of Agriculture.

sulphuric acid in a 0.01 per cent solution, 18 per cent mortality occurred in 5 days. Logwood in a 0.1 gram per liter solution exhibited only a moderate fatality—25 per cent in 12 days—but was evidently more harmful than the rate of fatality indicated, for it proved so obnoxious to the spat that they remained closed a large portion of the time. Such an effect would be very harmful to oysters in any stage, and probably would be fatal to the larvæ.

Larvæ succumb to poisoning more readily than do spat, but they are much more difficult to manipulate and observe. With large larvæ, copper-salt solutions in strengths varying from 10 to 0.5 parts of copper per million, and zinc or lead salts in solutions of 10 parts of the metal per million proved fatal in less than a day. In the controls the greater portion of the larvæ lived into the second day and frequently many of them survived for several days longer.

Embryos were used in only one poisoning experiment with a copper-salt solution of 10 parts of the metal per million. In this the embryos suffered no apparent ill effects for a little over an hour. The next morning, however, all were dead and disintegrating. No marked mortality was observable at this time in the control, in which considerable numbers of the embryos lived until night.

These experiments make it clear that copper, even in very small amounts, is a serious menace to the oyster industry, and especially to that vital part of it—seed production. If anything is to be done to bring the estuaries back to their former high productivity the prevention of the discharge of copper-containing wastes should be the first step taken. Zinc, lead, strong acids, and logwood, among the substances tested, should also be guarded against. J. W. Sale, water and beverage laboratory, United States Department of Agriculture, while investigating for the bureau, found all of these substances in, or being discharged into, the waters of industrialized rivers and harbors opening into the Sound. The metals, in particular, have not only been found in the effluents from industrial plants, but have also been revealed by analyses of water samples taken from the rivers and harbors of the region. Copper, indeed, has been found in solutions of just under 0.5 parts per million where oysters formerly abounded. It is altogether probable that at some stage of the tide this strength may, on occasion, be equaled or even slightly exceeded.

Although something can be and has been accomplished by planting oysters in harbors and rivers solely for spawning purposes, yet unless the pollution of these waters can be prevented the source of any really extensive set must be sought in the Sound, where far the greater portion of the oysters is located.

In the Sound, oyster lots are roughly graded into two classes—inshore and offshore. Offshore lots frequently possess advantages over inshore lots as holding grounds, as otherwise, with the increased depth and other drawbacks, they would not be kept stocked with oysters when inshore lots are available. However, from the fundamental standpoint of seed production—that is, as a location for oysters to produce the great and early abundance of larvæ needed for "heavy" and sufficiently early sets—they are almost hopeless.

The bureau's investigations have shown[7] that the time elapsing between fertilization of the egg and setting is approximately two weeks. Another two weeks is required to bring the spat to about one-fourth of an inch in diameter. Spat should have attained this size early in September to be commercially valuable, able to withstand shifting from starfish or drill-infested grounds, or capable of withstanding the September storms. If September 7 (about the latest reasonable date) is allowed for the attainment of this size, then setting should occur by August 24 and spawning by August 10. This eliminates deep-water offshore lots, over which the bottom water warms slowly, to no very high degree, and for a brief season only, for on these active oyster spawning at such an early date is almost unknown.

With the inshore lots the story is a different one. On these, even in the colder summers, spawning begins in earnest only a little too late to be effective. In the warmer, more favorable summers it begins two weeks or more before the limit chosen. Spawning on these lots has, therefore, in so far as time is concerned, an excellent chance to be effective. For it really to be effective, however, large plantings of oysters should be maintained on inshore lots—that is, lots within three-quarters of a mile or even a mile of shore. Although the danger from storms prevents the use of quite a portion of the inshore lots, especially those nearest shore and therefore most desirable for the location of oysters for spawning, many of them are available. To keep these well stocked, all planters should cooperate so that one planter may not feel that he is supplying the set for somebody else instead of for himself. With such action properly and continuously carried out, there is, from the data available, substantial evidence that improved sets would result.

CONCLUSIONS.

The chief conclusions as to improvement in oyster production in Connecticut are as follows:

1. For the restoration of the Connecticut oyster industry, in both quantity and quality, to its former productivity, it will be necessary greatly to improve water conditions, especially in the almost barren harbors and rivers from which formerly came the more highly prized oysters and in which were produced the vast numbers of oyster larvæ so largely responsible for the "heavy sets" of the past. To accomplish this, municipal sewage discharge should be controlled, and the discharge of harmful trade wastes, especially those from copper and brass works, should be prevented.

2. Until a change of conditions in estuaries makes oyster growing in them generally and extensively profitable, any great improvement by methods available at present must be produced by increased "sets" derived from the spawning of Sound oysters. Oysters on offshore Sound lots spawn too late to be effective. On the other hand,

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[7] Annual manuscript reports of Doctor Churchill and the author. Also the work of Drs. Julius and T. C. Nelson (see report of the department of biology of the New Jersey Agricultural College Experiment Station, New Brunswick, N. J., for 1922, p. 330), and experiments by H. F. Prytherch, of the Bureau of Fisheries.

oysters on inshore lots (those within three-quarters of a mile or even a mile of shore) quite frequently spawn early enough to produce usable and hardy set. Therefore special and concerted action should be taken by the growers to keep such of the inshore grounds as are at all satisfactory well stocked with oysters. The evidence strongly indicates that by this means an improvement—small in comparison to that which would result from a thorough reestablishment of harbor and river growing, but still a considerable and much needed one—could be brought about.

EXPERIMENTS IN THE ARTIFICIAL PROPAGATION OF OYSTERS.[1]

By HERBERT F. PRYTHERCH, *Scientific Assistant, U. S. Bureau of Fisheries.*

CONTENTS.

INTRODUCTION.

The great oyster fisheries of the Atlantic coast have in the past few years experienced an alarming decline in productiveness. Though the extensive methods of oyster culture practiced by many of the oyster growers have assisted greatly in maintaining a constant supply, they have not been sufficiently reliable to guarantee a crop from year to year. The rapid decline of this valuable industry has been brought about by a constant depletion of the oyster beds from various factors, such as pollution, overfishing, unfavorable climatic and hydrographic conditions, natural enemies, and use of shells for various commercial purposes.

Careful scientific studies of the life history and environment of the oyster have assisted greatly in improving the cultural methods now in use but have not perfected them to such an extent that an annual harvest can be relied upon from year to year. Briefly stated,

[1] Appendix XI to the Report of the U. S. Commissioner of Fisheries for 1923. B. F. Doc. 961.

oyster culture in the United States consists of (1) acquiring suitable submerged bottom, (2) cleaning and preparing that bottom for the growth of oysters, (3) sowing thereon shells or other material (cultch) for the attachment and growth of the young oysters, (4) insuring the production of larval oysters by the proximity of natural or planted beds of adult oysters, (5) protecting the oyster beds from enemies, (6) transplanting as occasion requires to prevent over-crowding and to facilitate growth and fattening, and (7) culling and sorting for market.[2]

To conduct oyster cultivation along such lines a considerable investment of capital is necessary, and the yearly program involves a heavy expense in preparing to catch a "set" of the young oysters. In the event of a failure to obtain a good "set," which unfortunately has been the common occurrence of late years, the expenditure that has been made is a total loss, and is further increased if the cultch is taken up and dried out for use the following year.

Consequently the aim of oyster growers and biologists interested in this work is to place oyster culture on such a basis that a harvest may be expected each year from the capital expended in planting and cultivating the beds.

In view of existing conditions, experiments were undertaken at Milford, Conn., during the summer of 1923 to perfect a method of artificial propagation by which oysters could be raised from the egg in sufficiently large numbers to make the process one of practical value, and to determine under controlled laboratory conditions the most important factors necessary and favorable for growth.

The author wishes to acknowledge his appreciation of the valuable and cordial cooperation rendered by the Connecticut Oyster Farms Co. in carrying on these investigations, and especially the help and suggestions given by Capt. Charles E. Wheeler of that company relative to various studies of the oyster situation and for generously supplying oysters, laboratory facilities, men, and boats for this work.

LIFE HISTORY OF THE OYSTER.

The common oyster (*Ostrea elongata* Solander) of the Atlantic and Gulf coasts of the United States is bisexual; that is to say, each individual possesses only one kind of reproductive organs, either male or female, which do not change during the life of the individual.

During the summer millions of eggs are discharged by the female oyster, which, after fertilization by the elements from the male, develop after a day or two into free-swimming larvae. These float and swim about with the tides and currents for a period of two or three weeks, depending upon the existing conditions, such as temperature, density, food, and tides. At the end of this free-swimming period they attach themselves, if possible, to such suitable objects as shells, rocks, brush, etc., which offer a clean hard surface to which they may adhere (see figs. 7, 8, and 9). Though ten to sixty million eggs are produced by a single full-grown oyster, only a few survive and grow to a size suitable for market. After the young oyster has attached itself, or "set," it is incapable of changing its position,

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[2] "Oysters: The world's most valuable water crop." By Hugh M. Smith. National Geographic Magazine for March, 1923. Washington.

and if successful in surviving its natural enemies and occasional unfavorable conditions it will mature to marketable size in two to four years.

HISTORY OF ARTIFICIAL OYSTER CULTURE.

The idea of artificial oyster culture is not a new one. Since the first attempts in France in 1858 by Professor Coste to raise oysters by artificial means, very much has been done and written concerning the oyster and its culture. Unusual accounts of the immense production that might result from the artificial culture of the oyster have appeared from time to time in papers and books, of such plausibility that even practical oyster growers were led for a time to believe that with little labor great sums might be realized by raising oysters for the table. The first experiments in France were for the most part complete failures, but gradually, from a study of the localities where favorable results were obtained, a method such as may be found in use along the shores of France to-day was perfected. This method of artificial oyster culture comprised two very distinct branches—one being production, and the other rearing and fattening.

Production consists in placing adult oysters on the beds as a source of spawn and collecting the spat or embryo oysters that attach to suitable objects in the water after swimming about for a short time. These objects or collectors save vast numbers that otherwise would be lost and enable the oyster growers to harvest a crop each year on the grounds they have prepared.

Rearing consists in placing the spat, when sufficiently developed, in the best locations possible, where they will grow rapidly and be sheltered from the attacks of their natural enemies. When large enough for market the oyster is kept under such physical conditions as will fatten it and render it most suitable for the table. This method, as developed along the shores of France, is the most perfect and thorough system of oyster culture in the world. However, though methods similar in principle to those of the French have been carried on to some extent in the United States, they have been limited necessarily by the high cost of labor, different tidal and climatic conditions, and the difference in the species of oyster. In order to improve upon the methods of cultivation as practiced in the United States at present, attempts have been made since 1880 to develop a process whereby the oyster larvæ can be hatched and reared in receptacles or tanks until they set. These studies in artificial propagation were first carried on by Brooks, Ryder, Rice, and Winslow, but proved unsuccessful after several years of endeavor.

In carefully reviewing the results of their work the reason for failure is attributed mainly to one thing—filtration. The oyster eggs and larvæ are microscopic in size, and the greatest problem has been to find a means of permitting a flow of water and yet retaining the larvæ.

Later, in 1920, oyster larvæ were reared to setting size by W. F. Wells, of the New York State Conservation Commission, by the use of a milk separator for renewing the water in which the young oysters were kept. The process again proved successful in 1923, when a greater number of oysters was produced by artificial means, but as yet this method has not been perfected to such an extent that it is commercially practicable. Further experiments with a new method of artificially propagating the oyster were conducted by the U. S. Bureau of Fisheries at Milford, Conn., during the summer of 1923, the results of which will be described in the following work.

OBJECT AND SCOPE OF THE INVESTIGATION.

The various reasons for undertaking experiments in artificial propagation are, first, to determine a reliable method for obtaining healthy, vigorous spawn in quantities; second, to devise a means for rearing the free-swimming oyster larvæ until they reach the setting stage; third, to make more extensive studies of the oyster larvæ under controlled conditions in regard to embryonic development, habits, food, and most favorable environmental conditions; fourth, to produce larvæ for tests in regard to the effect upon them of various chemicals in solution; fifth, to try out new materials for collecting and handling "set"; and sixth, to determine from the results obtained the possibilities of making artificial propagation successful on a practical commercial scale.

The many steps involved in artificially propagating oysters consist briefly of (1) obtaining natural spawn from the adults, (2) rearing the larvæ during the long free-swimming period, (3) placing suitable collectors in the water at the proper time for the attachment or "setting" of the larvæ, and (4) transferring the young attached oysters or "spat" to protected beds where conditions are most favorable for growth and development.

EQUIPMENT USED IN THE INVESTIGATION.

Careful observations of salt-water aquaria have indicated that, in general, metallic apparatus is unsuitable if a pure and natural water supply is to be maintained. The corroding action of the sea water upon brass, copper, galvanized iron, etc., renders them unfit as receptacles for the storage and conveyance of salt water. For this reason the equipment used in this investigation was constructed of wood, hard rubber, and glass when possible, in order that nearly natural conditions might be produced. The apparatus used consisted of one cylindrical 500-gallon wooden storage tank, one rectangular 100-gallon wooden spawning tank with trays, four rectangular 25-gallon rearing tanks, two small cylindrical rearing tanks, an air-compressor, rotary water pumps, glass pipe, and hard rubber and wood faucets. The problems of filtration were solved to a great extent by the use of a new material known as "filtros." It is a white, rigid, porous, artificial stone, composed essentially of silica, and is similar to a sand filter in block form. The various grades of uniform porosity in which it is made make it suitable for retaining materials or organisms of any definite size and still allow a good flow of water. The filtros blocks used in the experiments were 12 inches square and 1½ inches thick and were fitted into grooves in the rearing tanks as shown in Figure 1. Blocks of various densities were used in accordance with the growth and size of the larvæ, and after being in use for five or six days were easily cleaned with

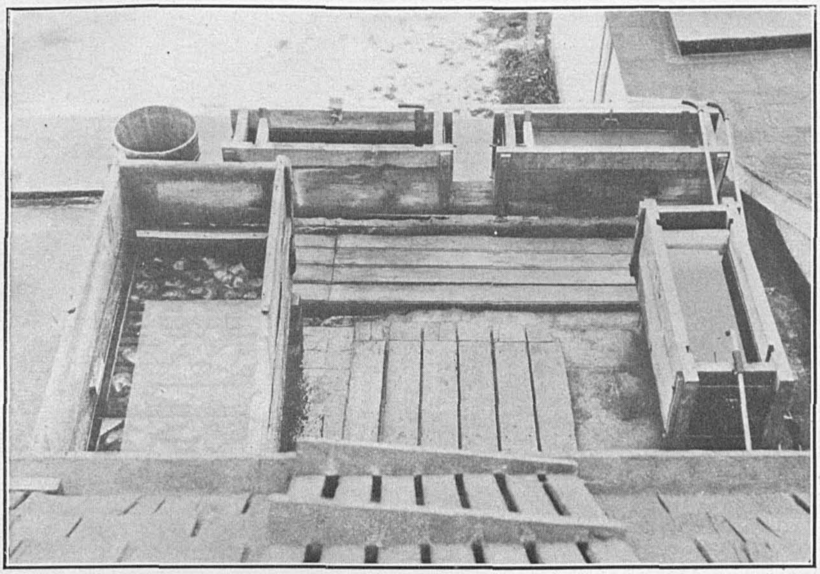

FIG. 1.—Experimental oyster hatchery, showing outdoor equipment consisting of one large spawning tank and three rearing tanks with filter blocks in place.

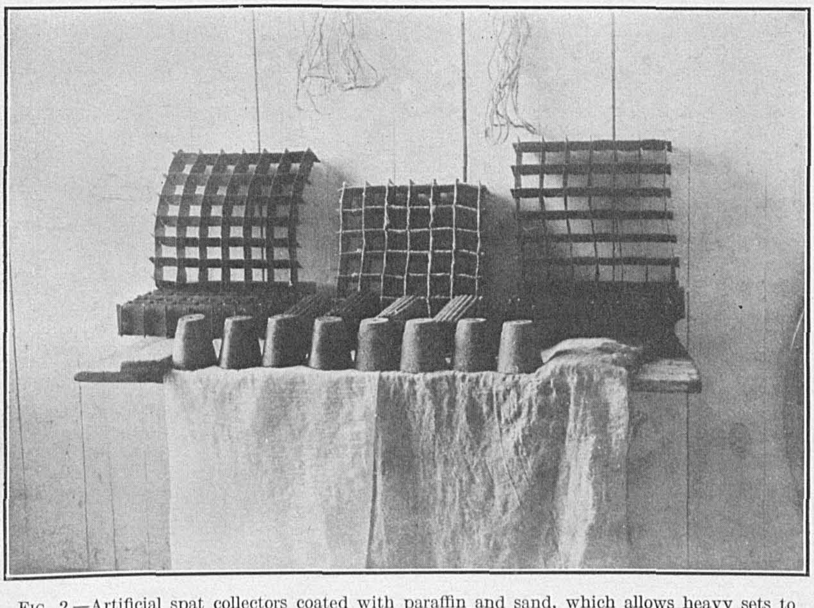

FIG. 2.—Artificial spat collectors coated with paraffin and sand, which allows heavy sets to break up into single oysters after one or two months.

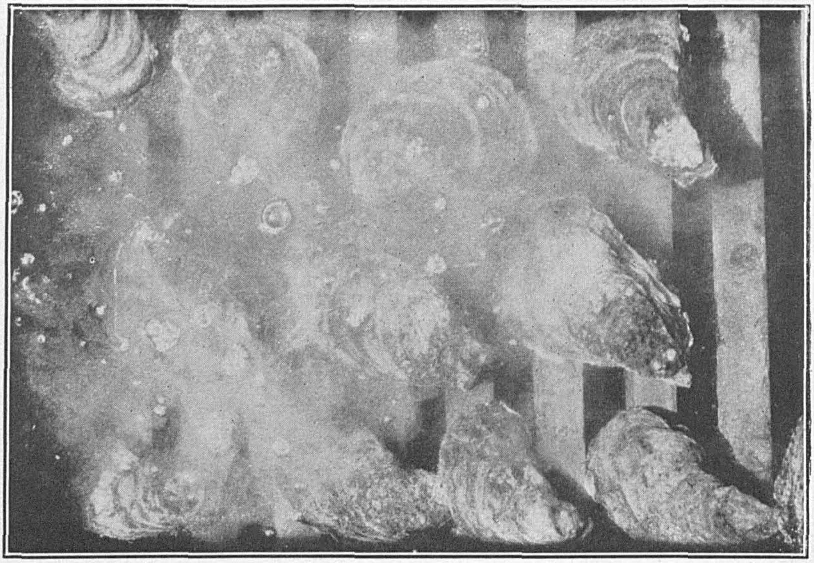

FIG. 3—Adult oysters spawning naturally on tray in large spawning tank.

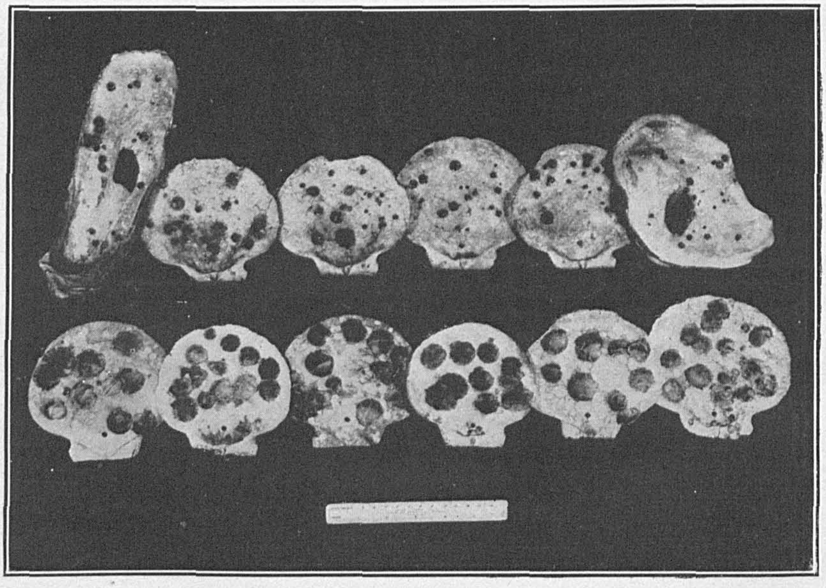

FIG. 4.—Artificially propagated oyster spat collected on sea-scallop shells for observation. Lower row, spat 7 weeks old; upper row, spat 3 weeks old. The three shells on the left in the upper row were kept in the rearing tank while the others were placed in the harbor.

a garden hose. For retaining the larvæ when 10 days old, fine monel metal screen was used and proved quite satisfactory for use in salt water.

SUCCESSFUL METHOD OF HATCHING AND REARING YOUNG OYSTERS.

In order that the various important factors affecting the artificial propagation of the oyster may be clearly understood, a résumé will first be made of the method that proved successful in hatching and rearing the young oysters. The brood stock of adult oysters used for producing spawn consisted of native oysters grown at Milford and southern oysters planted there by the bureau in 1919. These oysters were planted on shallow inshore beds in Gulf Pond, where the warm temperatures would mature them for spawning at an early date.

Numbers of the large oysters were placed on trays in the spawning tank, and the temperature was gradually increased until the water was filled with the spawn ejected by the adults (see fig. 3). Immediately after spawning had ceased, the oysters were removed and the eggs allowed to develop to the swimming stage in the warm water. Then the embryo oysters were transferred to the rearing tanks, and when supplied with running water they developed shells in 40 to 48 hours. The use of a mechanical agitator at this time helped greatly in bringing about a natural and rapid development of the oyster larvæ. For retaining the embryos a combination filter of loose, fine sand and filtros was used until the embryo oysters had reached the shell stage. From that time on the larvæ were held in by the filtros blocks of various grades, which were changed to suit the growth and size of the forms. When the larvæ were 10 days old, or older, they were held in by means of fine monel metal screens, which permitted an unusually good flow of water.

After a period of from 15 to 20 days the larvæ were ready to "set," and collectors of various materials were placed in the tanks for their attachment. In the first successful test over 150 spat were found "set" on the collectors, and in the last over 1,000 spat became attached (see fig. 4). The loss in numbers from the countless eggs produced by the adult oysters was traced to mechanical defects in making the filters fit closely and not to a mortality of the larvæ. After the spat had grown for a day or two in the rearing tanks they were transferred to favorable places in the harbor, where a maximum growth might be obtained. The care of the oyster after attachment is easily accomplished by the modern methods of culture.

REPRODUCTION AND DEVELOPMENT.

SELECTION OF THE OYSTERS.

The adult oysters used for the production of spawn were taken from the inshore beds early in the summer and from the deep-water offshore beds later in the season. In this way it was possible to obtain mature spawn from oysters in Long Island Sound from early in July until September, as the genital products of the oysters in the warm, shallow waters mature earlier than those of oysters in deep water.

The quantity of spawn found in the oysters is determined largely by the time of spawning and the previous weather conditions. Oysters one year old are capable of producing mature spawn, though for artificial propagation oysters three to five years old are considered the best. In sorting over the brood stock to be placed on the trays in the spawning tank only those oysters are selected that are free from the boring sponge, drill spawn, mussels, barnacles, hydroids, and tube-building worms, and which, from a noticeable amount of new growth around the edges of the shell, appear to be healthy. If necessary they can be scrubbed with a stiff brush to remove any excessive growths that may cover them.

SPAWNING.

The act of spawning consists in the discharge of the ripe reproductive elements into the surrounding water by both sexes of the oyster. The actively moving spermatazoa swarm about and fertilize the eggs, a single spermatazoon penetrating each egg membrane, the head of the spermatazoon passing on in after the tail has dropped off. The material of the head unites with that of the egg and causes the development of the egg cell into an embryo oyster.

The general method, since Brooks's initial experiment, for obtaining fertilized eggs has been to artificially mix the spermatazoa and eggs after stripping them from the ripened oysters, which have been opened. This method is unreliable, crude, wasteful, unnatural, and in most cases unnecessary, and undoubtedly accounts for many of the failures in the various attempts to artificially propagate oysters. It is impossible to determine how nearly ripe the spawn may be in any group of oysters without opening them, and consequently many are wasted before specimens apparently suitable for stripping are found. The experiments conducted at Milford have proved without a doubt that an enormous number of fertilized eggs can be produced by a natural process and the adults saved for future use. This process consists in placing the oysters in tanks of slowly running water, in the sunlight, where spawning is induced by the rising temperature. In every attempt made from July 10 to September 1 the oysters spawned readily and produced a greater amount of spawn than could be taken care of with the small-scale equipment. The spawning occurred at temperatures ranging from 68 to 75° F., and lasted over intervals of 15 to 30 minutes (see fig. 3). At higher temperatures than 75° the spawn was released slowly and immediately settled to the bottom of the tank, whereas normally it would be forcibly ejected into the water and would float about for some time. It was observed that the female oyster discharged the eggs in puffs at intervals of about 30 to 50 seconds, while the products from the male were emitted continuously in a slender, white, thread-like stream. In this way, when the trays of oysters were placed near the surface of the water, it was possible to proportion the numbers of each sex when spawning began, and one male was found to produce sufficient spermatazoa to fertilize the eggs from four females. The genital products can also be distinguished with the naked eye as the eggs appear as clouds of tiny white specks when discharged into the water, while the spermatazoa appear to fade away almost immediately after leaving the oyster. From these experiments it is evident that if oysters have reached sexual maturity, it is far better to have them release the spawn naturally than to sacrifice the parent oysters by stripping it from them together with considerable débris and unripened eggs, which quickly foul the water. When spawning first begins the running water is shut off and in some cases the spawning is temporarily arrested by draining and flushing out the tank and refilling with a fresh supply, after which spawning takes place more vigorously than ever.

When the oysters have ceased spawning they are immediately removed from the tank and the eggs allowed to remain in the warm water until the first swimming stage is reached. The transfer of the swimming embryos to the rearing tanks may be accomplished in either one of two ways—first, by pouring them through No. 20 bolting silk to remove any possible débris or enemies which may have gotten into the water; or second, by having a steady stream of water from the surface of the spawning tank to the rearing tanks, which will carry over only the most vigorous of the swimming embryos and leave any unfertilized eggs, débris, etc., behind.

In one instance (on July 26) a group of 11 month-old oysters spawned for over five minutes at a temperature of 69½°. A sample of this observed in a watch glass developed as normally as that of the older oysters.

EMBRYONIC DEVELOPMENT.

The young oyster that develops from the egg is extremely unlike the adult and undergoes a variety of changes until some time after it sets, when it acquires the asymmetrical characteristics of the adult. The fertilized egg develops into a swimming form in from 6 to 10 hours at moderate temperatures, and when about two days old acquires two tiny shells that continue to grow and surround the body of the larva. This early stage is characterized by a straight hinge where the shells are joined together, and precedes the most critical period in the development of the larva. At the time that the straight hinge disappears and the larva becomes more rounded in shape, it has apparently used up the yolk supply from the egg and is beginning to take in microscopic food from the water. If it survives this period, it can be reared through the succeeding stages without difficulty.

As the larva increases in size one valve becomes much deeper than the other and has a more prominent umbone, which enables one to distinguish the oyster larva from that of any other bivalve.[3] The deeper valve is the left one and that by which the oyster later becomes attached. After swimming about for a period of two or three weeks the larva becomes about one-third of a millimeter (one seventy-fifth of an inch) long, and if the proper conditions are present it "sets."

SETTING.

The terms "fixation," "spatting," and "setting" are applied to the attachment of the larva to some firm, clean surface with which it comes in contact. The left valve becomes attached by means of a shelly secretion of the left lobe of the mantle, which serves to cement it to the surface the larva has selected. In artificial propagation the

[3] The oyster and the oyster industry of the Atlantic and Gulf coasts. By E. P. Churchill, jr. Appendix VIII, Report U. S. Commissioner of Fisheries, 1919 (1921). Washington.

various collectors are placed in the tanks previous to the setting stage and become quite evenly covered with the spat. The number of spat desired on any particular collector can be regulated by the length of time they are left in the tanks and by observing the numbers that have become attached from time to time.

GROWTH OF SPAT.

The growth of the oyster spat after "setting" is quite rapid under favorable conditions. Observations made in 1922 of the growth from the time of setting showed that in 13 days the spat attained an average size of one-fourth of an inch (6 mm.) when placed just below the surface of the water. The daily average sizes (maximum diameters) of set measured in August, 1922, are given below in millimeters:

Just attached (larval shell only)	0.33	7-day-old spat	1.675
1-day-old spat	.402	8-day-old spat	2.144
2-day-old spat	.603	9-day-old spat	2.680
3-day-old spat	.737	10-day-old spat	3.216
4-day-old spat	1.005	13-day-old spat	6.000
5-day-old spat	1.139	18-day-old spat	10.000
6-day-old spat	1.273	23-day-old spat	14.000

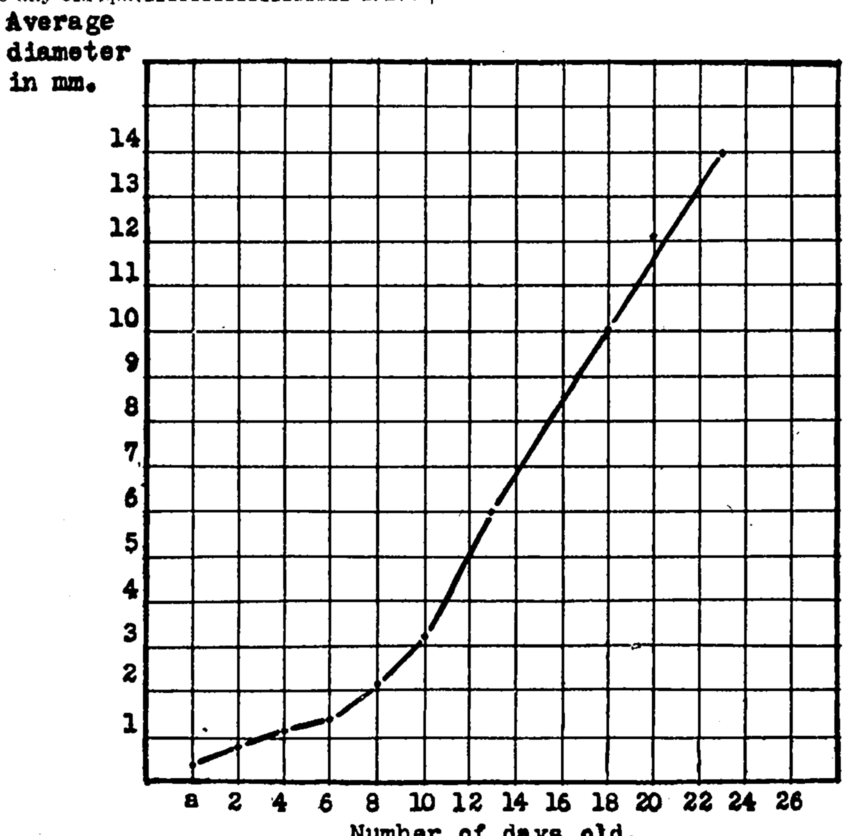

FIG. 5.—Average rate of growth of spat after setting, from August 2 to August 25, 1922, Milford Harbor, Conn. *a*, Size of spat at time of setting.

Artificially grown spat that set on sea-scallop shells placed in the rearing tanks on August 2, 1923, attained an average growth of 27 mm. ($1\frac{1}{16}$ inches) in two months. Some of the others, which set on August 18, 1923, were kept in the rearing tanks, while the rest were placed in the harbor. The average growth, for a period of three weeks, was 12.5 mm. for those in the harbor and 14 mm. for those kept in the tanks (see fig. 4). The temperature of the running water in the tanks was generally higher than that found in the harbor and undoubtedly accounts for the better growth. In one year the oysters attain an average length of 3 inches and width of $1\frac{3}{4}$ inches when placed on inshore beds in Milford Harbor. In two years they can be taken up for the half-shell trade, and measure on the average $4\frac{1}{4}$ inches in length and $2\frac{3}{4}$ inches in width, and are much deeper. This rapid development occurs only on the inshore flats where food is abundant and the temperature of the water is high. On the deep-water beds of the Sound it requires about four years for an oyster to attain a length of 4 or 5 inches, or a marketable size.

FACTORS OF ENVIRONMENT.

TEMPERATURE.

The temperature of the water during the development of the oyster from the egg to the spat is of considerable importance. It is undoubtedly the greatest influence in determining the rate at which growth and development take place and is coincident with the success of the experiments. The life processes of the egg, embryo, and larval oyster are hastened by a high temperature and retarded by a low one. A violent change or extreme high or low temperature will kill the young oysters or considerably impair their vitality. Several attempts were made to hasten the development of larvæ by keeping the temperature from 80 to 85° F., but this invariably resulted in a total loss of the forms. In the successful experiments the temperature ranged from 65 to 75°, and was kept as near 70° as possible.

DENSITY OF WATER.

The water used for rearing the larvæ was pumped on the flood tide and had a density ranging from 1.019 to 1.0218 during July and August. Just how great an influence the density of the water has on the oyster embryos can not be stated, though it seems probable that any considerable change in this respect would be detrimental to such a delicate organism. Changes in density and temperature are closely correlated so that it is hardly possible to state the exact influence of either without allowing for the other. Due to the supply of fresh water from the land the density of the water in the harbors and on the inshore beds is generally lower than that found offshore, and when within a range of density between 1.011 and 1.022 is most suitable for oyster growth.

LIGHT.

A comparative study of conditions in the rearing tanks that were placed in the sunlight with those that were kept in indirect light strongly indicates that for the purpose of artificial propagation the latter are more desirable. The tanks receiving less light maintained a more even temperature, kept clean longer, and developed the larvæ more rapidly than those placed in the sunlight. Sunlight and high temperatures do not accelerate the development of the larvæ but promote the growth of bacteria, infusoria, and minute plants which foul the water and necessitate frequent changes of tanks and filters. The setting of the larvæ occurred as heavily on the light side of the collecting shells as it did on the darkened side as both sides were equally clean.

WATER SUPPLY.

A pure and uncontaminated supply of salt water is essential and necessary for the propagation of any marine animal. By pumping on the flood tide the water in Milford Harbor was found suitable but not ideal for experimental work. Each year a small scattered set occurs in the harbor, which indicates that in general conditions there are favorable for the development of oyster larvæ. The water was pumped to the 500-gallon reservoir at every flood tide when possible, in order to maintain a good quality in storage for distribution to the spawning and rearing tanks. The reservoir was drained and cleaned occasionally though very little sediment was found to have settled in the bottom.

From the reservoir five glass pipe lines with separate wood valves conveyed the salt water to the various tanks where it was projected through fine sprays in order to create a circulation. The water level in the rearing tanks was controlled by hard-rubber overflow valves that were located at one end of the tanks outside of the filters.

FOOD AND ENEMIES.

The food of the oyster larvæ consists of ultra-minute organisms or nannoplankton, which are found in abundance in ordinary sea water. The plankton was excluded from the water supply by means of a net made of No. 20 bolting silk through which the water was pumped before going into the reservoir. This also removed all large known enemies of the larvæ and allowed only the nannoplankton to pass through.

The presence of infusoria in abundance in the tanks is an indication that conditions are becoming unsatisfactory and foul as a result of the death and decomposition of many of the embryos. To separate the healthy embryos from these organisms, which collected at the bottom of the tanks, was at first a problem but by allowing a good overflow of water to a new tank the more vigorous ones soon swam out to the new quarters. As the larvæ increase in size and pass the straight-hinge stage they can be readily separated from infusoria, sediment, etc., by the use of bolting silk. However, a troublesome growth of infusorians was experienced only in the tanks placed in sunlight and with spawn taken from artificially fertilized eggs, when making various tests with it in comparison with natural spawn under the same conditons.

ÆRATION.

Æration as a means for producing conditions favorable to the development of the eggs and larvæ was tested out in many experiments. Apparatus of many designs with varying degrees of æration proved useless when tried out with the young oysters at every stage of development. It was hoped to carry the minute embryo oysters through the first stages in water that was purified and agitated by compressed air, as the filtros blocks were not fine enough to restrain them until they had developed shells, but their development in ærated water was slow and generally resulted in an early death of the embryos or produced shell forms of such decreased vitality that they lived only a short time. Winslow's experiments in 1822 to oxygenate the water by æration likewise proved unsuccessful, and this factor as a necessary step to success is questionable.

RUNNING WATER.

The most important result of the summer's investigation into the controlling factors necessary for success in artificial propagation is that oyster eggs and larvæ will develop and grow in salt water aquaria as fast and as vigorously as they will in nature if supplied with *running water*. The first batch of spawn placed in the unseasoned apparatus was given a constant supply of water from the beginning in spite of the fact that many got around the filters and were lost. They developed normally from day to day and "set" with practically no mortality 15 days after spawning. In the succeeding experiments the water supply was diminished and every attempt made to retain all of the larvæ, with the result that stagnation and fouling occurred and all of the forms died. The next successful experiment was accomplished by providing a good supply of running water and would have yielded a greater crop of spat had it been possible to prevent the soft embryonic forms from passing through the filters.

By introducing the water into the rearing tanks in fine jets it was easy to produce a circulation and agitation throughout the tanks similar to that found in nature. For carrying the embryos through to the shell stage, a glass rod agitator proved effective for use with a very slight flow of water. This prevented a heavy loss of the forms up the shell stage but was not perfected in operation until September, when it became too cold to conduct the experiment further.

FILTRATION.

Oyster eggs and embryos are so extremely small that they will pass through felt or the finest bolting silk and consequently it can readily be seen that it is a difficult problem to create a flow of water and at the same time prevent the passage of such minute organisms. A method for accomplishing this was not found until the first week in September, when thousands of healthy straight-hinge larvæ were produced but could not be reared to setting size because of the cold weather when water temperatures dropped overnight to 50 and 54° F. and soon killed them.

The apparatus that solved this perplexing problem consisted of a half barrel equipped as shown in Figure 6. The filtros plate was covered with a 2-inch layer of fine white sand and the rate of flow through it was regulated by the valve *e*. The half barrel was filled with water up to about 6 inches over the sand and freshly fertilized eggs placed in it. A fine stream of water from the faucet *a* kept up a constant circulation in the barrel from the time the eggs were put in. Tests from time to time at the drain *e* indicated that none of the eggs were passing out through the sand or filtros, but as no trace could be found of the embryos in the barrel above the sand layer it

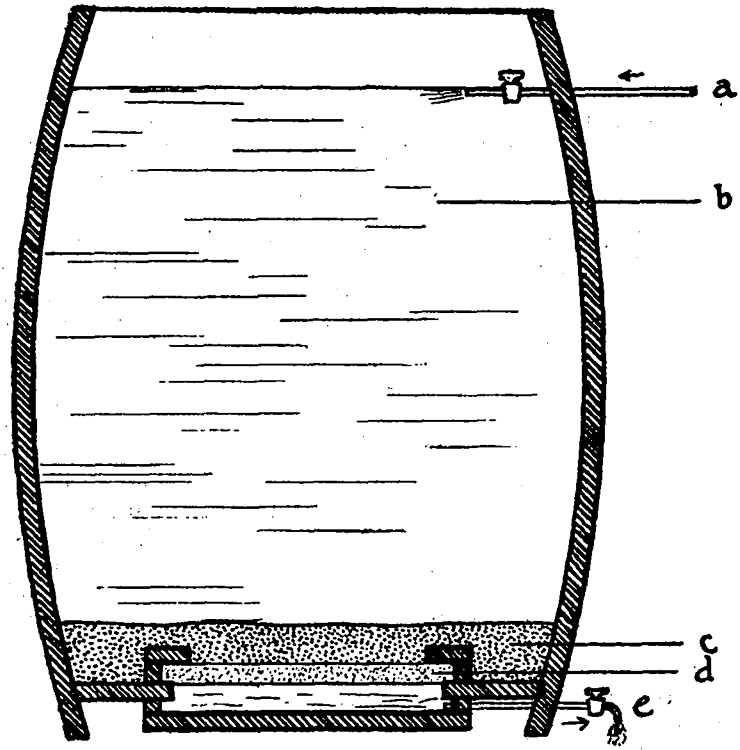

FIG. 6.—Barrel equipped for developing oyster embryos to the shell stage. *a*, Fine stream for supplying salt water and circulation in the barrel; *b*, salt water containing embryos; *c*, 2-inch layer of fine sand; *d*, filtros block; *e*, drain pipe with control valve.

was thought at first that they had died and that the apparatus was a failure. However, after a period of 48 hours, it was decided to wash out the sand and try a new batch of spawn. In turning a heavy stream of water into the barrel and opening wide the valve *e* it was found that thousands of vigorous larvæ with well-developed shells were washed out into the triple layers of bolting silk placed there. This was indeed encouraging, as the filtros blocks were suitable for rearing them once they had developed shells. This experiment was repeated several times with success and it is to be regretted that the lateness of the season prevented carrying the larvæ through to setting and making the summer's work one of production as well as theory.

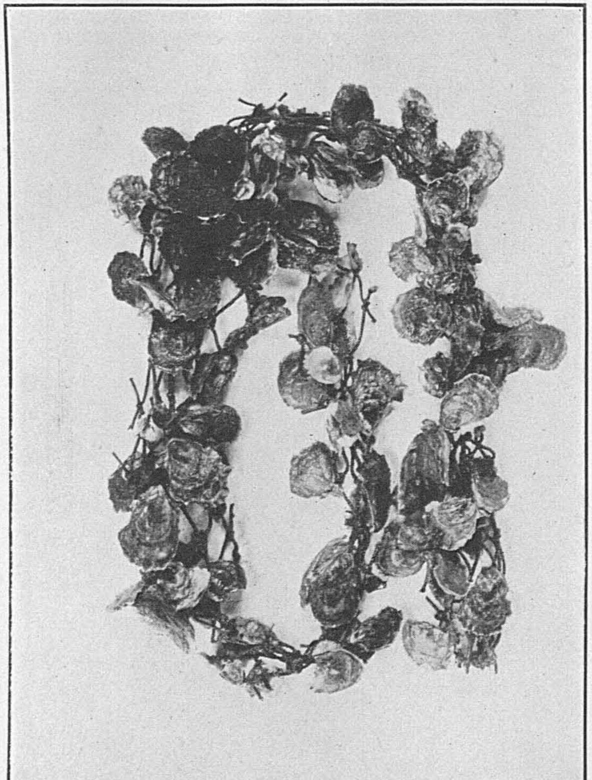

FIG. 7.—One-year-old oysters that set on tar-coated pound nets in Great South Bay, Long Island, 1921. Such a collector is suitable for producing excellent single oysters from heavy sets, with little mortality from overcrowding.

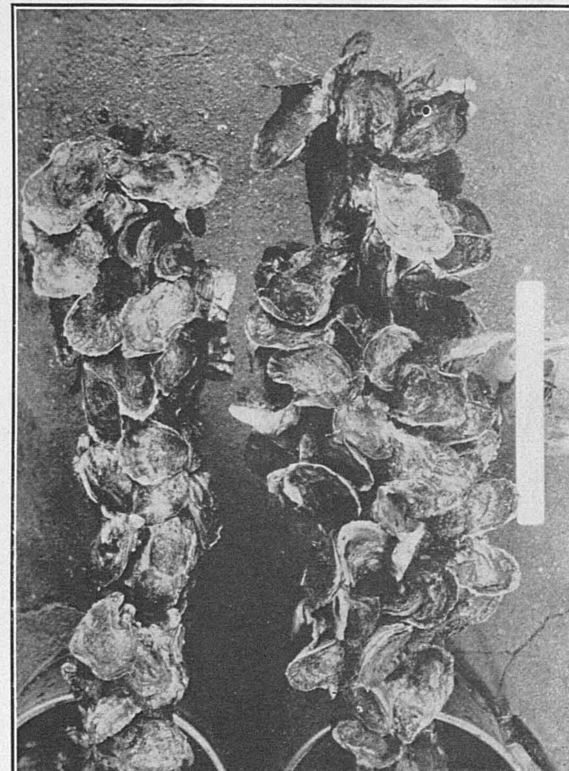

FIG. 8.—Pound stakes covered with a heavy set of year-old oysters from Great South Bay, 1921. The convex surface of brush, stakes, tarred rope, etc., will produce good oysters when thickly covered with spat.

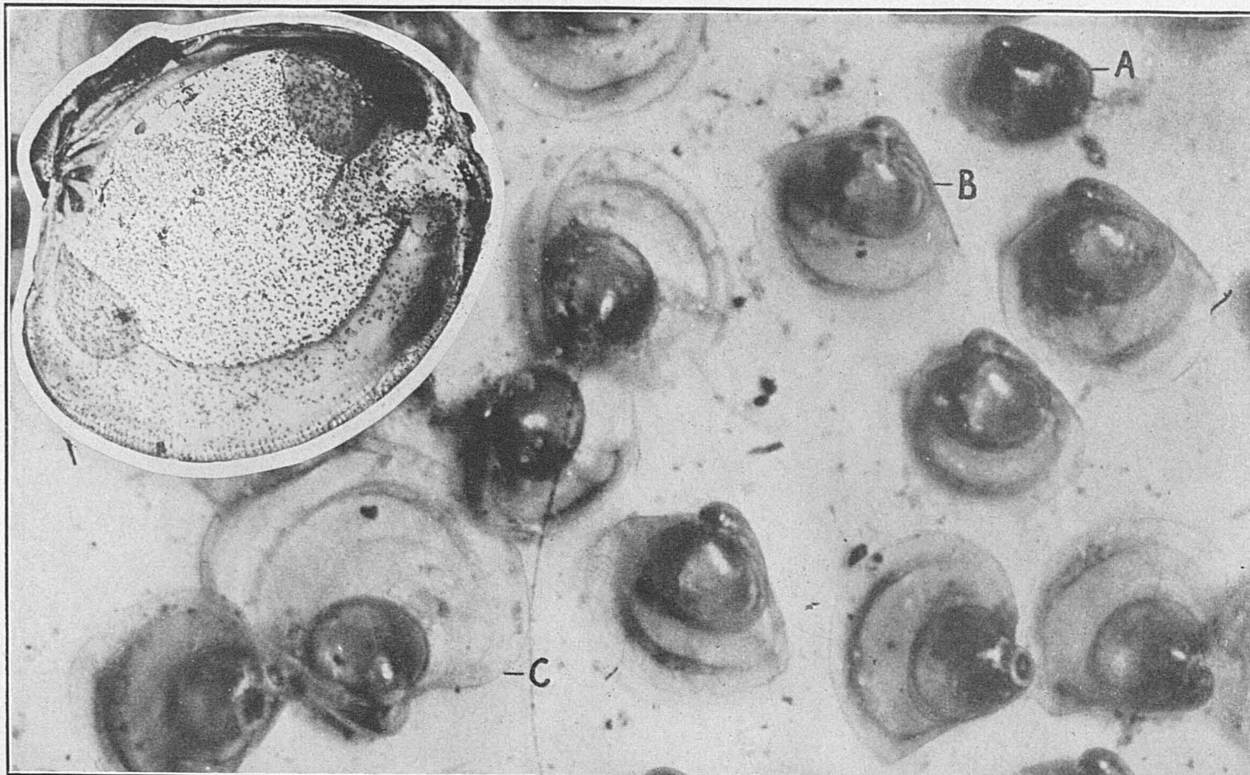

FIG. 9.—Clamshell heavily set with thousands of young spat, actual size (inset), and a portion of the shell enlarged to show the detailed structure of the spat. *A*, Spat just attached; *B*, spat one day old; *C*, spat two days old. The clamshell was taken from Great South Bay in 1921 and illustrates the heavy loss of young oysters that must occur on such a hard, firm material on which all but 8 or 10 are lost from overcrowding and suffocation.

COLLECTION AND TRANSPLANTING.

An important consideration in placing artificial propagation on a commercial scale is that of collecting and transplanting heavy "sets" by a method that would be practical and efficient. A variety of collecting materials was tried out in Milford Harbor to determine just how certain ones would weather unfavorable conditions on the beds. A new type of collector for handling artificially propagated oyster spat was made from cardboard egg-crate partitions, which were dipped in hot paraffin and then covered with coarse sand (see fig. 2). They quickly sank to the bottom and were heavy enough to withstand tides and storms in a moderate depth of water. The partitions remained in place for over a month when suspended at the surface of the water, and longer when placed on the bottom, and regardless of how they are dropped into the water they settle in such a way that there is no chance of smothering the spat. They are cheap collectors, capable of collecting thousands of spat and in two or three months will break up, producing large numbers of small single oysters, the most desired product in oyster culture to-day. The degree of spat concentration that is most suitable will be determined by future experiments.

Other objects, such as brush, rope, netting (fig. 7), shells (fig. 9), tin cans, etc., coated with paraffin and sand, asphalt, cement, and plaster of Paris were also found suitable to some extent as collectors. The artificially propagated spat were caught on a sea-scallop, clam and oyster shells, and small clay flower pots, as there were not sufficient numbers to warrant using the larger collectors. The loss of spat from handling or other agencies was less than 1 per cent, and in transplanting them to the most suitable grounds no greater loss should be sustained if they are properly handled. The problem of catching and handling the set is insignificant in comparison with that of producing larvæ ready to attach themselves, and improvements in this respect will quickly come when a dependable method for the latter has been perfected.

SUMMARY.

The primary object in writing this paper is to lay before practical oyster growers and biologists the various problems that have made artificial propagation of the oyster a difficult task, and to briefly describe experiments used in finding some solution for them. The summer's work was conducted for the purpose of studying these problems more thoroughly and to make detailed observations of the many natural conditions in the environment of the oyster to determine the influence they exert upon the eggs, embryos, and free-swimming larvæ. The continuation of this work in the future will aim to develop this method on a production basis so that it may be perfected to such an extent as to be of value to the practical oyster industry.

Northern oyster growers are to-day paying as high as $1,000 for 1,000,000 year-old oysters, or for one-fiftieth of the number that a single full-grown female oyster is capable of producing.

Surely a system of artificial propagation that can produce the same results with a smaller expenditure can be perfected in the future if natural conditions are studied, imitated, and placed under control. Such an important object can hardly be attained at a single leap; but eventually it will be reached after a series of careful and painstaking experiments and the accumulation and study of facts have broadened our knowledge in regard to the habits and requirements of the oyster throughout its life history.

FIG. 1.—A part of the Key West fleet which fishes the near-by reefs for small bottom fish. On the dock can be seen the type of slat live car that is used to retain the surplus catch of live fish.

FISHERIES OF KEY WEST AND THE CLAM INDUSTRY OF SOUTHERN FLORIDA.[1]

By WILLIAM C. SCHROEDER, *Scientific Assistant, U. S. Bureau of Fisheries.*

CONTENTS.

KEY WEST FISHERIES.

Key West was settled in 1822, and from the very beginning of its existence fishing formed one of its principal industries. At the present time fishing is, perhaps, of first importance to the inhabitants, although in value of output it is exceeded by the cigar industry.

The fishermen's equipment and their methods of fishing and disposing of their catches are practically the same to-day as they were 40 or 50 years ago. Indeed, many of the small fishing boats now in use are at least 40 years old. The only fisheries which have shown noteworthy developments during the last half century are those of the spiny lobster and the Spanish mackerel.

The Bureau of Fisheries' statistical canvas of 1918 shows that 458 persons were engaged in the fisheries of Monroe County at that time, and nearly all of these were credited to Key West. This number is considerably augmented in winter, however, during the height of the mackerel and kingfish season. In 1918 fishing vessels not engaged in shore fishing, together with outfits and various apparatus, were valued at $38,435; transporting vessels with their outfits at $14,450; 311 sailboats, power boats, and rowboats, together with various equipment and apparatus, at $80,837; and shore and accessory property amounted to $56,287 in value—a grand total of $190,009. The

[1] Appendix XII to the Report of the U. S. Commissioner of Fisheries for 1923. B. F. Doc. No. 962.

various fishery products credited to Monroe County in 1918 totaled 3,752,355 pounds, which represented a first value to the fishermen of $290,170.

Most of the wholesale trade in fish is carried on from November to April, when perhaps 90 per cent of the annual catch of fish is taken. Several dealers operate during the entire year, but others are actively engaged in Key West only during the winter. Dealers in sponges and turtles operate throughout the year. All the wholesaling is done with dealers outside the city.

It was not until 1920 that an ice-making and cold-storage plant was built to take care of excess catches of fish. Previous to that time, notably early in 1919, the fishing industry suffered severe losses when the one small ice-making plant in the city became disabled.

The retail fish trade is taken care of at the wharves, where the fishermen keep their catches alive in boat wells or in live cars, selling direct to the consumer. There are no local retail stores that sell fish, but small quantities are peddled in pushcarts throughout the city. A person desiring to buy fish goes to the wharves, looks over the stock in the various live cars, and selects the fish he wants. The fisherman then removes the fish selected from the live car with a dip net and cleans and strings them without severing their heads. This method of keeping fish is especially desirable in such a warm climate, as it eliminates icing and insures fresh fish at all times. The variety of fish sold in Key West is probably greater than in any other locality in the United States. A string of fish as sold at the fish wharves usually consists of from 2 to 4 species, but if one so desired one would have no difficulty in buying a string containing 20 fish of different kinds.

The fishing fleet is composed mainly of small boats, some of which are equipped with sails only, some with gasoline engines, and some with a combination of the two. These boats seldom travel far from land and are used chiefly in fishing on near-by reefs, which are numerous about Key West. Very few boats of the larger and better type are owned locally, but a number of such vessels come from the east and west coasts of Florida to fish at Key West during the winter.

The most important products of the Key West fisheries are reef fishes, Spanish mackerel, kingfish, mullet, sponges, turtles, spiny lobsters (*Panulirus argus*), and stone crabs (*Menippi mercenaria*). The catch of conchs, although small, is peculiar to the Atlantic coast of the United States, and while the hard clam, or quahaug (*Venus mercenaria mortoni*), does not occur at Key West, the clam industry of southwest Florida is of great importance. Each of these furnishes an individual fishery that will be described in the following pages.

SMALLER REEF FISHES.

The small fishes inhabiting the reefs among the Florida keys are caught at all seasons of the year. They comprise, for the most part, grunts, snappers, yellow-tail, porkfish, porgies, turbot, jacks, and small groupers.

The boats used in this fishery are from 20 to 40 feet in length, with cockpit aft, fish well in the center, and with space for sleeping quarters, if so utilized, forward below deck. Generally but one person, or at the most two, constitutes the crew. Fishing is done entirely with hook and line. The general equipment consists of numerous fish hooks and lines, a small minnow seine or cast net with which to secure fish bait, a pair of "grains" for spearing spiny lobsters also for bait, a small dip net for removing fish from the well when desired, a barrel of fresh water, a supply of food, an open-grate wood stove, some dry firewood, and the necessary bedding for accommodation over night.

Some of the fishermen return from the day's fishing by late afternoon, while others remain away for one or more days, fishing at more distant points where somewhat larger or perhaps more desirable fish may be found. The fishery is of local importance only, as these fish rarely are shipped from the city. Because of the regularity of the fishing throughout the year the value of the annual catch is quite large and assumes a prominent place among the other fishery resources of the region.

Practically all of these smaller fishes are kept alive until sold. Each boat, as already stated, is equipped with a fish well, where the fish are retained after they are removed from the hook. At the wharf the fisherman has one or more live cars in which the fish are placed in order to display them for sale, leaving the boat's well empty for the next fishing trip. A well-stocked live car is a pretty sight, as many of the reef fishes are beautifully colored.

A fishing boat without a well would be quite useless for reef fishing in this region, as the fish would spoil long before they could reach the market. Ice is used to preserve only those species that will not live in confinement, such as the mullet, kingfish, or Spanish mackerel. The fish well is carefully constructed of from 2 to 4 inch lumber, according to the size of the boat, and the seams are caulked with the same care that is given to the outer hull. At the base the four sides fit snugly with the contour of the boat and converge toward the top like a frustum of a pyramid, which the well diagrammatically resembles. The top of the well fits flush with the deck and is covered with a trapdoor, which is removed during actual fishing. The floor of the well, which is part of the hull, is pierced with numerous 1-inch holes to permit a constant interchange of water.

The necessary equipment for reef fishing is simple, the running expenses are small, the fishing grounds are near by, and the fish are readily caught and quickly sold. The fishery, however, does not appear to be overcrowded, for the markets are more liable to be without fish than to be overstocked.

LARGER REEF FISHES.

The larger reef fishes consist mostly of groupers, jewfish, hogfish, large porgies, and large snappers. They are taken throughout the year, although each at certain seasons furnishes better fishing than at other times. Larger boats are used, and fishing is carried on in deeper water than for the smaller reef fishes.

The few Key West boats that engage in this fishery range in length from 30 to 75 feet, or from the half-cabin dory type to the small schooner. Since hand lines only are used, the equipment is similar to that of the smaller boats. A crew of from two to five is usually carried, and the boats remain away from several days to a week, or until the fish wells are sufficiently stocked to warrant a return to port. Cuban boats often fish near Key West, and sometimes they land at that city and dispose of their fish.

A portion of the catch is sold locally in Key West, but much the greater part is shipped to Cuba and to various cities in this country. The fish are brought in alive by the fishermen, but they are iced in the markets. Large boxes weighing about 200 pounds each, and holding 900 pounds of fish and 400 pounds of ice, are used in shipping fish to Cuba. The fish are transported to Cuba by large freight and passenger steamers that sail almost daily during the winter and several times a week during the summer. Each box is heavily constructed, and a number is painted on the side in large figures, so that a consignment can be checked and a record made of the empty boxes when returned. Shipments within the United States are made in barrels containing 200 pounds of fish and about 100 pounds of ice.

ANNOTATED LIST OF COMMERCIAL FOOD FISHES FOUND IN THE VICINITY OF KEY WEST.

In the following annotated list of fishes an attempt has been made to include every species found within the general vicinity of Key West that is locally considered a food fish. Some of the species mentioned are too scarce to be of much importance, while others are not regarded very favorably, but, nevertheless, these are included in order to make the list as complete as possible. Other species, such as sharks, rays, morays, and salt-water catfish, are taken but are excluded here because they are not locally regarded as food fish. All of the fishes listed are to be found within Monroe County, which includes the islands or keys from Key Largo south and a small area in the southwestern part of the Florida peninsula.

1. **Tarpon atlanticus** (Cuvier and Valenciennes). Tarpon; Silverfish.

The tarpon visits Key West during the winter months, but is not as common there as along the western coast of Florida. It is primarily a game fish and is rarely eaten. However, it is sometimes seen in the Key West markets, where it is sold in steaks at a low price. Because of its great game qualities the tarpon attracts many sportsmen to the State and is directly and indirectly a source of large annual revenue to the inhabitants. It is a very powerful fish and is caught only with hook and line, generally by trolling, using mullet for bait. It is most common in Florida and the West Indies. Maximum length about 8 feet; average, about 5 feet.

Range.—Isaacs Harbor and Harrigan Cove (Nova Scotia) to Brazil.

2. **Albula vulpes** (Linnæus). Ladyfish; Bonefish.

This fish is not rare among the Florida Keys and is sometimes found in the markets. However, it is not highly regarded as a food fish, and its commercial value is negligible. Maximum weight, about 5 pounds; average, $1\frac{1}{2}$ pounds.

Range.—Tropical seas. Generally common on our coasts north to San Diego (Calif.) and Florida. Stragglers have been recorded as far north as Woods Hole, Mass.

3. **Tylosurus marinus** (Walbaum). Houndfish; Garfish; Needlefish.

The houndfish is common about Key West and other Florida keys. It is not highly regarded as a food fish and therefore is but rarely eaten. Usually only large examples, about 3 feet in length, are to be found in the markets. Several smaller species (*T. notatus* and *T. timucu*) are common, but never appear in the markets. *T. raphidoma* and *T. acus*, each attaining a length of 4 feet or more, are sometimes utilized for food. Although unimportant in the markets, all these species are good food fishes. On a dark and quiet night when rowing or poling a small boat these fish are commonly struck while swimming at the surface. On such occasions they rather startle one with their vigorous splashes over the surface gradually dying out in the distance, like stones skittered over a pond. Houndfish are taken in seines and with hook and line, but they take only a moving bait.

Range.—*T. marinus* is found from Casco Bay (Me.) to Texas, and is generally common from Chesapeake Bay southward. The other species mentioned are common from the Florida keys to Brazil, sometimes straying to North Carolina and northward. *T. acus* is recorded from as far north as Nantucket, Mass.

4. **Mugil curema** Cuvier and Valenciennes. White mullet; Silver mullet.

The silver mullet is abundant about Key West and all the other Florida keys, where the annual catch is nearly as great as that of the striped mullet (*M. cephalus*). It is taken with gill nets in brackish or salt water throughout the year. It prefers protected regions in bays, rivers, and about islands, and generally travels in schools over shallow bottoms, stirring up the mud in a search for food. Sometimes schools of a few hundred or a thousand fish simultaneously leave the water with a single jump, falling back with a resounding splash. Most of the spawning is believed to occur during May and June along the Florida keys, but no gravid fish have been observed. The silver mullet is a food fish of some importance in Key West, where it is sold either salted or fresh. Maximum size, about 14 inches; average, about 10½ inches.

Range.—Cape Cod to Brazil; Lower California to Chile.

5. **Mugil cephalus** Linnæus. Mullet; Jumping mullet; Striped mullet.

The striped mullet is fairly common among the Florida keys, but is not taken in large quantities in the immediate vicinity of Key West. The bulk of the catch is taken with gill nets. The striped mullet is an excellent food fish, and commercially it is the most valuable fish caught within the State of Florida. The mullet fishery is described elsewhere in this paper. Maximum size, 10 pounds; average size among Florida keys, 1½ pounds.

Range.—Widely distributed. Coasts of southern Europe and northern Africa; Atlantic coast of America from Casco Bay (Me.) to Brazil, and in the Pacific from Monterey to Chile. Abundant from Virginia to Texas.

6. **Sphyræna barracuda** (Walbaum). Barracuda; Picuda.

The barracuda is rather common among the Florida keys, where it is taken throughout the year, generally by trolling. It is a game fish of some merit and is much sought after by sportsmen. It is a large voracious fish, attacking prey larger than itself, and is much feared by bathers. At Key West it is a food fish of some importance, although its flesh is considered inferior. It is not sold in large quantities, but as many as 2 dozen may be seen in the market on certain days during the winter. Maximum size, about 8 feet; average, about 4 feet.

Range.—Cape Cod to Bahia, Brazil; Bermuda; Gulf of Mexico, north to Pensacola. Generally common in the West Indies and among the Florida keys; not common north of Florida.

7. **Upeneus maculatus** (Bloch). Red goatfish.

The goatfish is comparatively rare along the Florida keys, but is occasionally seen among the smaller fishes brought in by the hand-

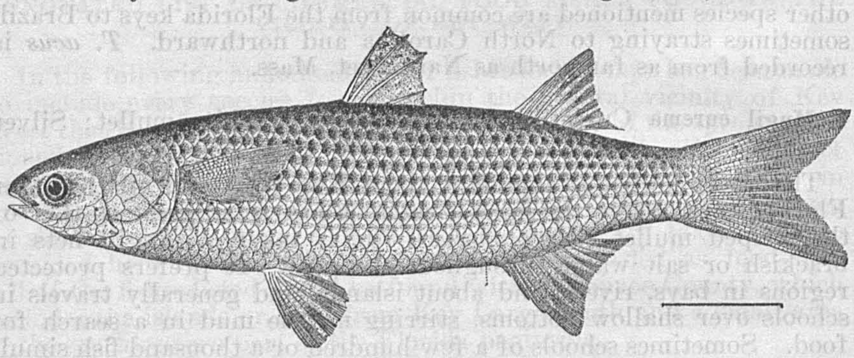

FIG. 2.—Striped mullet (*Mugil cephalus*).

line fishermen. In Porto Rico it is a food fish of considerable importance. Maximum size, about 12 inches; average, about 9 inches.

Range.—North Carolina to the West Indies; Bermuda, Cuba, Porto Rico, and Martinique. Rare north of Key West.

8. **Sarda sarda** (Bloch). Bonito.

The bonito is taken as a straggler along with the Spanish mackerel. It is a pelagic species inhabiting the Atlantic Ocean and is found both in Europe and in this country. It is a food fish of some importance, although inferior to the mackerel. The annual catch along the Florida keys is negligible. The maximum weight is about 15 pounds; average, 3 pounds.

Range.—Atlantic Ocean. Found along the European coast and on the North American coast from Casco Bay (Me.) to Florida, or perhaps farther south; not definitely recorded from Central or South America.

9. **Scomberomorus maculatus** (Mitchell). Spanish mackerel.

The Spanish mackerel is now the most valuable food fish taken in the immediate vicinity of Key West. However, it is only during recent years that large numbers have been caught in southern Florida. It is taken from November to April in this locality and is caught with gill nets, purse seines, and hook and line. It is one of the choicest food fishes taken on the Atlantic coast. A description of the fishery is included elsewhere in this paper. Maximum size, 25 pounds, which, however, is very exceptional, as individuals weighing 10 pounds are rare; average size of Key West fish, 2 pounds.

Range.—Monhegan (Me.) to Brazil. Not common north of Maryland. Small quantities taken in lower Chesapeake Bay from June until October; rather common off the North Carolina coast from May until October; most abundant in southern Florida. Distributed throughout the Gulf of Mexico, where its movements are irregular. Recorded from Jamaica, Porto Rico, and Panama. In Cuba it is rare. Found also on the Pacific coast from California southward.

10. **Scomberomorus regalis** (Bloch). Kingfish; Cero; Spotted cero; Sierra; Pintado.

The sierra, or kingfish, is a food fish of considerable importance among the Florida keys, but is somewhat less common than *S. cavalla*, with which it is closely associated. It is caught exclusively by trolling from motor or sail boats. The fishing season for this species extends from November to March. The kingfish fishery is described elsewhere in this paper. Maximum weight, about 35 pounds; average, about 5 pounds.

Range.—Monomoy (Mass.) to Brazil. Uncommon north of Florida; known from Cuba, Jamaica, Martinique, and Porto Rico.

11. **Scomberomorus cavalla** (Cuvier). Kingfish; Cero; Cavalla; Sierra.

This species is taken during the same season and under the same conditions as is the sierra (*S. regalis*), but because of its larger size and somewhat greater abundance it is the more important of the two. Considerable confusion has arisen over the common names of these two species, and the terms used appear to be interchangeable. As a rule, however, in the Key West markets *S. regalis* is known as "kingfish" or "sierra," while *S. cavalla* is called "kingfish" or "cero." Maximum weight about 75 pounds, but examples over 50 pounds are comparatively rare. Notwithstanding the many large fish caught, the average weight is only about 7 pounds.

Range.—Cape Cod to Africa and Brazil. Not common north of North Carolina; found in open seas of tropical Atlantic.

12. **Seriola dumerili** (Risso). Amberfish; Amber jack.

The amber jack is caught about Key West by trolling and is taken incidentally only during the winter along with the kingfish. It is considered a fine game fish. Its occurrence is irregular, and it appears never to be taken in large numbers in this region. Several hundred were brought to the Key West market during one week in January, 1919, and 35 fish were seen during the last week of February of the same year. The fish taken near Key West generally weigh from 20 to 70 pounds. In the markets the fish are dressed and cut into steaks for the local trade. Maximum weight, about 100 pounds; average, about 35 pounds.

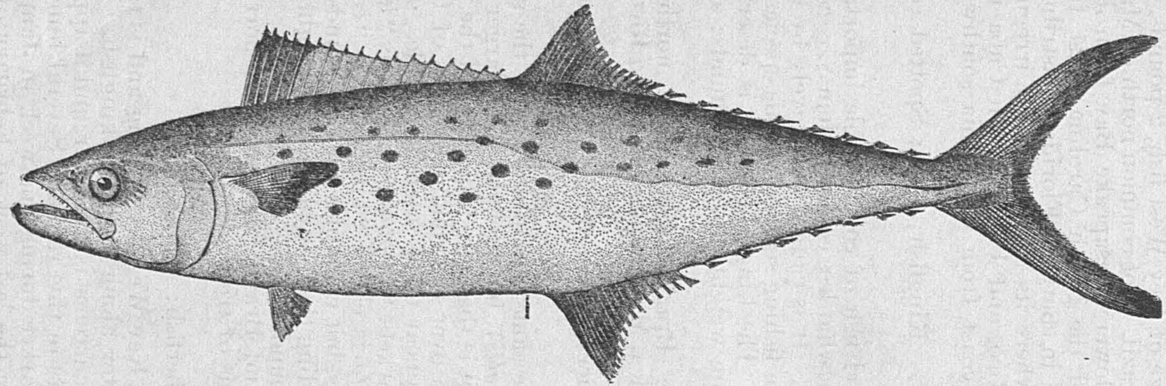

FIG. 3.—Spanish mackerel (*Scomberomorus maculatus*).

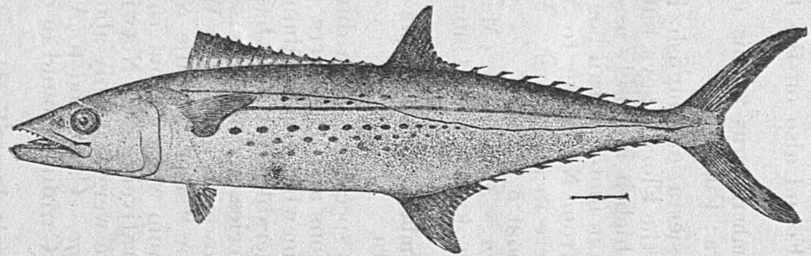

FIG. 4.—Kingfish, or sierra (*Scomberomorus regalis*).

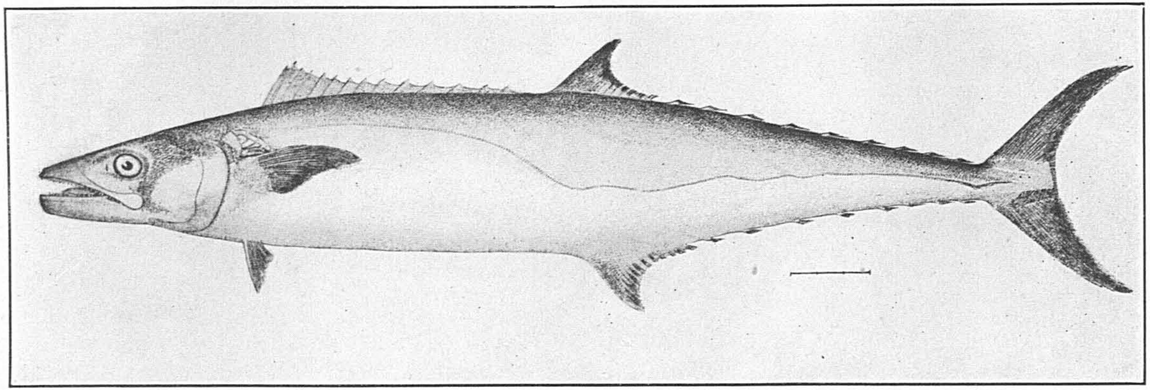

FIG. 5.—Kingfish, or cero (*Scomberomorus cavalla*).

With regard to this species the following is stated in "Fishes of Panama," by Meek and Hildebrand, now in press: "A study of material available in the National Museum indicates that this genus is in need of revision. We have included *Seriola lalandi* in our synonymy, believing it to be identical with the present species. There is a difference in the depth of body, but this appears to be only a variation among individuals. It also seems probable that the banded forms may yet prove to be the young of this species."

Range.—Cape Cod to Africa and Brazil. Not common north of North Carolina; found in open seas of tropical Atlantic.

13. **Decapterus punctatus** (Agassiz). Scad; Cigar-fish.

The scad is said to be rather common on the coasts of Florida, but its appearance in the Key West markets is only occasional. The annual catch does not exceed a few hundred pounds. The maximum size is not definitely known, but probably does not exceed 2 pounds, with an average of one-half pound.

Range.—Woods Hole (Mass.) to Brazil. Common in Bermuda and West Indies; small fish sometimes rather common about Woods Hole, Mass., and Long Island, N. Y.

14. **Selar crumenopthalmus** (Bloch). Big-eyed scad.

This fish is not common in the Key West markets. It is taken from time to time by the hook-and-line fishermen and is considered a fair food fish. Maximum weight, about 8 pounds; average, 1 pound.

Range.—Both coasts of tropical America and in tropical seas generally; on the Atlantic coast it is extremely rare north of southern Florida.

15. **Caranx bartholomæi** Cuvier and Valenciennes. Yellow jack.

This species is less abundant than the several other species of "jacks" commonly seen in the fish markets at Key West. It is common in the West Indies. The maximum weight is not definitely known, but it probably does not exceed 3 pounds; average, one-half pound.

Range.—Usual range Florida to West Indies and Panama. Known from Porto Rico, but not common there; common in Cuba; rare north of Florida, but sometimes straying to Woods Hole, Mass.

16. **Caranx hippos** (Linnæus). Jack; Runner; Crevalle.

This species is the most abundant of the various species of "jacks" or "runners" that are found about Key West. It is a good food fish and commands a ready sale in the markets. Fish weighing 5 or 6 pounds are not rare. It is taken by bottom fishing or by trolling and is worthy of mention as a game fish. It is found throughout the year, but is most common during the winter. Its maximum weight is 20 pounds, but it seldom weighs more than 10 pounds, and its average is 1 pound.

Range.—Both coasts of tropical America, north to Lynn, Mass., and Lower California; East Indies.

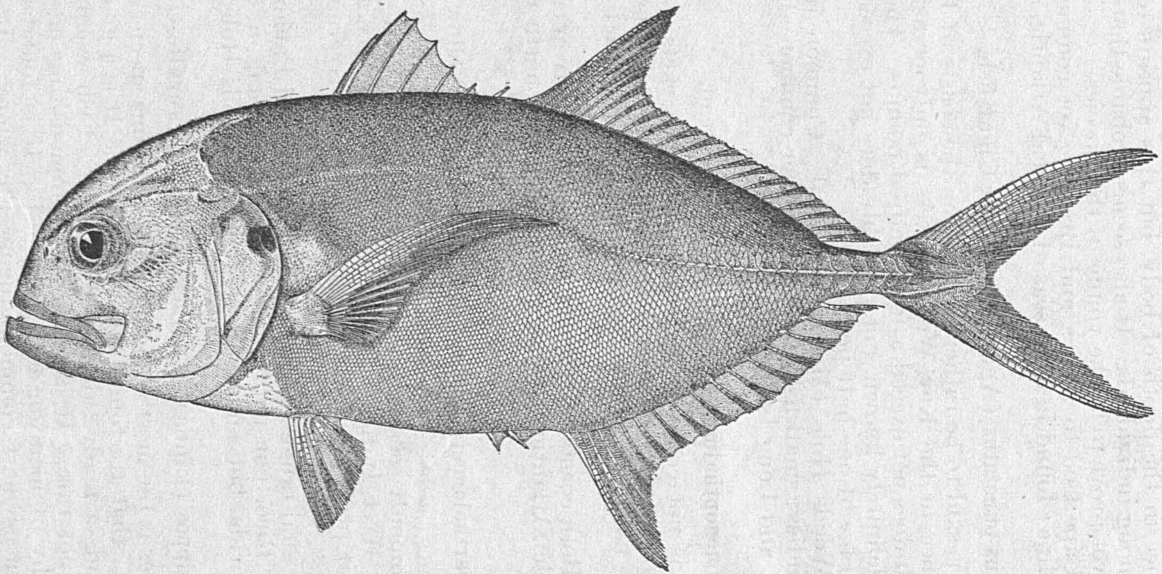

FIG. 6.—Jack (*Caranx hippos*).

17. **Caranx crysos** (Mitchill). Hard-tail; Jurel; Runner; Jack; Crevalle.

This species is taken throughout the year about Key West under the same conditions as is *C. hippos*. It is a food fish of importance locally but is smaller in size than *C. hippos*. Large numbers of half-pound fish are commonly found in the live cars about the fish wharves. Maximum weight, about 3 pounds; average, one-half pound.

Range.—Ipswitch Bay (Mass.) to Brazil. Common south of Maryland, entering lower Chesapeake Bay, where it rarely takes the hook but is rather common in pound-net catches.

18. **Caranx latus** Agassiz. Horse-eye jack; Jurel; Runner.

This species is less common about Key West than *C. hippos* or *C. crysos*. It is taken in small numbers by trolling, and sometimes a small school is captured in a Spanish-mackerel net. As a food fish it is not as highly regarded as the other species of Caranx. The maximum size is not known, but the average is not over one-half pound at Key West.

Range.—Virginia to Brazil.

19. **Vomer setipinnis** (Mitchill). Moonfish.

This little fish is caught very infrequently and only during the winter. It is taken on the bottom with hook and line and is esteemed as a food fish. The maximum weight is about 1 pound, and the average is one-third of a pound.

Range.—Halifax (Nova Scotia) to Uruguay; not common north of Virginia. The young are common in lower Chesapeake Bay during the summer and fall.

20. **Selene vomer** (Linnæus). Moonfish; Lookdown.

This species is often confused with *Vomer setipinnis* but may be distinguished from the latter at a glance by the prolongation of the first rays of the dorsal and anal fins. Around Key West it is somewhat more plentiful than Vomer. It is taken chiefly in the winter and is highly esteemed as a food fish. The annual catch is very small. Maximum weight, about 2 pounds; average, one-half pound.

Range.—Casco Bay (Me.) to Uruguay; not common north of Chesapeake Bay.

21. **Trachinotus glaucus** (Bloch). Gaff-topsail pompano.

This species is seldom taken at Key West and is confused by fishermen with other species of pompano. It may be identified by the long anterior rays of the soft dorsal and anal and by the presence of four black vertical bars on the back and sides. It is utilized for food, but the annual catch is negligible. Maximum weight, about 2 pounds; average, one-half pound.

Range.—Virginia to Panama; generally common along east coast of Florida and in Porto Rico.

22. **Trachinotus falcatus** (Linnæus). Round pompano.

This species, like *T. glaucus*, is seldom seen in the Key West markets. The few fish caught are called "pompano" and are utilized for food. Maximum weight about 3 pounds; average, one-half pound.

Range.—Woods Hole (Mass.) to Brazil. Adults not common north of Florida; young, 1 to 2 inches long, taken in southern Massachusetts and lower Chesapeake Bay, whence they are transported by the Gulf Stream. Rather common in Bermuda.

23. **Trachinotus goodei** Jordan and Evermann. Great pompano; Permit.

The great pompano is taken with hook and line near Key West during the winter. The annual catch, however, is small. It is a fair food fish, but inferior to the common pompano (*T. carolinus*). Maximum weight, about 40 pounds; average, 8 pounds.

Range.—Usual range North Carolina to West Indies; rare north of Florida. The young (about 3 inches long) have been recorded from Woods Hole, Mass.

24. **Trachinotus carolinus** (Linnæus). Common pompano.

This species is the most valuable of the pompanos and is considered one of the choicest of all salt-water fishes. About Key West it is taken in small numbers during the winter, but the annual catch is small. It is more common along both coasts of Florida, preferring sandy bottom, where it feeds near shore on small mollusks and crustaceans. At Key West it is taken with hook and line and, incidentally, in mullet seines. It always commands a high price and is esteemed for its rich flavor in all parts of its range. Maximum weight, 8 pounds; average, 1½ pounds.

Range.—Woods Hole, Mass., along the South Atlantic coast and Gulf of Mexico to Brazil. Not common north of Chesapeake Bay, in the West Indies, or Brazil.

25. **Pomatomus saltatrix** (Linnæus). Bluefish.

The bluefish is taken along the Florida keys only during the winter—generally between December 15 and February 15. A few are caught by trolling, but the greater part of the catch is taken along with the Spanish mackerel in gill nets or purse seines. During the past 10 years the annual catch has been from 10,000 to 15,000 pounds. The entire catch is shipped to New York, where it commands a high price, for fresh bluefish are scarce in northern markets during the winter. The bluefish is one of the best American food fishes. Its maximum weight is given as 27 pounds, but examples weighing more than 12 pounds are uncommon. The usual weight of the Key West fish is between 2 and 4 pounds, while 6 pounds is about the maximum.

Range.—Wide distribution; Atlantic and Indian Oceans; occasionally enters the Mediterranean Sea; Malay Archipelago; Australia; Cape of Good Hope; Natal; Madagascar. Not recorded from the Atlantic coast of Europe or from Bermuda. On our coast it has been recorded as far north as Mount Desert, Me.

26. **Rachycentron canadus** (Linnæus). Sergeant fish; Crab-eater; Black bonito.

This species is rarely caught along the Florida keys. It is a good food fish and has some commercial importance in the West Indies and along our Middle and South Atlantic States. It is taken with hook and line on rocky bottom, generally in 40 to 80 feet of water. In Chesapeake Bay, where it is called "black bonito," it is caught in small numbers from May until October, but it is most abundant during June. The largest fish recorded weighed 84 pounds and was taken in Chesapeake Bay during June, 1921. The average weight is about 10 pounds.

Range.—New Jersey to Brazil; East Indies.

27. **Centropomus undecimalis** (Bloch). Snook; Rabalo; Sergeant fish.

The snook is rarely taken in the immediate vicinity of Key West, but is common on the southwest coast of Florida, where it is one of the principal game fish taken during the winter. There it is taken by trolling, close to shore, from a rowboat that is operated as noislessly as possible. At Fort Meyers and Marco large snook are fre-

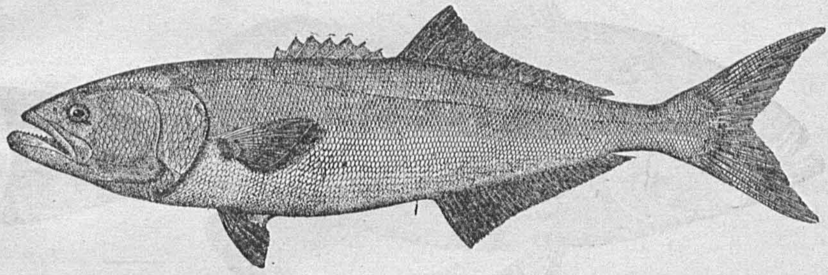

FIG. 7.—Bluefish (*Pomatomus saltatrix*).

quently seen swimming within a few feet of the shore. It ascends streams but does not stray far from brackish water. The snook is rather uncommon among the Florida keys and is too scarce in the Key West markets to be of local commercial importance. It is considered a fair food fish. The maximum weight is about 30 pounds, while the average is about 3 pounds.

Range.—Atlantic coast of tropical America. Recorded from Florida; Porto Rico; Cuba; Haiti; Jamaica; Martinique; Barbados; Vera Cruz, Mexico; Belize, British Honduras; Toro Point, Colon, Mindi, New Gatun, and Porto Bello, Panama; British Guiana; French Guiana; and Bahia, Sao Mathews, and Rio Janeiro, Brazil. (Meek and Hildebrand.)

28. **Epinephelus adscensionis** (Osbeck). Rock hind; Cabra mora.

This beautiful species is less common than most of the other groupers found about Key West. Its habitat is restricted to rocky bottoms in rather deep water, and it is seldom caught on shallow reefs along with grunts and snappers. Generally not more than half a dozen are to be seen on any one day at the fish markets, but when a deep-water fisherman comes to port this fish is usually well represented in his catch. In Key West it is esteemed as a food fish. Maximum weight, about 15 pounds; average, 2 pounds.

Range.—Usual range southern Florida to Brazil. Known from Ascension and St. Helena Islands and Cape of Good Hope; rare north of Miami. The young are reported from Katama Bay, Mass.

29. **Epinephelus striatus** (Bloch). Nassau grouper; Cherna criolla.

This grouper is one of the large and important food fishes of Key West. It is caught on the bottom with hook and line and is taken throughout the year. Market fish are seldom found in water less than 30 feet in depth. Very small examples of about 1 pound are seldom seen, and most of the market fish range from 3 to 35 pounds. Large fish will live for some time in the live cars attached to the wharves. The Nassau grouper closely resembles the red grouper (*E. morio*), but it is easily separated from the latter by the presence of a persistent black spot between the dorsal and upper part of the tail fin. Maximum weight, about 50 pounds; average, 5 pounds.

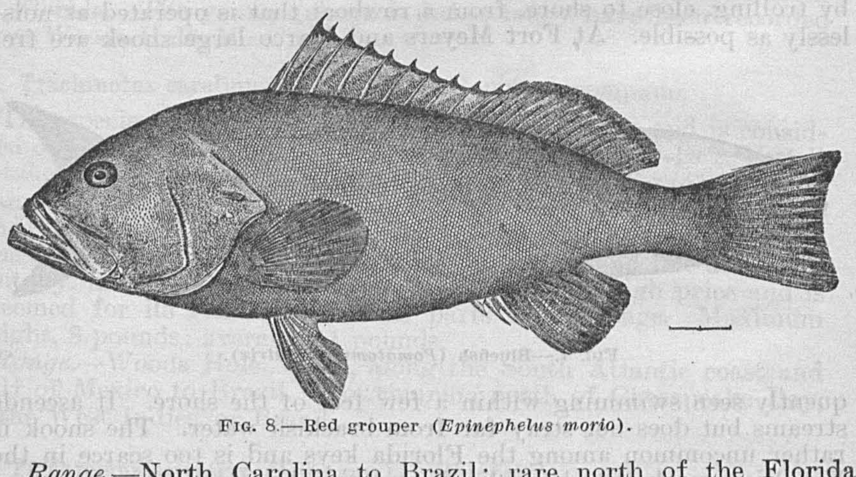

FIG. 8.—Red grouper (*Epinephelus morio*).

Range.—North Carolina to Brazil; rare north of the Florida keys; common in Porto Rico and Bermuda.

30. **Epinephelus guttatus** (Linnæus). Red hind.

This is one of the most strikingly colored of the groupers, the body being marked everywhere with vivid scarlet spots. It is fairly common among the Florida keys and is a valuable market species, although much less so than the red grouper. It is caught with hook and line at moderate depths. Maximum weight, about 5 pounds; average, 2 pounds.

Range.—South Carolina, Florida, Bermuda, throughout the West Indies to Brazil.

31. **Epinephelus morio** (Cuvier and Valenciennes). Red grouper.

The red grouper is the most abundant and best known of the Key West groupers. It is most common during the winter, but is taken throughout the year on rocky, coral, and grassy bottoms. This fish is widely distributed over the fishing grounds and may be taken in

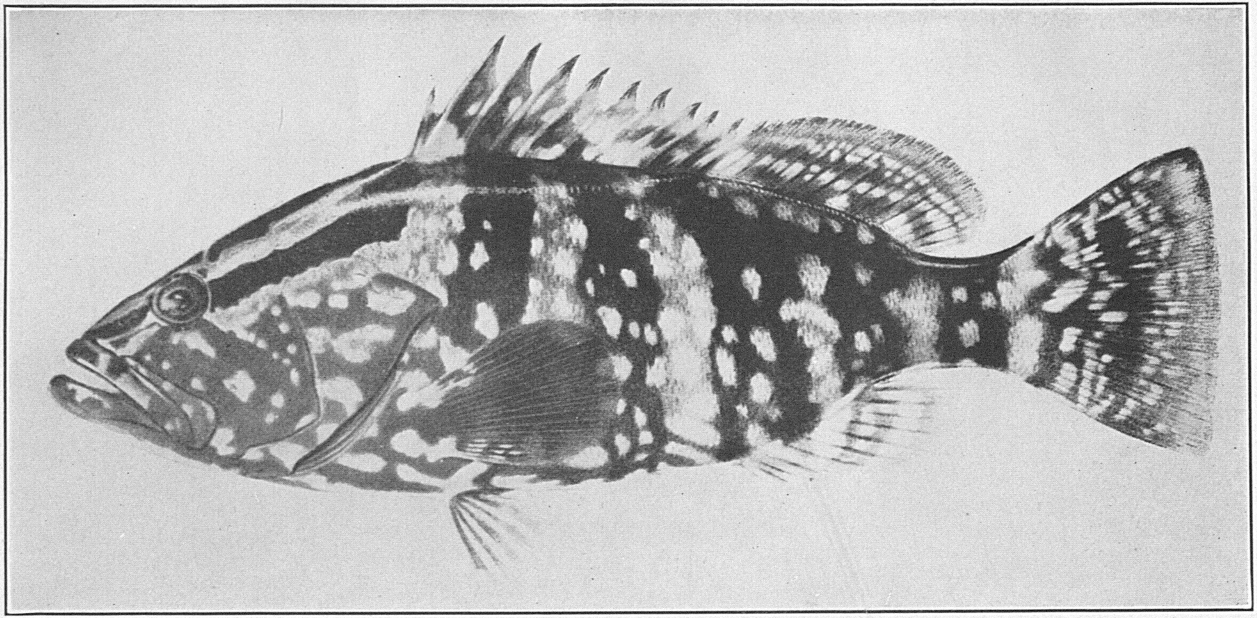

FIG. ~~8~~ 9.—Nassau grouper (*Epinelphelus striatus*).

from 10 to 20 feet of water along with grunts, porgies, etc., or it may be caught on the deeper rocky reefs. The fish taken in shallow water usually are small, weighing from one-half to 2 pounds, while those from deeper water generally range from 2 to 15 pounds. Fish weighing more than 20 pounds are not common. The red grouper bears transportation well and is shipped north and to Cuba. It will live for long periods in live cars and fish wells and is one of the favorite food fishes of Key West. Maximum weight, 40 pounds; average, 5 pounds.

Range.—Massachusetts to Brazil; common in the Gulf of Mexico and at Bermuda; uncommon north of Florida, and found only as a rare straggler north of North Carolina.

32. **Epinephelus nigritus** (Holbrook). Black jewfish.

This large grouper is reported as fairly common off the coast of Florida, but it is rarely seen in the Key West markets. Maximum weight, 500 pounds.

Range.—South Carolina to Brazil; Mediterranean Sea.

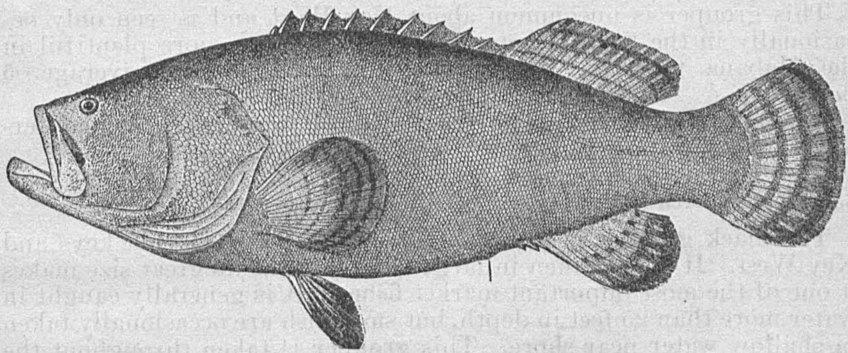

FIG. 10.—Spotted jewfish (*Promicrops itaiara*).

33. **Promicrops itaiara** (Lichtenstein). Jewfish; Spotted jewfish.

The spotted jewfish is the largest food fish caught in the vicinity of Key West and is one of the largest of all fishes. This fish is not plentiful in the Key West region in point of numbers, but because of the large size attained the comparatively few fish taken are of some commercial importance. During the greater part of the years 1918 and 1919 from two to six jewfish were brought to the Key West market each week. Spawning occurs during July and August, when the fish become gregarious and are caught in greatest numbers. During six weeks of July and August, 1918, there were brought to market 74 jewfish, ranging in weight from 35 to 350 pounds, with a mean average of 125 pounds. Nearly all of these were taken off Knights Key, about 40 miles above Key West.

The jewfish is caught with hook and line on very strong tackle. Regardless of its large size, it is placed in the well of the boat after capture and is brought to market alive. At the market the fish are transferred to commodious live cars, and as an extra precaution to preclude their escape, a large hook is placed in the mouth of each big fish and each is securely hitched to a pile by means of a strong line. The fish are removed from the live cars as wanted. When the fish are dressed, the scales are shaved off with a sharp knife, and the flesh is cut into steaks and strips. The flesh sells for about 20 cents a pound and always finds a ready sale, the entire catch being consumed locally.

The jewfish prefers moderately deep water with rocky or coral bottom. Small individuals weighing from 1 to 10 pounds, however, are frequently taken in shallow water close to shore. The species is particularly common on the southwest coast of Florida. The largest fish of which there is a reliable record weighed, according to a measurement formula, 693 pounds. This fish was caught with shark tackle on January 23, 1923, about 35 miles south of Miami, and it was 8 feet long and 6 feet 4 inches in girth.

Range.—Both coasts of tropical America, north to Florida and the Gulf of California.

34. **Mycteroperca venenosa** (Linnæus). Yellow-finned grouper; Yellow grouper.

This grouper is uncommon about Key West and is seen only occasionally in the fish markets, but it is somewhat more plentiful in the Habana markets. Maximum weight, 20 pounds; average, 5 pounds.

Range.—North Carolina to the Bahamas; southern Florida, Bermuda, and the West Indies; rare north of Miami.

35. **Mycteroperca bonaci** (Poey). Black grouper.

The black grouper is rather common about the Florida keys and Key West. It is not taken in large numbers, but its great size makes it one of the most important market fishes. It is generally caught in water more than 25 feet in depth, but small fish are occasionally taken in shallow water near shore. This grouper is taken throughout the year, but it is most common during February, March, and April. The usual market fish weigh from 5 to 50 pounds; fish weighing more than 50 pounds are uncommon though not rare. Large or small fish can be kept in live cars for long periods. Maximum weight, about 100 pounds; average, 10 pounds.

Range.—Usual range Florida to Brazil. The young have been carried by the Gulf Stream as far north as Woods Hole, Mass.

36. **Mycteroperca microlepis** (Goode and Bean). Gag.

This species is rather common about Key West and may be caught there throughout the year. It is generally taken on the shallow reefs in 10 to 25 feet of water and on rocky, coral, or grassy bottoms. When hooked, it puts up a somewhat better fight than do most of the other groupers. It is a good food fish. Maximum weight, 20 pounds; average, 1½ pounds. Fish weighing more than 10 pounds are rare, and the weight of the market fish usually ranges from one-half to 3 pounds.

Range.—Beaufort (N. C.) to Florida; on the Gulf coast to Pensacola.

37. **Mycteröperca falcata phenax** Jordan and Swain. Scamp.

This species is rather common about the Florida keys, although much less so than the red grouper. It is caught with hook and line and is present in the markets throughout most of the year. Another species (*M. falcata*) closely resembling this one is common in the Habana markets. As a food fish it is well regarded and ranks higher than many of the other groupers. Maximum weight, 10 pounds; average, 2 pounds.

Range.—Southern Florida.

38. **Lobotes surinamensis** (Bloch). Triple-tail.

This fish is rare at Key West but occasionally is seen in the markets. A 20-pound individual was observed in the market during January, 1919, and was considered an oddity by the fishermen, who had no name for it. The triple-tail is considered a good food fish, but it is not common anywhere. A specimen 6 inches long was caught near the Bureau of Fisheries' biological station at Key West. Maximum weight, about 35 pounds; average, 8 pounds.

Range.—Massachusetts south to Uruguay; taken sparingly in lower Chesapeake Bay pound nets, where it is called "strawberry bass."

39. **Lutianus griseus** (Linnæus). Gray snapper; Mangrove snapper.

The gray snapper is the most abundant species of snapper found at Key West. The fish always travel in schools, generally containing from a few hundred to a thousand fish of various sizes, and prefer the sloping ledges of reefs and channel ways. If not alarmed, they will hover in one place for hours and afford a beautiful sight in the clear water. Under certain conditions it is extremely difficult to catch adult gray snappers with hook and line, but fish of less than 6 inches are less wary and can be taken without difficulty. Many attempts to catch one were made by the writer, with various lures. Pieces of bait thrown into the water were readily taken by the larger fish, but as soon as fishing tackle was introduced the fish looked askance at the bait and kept their distance. A tiny hook and black sewing thread were tried without much success. The best snapper fishing was found to occur when the weather was cloudy and the water not very clear.

This snapper has the peculiar habit of lying in a few inches of water among the roots of the mangroves, especially where the tide flows swiftly between small islands, hence the name "mangrove snapper." The writer has found five or six fish within half an hour under such conditions.

The gray snapper is an abundant species but because of its wariness is not caught in large quantities by the fishermen. Enough are caught, however, to make it an important market species. It is a good food fish and is taken throughout the year. It is caught along the west coast of Florida as far north as Bay County and is especially common on the southwest coast. It is also found along the east coast of Florida and as far north as Woods Hole, Mass. It is rare above North Carolina, however. Market fish usually range in weight from one-half to 5 pounds. Large fish weighing fully 10

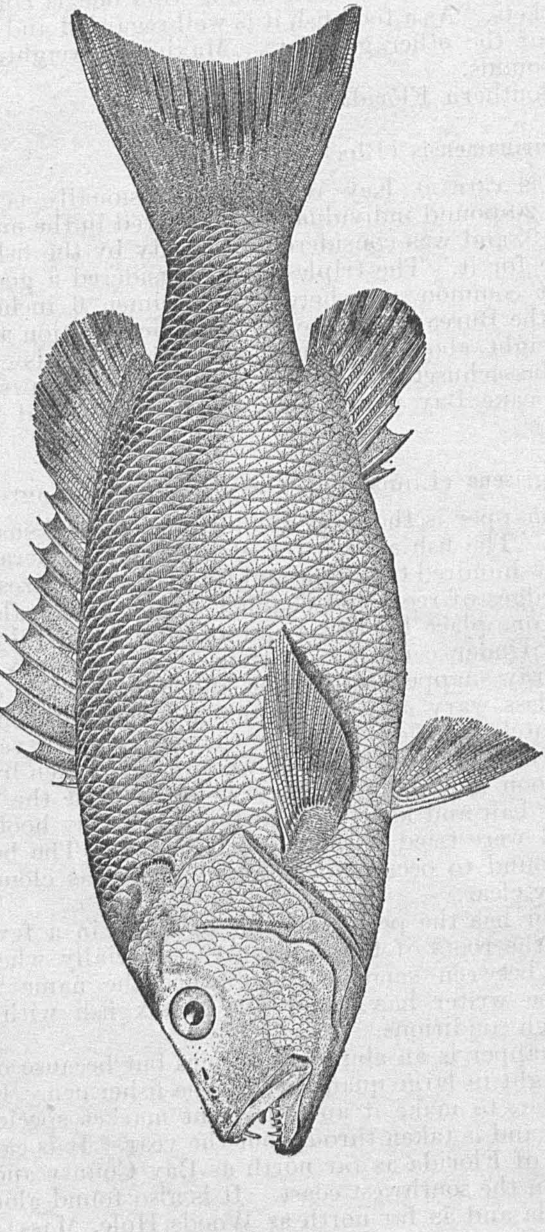

FIG. 11.—Gray snapper (*Lutianus griseus*).

pounds are often seen in the water, but fish of this size are seldom caught. The maximum weight is said to be 18 pounds.

Range.—Usual range both coasts of Florida to the West Indies. The young, a few inches long, have been recorded from North Carolina, lower Chesapeake Bay, New Jersey, Rhode Island, and Woods Hole, Mass.; common in Bermuda.

40. **Lutianus jocu** (Bloch and Schneider). Dog snapper.

This snapper is not common about the Florida keys. It is caught chiefly in the fall and winter, and only an occasional fish is seen throughout the summer. It is taken with hook and line along with other snappers and grunts and is a good food fish. Maximum weight, 20 pounds; average, 2 pounds.

Range.—Usual range Miami to Bahia, Brazil. The young have been taken at Woods Hole, Mass.

41. **Lutianus apodus** (Walbaum). Schoolmaster.

This species is rather common in the vicinity of Key West, but its commercial value is relatively small. The young are abundant about the shores of Key West and all the Florida keys. Small fish are sometimes found lying motionless at the base of rocks close to shore. Fish of about one-third to one-half pound are taken on the shallow reefs along with grunts, porgies, etc. Larger fish, weighing 2 to 6 pounds, are taken in small numbers in deeper water. Maximum weight, 8 pounds; average, three-fourths of a pound.

Range.—Usual range Florida to Bahia, Brazil; Bermuda. It occurs as a straggler north of Florida. The young have been taken at Beaufort, N. C., and Woods Hole, Mass.

42. **Lutianus aya** (Bloch). Red snapper.

The red snapper is one of the most abundant and valuable fish caught within the State of Florida, but near Key West it is comparatively scarce. At times a few are taken in deep channels near certain of the keys. Several million pounds are caught annually in the Gulf of Mexico, where the greater part of the catch is landed at Pensacola. It is caught with hand lines in 15 to 50 fathoms of water, and the bait used generally consists of pieces of meat or fish. The red snapper bears transportation well and is shipped to all the important fish markets of the north. It is considered a choice food fish. Maximum weight, 79 pounds; average, 6 pounds.

Range.—Woods Hole (Mass.) to Brazil; Bermuda; rare north of North Carolina; taken in commercial quantities off Cape Fear (N. C.), Georgia, eastern Florida, Gulf of Mexico, Porto Rico, and Central America.

43. **Lutianus analis** (Cuvier and Valenciennes). Muttonfish; Pargo.

The muttonfish is one of the most important species of snappers caught about Key West, ranking close to the yellowtail (*Ocyurus chrysurus*). It is found throughout the year but is scarcest during July and August, which is the spawning period and at which time it schools. The muttonfish is an excellent food fish and is always in demand. It takes the baited hook freely and is quite gamey. Near Key West it is taken on rocky or coral bottom in 3 to 9 fathoms of water, but small fish of one-half to 2 pounds are sometimes taken on the shallow reefs, in 2 to 4 fathoms, along with grunts, porgies, etc. The average size of deep-water fish is about 3 pounds, but examples weighing 15 and 20 pounds are not rare. It is reported that a 25-pound fish was caught off the railroad pier at Key West by an angler using rod and reel. Maximum weight, 25 pounds; average, 3 pounds.

Range.—Usual range both coasts of Florida to Brazil. The young have been recorded from Beaufort, N. C., and Woods Hole, Mass.

44. **Lutianus synagris** (Linnæus). Lane snapper; Red-tailed snapper.

The lane snapper is a beautiful and abundant fish about Key West. It is usually caught on rocky, coral, or grassy bottoms in water ranging in depth from 2 to 6 fathoms. It is found in company with various species of grunts, porgies, snappers, and groupers. Although the average size is only about one-half pound, it is rather gamey when hooked. It is caught in greatest numbers during the winter and spring. Spawning is said to take place in October, at which time the fish gather in schools. Maximum weight, 4 pounds; average, one-half pound.

Range.—Pensacola and Indian River, Fla., southward to Brazil; known from the Bahamas, Cuba, Martinique, Jamaica, Santo Domingo, Porto Rico, and Panama.

45. **Ocyurus chrysurus** (Bloch). Yellowtail; Rabirubia.

The yellowtail is perhaps the most important of all the snappers found about Key West. It is one of the most esteemed of the local fishes and is abundant throughout the year excepting during the winter when the cold drives it away to deeper water. It may be caught at depths of 2 or more fathoms, and it is especially abundant on the rocky edges of the outer reefs near Key West. This fish is rather gamey and is caught with crawfish or sardine bait. Fish weighing 3 and 4 pounds are not uncommon; the maximum size is 6 pounds and the average 1 pound.

Range.—Usual range southern Florida to Brazil; known from Bermuda, Cuba, Martinique, St. Kitts, Jamaica, Porto Rico, and Brazil. The young are recorded from Katama Bay, Mass.

46. **Hæmulon album** Cuvier and Valenciennes. Margate fish; Margaret grunt.

This species is not as common about Key West as are several other grunts, but is one of the largest of the grunts and a good food fish. It is taken in rather deep water on rock or coral reefs. Spawning occurs during the early summer. Its food consists chiefly of crabs, crawfish, worms, etc. Maximum weight, 10 pounds; average, 2 pounds.

Range.—Southern Florida to Brazil; reported from Bermuda, the Bahamas, Habana, Jamaica, Porto Rico, and St. Thomas.

47. **Hæmulon macrostomum** Günther. Gray grunt; Striped grunt.

This grunt is common among the Florida Keys but because of its small size is considerably less important than various larger species. Young fish 4 to 6 inches long are sometimes abundant close to shore

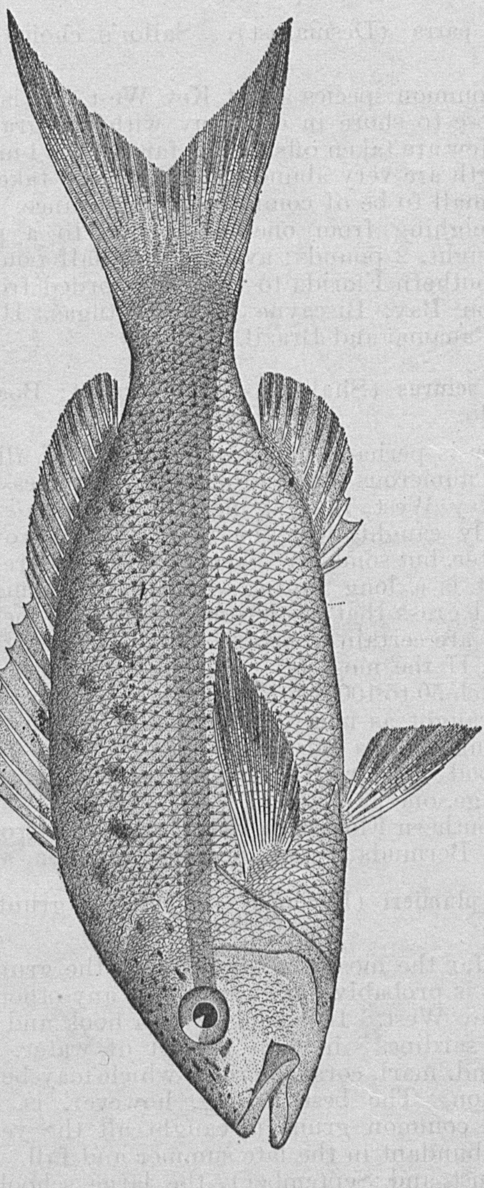

FIG. 12.—Yellow-tail (*Ocyurus chrysurus*).

in shallow water. Like all the grunts, it is caught with hook and line, and fish taken for market purposes are at least 7 inches long. Maximum weight, 1 pound; average, one-third pound.

Range.—Southern Florida to Panama; known from Bermuda, Jamaica, St. Thomas, Porto Rico, and Panama.

48. **Hæmulon parra** (Desmarest). Sailor's choice; Grunt; Ronco prieto.

This is a common species about Key West. It is generally found in schools close to shore in company with the gray snapper. Apparently but few are taken offshore as far as even 1 mile. Fish 5 and 6 inches in length are very abundant and readily take the baited hook but are too small to be of commercial importance. However, many are taken weighing from one-half pound to a pound, or more. Maximum weight, 2 pounds; average, one-half pound.

Range.—Southern Florida to Brazil; recorded from Cards Sound, Marco, Lemon Bay, Biscayne Bay, Tortugas, Habana, Jamaica, Porto Rico, Panama, and Brazil.

49. **Hæmulon sciurus** (Shaw). Yellow grunt; Boar grunt; Ronco amarillo.

This species is perhaps the most beautiful of all the grunts and is marked by numerous longitudinal yellow stripes. It is very common about Key West, ranking next to *H. plumieri* in abundance. It is generally caught near the roots of mangrove trees in 6 to 15 feet of water, but some are taken farther offshore on hard bottom. The best bait is a long worm, which the fishermen get from the stem of a tall grass that grows on certain bars near shore. These "podworms" are certain to attract yellow grunts if there are any in the vicinity. If the most favorable places to fish are known, it is possible to catch 50 to 100 fish in a few hours. One fisherman reports that he has caught as many as 600 yellow grunts in a single day. The best fishing obtains during the summer. The yellow grunt is an important food fish in Key West. Maximum weight, about 1 pound; average, one-half pound.

Range.—Southern Florida to Brazil; recorded from Biscayne Bay, the Tortugas, Bermuda, Cuba, Jamaica, Panama, and Bahia.

50. **Hæmulon plumieri** (Lacépède). Common grunt; White grunt; Ronco.

This is by far the most abundant of all the grunts, and in point of numbers it is probably not exceeded by any other food fish in the vicinity of Key West. It is caught with hook and line baited with crawfish or "sardines" in 8 to 40 feet of water. It is found on bottoms of sand, marl, coral, or rock, which may be open or covered with vegetation. The best fishing, however, is found on rocky bottom. The common grunt is caught all the year round but is particularly abundant in the late summer and fall. After spawning (during August and September), the large schools break up and scatter but the fish are usually found in small schools on the bottom. Maximum weight, 3 pounds; average, one-third to one-half pound.

Range.—Cape Hatteras and Pensacola to Brazil; recorded from Panama.

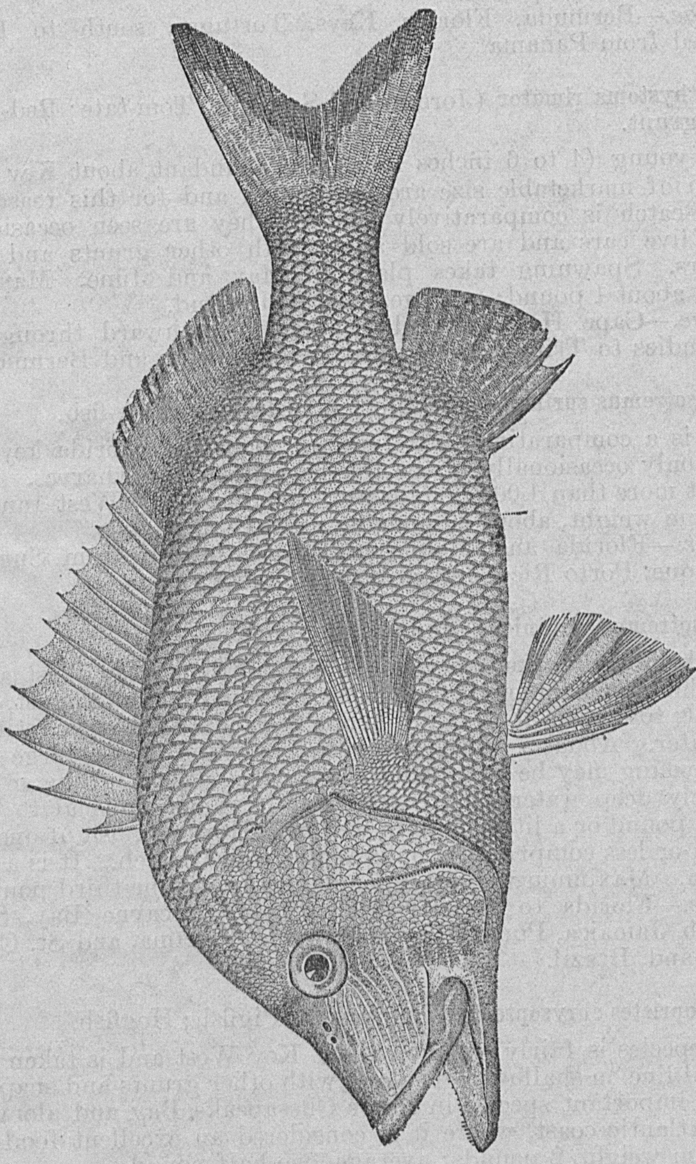

FIG. 13.—Common grunt (*Hæmulon plumieri*).

51. **Hæmulon flavolineatum** (Desmarest). French grunt; Ronco condenado.

This little grunt is not very common at Key West and is only occasionally seen in the fish wells. Maximum weight, 1 pound; average, one-third pound.

Range.—Bermuda, Florida Keys, Tortugas, south to Brazil; recorded from Panama.

52. **Bathystoma rimator** (Jordan and Swain). Tom-tate; Red-mouth grunt.

The young (4 to 6 inches long) are abundant about Key West, but fish of marketable size are uncommon and for this reason the annual catch is comparatively small. They are seen occasionally in the live cars and are sold along with other grunts and small snappers. Spawning takes place in May and June. Maximum weight, about 1 pound; average, one-third pound.

Range.—Cape Hatteras and Pensacola, southward through the West Indies to Trinidad; recorded from Panama and Bermuda.

53. **Anisotremus surinamensis** (Bloch). Black margate-fish.

This is a comparatively rare species about the Florida keys and is seen only occasionally in the live cars about the wharves. Probably not more than 1,000 pounds are brought to Key West annually. Maximum weight, about 20 pounds; average, 2 pounds.

Range.—Florida and Mobile to Brazil; known from Surinam, Martinique, Porto Rico, Jamaica, Cuba, and Panama.

54. **Anisotremus virginicus** (Linnæus). Porkfish.

This brightly marked species is common about Key West and is one of the important small food fishes. From June to August, when it schools to spawn, it is found about the shoals but soon retires to deep water. About a month after the spawning season large numbers of young may be seen about the shoals. When fishing in comparatively deep water (30 to 40 feet), it is not unusual to catch fish of a pound or a little more in weight. However, fish of one-half a pound or less comprise the bulk of the annual catch. It is a good food fish. Maximum weight, 2 pounds; average, one-third pound.

Range.—Florida to Brazil; known from Biscayne Bay, Santo Domingo, Jamaica, Porto Rico, Martinique, Panama, and St. Catherines Island, Brazil.

55. **Orthopristes chrysopterus** (Linnæus). Pigfish; Hogfish.

This species is fairly common about Key West and is taken with hook and line on shallow reefs along with other grunts and snappers. It is an important species in lower Chesapeake Bay and along the South Atlantic coast, where it is considered an excellent food fish. Maximum weight, 2 pounds; average, one-half pound.

Range.—New Jersey to Mexico; recorded from Bermuda.

(NOTE.—The author is indebted to Dr. H. B. Bigelow for furnishing extensions to the northern range of certain species included in this list. These new ranges are included in "Fishes of the Gulf of Maine," by H. B. Bigelow and W. W. Welsh, now in press.)

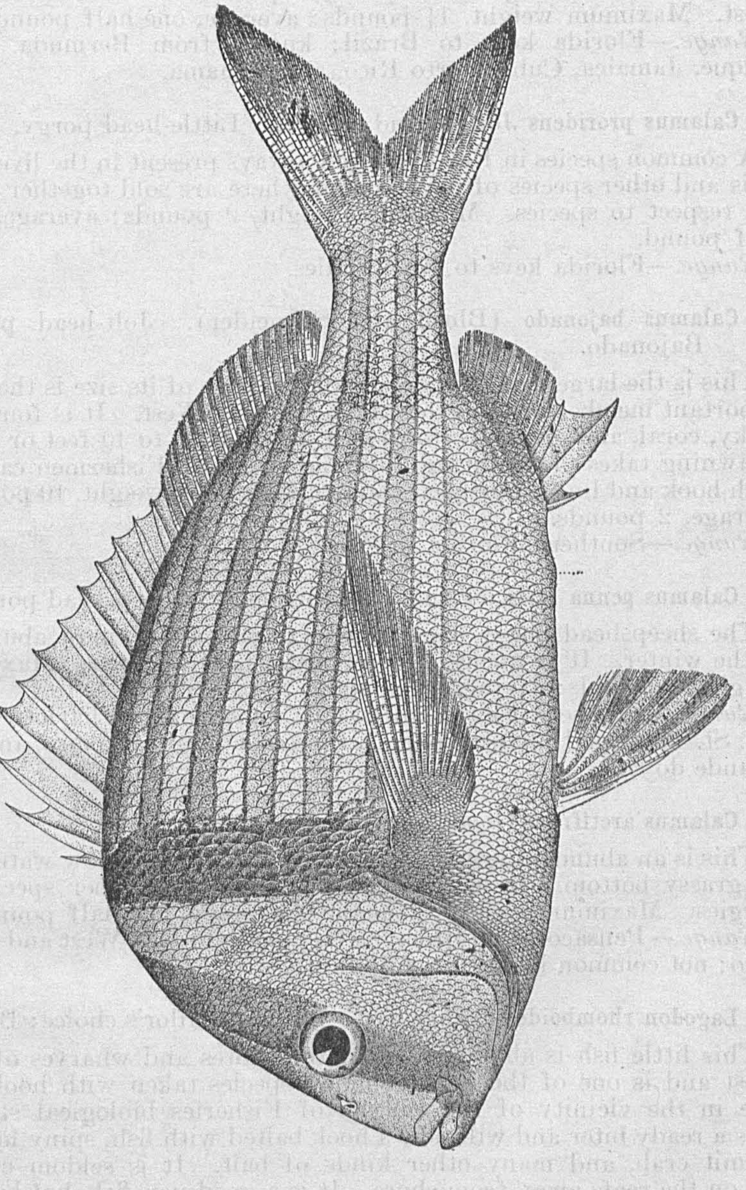

FIG. 14.—Porkfish (*Anisotremus virginicus*).

56. **Calamus calamus** (Cuvier and Valenciennes). Saucer-eyed porgy.

This is a common species about Key West and is found throughout the year, but it is most abundant during the winter. It is taken with hook and line on coral bottom in 12 to 40 feet of water. This and other species of porgies all are important food fishes in Key West. Maximum weight, 1¼ pounds; average, one-half pound.

Range.—Florida keys to Brazil; known from Bermuda, Martinique, Jamaica, Cuba, Porto Rico, and Panama.

57. **Calamus proridens** Jordan and Gilbert. Little-head porgy.

A common species in Key West and always present in the live cars. This and other species of porgies found here are sold together without respect to species. Maximum weight, 2 pounds; average, one-half pound.

Range.—Florida keys to West Indies.

58. **Calamus bajonado** (Bloch and Schneider). Jolt-head porgy; Bajonado.

This is the largest of the porgies and because of its size is the most important member of the group found at Key West. It is found on rocky, coral, and grassy bottoms at a depth of 15 to 40 feet or more. Spawning takes place during July and August. Fishermen catch it with hook and line all the year round. Maximum weight, 10 pounds; average, 2 pounds.

Range.—Southern Florida to West Indies.

59. **Calamus penna** (Cuvier and Valenciennes). Sheepshead porgy.

The sheepshead porgy is a common species and is most abundant in the winter. It frequents shallow water near the keys. Maximum weight, 4 pounds; average, 1 pound.

Range.—Southern Florida to Brazil; known from Charlotte Harbor, St. Thomas, Habana, Panama, Camamu, Rio de Janeiro, and Rio Grande do Sul.

60. **Calamus arctifrons** Goode and Bean. Grass porgy.

This is an abundant species locally, especially in shallow water and on grassy bottom. It is found in company with other species of porgies. Maximum weight, 2 pounds; average, one-half pound.

Range.—Pensacola and Biscayne Bay south to Key West and Porto Rico; not common in the West Indies.

61. **Lagodon rhomboides** (Linnæus). Pinfish; Sailor's choice; Bream.

This little fish is abundant about the shores and wharves of Key West and is one of the most common species taken with hook and line in the vicinity of the Bureau of Fisheries biological station. It is a ready biter and will take a hook baited with fish, spiny lobster, hermit crab, and many other kinds of bait. It is seldom caught out on the reefs away from shore. It is a good pan fish, but because of its small size its commercial value in Key West is slight. A fish

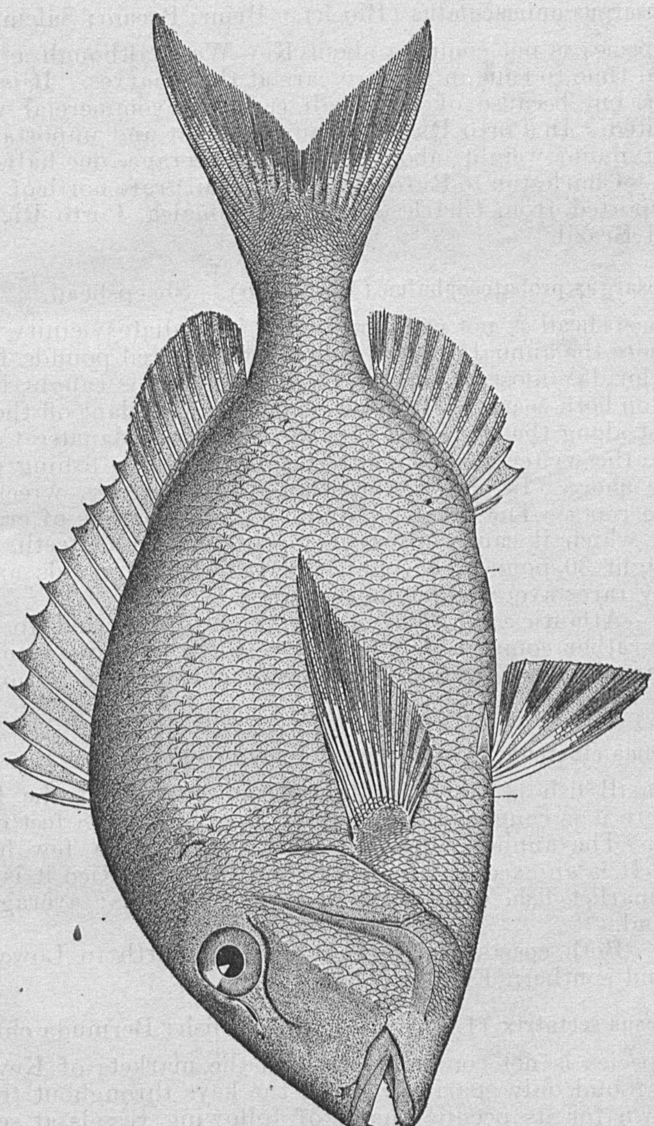

FIG. 15.—Jolt-head porgy (*Calamus bajonado*).

13 inches long, taken by the writer, is the largest recorded. Its average size is 6 inches.

Range.—Cape Cod to Texas; Bermuda and Cuba; common in lower Chesapeake Bay and abundant off the Carolina coast.

62. **Archosargus unimaculatus** (Bloch). Brim; Bream; Salema.

This species is not common about Key West, although a few are seen from time to time in the live cars at the wharves. It is a good food fish, but because of the small catch its commercial value is very limited. In Porto Rico it is an abundant and important food fish. Maximum weight, about 2 pounds; average, one-half pound.

Range.—Charleston to Rio de Janeiro, Brazil; rare north of Florida Keys; reported from Charleston, Cuba, Jamaica, Porto Rico, Panama, and Brazil.

63. **Archosargus probatocephalus** (Walbaum). Sheepshead.

The sheepshead is not common in the immediate vicinity of Key West, where the annual catch is only a few hundred pounds, but it is one of Florida's most important food fishes and is caught in large numbers on both coasts. However, it is most abundant off the southwest coast along the shores of Lee, De Soto, and Manatee Counties. At Marco the writer caught many sheepshead while fishing directly from the shore. It is found chiefly about wharves, wrecks, and mangrove roots. The greater part of its food consists of crabs and mollusks, which it can easily crunch with its strong teeth. Maximum weight 30 pounds, but individuals over 15 pounds are comparatively rare; average weight, 3 pounds.

Range.—Atlantic and Gulf coasts, from Cape Cod to Texas; formerly rather common, but now rare north of Cape Henry, Va. In Chesapeake Bay, where it was once common, it is now very scarce.

64. **Xystæma cinereum** (Walbaum). Broad shad; Majarra.

This small fish is taken in limited numbers about the Florida keys, where it is caught with hook and line in water 8 feet or more in depth. The annual catch is perhaps not over a few hundred pounds. It is an excellent food fish, and in Porto Rico it is an important market fish. Maximum weight, 2 pounds; average, one-half pound.

Range.—Both coasts of tropical America, north to Lower California, and southern Florida.

65. **Kyphosus sectatrix** (Linnæus). Rudder-fish; Bermuda chub.

This species is not commonly seen in the markets of Key West, and it is found only sparingly about the keys throughout the year. It is known for its peculiar habit of following vessels at sea, presumably for the waste food thrown overboard. It is said to be a worthy game fish. Maximum weight, 9 pounds; average, 2 pounds.

Range.—Cape Cod to Panama; not common on the Carolina coast, north of which it is a rare straggler; recorded from Bermuda and Porto Rico and said to occur in the Canary Islands and rarely in the Mediterranean.

66. **Cynoscion nebulosus** (Cuvier and Valenciennes). Spotted trout; Speckled trout; Spotted squeteague.

This important food fish is rarely, if ever, taken within the immediate vicinity of Key West. It is a valuable and abundant species on both coasts of Florida, however. Small numbers are taken among the Florida keys, near Cape Sable, while fishing for mullet, and it is seen in the Key West markets in company with this species. Various methods are used in catching the spotted squeteague. In lower Chesapeake Bay, where it is an important food fish, it is caught in pound nets, haul seines, and set seines; in southern Florida it is taken in mullet nets and with hook and line. Among the Ten Thousand Islands a fisherman was observed fishing from a flatboat with hook and line attached to a long bamboo pole. He drifted over grassy flats, repeatedly casting with mullet bait, and succeeded in catching many squeteagues. In St. Andrews Bay, Fla., the writer caught many "speckled trout" while trolling from a boat and using artificial lures. The largest fish recorded weighed 16½ pounds and was taken in the Neuse River, N. C. Two 16-pound fish were observed in Chesapeake Bay during 1922. The average weight is about 2 pounds.

Range.—New York to Texas; rare north of Chesapeake Bay.

67. **Sciænops ocellatus** (Linnæus). Redfish; Channel bass; Red drum.

This species, called "redfish" in the South, is not caught in the immediate vicinity of Key West, but it is occasionally taken among some of the Florida keys, and at times small numbers are seen in the local markets. On both coasts of Florida it is a food fish of considerable value. In traveling from one coast to the other it appears evident that the channel bass rounds Cape Sable and does not stray very far south among the keys. It is a good game fish, and large individuals are caught by surf-casters along the New Jersey coast and elsewhere. Maximum weight, 75 pounds; average, 2 to 35 pounds.

Range.—Massachusetts to Texas; not common north of Chesapeake Bay.

68. **Pagonias cromis** (Linnæus). Black drum.

The black drum is not caught in the immediate vicinity of Key West but, like the red drum, is occasionally taken among the keys. It is seldom seen in the local markets. As a food fish it is rather inferior, the flesh being coarse and stringy. Maximum weight, 146 pounds; average, about 25 pounds.

Range.—Massachusetts to Texas.

69. **Lachnolaimus maximus** (Walbaum). Hogfish; Capitan.

The hogfish is common about Key West and is caught the year round on rocky reefs in rather deep water. It is a fairly good food fish, though not choice, and is always present in the fish wells and live cars. When the fish is dressed, the scales are shaved off with a sharp knife in the same manner as with groupers and jewfish. Maximum weight, 20 pounds. Fish weighing 10 pounds or more are not

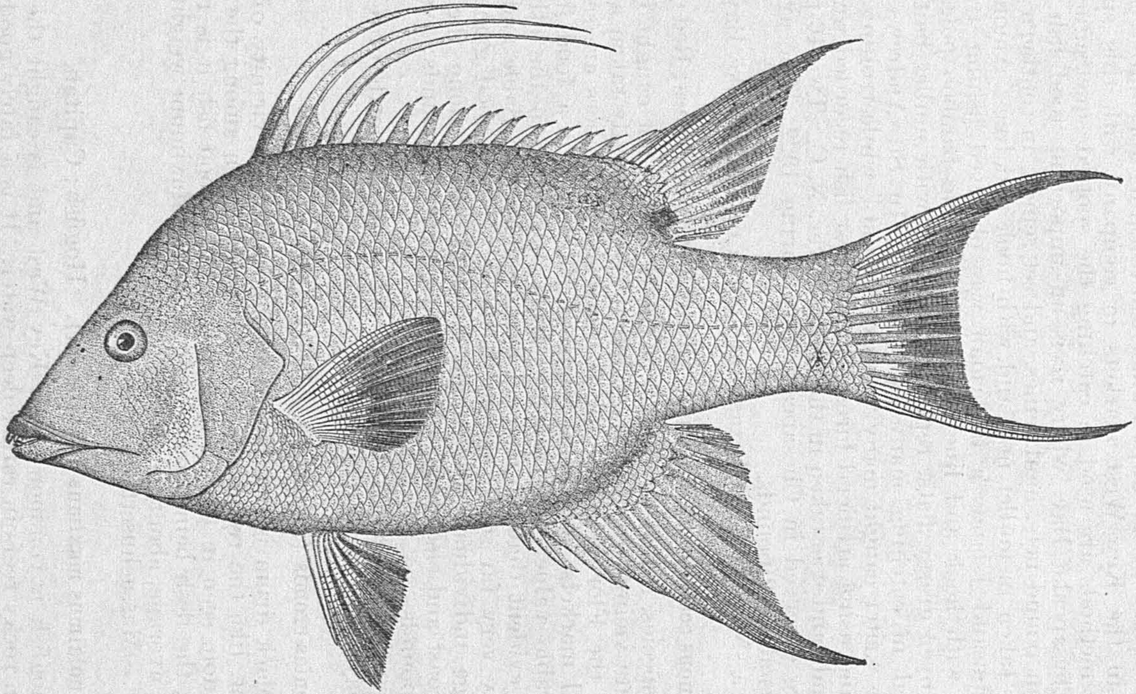

FIG. 16.—Hogfish (*Lachnolaimus maximus*).

uncommon, but the average weight is about 3 pounds. Fish weighing less than 1 pound are rarely seen in the markets.

Range.—Beaufort (N. C.) to West Indies; Bermuda; rare north of Florida.

70. **Sparisoma viride** (Bonnaterre). Parrot-fish.

This fish is occasionally caught by hook-and-line fishermen and is eaten to a small extent locally. Very little is known of its habits, and its value is very slight. It is a rich bluish-green in color. Maximum weight, 10 pounds; average, 2 pounds.

Range.—Bahamas and Florida Keys to West Indies; known from Bermuda, Jamaica, Porto Rico, St. Thomas, and St. Croix.

71. **Sparisoma flavescens** (Bloch and Schneider). Parrot-fish.

This parrot-fish is common in the vicinity of Key West. It is found in shallow water, chiefly on grassy bottom. Its color is mostly olivaceous, flushed with pink or orange. Its flesh is soft and rather poor, but it is used to a limited extent as food. Maximum weight, 1 pound; average weight of market fish, one-half pound.

Range.—Southern Florida to Brazil; found in the Bahamas and throughout the West Indies.

72. **Pseudoscarus guacamaia** (Cuvier). Green parrot-fish.

Of the large parrot-fishes this is the most common species found about Key West. In color it is mottled or barred with brown and blue; its teeth are green. It is not held in high esteem as a food fish, but is eaten sparingly in Key West. Maximum weight, 10 pounds; average, 1 pound.

Range.—Florida to Rio de Janeiro, Brazil; recorded from St. Augustine, Habana, Porto Rico, and Panama.

73. **Chætodipterus faber** (Broussonet). Spadefish; Angelfish.

The spadefish is found about Key West during most of the year and is especially common during the summer and fall. It is generally found close to shore in shallow water and travels in small schools. It is frequently taken in wire crawfish traps. After hauling crawfish traps daily for a long time and catching no spadefish at all the writer suddenly one day caught 18 of the fish in one trap, which illustrates their habit of schooling. The young (less than 1 foot long) are marked along the sides with six prominent black vertical bands on a silvery ground, but in the adult the entire body coloration is darker and the bands are less conspicuous. As a food fish it is held in high esteem, but the annual catch at Key West is not large. Maximum weight, 20 pounds; average, three-fourths pound. In Chesapeake Bay, where this fish is known as "porgee" and where small numbers are taken from spring until fall, they generally weigh between 3 and 12 pounds.

Range.—Cape Cod to Rio de Janeiro, Brazil; rare north of Chesapeake Bay; known from Cuba, Santo Domingo, Jamaica, Martinique, Porto Rico, and Panama.

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74. **Pomacanthus arcuatus** (Linnæus). Black angelfish.

This beautiful species is rather common about Key West. It is found throughout the year but is not taken in large numbers. By visiting the markets a few may be seen at almost any time among the many species of fish held in the live cars. It is caught in wire crawfish traps and with hook and line. It is a food fish of some importance locally. Maximum weight, 6 pounds; average, 1½ pounds.

Range.—New Jersey to Bahia, Brazil; comparatively rare north of Florida; known from Tortugas, Cuba, Jamaica, Porto Rico, and Martinique.

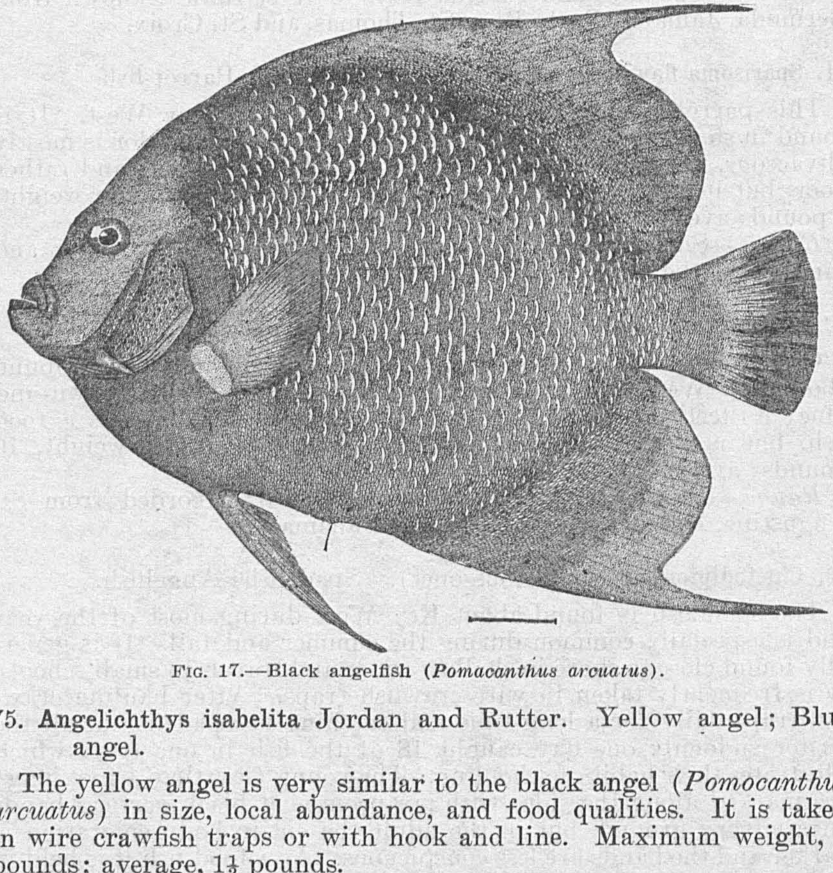

FIG. 17.—Black angelfish (*Pomacanthus arcuatus*).

75. **Angelichthys isabelita** Jordan and Rutter. Yellow angel; Blue angel.

The yellow angel is very similar to the black angel (*Pomocanthus arcuatus*) in size, local abundance, and food qualities. It is taken in wire crawfish traps or with hook and line. Maximum weight, 6 pounds; average, 1½ pounds.

Range.—Florida Keys to Brazil; known from Tortugas, Bahamas, Cuba, Jamaica, Lesser Antilles, and Bahia.

76. **Hepatus cœruleus** (Bloch and Schneider). Blue tang.

The blue tang is a very beautiful fish and is fairly common about Key West. It is generally taken in water from 15 to 25 feet in depth on grassy or rocky bottom. It is caught with hook and line or in crawfish traps, and is used for food purposes, but the annual catch is small. Maximum weight, 1½ pounds; average, one-half pound.

Range.—Usual range from the Florida keys to Brazil; recorded from Bermuda, Tortugas, Cuba, and Jamaica. The young are recorded from Woods Hole, Mass.

77. **Hepatus hepatus** (Linnæus). Tang; Doctor-fish.

This tang is rather common about Key West, where it is a food fish of slight importance. It is taken with hook and line, in crawfish traps, and with crawfish "grains." It is the most abundant of the tangs. Maximum weight, 2 pounds; average, one-half pound.

Range.—Usual range from North Carolina to Brazil; uncommon north of Florida; recorded from Beaufort, Charleston, Tortugas, Bermuda, Habana, Jamaica, Martinique, and Bahia. The young have been recorded as far north as Woods Hole, Mass.

78. **Hepatus bahianus** (Castelnau). Ocean tang.

The ocean tang is less common about Key West than is either the common tang (*H. hepatus*) or the blue tang (*H. cœruleus*). It is

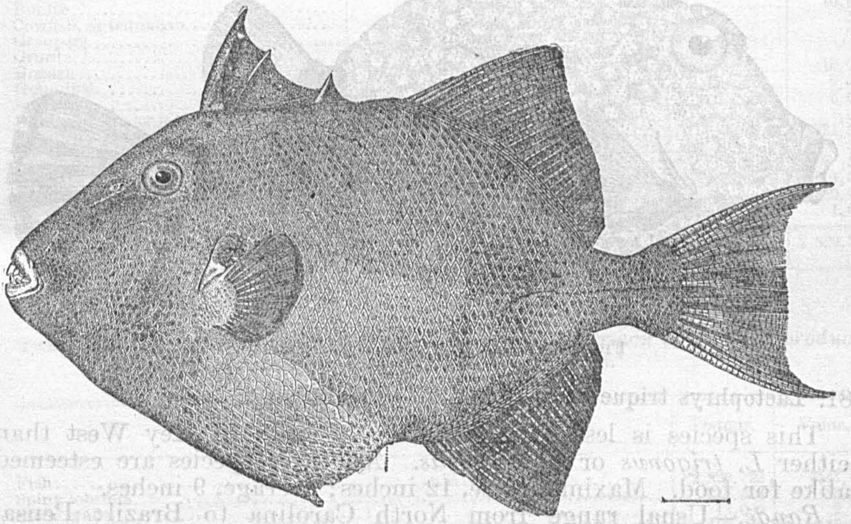

FIG. 18.—Turbot (*Balistes carolinensis*).

considered a good food fish but is seen only occasionally in the local markets. Throughout the West Indies this species is the most important of the tangs. Maximum weight, about 4 pounds; average, 1 pound.

Range.—Usual range from North Carolina to Brazil; rare north of Florida; found throughout the West Indies and common in Bermuda. The young have been recorded as far north as Woods Hole, Mass.

79. **Balistes carolinensis** Gmelin. Turbot; Trigger-fish; Leather-jacket.

The turbot is common about Key West, where it is caught with hook and line throughout the year. It is nearly always present in the live cars about the wharves, and is a food fish of importance locally. Maximum weight, 2 pounds; average, 1 pound.

Range.—Banquereau Bank off Canso (Nova Scotia) to West Indies; also found in Bermuda and the Mediterranean Sea; uncommon north of Florida; recorded from Massachusetts, Rhode Island, New Jersey, Chesapeake Bay, and North Carolina.

80. **Balistes vetula** Linnæus. Turbot; Trigger-fish.

This species is fairly common at Key West although somewhat less so than *B. carolinensis*, with which it is closely associated. Locally it is a food fish of some importance. The maximum size is not definitely known but is believed to be 2 or 3 pounds; average, 1 pound.

Range.—Usual range from Florida to West Indies; known from Bermuda, Bahamas, Jamaica, Ascension Island, and Porto Rico. The young have been recorded from Nantucket and Woods Hole, Mass.

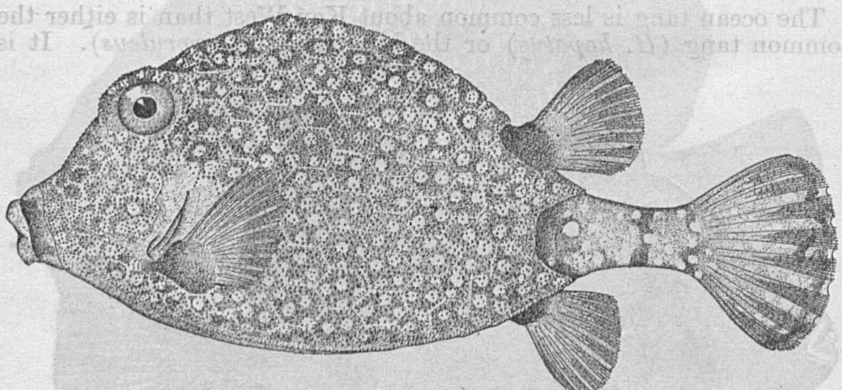

FIG. 19.—Cowfish (*Lactophrys triqueter*).

81. **Lactophrys triqueter** (Linnæus). Trunkfish.

This species is less common in the vicinity of Key West than either *L. trigonus* or *L. tricornis*. All three species are esteemed alike for food. Maximum size, 12 inches; average, 9 inches.

Range.—Usual range from North Carolina to Brazil; Pensacola; rare north of Florida; known from Bermuda and Porto Rico, where it is common. The young have been recorded from Katama Bay, Mass.

82. **Lactophrys trigonus** (Linnæus). Trunkfish.

This trunkfish is comparatively common about Key West and is taken throughout the year, hook-and-line fishermen catching this species while fishing for grunts, porgies, and other small fishes. It is sometimes found very close to shore amid sponges and other bottom growths. While using a 100-yard collecting seine near the island of Key West, about 15 adults of this species and *L. tricornis* were taken in one haul. It is a good food fish and is esteemed locally. Maximum size, 18 inches; average, 10 inches.

Range.—Usual range from North Carolina to Brazil; rare north of Florida. The very young, about 1 inch long, have been taken at Woods Hole, Mass.

83. **Lactophrys tricornis** (Linnæus). Trunkfish; Cowfish.

This species, sometimes called cowfish because of the two horn-like spines extending from the head, is about equally as common as *L. trigonus*, with which it is closely associated, and its habits and food qualities are very similar to the latter species. Maximum size, about 15 inches; average, 9 inches.

Range.—Usual range from Florida to Brazil and eastward to the Cape of Good Hope; recorded from Jamaica, Porto Rico, and Panama. The young have been taken in Katama Bay, Mass.

TABLE 1.—*Estimated catch of various species of fish landed in Key West during 1918 and caught within about 50 miles of the city.*

Species.	Pounds.	Species.	Pounds.
Amberfish	2,000	Parrot-fish	500
Angelfish	5,000	Pigfish	2,000
Barracuda	3,000	Pompano	545
Bluefish	16,614	Porgies	60,000
Bonito	350	Porkfish	10,000
Cowfish, or trunkfish	1,000	Sailors' choice	500
Groupers	200,000	Sheepshead	300
Grunts	150,000	Snappers:	
Hogfish	10,000	Mangrove	15,000
Houndfish	500	Red	9,000
Jewfish	15,000	Others	5,000
Jurel, runners, or jacks	20,000	Spadefish	1,000
Kingfish and cero [1]	373,500	Spanish mackerel [1]	1,734,200
Margate-fish	1,000	Tang	600
Moonfish	300	Tarpon	500
Mullet:		Turbot	4,000
White	27,318	Yellowtail	50,000
Striped	85,000	Miscellaneous	1,000
Muttonfish	25,000		
		Total	2,829,722

[1] Winter of 1918-19.

TABLE 2.—*Estimated catch and first value to the fishermen of various products landed in Key West during 1918.*[2]

Products.	Pounds.	Value.
Fish	2,829,722	$141,486
Spiny lobsters	345,518	33,335
Stone crabs	18,000	2,750
Turtles	150,000	15,000
Sponges	107,743	82,377
Clams	1,265	760
Conchs	2,000	100
Total	3,454,248	275,808

[2] The total catch given herewith varies somewhat from that listed in the Bureau of Fisheries statistical report for 1918, owing to the inclusion of the kingfish and Spanish mackerel catches for the season 1918-19 instead of for the year 1918 alone.

MULLET FISHERY.

The striped mullet (*Mugil cephalus*) is not caught in large quantities in the immediate vicinity of Key West, but it is one of the principal fish to be found in the local markets during the late summer. The season when this mullet is abundant generally lasts from July until November. In 1918 about 85,000 pounds, worth $3,000 to the fishermen, were landed during this period. The total catch of striped and silver mullets (*M. curema*) landed in Key West during 1918 was 112,313 pounds, valued at $4,531.

The mullet is by far the most valuable fish caught in the State of Florida. During 1918 the catch on the west coast amounted to 25,023,666 pounds, worth $1,151,103, and on the east coast to 10,417,889 pounds, worth $397,147. In addition 86,285 pounds of salted roe, worth $17,593, were prepared, making the total weight of the fish 35,527,840 pounds, with a value of $1,565,843.

Mullets are found in large numbers along the entire coast line of Florida. They are particularly abundant in or about bays, rivers, or creeks, and the greater part of the catch is taken in brackish water within almost a stone's throw of land. Large numbers are found in the vicinity of Cape Sable, doubtless because the schools pass there going from one coast to the other, but among the Florida keys they decrease in numbers southward or as Key West is approached.

Nearly the entire catch of mullet is taken with gill nets of 1½-inch bar mesh. To make a catch in open water, two dories are used. The best type of dory has a platform in the stern, which is raised several inches from the bottom of the boat, and on this the net is stowed, payed out, and hauled in. It is essential that the woodwork of the boat, edges of the gunwale, and such places where the net is liable to touch be smooth, so that the net may not catch or impede operations. In each of the dories is placed a net 150 yards or more in length, properly corked and leaded, and with a staff at each end. When a school of fish is located, the boats come together and the fishermen connect their nets and from this point quickly surround the mullets, describing a semicircle and bringing the staffs of the nets together at another point. After sufficient time has been given for the fish to gill themselves each net is hauled aboard its respective dory and the fish are removed as they come aboard.

When mullets are caught in close quarters, such as in rivers or creeks, the operations of the fishermen are more simple and large catches are often made under such conditions.

A river bank often proves an effective aid in netting, as the fishes' chances of escape are considerably lessened by such a barrier. As a school of mullets advances along the shore the net staff is planted near the water's edge, and at the proper time the net is set around the fish and returned to the shore some distance up or down stream. Sometimes it is unnecessary to use all of the net, in which case the unused portion is distributed either within the inclosure or around the outside in order to effect additional obstruction for the fish. Often from 5 to 10 per cent of the fish escape by jumping over the outer edge of the net, and many others gain their freedom by swimming under the lead line at some point where it does not lie close on the bottom. It would be far more difficult to make large catches of mullets if they did not jump from the water or cause a disturbance at the surface, thereby betraying their presence. Catches made otherwise are the result only of chance. However, under ordinary conditions schools of mullet follow close along the shore and give evidence of their presence to the fishermen. A school swimming along at a speed of 2 or 3 miles an hour can be sighted in sufficient time for all preparations to be made for their capture. As a rule the fishermen lie in wait at selected points and sometimes remain for hours on the lookout for the fish. The mullet is a very elusive fish, and at the slightest opportunity an entire school will evade capture or escape from a seine.

A large part of the fishing is done at night, fishermen selecting certain localities where the mullets are known to occur and where the water is free of snags. On moonlight nights the fish can be seen approaching, and on very dark nights they are located by their noisy splashes. Sometimes, also, a large net is set on a chance of surrounding a school that may be swimming deep, as they do on certain occasions. The fishery is rather uncertain, and sometimes the fishermen return without a fish. On the other hand, large catches are frequently made.

The greater part of the catch of striped mullets brought into Key West is taken at or near Cape Sable. During the fall of 1919 from 10 to 20 sloops and power boats operated in this vicinity. A run boat collected and iced the combined catch and made trips back and forth to Key West. Sometimes as many as 30,000 pounds of striped mullets are landed on one day in this locality, but generally the quantity is less.

In order to protect the mullet during the principal part of its spawning season, the State of Florida has enacted a law prohibiting the catching of striped mullet (*Mugil cephalus*) within the waters of the State from November 20 to January 20. During this closed season some of the fishermen resort to fishing for kingfish and Spanish mackerel.

Both fresh and salted mullets are shipped from Key West. Fresh mullets are packed in barrels, similarly to other species of fish, and the greater part of the catch is sent to points in this country. In dry-salting mullets the fish are split and several incisions made in the flesh in order that the salt may "take" better. They are placed in piles until part of the liquid drains off and are then packed in slack barrels topped with burlap. The greater part of the salted fish is shipped to Cuba.

Market fish generally range from 12 to 22 inches in length, with 16 inches as a fair average. The females, or roe fish, usually average about 2 inches longer than the males. It is not unusual to find large numbers of fish weighing 3 or 4 pounds each.

The silver mullet (*M. curema*) is abundant at Key West and throughout the Florida keys. It is common on both coasts of Florida. As the average length of this species is about 10½ inches, it is less sought after and of considerably less importance than the striped mullet. It is a good food fish, however.

On almost any day of the year schools of silver mullets can be found about Key West. They seem to prefer shallow water, 2 to 12 feet in depth, and as they move along the bottom is stirred up, probably in their search for food. An area of cloudy water surrounded by clear water invariably betrays the presence of silver mullets. They are captured in the same manner as the striped mullet, excepting that it requires a net of 1¼-inch bar mesh.

The fishermen distinguish the two species of mullet in the water by the way they jump, for, as a rule, the striped mullet jumps clear of the surface, while the silver mullet merely flips its tail out of the water. There are exceptions, however, when most or all of a school of silver mullets will jump out of the water simultaneously. This jumping in unison has not been observed with the striped mullet, and only one or two individuals of a large school appear to leave the water at the same time.

Although the silver mullet is abundant, the catch landed in Key West is small and the greater part of it is dry salted and shipped to Cuba.

KINGFISH FISHERY.

Kingfish (*Scomberomorus cavalla* and *S. regalis*) are caught in southern Florida from early November until late March. The season usually covers the same period as that of the Spanish mackerel, but the fishing is somewhat more uncertain. In some years very few kingfish are caught before December 1, but it is the custom of the fishermen to commence operations about November 10. The catch of kingfish in Florida for the season 1917–18 is given in the report of the Commissioner of Fisheries for 1919, Appendix X, as follows:

TABLE 3.—*Catch of kingfish in Florida for the season 1917–18.*

West coast.		East coast.	
County.	Pounds.	County.	Pounds.
Pinellas	25,537	Palm Beach	1,298,161
Manatee	42,367	Broward	300
De Soto	3,011	Dade	973,331
Monroe	394,945	Total	2,271,792
Total	465,860		

The total catch for both coasts was 2,737,652 pounds. The entire catch of Monroe County was landed at Key West. Monroe County includes a portion of the extreme southwestern part of Florida and the Florida keys, which extend southwestward from the mainland forming the line dividing the Atlantic Ocean and the Gulf of Mexico. The major part of the fishing is done on the Atlantic side of the keys. The kingfish, therefore, are found in greatest abundance from Palm Beach County to Key West.

In this country the kingfish fishery is confined almost entirely to Florida, the only other State where it may be considered as of importance being North Carolina, which reports a catch of 211,781 pounds for the season of 1918. Off the Carolina coast kingfish are caught from May until October or during the months when they are not found in Florida.

TABLE 4.—*Catch of kingfish, by months, taken along the Florida keys and landed at Key West during the seasons from 1918 to 1920.*

Month.	1918–19	1919–20
	Pounds.	*Pounds.*
November	1,000	25,000
December	25,000	28,000
January	168,200	248,000
February	154,300	45,000
March	25,000	103,000
Total	373,500	449,000

The first two fish of the 1918–19 season were landed at Key West on November 20, 1918, and the fishing ended abruptly on March 10, 1919, owing in part to the breakdown of the city's only ice plant.

The first fish of the 1919–20 season was landed at Key West on November 6, the second on November 7, and the third, weighing 30 pounds, on November 10. Favorable weather during March permitted an unusually good catch for that month. The fishing ceased on March 25.

For kingfish fishing a seaworthy power boat is of first importance. The majority of those seen in Key West range in length from 24 to 50 feet. The most serviceable boats are of the half-cabin type, for on these sleeping accommodations may be provided and the boats are in many ways more satisfactory. A few open boats generally are employed for near-by fishing. Sometimes sailing vessels are seen, but without auxiliary engines they prove rather unsuitable except under unusually favorable weather conditions, as the speed of the boat must be evenly regulated in order to travel in any direction the fish may choose to take. As kingfish die soon after capture the fish well, if present in the boat, is not utilized.

With the exception of the boat the necessary equipment for kingfish fishing is very simple and inexpensive. A small supply of heavy cotton trolling lines, wire leaders, and metal squid hooks are all that is needed. After the first fish has been landed by the bare squid strips of flesh and skin are cut from the belly of this fish and are used as bait for other fish.

At least two men are required to man a boat—one to attend exclusively to fishing and one to manage the boat and fish when opportunity affords. Two or more lines are trolled, according to the size of the boat. Slipknots are made on the lines, and when one of these pulls out it is a good indication that a fish has taken the hook. After hauling in fish for several hours this fishing seems more like work than sport, but an element of excitement and expectancy is always present.

It is not unusual for a boat to cruise about for most of a day without catching a fish, and often the catch scarcely pays for the fuel consumed, but in the long run the fishing is usually profitable, as a catch of several thousand pounds now and then more than offsets the days of loss.

The fish usually range in weight from 4 to 40 pounds. Occasional examples reach 50 pounds or more, but such fish are rare. During the early part of the season when fish are scarce the few taken as a rule are large, weighing from 10 to 40 pounds, but when the schools strike in the weight of individual fish usually varies from 4 to 15 pounds. Fish of about the same size are generally found in a school, as it was observed that certain boats brought in fish weighing from 5 to 8 pounds, others brought fish weighing 6 to 10 pounds, and still others had fish weighing 8 to 12 pounds, etc. It is probable that each of these boats caught their fish from a single school.

A large part of the kingfish catch is exported to Cuba or consumed locally. Some shipments are made to points in this country where the kingfish, however, are not regarded as favorably as the Spanish mackerel. The Key West markets are never glutted, and the annual catch is easily disposed of. The fishermen receive a uniform price for their fish, as the rate is fixed at the beginning of the season. During the 1919–20 season the price was the same as for Spanish mackerel, 6 cents per pound. The retail price is generally about 25 cents per pound.

The kingfish is an excellent food fish when fresh, and its few bones and good flavor place it in great demand in Florida and Cuba. It is a fine game fish and is eagerly sought after by sport fishermen.

SPANISH-MACKEREL FISHERY.

On the Atlantic coast the Spanish mackerel is found from Monhegan, Me., to Brazil and in the Gulf of Mexico. It is taken in commercial quantities south of Sandy Hook, N. J. As a food fish it is held in high esteem and commands a good price at all times. The retail price during the last few years has ranged from 25 to 50 cents a pound.

It is only in recent years that the migrations of the Spanish mackerel have been partly understood. Less than 50 years ago it was not known where the fish spent the winter months, and it was only from April until early November that they were caught and brought to market. At that time Spanish mackerel apparently were not known to be in abundance in the waters of southern Florida during the winter.[2]

The following table shows the quantity of Spanish mackerel taken in 1880, by States, and the total catch for the United States:

	Pounds.
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

It is noteworthy that at the present time Spanish mackerel are caught and shipped to market in greatest abundance from November to March or during the months when 50 years ago the fish were seldom seen. It is now believed that these fish migrate southward and spend the winters in warmer waters. In 1880 the total catch for Florida and the Gulf of Mexico was recorded as only 20,500 pounds. The entire catch for the United States in that year only slightly exceeded the Key West catch for 1918–19 (1,734,200 pounds), and it was less than the Key West catch for 1919–20 (2,322,000 pounds). The distribution of the mackerel along the coasts of Florida is shown by the following statement giving the catch for the season 1917–18:

[2] The Fisheries and Fishery Industries of the United States. By G. Brown Goode and associates. 1887. Section V, History and Methods of the Fisheries, Vol. I, pp. 543–552.

	Pounds.
East coast counties:	
St. John	1,510
St. Lucie	696, 721
Palm Beach	1, 493, 319
Dade	870, 415
Total	3, 061, 965
West coast counties:	
Escambia	124, 076
Okaloosa	147, 297
Bay	508, 784
Calhoun	19, 994
Franklin	53, 809
Wakulla	750
Levy	23, 950
Pinellas	8, 176
Manatee	147, 463
De Soto	278, 355
Lee	57, 971
Monroe	2, 065, 276
Total	3, 435, 901

The total catch for the State of Florida was 6,497,866 pounds, with a value to the fishermen of about 6 cents a pound. Practically the entire catch of Monroe County was landed at Key West.

During each of the seasons 1918–19 and 1919–20 the first commercial catch of Spanish mackerel was brought in to Key West on about November 20. The season 1918–19 ended March 1, and only a few fish were caught after that date. This, together with the small catch for February, was partly due to a shortage of ice caused by the disability of the city's only ice plant. The catches, segregated according to months, were as follows:

TABLE 5.—*Catch of Spanish mackerel, by months, landed at Key West during the seasons from 1918 to 1920.*

Month.	1918–19	1919–20
	Pounds.	*Pounds.*
November	154,000	7,200
December	345,000	850,000
January	1,149,200	998,800
February	86,000	170,000
March	....	296,000
Total	1,734,200	2,322,000

Gill nets and purse seines are used for catching Spanish mackerel in the vicinity of Key West. A few are caught with trolling lines, but the catch from this source is small. At other points along the coast, particularly in Virginia and North Carolina, a large part of the catch is taken with pound nets. The gill net is more extensively used than the purse seine. The usual net is 20 feet in depth, 150 to 175 yards in length, having a stretched mesh of 3⅜ to 3⅝ inches built of 6-thread cotton seine twine and tarred. In the fishery several shorter nets are joined together to form one 500 to 1,800 yards in length, according to conditions and the facilities of the boat.

The boats employed are usually from 30 to 50 feet in length, gasoline driven, and of the open or half-cabin type. In order that fishing may be done at night, a searchlight is carried on the bow. Most of the fishing is done between sunset and sunrise, owing to the fact that many more mackerel gill themselves in the darkness than in the daylight, when they are able to see the net.

Gill netting appears to be an effective method of fishing, as a crew of two men often makes large catches. Some of the fishermen work independently, owning their own equipment, while others are attached to an individual or company and are supplied with the necessary boats and nets. At least one company that employs a small fleet of boats has a houseboat, which is anchored in a protected locality near the scene of operations and on which the men eat and sleep. Racks for drying the nets are built on the roof of the houseboat.

The schools of fish are found at night by searchlight. When located, the mackerel are surrounded as rapidly as possible, and the direction of the net is indicated by lanterns mounted on cork floats placed at convenient intervals along the cork line. After the fish have been trapped the dories encircle the net, splashing the water to frighten the fish into gilling themselves. Sometimes the boats enter the inclosure to agitate the fish. As the bottom of the net is entirely open the fish could easily escape by sounding, but apparently the greater part of them remain at the surface, where they either gill themselves in the net or succeed in jumping over the top.

During the 1919–20 season Key West had only one purse-seine boat, but several vessels came down from the mainland to operate in the vicinity of the keys. The local vessel was 90 feet in length with a 20-foot beam, and carried a crew of about 15 men. It was formerly schooner rigged, but it had recently been overhauled by having its topmasts removed and an auxiliary engine installed. The mackerel purse seine is about 600 yards in length. The upper part of the seine near the cork line is made of $3\frac{3}{8}$ to $3\frac{3}{4}$ inch stretched mesh, while the bunt is of 3-inch mesh.

Purse seining is an effective method of fishing for Spanish mackerel, and large catches are often made. However, during the 1919–20 season the gill netters, because of their greater number, took the major part of the catch.

The advantages of gill netting over purse seining, especially to fishermen with small capital, are: (*a*) The gill netters can operate with a small power boat and with a crew of two or three men, whereas the purse seiners require a larger boat and more men. If one company owns a number of gill-netting boats, these can operate in several localities at the same time, and thus cover more territory with the reasonable assurance that one or more of the boats will make a good catch. (*b*) The cost of equipment and operating expenses is smaller for the gill netters than for the purse seiners. When fishing some distance from Key West, the catch of the gill netters is collected by a run boat, which brings the fish to the city and saves the fishermen much valuable time, and in addition the run boat transports necessary supplies and food. The purse-seine boats generally bring their own fish to market and restock for the next trip. On the other hand, the purse seiners sometimes make large catches that prove very profitable.

In packing mackerel for shipment the fish are iced in barrels containing 200 pounds net, and in shipping they are removed from the market as quickly as possible to make room for subsequent receipts. The fish are delivered by the fishermen with the entrails removed, and at the markets they are washed, weighed, and immediately packed for shipment. During the height of the season as many as 100,000 pounds of fish must be disposed of within one day in one fish house, and considering the relatively few men who execute this work it can only be accomplished by the speed, dexterity, and cooperation of the entire force.

At times as many as 10 small boats are lined up at one of the fish wharves waiting to dispose of their cargo. In unloading the fish a 2-bushel basket is lowered into the boat, filled, hoisted to the dock, and dumped into a wire-meshed, semicylindrical basket that rests in a tub of water. In this basket they receive a superficial washing by being raised and lowered several times in the tub of water. The fish are then dumped on a large table, from which they are thrown on a scale and weighed in 100-pound lots. A barrel with broken ice on the bottom of it is always in readiness near the scale, and the fish are packed so as to form alternate layers with the ice, which is added as necessary. When 200 pounds of fish have been placed in a barrel it is rolled away, the remaining space being filled with ice well tamped. A wooden cover is nailed on, the barrel is properly consigned, and is then ready for shipment.

Most of the mackerel are shipped to points east of the Mississippi River, New York being the principal market. As a rule a glut seldom occurs on the market, but when heavy catches are received at Key West and other points in Florida simultaneously the price tends to drop until the heavy run is over. The fishermen receive a uniform price throughout the season, which in 1919–20 was 6 cents per pound to fishermen owning their own equipment and 3½ cents to those who were furnished equipment by the dealers. When the gill-net fishermen deliver their catch to the run boat that visits the fishing grounds, a slight reduction—usually one-half cent a pound—in the price paid is made. To the fish dealers the mackerel bring the highest prices in November and March, when catches usually are small. For a number of seasons past a representative from Fulton Market, New York, has been stationed in the largest fish house in Key West, where he supervises the packing and shipping of all fish consigned to his market. He purchases probably one-half of the Key West catch of mackerel. The quantity of mackerel sold to the local trade in Key West is negligible.

Florida has the only special fishery for Spanish mackerel, although in North Carolina about 100,000 pounds were caught with gill nets during 1918. From New Jersey to North Carolina it is caught in pound nets along with other species of fish. In Chesapeake Bay the first fish are caught in pound nets during the last week in May or the first week in June. The fish leave the bay the latter part of September or early in October.

SPINY-LOBSTER FISHERY.

The Florida spiny lobster (*Panulirus argus*) differs considerably from the northern lobster (*Homarus americanus*), the chief differences visible at a glance being the very long legs, the long whiplike antennæ studded with spines, the spines of the cephalathorax, or body, two of which protrude over the eyes like a pair of horns, and the absence of the great claws. Its flesh has a delicate flavor, and it is said to equal that of the northern lobster. Aside from being an important food for man, it is extensively used as bait by the hand-line and fish-trap fishermen. Besides the name "spiny lobster," this crustacean is known as "crawfish," "sea crawfish," "langouste," and "rough, thorny, or rock lobster." The name in general use among the fishermen is crawfish, but dealers ship the animal under the name "Florida lobster." Spiny lobster is perhaps the most suitable name, but for the sake of brevity the name crawfish has been most generally used in this paper.

Within recent years the crawfish has found an important place in the fishery industry of Key West. Shipments to Cuba and cities of the eastern United States have steadily increased during the past decade, whereas prior to 1910 few crawfish, if any, were sold outside of the State.

For many years the crawfish has found a ready sale in the city of Key West, and the price has been as low as 25 to 50 cents for one dozen, according to the season and the weather. The retail price during 1922 ranged from 75 cents to $3, with a general average of $1.50 a dozen, depending upon the available supply. They are sold at retail by the piece or by the dozen and are seldom weighed.

The average market size throughout the year is 9 to 10 inches in length, exclusive of the long antennæ, and the weight of a 9-inch crawfish is about 1 pound. The males grow larger than the females, and adult males are heavier than females of the same size, partly because of the longer legs. A comparison of the following weights indicates the difference: Males, 8 inches, 10½ ounces; 9 inches, 1 pound 1 ounce; 11 inches, 2 pounds. Females of these same sizes weighed 10¾ ounces, 15½ ounces, and 1 pound 11 ounces, respectively. During two years of intensive market observations it was found that the weights of about 99 per cent of the crawfish sold for food would fall between the extremes of one-half and 6 pounds. Very small crawfish are common in their natural habitat, but they are used only for fish bait. Crawfish weighing more than 6 pounds are rarely seen. The largest of which the Bureau of Fisheries has an authentic record was caught the latter part of January, 1922, with hook and line in 8 fathoms of water about 8 miles off the coast of Sarasota County, Fla. This specimen, which weighed over 8 pounds when caught and the total length of whose body and tail was 17 inches, is now in the United States National Museum collection.

The crawfish is found close to shore, and most of the fishing is carried on within a mile of land. Rocky reefs and their adjacent territories are the most favorable fishing grounds. Its range in the United States extends from Beaufort, N. C., to the Florida Keys, principally on the Atlantic side, and among the islands of the Dry Tortugas. However, it is not numerous enough north of Miami, Fla., to be of commercial importance. Large numbers are reported from the Bahama Islands, and it is known to occur as far south as Rio de Janeiro, Brazil. A spiny lobster resembling *P. argus* in general appearance is found on the Pacific coast, but it is of a distinct species.

The same type of boat is employed in the spiny-lobster fishery as that used in the hand-line fishery. Fishing lines are always kept aboard, so that if crawfish fishing proves unsuccessful the fishermen may return to port with a fare of fish. All boats in the vicinity of

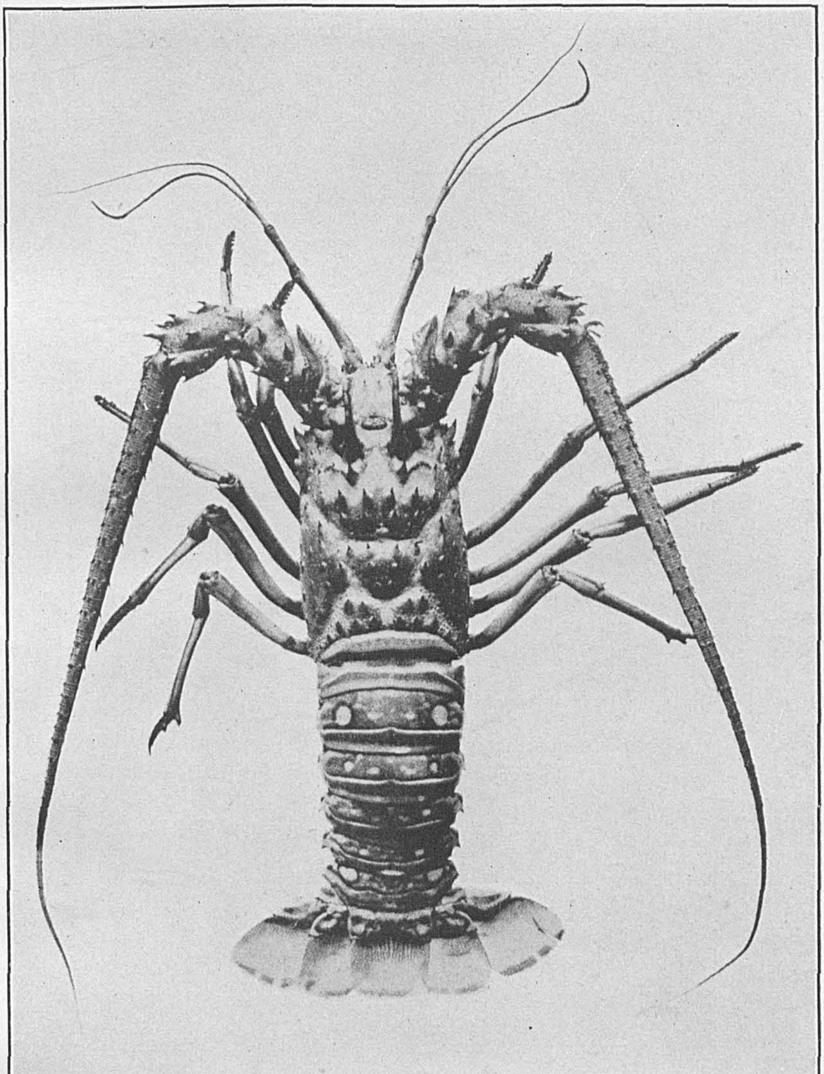

FIG. 20.—Spiny lobster (*Panulirus argus*).

44—2

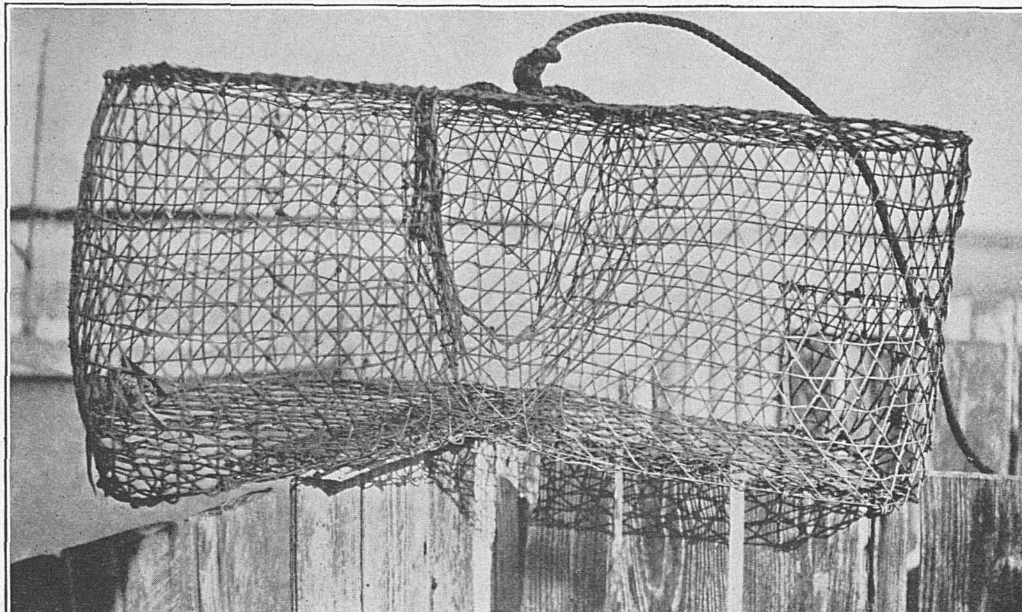

FIG. 21.—Spiny-lobster trap, also utilized for catching stone crabs and fish.

44—3

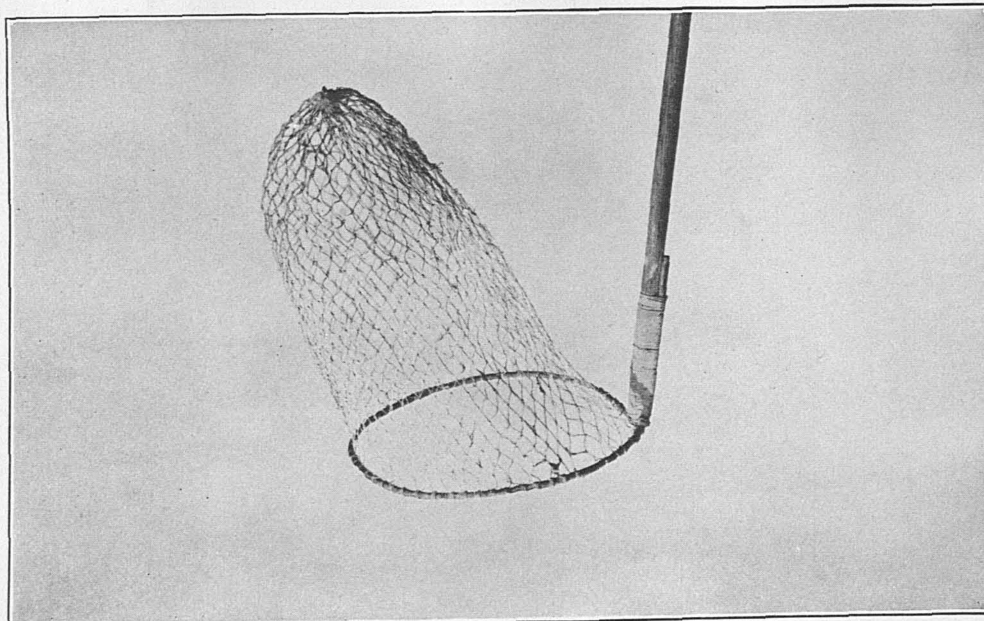

FIG. 22.—Bulley net used for catching spiny lobsters.

Key West are equipped with fish wells, which, according to their size, may accommodate from several hundred to about 1,000 crawfish. When using the bully net or the grains a small flatboat is utilized in making the catch. The typical flatboat has a rather blunt bow, to afford sufficient room for standing. This is an important feature, as the operator always works in the extreme bow of the boat. Some flatboats are equipped with a small fish well, but this is not absolutely essential for crawfish fishing, as the catch can be deposited from time to time in the well of the larger boat. Crawfish fishermen often remain away for a week or more at a time and seldom leave port with less than a 10-day supply of staple food products.

Three methods are employed in catching the crawfish—trapping, "bullying," and striking. The method of trapping crawfish differs in no special way from that used in trapping the northern lobster (*Homarus americanus*), except that the trap itself is of a distinct type. The traps are handmade and are built of heavy galvanized wire. It requires considerable skill to manufacture a good trap, and in 1919 only one person made them for sale. The price at that time was $7. The trap is somewhat elbow-shaped and measures about 4 feet in length, 2 feet in width, and is 1¼ feet in depth. Crawfish, crabs, and fish can enter through an opening made in the center of the vertical apex. The traps are baited with fish and placed in favorable localities, generally within 1 mile of the shore. Buoys are usually attached to the offshore traps, but are dispensed with when fishing is done near land in shallow water. The traps are lifted every morning when the weather is favorable. The crawfish are taken out through a small door located on the upper part of the trap. Stone crabs and fish are often caught along with the crawfish; the crabs and larger fish are retained for market, while the smaller fish are used to rebait the traps. The principal advantages of trap fishing for crawfish are (*a*) one fisherman can work alone and independently, (*b*) the traps will fish in deep water where at times most of the crawfish migrate, and (*c*) fishing can be done during moderately heavy weather when other methods of crawfish fishing are curtailed.

While trap fishing is somewhat of a success on a small scale, as yet no one has specialized in this method. It is not uncommon to catch from 6 to 15 good-sized crawfish in one trap over night, while 4 per trap might be considered a very fair average. The fishermen do not lift their traps during periods of rough weather, and at times they remain down for a week or more. When lifted at the termination of such a period, they do not contain many more crawfish, if any, than if they had been down but one night, and it is evident that some of them must escape after being trapped. According to the fishermen, the disadvantages of trap fishing are the high cost of the traps and the labor required for making them, the frequent repairs that are necessary when corrosion begins, the loss of traps through storms, theft, or otherwise, and the fact that they must continually be baited with fish.

"Bully" fishing for crawfish is done chiefly at night. Two men generally work together, but some fishermen work alone and independently. Besides the small flatboat, the necessary equipment consists of a bully net and a lantern. The bully net resembles a long-handled dip net, but differs in having the iron hoop placed at right angles to the pole. The pole is 12 feet or more in length, and the pocket of the net is about 24 inches deep. The lantern is placed in a glass case as a protection from the wind and is set in the bow of the boat.

When a "bully" fisherman discovers a crawfish crawling on the bottom he gives his partner directions for maneuvering the boat to a point of vantage, whereupon the bully net is carefully but swiftly placed over the crawfish. With due caution the animal can be approached without its becoming alarmed, but upon the slightest touch of the net it makes a desperate effort to escape. The hoop of the net must entirely surround the crawfish and touch upon even bottom or the animal will escape. When the crawfish finds that it can not escape beneath the hoop it thrusts itself back into the bunt of the net, and it is then that the fisherman raises the net to the surface with the crawfish secure in the bunt, which hangs over the side of the hoop. A fisherman working alone must push his boat along with the bully pole and is at a great disadvantage, especially in a strong tide.

During the course of a night one boat may capture as many as a thousand crawfish, but frequently only a few dozen are taken. The average catch probably ranges between 50 and 100.

Striking is perhaps the most productive as well as destructive method of catching crawfish. The weapon used, known locally as the "grains," is a two-tined barbed spear, each prong being about 3 inches long. By means of a ferrule it fits on the end of a pole 15 feet or more in length. This fishing is pursued in the daytime and when the sea is smooth. The crawfish, which can usually be distinguished by its long whiplike antennæ protruding from the shelter of a rock or sponge, is located by the use of a water glass.[a] By touching the antennæ the animal is usually frightened from its shelter, and at the crucial moment it is speared with the grains. Many badly injured animals escape and soon die, while most of those caught do not survive long, and if the fishermen remain out too long a part of their catch is liable to spoil and can not be used as food. This method of fishing, therefore, is destructive and wasteful.

Several Key West dealers ship relatively large quantities of crawfish out of the city. The principal markets are hotels and restaurants located in Miami, Jacksonville, Atlanta, Washington, Philadelphia, New York, and Boston. The restaurants utilize the crawfish to prepare various fancy dishes calling for lobster meat other than in the shell. For long-distance shipments two methods are employed in preparing crawfish—some are shipped alive and some are shipped after being cooked.

When shipping live crawfish they are carefully packed in sugar barrels. They must not be overcrowded, and therefore not more than 6 dozens are placed in one container. A substantial layer of ice is first placed in the bottom of a barrel, and on the ice is put a layer of sponge clippings—a waste material obtained when prepar-

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[a] A water glass such as is used in the Key West sponge and crawfish fisheries is simply a wooden bucket, the bottom of which has been replaced by glass, all joints being made water-tight. It is used when the water is choppy and the bottom could not otherwise be seen. The operator holds it in the water with one hand, thrusts his head into the pail, and with the other hand holds his implement of capture, whether it be sponge hook or grains. In very rough water it can not be used because of the violent action of the boat.

ing sponges for the market. The crawfish are then placed in a single layer on the sponge and covered with more clippings and ice. Thus, when completely packed, a barrel contains alternate layers of ice, sponge, crawfish, and sponge. The sponge clippings are used to absorb moisture and to keep the crawfish from direct contact with the ice. The barrels are conspicuously marked "re-ice," and it is sometimes necessary for transportation companies to re-ice a shipment several times when it is consigned to a distant point.

During the experimental stage of shipping live crawfish many of them were received in a spoiled condition, and it was thought that shipments could not be made with profit. It developed, however, that the most unsatisfactory shipments were caused by poor packing, and by experimenting the system just described was established and reduced losses to a minimum. It is very important that the crawfish be handled with great care from the time they are removed from the water until they reach their final destination. No injured crawfish are shipped alive, which fact excludes all those captured with the grains.

More crawfish are shipped in a cooked state than alive. More labor is required to prepare cooked crawfish, but shipping losses are very small and considerable packing space is saved by the elimination of the waste parts of the animal. Crawfish that are to be shipped in the cooked state are prepared as follows: The live animals are placed in a steam cooker and cooked until they are sufficiently well done to be eaten. After they have cooled sufficiently to be handled with unprotected hands the abdomen, or tail, is removed and the remainder of the animal is thrown away. The tail is split open and the meat is removed from the shell. Four or five tails are placed in a No. 2 friction-top can, which is perforated with small holes to admit air. These cans are then packed in a slack barrel, iced as in the case of fish, and are ready for shipment. A standard barrel contains 64 cans of 105 pounds net weight, representing the meat of 24 dozen crawfish. The barrels, however, vary somewhat in the weight of the crawfish they contain. One dealer dispenses with the cans entirely and packs the tails, without removing the shell, in barrels with an abundance of broken ice. He has used this method for a number of years with satisfactory results.

The trap and bully furnish the most select crawfish and the only ones that can be retained in captivity or shipped alive for long distances. Fortunately for the industry, many of the fishermen and most of the dealers look with disfavor upon the "striking" of crawfish. The abdomen or tail of a "struck" crawfish is usually removed from the body before it is cooked, and by this operation much space is saved in the cooking kettle or pot. Owing to the rapid deterioration of the flesh it is a question, however, whether this practice is a good one, as crawfish, lobsters, and crabs are in the best condition when killed in the cooking process.

No crawfish are canned in Key West at the present time (March, 1920). Several attempts to do so have been made during the past 10 years, all of which failed because of the tendency the meat has of turning dark. It is believed, however, that by experimenting along these lines and carefully studying the methods used in canning shrimp, lobsters, and crabs that the crawfish can be successfully canned. It is very probable that properly canned crawfish could readily establish itself on the market.

Because of the large numbers of crawfish used for fish bait it is difficult to estimate the annual catch with much exactness. The approximate catches made in previous years are as follows: 1895, 157,500 pounds; 1897, 161,500 pounds; 1902, 57,664 pounds; 1918, 345,518 pounds. During the month of December, 1918, shipments sent out under the trade name of "Florida lobsters" totaled about 500 barrels. This amount established a record up to that time, but this record was exceeded several times during 1919. During the year 1919 about 360,000 crawfish, weighing approximately 375,000 pounds, were caught. Of these about 40 per cent were shipped, 40 per cent were consumed locally, and 20 per cent were used as bait by the fishermen. On September 10, 1919, a severe hurricane visited Key West, wrecking many of the boats and paralyzing the fishing industry for several weeks; but for this incident the catch of crawfish would have reached 400,000 pounds.

The crawfish is taken at all seasons of the year, but the period of greatest abundance is from November to June. Most of the spawning occurs during the spring and summer, but occasional eggbearers are found as late as early winter. Unlike the northern lobster (*Homarus americanus*), whose eggs are carried for about 10 months before hatching, the incubation period of the eggs of the Florida spiny lobster is only about three weeks.

Large numbers of crawfish congregate along the shores during the spring for the purpose of spawning, and they are easily captured there. To conserve the supply of crawfish, the State of Florida has enacted a law, approved May 23, 1919, and effective for the first time during 1920, protecting the crawfish during the principal part of its spawning season. The text of this law is as follows:

SECTION 1. It shall be unlawful for any person, firm, or corporation, or association of persons to take or catch any salt-water crawfish from the waters of the State of Florida for commercial purposes, or to have in their, or its, possession between the first day of March and the first day of June of any year: *Provided*, That salt-water crawfish may be caught or taken at any time for purposes of bait, for catching fish, or for purposes of propagation or research by any State or biological station.

SEC. 2. It shall be unlawful for any common carrier, agent, or employee of such carrier to receive for carriage or permit the carriage of any such crawfish between the first day of March and the first day of June of any year.

SEC. 3. Any person, persons, firm, or corporation, or association of persons violating any provision of this act shall be deemed guilty of a misdemeanor, and upon conviction shall be punished by a fine of not more than two hundred and fifty ($250) dollars, or by imprisonment in the county jail for not more than six months, or both.

The future of the crawfish industry appears to be promising. A large commercial enterprise could hardly be supported by the demands of southern Florida, but there is almost unlimited opportunity for expansion by introducing this delicacy into the hotel and restaurant trade and even as a familiar object in the fishmonger's store. The crawfish has already been put to the test and has been accepted by some of the foremost epicures in this country.

At the present time one of the chief drawbacks to the crawfish industry is the irregularity of the supply owing to weather conditions. During windy weather, with its resultant high seas, it is impracticable to bully or strike crawfish and the small catch of the traps at such times is usually insufficient to supply even local demands. Thus it happens that at times dealers are unable to secure a good supply for one or two weeks at a time. While crawfish can be retained in live boxes for long periods of time, it appears that dealers do not make a practice of accumulating large supplies.

STONE CRAB.

The Florida stone crab (*Menippe mercenaria*) is the only species of crab that is of commercial importance in southern Florida. It is found from Beaufort, N. C., to Matagorda Bay, Tex., and has been recorded from Yucatan. A closely related species (*M. nodifrons*) is found from Cuba throughout the West Indies to Brazil, with a single record from Cameron, La.

Judging from the small numbers to be seen in the markets throughout the year, the stone crab is not found in great abundance. The flesh of this crab may, indeed, be considered a delicacy, and it is doubtful if there is any animal caught among the Florida keys that surpasses it in excellence. The fishery is pursued almost entirely with traps, although a few crabs are caught by hand and with nets. Stone crabs do not necessarily inhabit rocky places, and they are frequently found on bottoms of sand, marl, or clay, and among corals, sponges, and other bottom growths.

These crustaceans are caught throughout the year, but the most favorable fishing obtains during February, March, and April. They are found rather near the shore and generally not farther than 1 mile from land. Very few fishermen specialize in catching crabs, and most of those caught are taken incidently with crawfish. During periods of stormy weather when the traps are inaccessible the markets are sometimes without crabs. Unlike the crawfish, stone crabs are not shipped out of the State, but during the winter small numbers are supplied to seaside hotels in southern Florida.

When the weather is favorable the Key West catch varies from about 10 to 50 dozens a day during the winter and spring season, but no doubt more could be caught if they were more keenly sought after. The estimated annual catch of crabs is recorded for the following years: 1895, 4,680; 1902, 8,160; 1918, 18,400; and 1919, 22,000.

Small crabs, measuring about 3 inches in width across the carapace, sell at retail for about $1 a dozen, while those 4 or more inches in width bring from $1.50 to $2. The size of the claws, rather than the size of the body, determines the value of the crab, for the body meat is not eaten except in the very largest ones, because of the tedious process of picking out the edible parts. Large crabs with small claws are therefore classed with the small animals, and those without claws are returned to the water without injury. It is not unusual to find large crabs with claws weighing nearly half a pound each. The maximum size attained by the stone crab is about 6 inches in width across the carapace. Since they have no large lateral spines, such as the blue crab has, an individual of this size with its great claws is larger than might be supposed. A crab having a carapace 4.8 inches in width was found to weigh 13 ounces, and one of 5.1 inches weighed 1 pound and 3 ounces. These specimens both possessed claws of normal size.

Stone crabs do not live long out of water and on a warm day probably would not survive more than several hours. When dead they deteriorate very rapidly, and in preparing them as food they should by all means be killed in the cooking process. Stone crabs, however, can be held in captivity for a long time, as a number were retained in pens at the Key West biological station for over two years, when they were finally lost in a hurricane.

TURTLE FISHERY.

Key West is one of the principal markets for marine turtles in the United States. Three species are seen in the markets—the green turtle (*Chelonia mydas*), the loggerhead (*Thalassochelys caretta*), and the hawksbill (*C. imbricata*).

The green turtle is by far the most important, the loggerhead is considered inferior and is eaten only by the fishermen, while the hawksbill is scarce and used only for its shell. Most of the turtles are brought in by foreign boats, making Key West principally a receiving station from which the turtles are forwarded to other markets in this country.

The green turtle inhabits the Atlantic, Indian, and Pacific Oceans, its preference being for the tropical and subtropical parts, although it sometimes strays to the northern part of the Temperate Zone. It is found in greatest abundance about the island of Ascension, the West Indies, and the Atlantic coast of Nicaragua, between latitudes 11° 30′ and 14° 10′ N.

The three external characteristics by which the green turtle may be distinguished from the loggerhead are the front flippers, head, and coloration. The green turtle has but one nail on each of its two front flippers, its head is considerably smaller than that of the loggerhead, and the color of the carapace or back is not uniform but may be a mixture of olive, olive green, and brown, which is usually mottled or streaked with yellow, somewhat resembling that of the hawksbill. Pleasing designs are often found, although the carapace is not used commercially in Key West. The under parts are pale yellowish. The turtle gets its name from the green color of its fat. At the present day the maximum size is 4 feet, with a weight of about 500 pounds, but examples weighing over 300 pounds are seldom taken. In its natural habitat this turtle is herbivorous, feeding on algæ and turtle weed, but in captivity it is said to show a preference for fish.

The egg-laying period is from April to July, at which time the female leaves the water to deposit her eggs on a sandy beach above the high-water mark and in a locality that receives the sun's rays. With her flippers she scoops a hole in the sand, 12 to 18 inches in depth, and after depositing her eggs replaces the sand, instinctively leaving the nest almost undetectable to the eye. This is accomplished by crawling over the freshly filled-in sand and blinding her trail so that the identity of the act is lost. A female is said to deposit about 100 or more eggs in a nest and to repeat this act two or three times during the several months of the egg-laying period. Many turtles are captured after they have come ashore to lay their eggs.

50—1

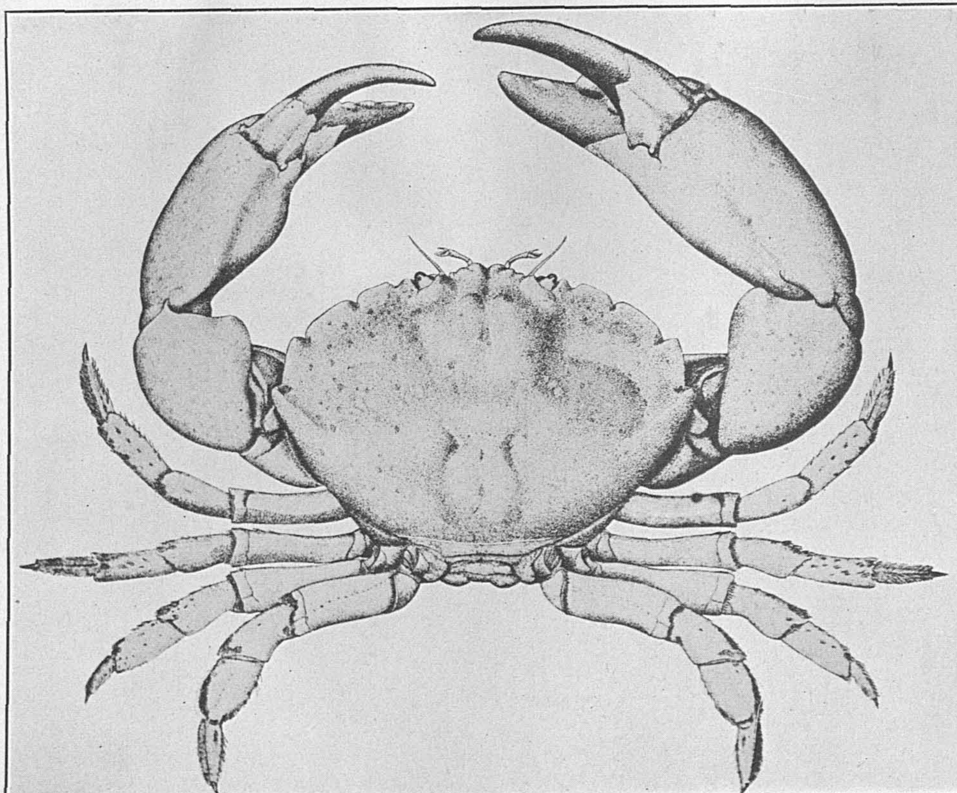

FIG. 23.—Stone crab (*Menippi mercenaria*).

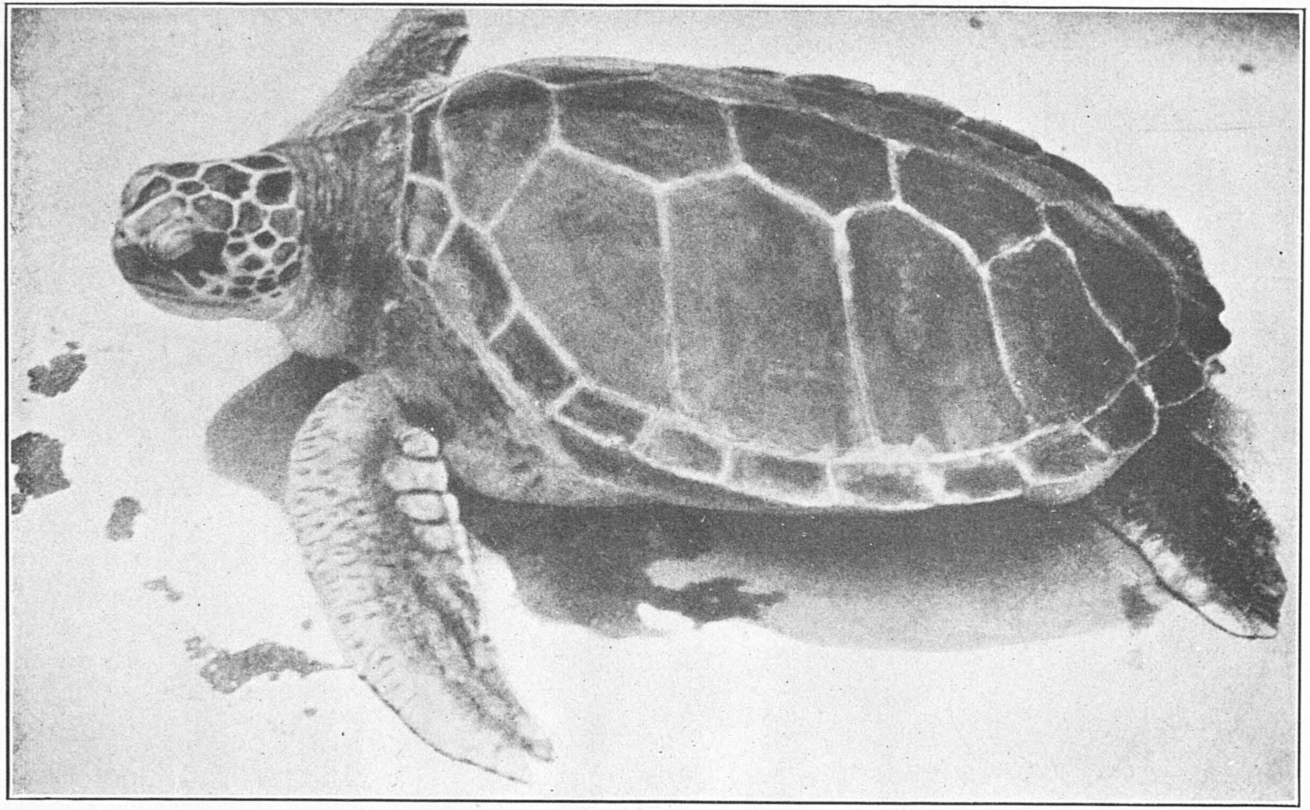

FIG. 24.—Green turtle (*Chelonia mydas*). (Illustration taken from "Reptiles of the World," by R. L. Ditmars. Courtesy of Doubleday, Page & Co.)

50—3

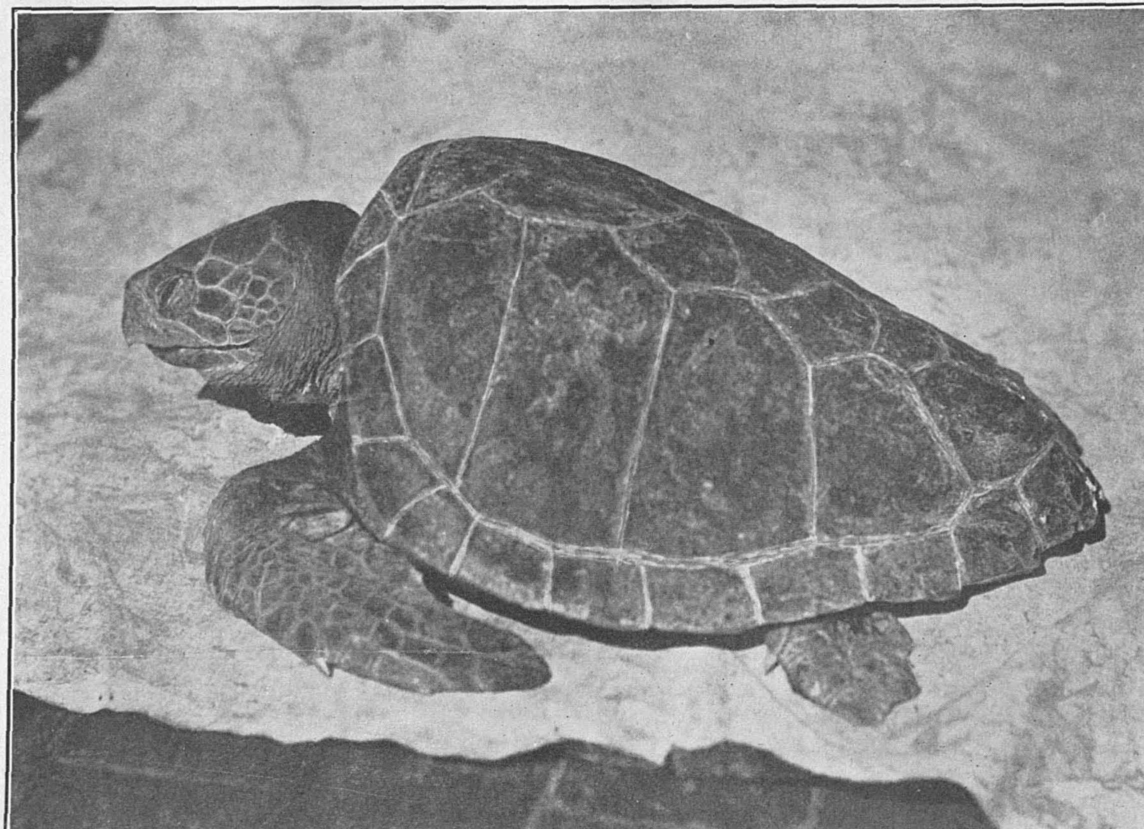

FIG. 25.—Loggerhead turtle (*Thalassochelys caretta*). (Illustration taken from "Reptiles of the World," by R. L. Ditmars. Courtesy of Doubleday, Page & Co.)

There is but one dealer in Key West who buys green turtles, and besides making shipments to the north he operates a small soup cannery.

The turtles are landed by fishing schooners known as "turtle boats," most of which fly the British flag. As soon as they are received in Key West the turtles are placed in a turtle crawl. This crawl—the only one in this region—is an inclosure of about 40 by 70 feet, which is surrounded by palmetto logs placed close together in water 15 feet in depth. It is divided into a number of smaller crawls in order that the turtles may be separated into different size groups. In these pens or crawls the turtles will live for a long time, and there is practically no loss to the dealer through mortality. As many as 800 turtles occasionally are held in captivity at one time.

Most of the turtles are landed during the spring and early summer, which is the egg-laying season. During May, 1919, five vessels landed 1,250 green turtles in Key West, each cargo containing from 225 to 300 animals. Many more were received throughout the summer, but by the end of November deliveries practically ceased. Very few turtles are received from December to March, but a good supply is kept on hand in the late fall to last throughout the winter. It is estimated that 170,000 pounds of green turtles were landed in Key West during 1919.

To remove a turtle from the crawl, a loop of manila rope is dropped into the water for the purpose of catching the flipper of a turtle when the animals come to the surface to breathe. When a flipper has been thus caught, the rope is at once made taut and several men haul the turtle up to the dock, where it is turned over on its back to prevent its escape and the rope is removed.

Turtles that are used for canning purposes are slaughtered on the turtle dock. Each day during the greater part of the year five or six are killed at 3.30 p. m., at which time an inspector is present to see that the butchering is done in a sanitary manner. No turtles are killed until the desired number has been removed from the pens and laid about 1 foot apart on the dock. Then one person takes a sharp ax and strikes the head and four flippers off each turtle, going from one to the other with great rapidity. In each case the appendages are almost completely severed, allowing the animals to bleed freely. Immediately after the axman finishes, two men commence cutting away the plastron and then remove the entrails. During the operation sea water is thrown over the carcasses to wash away the blood and slime. The edible portions of the turtle are removed in four large pieces, each of which contains one of the flippers. The flesh is cut away from the carapace and thrown into a barrel of sea water, where it is thoroughly washed. It is then taken to the cannery, where it is hung on hooks and allowed to remain over night for use the next day. The following day a small portion of the meat may be sold for local consumption, but the greater part is used in preparing canned turtle soup.

At least one prominent chef has stated that the carapace is one of the best parts of the green turtle for the making of soup, but the Key West cannery disposes of that part as well as the plastron and entrails by dumping them into the sea some distance from shore.

During May, June, and July the females contain eggs in various stages of development, which greatly enhances their value, as there is a great demand for the eggs. The white or mature eggs sell for 25 cents a dozen, while the yellow or immature ones bring about 50 cents a pound and are considered a great delicacy. The turtle has two ovaries, and the immature eggs are found in a large cluster in each one. The mature eggs, which are somewhat smaller than a golf ball, are found practically unattached inside the ovaries and have tough parchmentlike shells, which will not break even though the eggs are thrown down with force. A female is said to contain from 6 to 30 pounds of eggs, according to its size and condition.

The smaller turtles are shipped alive to the North, as they command a somewhat higher price per pound than do the larger ones. The following quotations are taken from the New York wholesale market prices of December 29, 1919: Turtles (green) under 100 pounds, 18 cents per pound; 100 to 150 pounds, 17 cents; 150 to 200 pounds, 16 cents; over 200 pounds, 13½ cents. New York, however, obtains only a part of its green turtles from Key West, for many are brought by steamship direct from the West Indies and Central America.

In preparing turtles for shipment on the coastwise steamships the four flippers are pierced and tied together, and the animals are placed back down. This method of shipping turtles has been branded as cruel, but it appears to be a necessity. The piercing of the flippers, however, is not absolutely essential. Because the marine turtles live almost entirely in the water the plastron is developed in such a way that it is not capable of sustaining the weight of the body without injuring the internal organs. Placing a green or a loggerhead turtle in its "natural" position when out of water results in pressure from the plastron against the lungs, causing death from suffocation.

The loggerhead turtle is recorded from all tropical and subtropical seas. The writer has observed one in New York Bay, one off Long Island, and several off the New Jersey coast. Since the loggerhead turtle is of much less commercial value than the green turtle, it has been fished for less aggressively, and for that reason it is probably the more abundant of the two.

The front flippers of the loggerhead are supplied with two nails, except occasionally in old examples, which have but one. The head of the loggerhead turtle is larger than that of the green turtle. The color of the carapace is usually a uniform brown, but sometimes it is faintly marked with yellow. The under parts are yellowish. Loggerheads weighing more than 700 pounds are comparatively rare, the usual size ranging between 40 and 400 pounds. This turtle is mostly carnivorous in its habits, but is said to feed also on a certain grass that fishermen call "turtle weed."

Most of the egg laying takes place during May and June. During the egg laying season one female, according to size and condition, may lay from 50 to 1,000 eggs. The eggs, which hatch in from six to eight weeks, are deposited in the same manner as those of the green turtle. The loggerhead is strictly a marine animal and, like the green turtle, the female forsakes the sea only to lay her eggs.

The loggerhead turtle is fairly plentiful in Florida waters, but it is most abundant on the southwest coast. Compared with the green turtle its value is slight, but it is utilized for food to some extent in the small fishing villages, and it is not infrequently found in the markets of certain large cities.

Two methods are employed in catching both the green and the loggerhead turtle in the vicinity of Key West—netting and pegging. There are well recognized localities that turtles are known to frequent in search of food, and it is at these places that the turtle fishermen look for them. The senses of smell and taste appear to be well developed, and they will travel long distances in search of their favorite food and feeding grounds.

In netting turtles a large-meshed net is used, and when one or more turtles are discovered in one locality the net is set in a straight line at a favorable place to intercept their progress. As all turtles must rise to the surface for air at more or less frequent intervals they are very liable to be seen in smooth water, and on calm days they can be located several hundred feet away by the sound made when they forcibly exhale air at the surface. While a turtle can not gill itself as fish do, the net nevertheless acts very much in the manner of a gill net. Upon striking the net the turtle usually becomes entangled in the meshes by its head and flippers, and after a futile struggle it rises to the surface where the fishermen are ready to haul it aboard their dory. Some of the turtles, of course, avoid the net, and others that strike it fail to become entangled, but a large percentage of those that strike the meshes are captured.

Pegging turtles is somewhat similar to spearing swordfish. A small sharp barbed spear, to which a line is attached, is fitted loosely on a staff, and upon approaching within a suitable distance of the turtle the spear is plunged into its back. The spearhead usually separates from the staff when it becomes embedded in the back of the turtle, and the animal is held by the line. If the spear is firmly embedded, the capture of the animal in a short time is assured. Fishermen living in isolated places and who desire turtles for food usually employ this method.

In the West Indies and off Central America the greater part of the catch is made during the egg-laying period in the spring, when the turtles are captured on sandy beaches upon which the females have emerged for the purpose of laying their eggs. The marine turtles are poorly equipped for travel on land, and their movements are slow and laborious. For this reason if carefully approached they are easily captured, and by being placed on their backs they are rendered helpless to escape.

The hawksbill turtle is found in the Gulf of Mexico and in the West Indies southward to Brazil. This species is easily recognized by its small size and hard, imbricated shields, of which there are 13 large ones normally surrounded by 24 marginal plates. The carapace shields overlap each other like shingles on a roof, differing in this respect from the green and loggerhead turtles whose shields are smooth. The fore and hind flippers each have two nails, and the horny covers of the jaws form a sharp hooked beak, from which the name "hawksbill" is derived. The carapace of the adult is beautifully mottled with yellow on a dark brown background. The tortoise shell of commerce is obtained from the carapace of this turtle. The shields can be fused by pressure and heat to form pieces of any desired size.

The hawksbill turtle is too scarce about Key West to be considered of much commercial importance. The shells of the few that are caught by local fishermen are kept or sold as novelties. The size of those that are seen ranges from 10 to 15 inches, measured over the longest distance of the back. In Key West these turtles bring from $1.50 to $10 each, according to the size and condition of the plates. The largest specimen of which there is a record measured 34 inches.

SPONGE FISHERY.

Detailed accounts of the Florida sponge fishery have already been published,[4] and therefore the subject will be treated only very briefly in this paper. The old methods of buying, selling, and packing sponges used 30 and 40 years ago are still in vogue, and the fishery of to-day is much the same as it was many years ago. The publication by Dr. H. F. Moore gives an exhaustive account of the sponge fisheries and has been drawn upon liberally in securing data for this chapter.

Florida sponges had a limited domestic use among the inhabitants as far back as the early part of the nineteenth century, or soon after Key West was settled in 1822. It was not until 1849, however, that these sponges became of commercial value. In that year a cargo of sponges was sent to New York on a venture and resulted in the gradual building up of this industry in Florida.

Until 1891 Key West held almost an absolute monopoly of the trade in the United States, but at that time a small sponge mart was established at Tarpon Springs. Because of more advantageous local conditions, the waning of the catch on the Key grounds, and especially because of the development of diving for sponges, Tarpon Springs has become the leading sponge center, relegating Key West to a poor second.

Table 6 shows the extent of the sponge fishery[5] on the Gulf Coast of Florida for the years indicated, from 1895 to 1918. The weights used are taken after the sponges have been cleaned and dried and before they are baled for shipment. The average weights of different grades are as follows: Glove, wire, and yellow, each 1½ pounds per bunch; grass and large wool, 2½ pounds per bunch; small wool, 1 pound per bunch.

TABLE 6.—*Quantity and value of sponges taken on the Gulf coast of Florida in certain years from 1895 to 1918.*

Kinds of sponges.	1895		1897		1900		1902		1918	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Sheepswool	231,272	$363,107	157,476	$240,599	181,311	$483,263	133,518	$297,727	276,168	$675,781
Yellow	29,509	11,798	32,362	13,082	74,466	44,045	56,787	31,113	91,641	34,187
Grass	21,387	5,464	128,622	29,188	143,112	83,263	140,682	29,765	73,033	12,125
Others	23,952	6,502	13,086	3,171	19,236	7,114	15,902	5,817	11,346	3,062
Total	306,120	386,871	331,546	286,010	418,125	567,685	346,889	364,422	452,188	725,155

[4] Commercial Sponges and the Sponge Fisheries. By H. F. Moore. Bulletin, U. S. Bureau of Fisheries, Vol. XXVIII. 1908 (1910), Part I. B. F. Doc. No. 667.

[5] Fishery Industries of the United States. Report of the Division of Statistics and Methods of the Fisheries for 1919. By Lewis Radcliffe. Appendix X, Report, U. S. Commissioner of Fisheries for 1919 (1921), pp. 160–161. B. F. Doc. No. 892.

TABLE 7.—*Relative importance of Key West and Tarpon Springs as sponge centers from 1888 to 1918.*

Locality.	1888		1895		1897		1900		1902		1918	
	Number of pounds landed.	Per cent of total catch.	Number of pounds landed.	Per cent of total catch.	Number of pounds landed.	Per cent of total catch.	Number of pounds landed.	Per cent of total catch.	Number of pounds landed.	Per cent of total catch.	Number of pounds landed.	Per cent of total catch.
Key West	238,038	94	280,372	92	270,906	82	359,854	86	266,841	77	107,743	24
Tarpon Springs	....	....	16,344	5	56,000	16	53,178	13	67,218	19	344,445	76
Others...	15,652	6	9,404	3	4,640	2	5,098	1	12,830	4	....	....

In 1919 the quantity of sponges sold at the Tarpon Springs exchange amounted to 424,075 pounds, valued at $707,964, and in 1920 the quantity sold was 409,746 pounds, valued at $678,209. The catch at Key West for these years is not available, but it is probable that it did not exceed 125,000 pounds for either year.

In 1921 the quantity of sponges sold at the sponge exchange, Tarpon Springs, Fla., was 386,390 pounds, valued at $540,093, of which 173,723 pounds, valued at $463,170 were large wool; 63,786 pounds, valued at $28,705, small wool; 70,218 pounds, valued at $30,428, yellow; 65,745 pounds, valued at $12,623, grass; and 12,918 pounds, valued at $5,167, wire. The prices of the small wool sponges were so low in the latter part of 1920 that several thousand bunches were held over for sale in 1921. For this reason the 1921 totals were larger than for the preceding year. It is estimated that sponges amounting in value to $40,000 were sold outside of the exchange at Tarpon Springs.[6]

In 1922 the quantity of sponges sold at the sponge exchange, Tarpon Springs, Fla., was 526,885 pounds, valued at $699,092, of which 248,475 pounds, valued at $596,199 were large wool; 70,478 pounds, valued at $42,286, small wool; 115,455 pounds, valued at $37,637, yellow; 84,892 pounds, valued at $20,379, grass; and 7,585 pounds, valued at $2,588, wire. It is estimated that sponges to the value of $50,000 were sold outside of the exchange at Tarpon Springs.[7]

The principal kinds of sponges brought into Key West, in the order of their importance, are the sheepswool, yellow, and grass. These are divided into numerous subvarieties and grades. Glove sponges, although generally common throughout the Florida keys, have but a small commercial value and are sold only in limited quantities. Other kinds, such as velvet and wire sponges, are of minor importance in the Key West market.

"The sponging grounds as at present developed are broadly divided into two widely separated areas—the 'bay grounds,' lying in the open waters of the Gulf of Mexico from about Johns Pass to St. Marks, and the 'key grounds,' stretching along and among the reefs and keys from Cape Florida to Boca Grande Key." (Moore, 1908.) Doctor Moore states further that "the grounds as exploited and

[6] Fishery Industries of the United States. Report of the Division of Fishery Industries for 1921. By Lewis Radcliffe. Appendix IX, Report, U. S. Commissioner of Fisheries for 1922 (1923), p. 70. B. F. Doc. No. 932.

[7] Fishery Industries of the United States. Report of the Division of Fishery Industries for 1922. By Harden F. Taylor. Appendix V, Report, U. S. Commissioner of Fisheries for 1923, p. 63. B. F. Doc. No. 954.

worked by the hookers up to the time of the introduction of diving apparatus, in April, 1905, covered an area of 4,350 square miles, of which the bay grounds contained about 3,400 and the key grounds about 950 square miles. It must not be considered, however, that all of this area is productive, for, on the contrary, the actual sponge-producing bottom in any given field is far less than the barren areas with which it is mingled." Since the introduction of diving a considerable area has been added to the sponge grounds, because operations can be carried on at greater depths.

In Florida two methods are used in gathering sponges—diving and hooking. A sponge-diver's outfit generally consists of a schooner of between 10 and 20 tons register and one or two machine boats. The schooner is used as living quarters for the crew and a place of deposit for the sponges. The machine boats carry the usual diving apparatus and are of the Greek type, with high bows and sterns. The diving dress consists of a helmet, rubber suit, breastplate, shoes, and weights. Generally seven to nine men are carried, consisting of a captain, deckhand, cook, and a diving crew. The great majority of divers' boats operate from Tarpon Springs.

The divers generally operate at a depth of 60 feet or less and remain down for about two hours at a time. As there are two divers to a boat, each man works about two hours and rests for a like period. At greater depths the working time is shorter and the rests longer. The sponges are gathered by hand and placed in a net basket, which is pulled to the surface from time to time to be emptied. The divers often work in places that are inaccessible to the "hookers," and it is probable that the sponges found in such localities could not be obtained by any other method. The daily catch varies considerably, but it usually averages from 10 to 15 bunches for each boat. Occasionally a prolific bed is found, resulting in a catch of 40 or 50 bunches in one day. The boats often remain away for one to two months, but sometimes a good catch is made in one week.

The Key West fishermen use the sponge hook almost exclusively. Prior to 1905 all sponges in this country were taken with hooks, but diving has proven so much superior that the old method is now of small importance in the fishery.

The sponge hook has the one advantage that it can be used by one or two men and at practically no expense. The hook is attached to a pole of convenient length and has three tines bent at right angles to the handle, so that a sponge may be lifted perpendicularly from the bottom. The typical hook fisherman has a sloop 25 to 40 feet long on which he lives and a 12 or 14 foot dory in which he works. Sails are generally depended upon in going to and from the grounds, as only a few of the boats used are equipped with auxiliary engines.

The hook fisherman usually operates among the keys where the water is clear and about 6 to 15 feet in depth. Except when the water is very smooth a sponge glass (that is, a wooden bucket with a glass bottom) is used for locating the sponges. When two men work together, the hooker remains in the bow with the sponge glass and directs his companion in the movements of the boat. Sometimes one man works independently, in which case he weights the stern of the dory with iron and propels the boat by pushing on the bottom with his sponge hook. It is seldom that a fisherman working alone is able to use the sponge glass.

A few larger boats of the small schooner type engage in hooking. Two or three dories are carried, each of which is manned by two men. Fishing is done in water ranging from 12 to 30 feet in depth, necessitating long poles that are difficult to handle.

When removing sponges from the bottom care must be taken not to mutilate them. Sometimes they are firmly attached, and the sponge hook either fails to dislodge them or tears them in such a way that their value is materially reduced. The diver, since he gathers them by hand, is able to take most of his sponges in perfect condition.

The sponge as an article of commerce is merely the skeleton of the living animal and is of very different appearance than when first removed from the water. When first taken, it is a comparatively heavy mass of living matter, most of the porousness of the market sponge being filled with live animal tissue. The color of live commercial sponges is usually dark brown or black.

After the sponges have been taken aboard the deposit boat they are laid on deck, where they undergo a three or four day exposure to the air to kill all of the living tissue. In this state decomposition sets in and some of the liquid organic matter drains away. It is advantageous to shade the sponges, or the sun will quickly dry the outside skin and render the subsequent cleaning more difficult. After sufficient exposure the sponges are beaten with a short heavy club to loosen the remaining skin, dead tissue, and foreign matter. They are then strung on strong cord and thrown overboard, where they are allowed to remain for several days to macerate by the action of the tide. Another method of cleansing sponges by tide action is to place them in crawls. Crawls are small inclosures made with stakes set closely together in shallow water generally very near to shore. "Usually on Friday night the vessels run in to the crawls, and Saturday is spent in 'crawling' the dead sponges of the recent catch and cleaning those deposited on the Saturday previous." (Moore.)

With a dull knife the remaining particles of the outside skin are scraped off, and with a stout club the small pieces of shell, coral, and other matter, together with the remaining dead tissue, are pounded out of the skeleton. Finally, water is taken up and squeezed through them a number of times, and after being strung in bunches they are ready for the auction market.

Sheepswool sponges caught on the Key grounds are usually small in size and of weak fiber as compared to those taken in the deeper water of the bay grounds. Inferior sponges can be distinguished readily by the red-brown color of the inner fiber. In some sponges this reddening is found only at the root, but in the most inferior it penetrates well into the body. The best quality sponges are of a grayish hue throughout, although some may show a reddish spot at the point of attachment to the ocean bed. The color itself is one of the least important factors in determining the value of a sponge, however. A fine sponge is determined by the following characteristics: Size and shape, softness, fineness, toughness and durability, resiliency, and absorptiveness.

The fishermen sell their catch by the bunch—a piece of cord 4⅝ feet in length being strung with sponges placed end to end. As far as practicable, sponges of the same grade and size are bunched together. In order to display them to the best advantage they are dampened and laid out on the sponge wharf, where they may be critically examined by the buyers.

The method of selling is rather unique. The auction is carried on in comparative silence, as the buyers are men of experience and require no advice as to the value of the various lots of sponges. The hour before the sale is spent by the buyers in examining the merchandise and making note of the highest price they will pay per bunch for each of the various lots. During the sale the auctioneer announces the number of bunches in the lot being offered and receives the offer of each bidder written on a small piece of folded paper. The highest bidder is awarded the sponges without argument, providing the owner considers the amount sufficient. No more ceremony enters into a $5,000 sale than in one of $5. The prices paid for any one variety of sponge may vary considerably according to quality and size. Selecting the extremes, the wide variation of prices is illustrated from the following data collected at Key West on January 21, 1920, during the morning's auction sale:

Sheepswool sponges: One lot of 200 bunches, $1,427; one lot of 226 bunches, $1,587; one lot of 17 bunches, $12; one lot of 5 bunches, $4. The best quality brought $7.13½ a bunch for a lot of 200 bunches, while the most inferior brought only 70 cents a bunch for a lot of 17 bunches. A feature of the sale, aside from the several lots of fine wool sponges, was the disposal of 9 very large wool sponges for $48, or $5.33 a sponge. These sponges were truly as "large as a bushel basket" and are now quite rare in the market. The highest price paid for yellow sponges was 96 cents a bunch for a lot of 49, and the lowest price was 56 cents a bunch for a lot of 48 bunches. The only lot of grass sponges (5 bunches) sold at 48 cents a bunch.

After the dealers purchase the sponges they prepare them for the market by trimming and shaping and by removing the remaining foreign matter which the fishermen did not succeed in beating out. The sponges are packed in burlap bales of 15, 30, 50, or 60 pounds net weight, and in each bale is placed but one variety and as a rule but one grade. Sponges that have large crab or coral holes and that are badly torn or otherwise imperfect are cut into smaller shapes known as "cuts." Those that have imperfections but do not require cutting are termed "seconds," while the whole perfect specimens are known as "forms."

The production of sponges on the Florida beds has not kept pace with the great demand, and the result is that the shallower grounds have been greatly depleted and in places completely devastated. This has necessitated fishing in deeper and deeper water and has forced many of the fishermen to resort to different occupations. This condition shows clearly that sponges should be allowed to propagate under natural conditions, and that they should be fully protected by law.

In 1917 the State of Florida enacted a law requiring that the minimum size of commercial sponges taken from State waters should be not less than 5 inches in horizontal diameter. A few years prior to that time the United States Government had enacted a similar law with regard to sponges taken from waters under its jurisdiction. This law if rigidly enforced should prove beneficial to the sponge industry. The law of Florida prohibits sponge divers from operating in State waters. However, most of the divers' boats fish not closer than 9 miles from shore.

Sponges have been grown by artificial culture [8] but comparatively little has been done in this direction during the past 10 years.

FLORIDA CONCH.

The conch of Key West (*Strombus gigas*) is a large gastropod that is used to a limited extent as food. It is found in shallow water near the shores of the keys and is easily captured with a sponge hook or by hand. It is also found in the Bahamas and the West Indies. It sometimes attains a length of 1 foot and a weight of 5 pounds. The animal itself, which averages about 1 pound in weight, is incased by a large thick shell. Very often the inner lining of the shell is beautifully tinted with pink, and choice specimens are sold in local novelty shops for 25 or 50 cents each. When sold as food, the flesh of the animal is removed from the shell and for convenience in handling is strung on a small stick. It is peddled about the city at about 5 cents for each conch. During 1918 about 2,000 pounds, worth $100, were sold in Key West.

The conch requires several hours' cooking to render it palatable. One person in the city prepares a chowder in concentrated form, which is preserved in glass jars or friction-top cans. In this form small quantities of the preparation are sold by mail. In the West Indies and the Bahamas the most desirable parts of the conch shell are exported to Europe, where they are utilized by cameo cutters. Conchs are plentiful enough to supply the present demand, but the supply could easily be depleted by overfishing.

CLAM INDUSTRY OF SOUTHERN FLORIDA.

What is probably the largest bed of hard clams in the United States is to be found off the southwest coast of Florida, in the region of the Ten Thousand Islands. The bed is about 40 miles long and 5 miles wide and is estimated to contain an area of nearly 150 square miles that produces clams. The southern part of this bed is about 70 miles from Key West and can be reached in less than 24 hours with a small sailboat.

The hard clam is of minor importance in the Key West fisheries but of considerable importance on the southwest coast of Florida. The small catch landed in Key West is due to the lack of demand by the local population rather than to the distance of the clam beds from the city.

Since 1889, at least, Key West boats have made occasional trips for clams during the spring, summer, and fall. The journey is seldom made during the winter because more profit can be made at that time in catching kingfish and spiny lobsters. From 1889 to 1915 the annual catch landed in Key West varied from 10,000 to 25,000 clams. During 1918 eleven trips were made by two fishermen, who operated the only boat engaged in this business. The total catch for the year amounted to 38,000 clams.

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[8] A Practical Method of Sponge Culture. By H. F. Moore. Bulletin, U. S. Bureau of Fisheries, Vol. XXVIII, 1908 (1910). B. F. Doc. No. 669.

The Florida hard clam (*Venus mercenaria mortoni*) bears a close resemblance to the New England quahaug (*V. mercenaria*). It is difficult to separate the two varieties when comparing specimens 3 or 3½ inches in length, but in general the southern clam attains a larger size and has a thicker and heavier shell. It is not unusual to find these clams weighing more than 2 pounds each. About 125 clams of average size fill a 5-peck basket, and as a full basket weighs about 125 pounds the average weight of a clam is 1 pound.

The clams may be divided into three types, although they all belong to one species. There is a thick-lipped type, a thin-lipped type, and an intermediate type. The thick-lipped clams are sometimes known as "bullnose," and are said to be somewhat inferior to the thinner-lipped variety. The shell of the thin-lipped clam is somewhat lighter than that of the "bullnose," but it is heavier than the shell of the northern quahaug. It is probable that the thickness of the shell at the lips is due to some extent to age and retarded growth, but the fact remains that small thick-lipped clams may be found in places where the clams are scattered, and large thin-lipped ones are found where clams of all three types are exceedingly abundant. The relative abundance of each type, judged by the averages obtained from numerous examinations made in various parts of the great clam bed, is as follows: Thick-lipped, 50 per cent; thin-lipped, 30 per cent; and intermediate, 20 per cent. The average size of 50 thick-lipped and 50 thin-lipped clams selected at random was 3½ inches for the former and 3⅓ inches for the latter variety. Measurements were taken with calipers, the points of which touched the hinge ligament and the farthest opposite point. Measured in this way about 95 per cent of the clams, whether dug by hand pickers or dredge, ranged between 2½ and 5 inches in length.

Dead clamshells are found almost everywhere on the clam beds. In some places they are very abundant, while in others they are occasional. It is said that the clam dredge kills many of the clams, but this is improbable for the following reasons: (*a*) The dead shells are found over almost the entire bar; (*b*) the dredge has worked over but a small portion of the clam bar and only in two or three restricted localities; (*c*) nearly all the shells are unbroken, while many of them would likely be mutilated had the dredge been responsible; (*d*) the writer dug several hundred clams in a locality where the dredge certainly never had operated and found many dead shells; and (*e*) sometimes a single valve was lying flat on the bottom and sometimes the two valves were intact and filled with mud but were buried in the same position as when living.

It is but natural that many clams should die where their numbers are vast and when they live in a region almost untouched by man. Like all living things, clams must die at some time of old age, if for no other reason, and this may be responsible for the presence of many dead shells. Sudden changes in the salinity of the water may also cause a part of the mortality. Fresh water supplied by the numerous small rivers of the Ten Thousand Islands lowers the density of the water on the clam bar, particularly during the rainy season. This brackish condition of the water is especially suitable for the growth of the clams. During the winter, however, when rains are very infrequent, the density of the water increases until it is equal to that of Key West or other points not affected by fresh water.

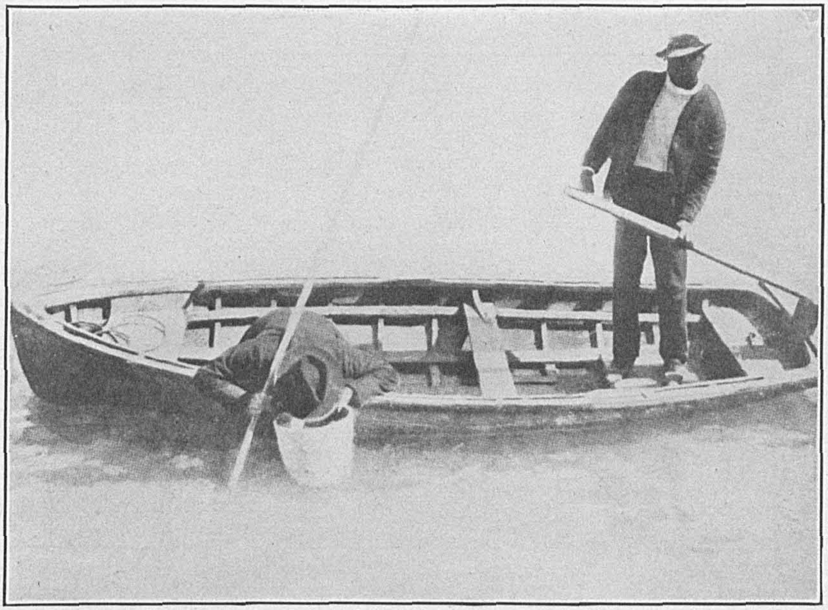

FIG. 26.—Hook fisherman searching for sponges, aided by a water glass.

FIG. 27.—Sponge yard at Key West, showing the sponges drying.

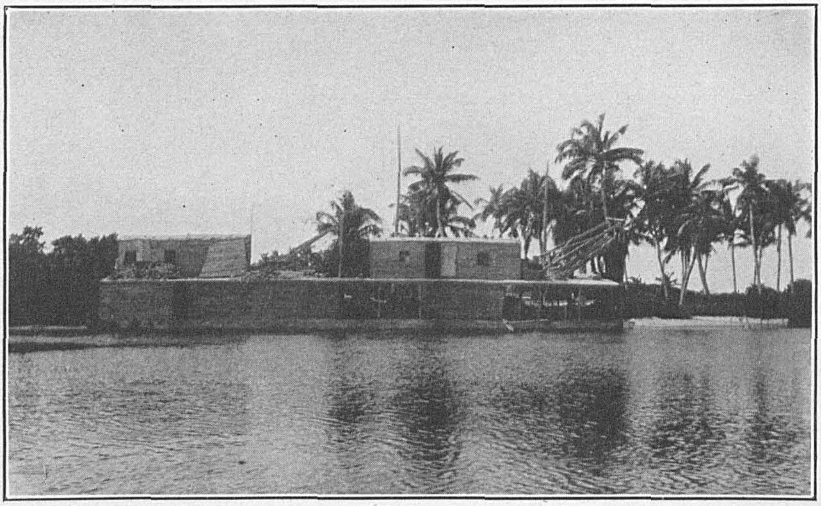

FIG. 28.—This dredge was used for digging clams along the coast of the Ten Thousand Islands, Fla., and until September, 1922, when a second dredge was put in operation, it was the only one of its kind in existence. As pictured, the dredge was stationed at Marco for repairs.

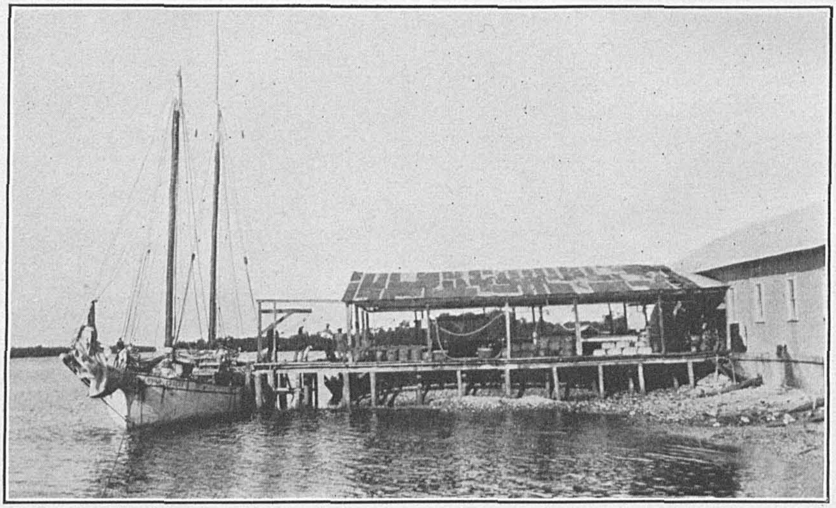

FIG. 29.—The dock of the Marco clam cannery and freight boat ready to leave for Key West with a cargo of canned clam products. At Key West the cases of clams are placed aboard a coastwise steamship for delivery in New York.

It is believed that long periods of high salinity have a deleterious effect on the clams.

Clams are found in varying abundance from Gullivan's Bay to Shark Point. The bed gradually widens from Coon Key to Pavilion Key, and thence continues to Porpoise Point, after which it narrows until Shark Point is reached. Below Shark Point the bottom is mostly of firm sand and is unsuitable for the growth of clams.

The clams are very plentiful over a large part of the bed, and no difficulty is encountered in finding a suitable locality for digging. The areas of greatest abundance occur immediately north to northwest of Pavilion Key, between Seminole and Porpoise Points and directly off Clam Point. There are places where few or no clams are found, and as a rule none are present within a few hundred feet of shore.

The following data will illustrate the general abundance of clams in the areas designated. The terms used can be interpreted as follows: "Scattered," where not more than five clams per square yard are present. "Fairly abundant," "abundant," and "very abundant," where from more than five to many clams per square yard are present.

Coon Key.—Two and one-eighth miles southwest of Pyramid Light; depth, 4 feet, mean low water. Clams abundant. One mile WSW. of Pyramid Light; depth, 4½ feet. Bottom of rather firm gray mud with scattering shell. No clams found. One-half mile SSE. of Pyramid Light; depth, 5 feet. Bottom of sticky mud with much eelgrass. Clams very abundant. One-third mile S. by E. of Coon Key, within a few hundred feet of Pyramid Light; depth, 4 feet. Bottom of mud and eelgrass. Clams abundant. One and one-fourth miles southeast of Pyramid Light; depth, 6 feet. Bottom of shell and hard mud; eelgrass. Clams fairly abundant. One and one-half miles southeast of Pyramid Light; depth, 7 feet. Bottom of mud and shell; eelgrass. Clams fairly abundant. Two miles southeast of Pyramid Light; depth, 7 feet. Bottom soft; broken shell. Clams scattered.

Horse Key.—One mile S. by W. ½ W. of Horse Key; depth, 7 feet. Bottom of rather hard mud and broken shell. Clams scattered. One mile W. ½ N. of outer shore of Horse Key. Bottom hard; eelgrass. Clams fairly abundant. Directly inshore from the last-mentioned locality and 600 feet from the shore of an unnamed island. Bottom hard mud and shell. No clams. One-half mile W. by N. of Horse Key; depth, 6 feet. Bottom soft mud; eelgrass. Clams scattered. Off Horse Key, close to shore; a reef of coon oysters surrounds this key and is exposed at low tide. Tests for clams were made several hundred feet beyond the reef, but none were found.

Panther Key.—One mile SSW. of Panther Key; depth, 7 feet. Bottom hard mud. Clams widely scattered. One-half mile SSW. of Panther Key; depth, 6 feet. Bottom rather hard; eelgrass. Clams fairly abundant.

Round Key.—Close to the shore of Round Key very few clams were found. Offshore 1 mile clams were abundant.

Tiger Key.—Three-eighths of a mile WSW. of the southeast end of Tiger Key; depth, 5 feet. Bottom hard mud. No clams. One-half mile S. by W. ¾ W. of the southeast end of Tiger Key; depth, 7 feet. Bottom rather hard mud. Clams fairly abundant.

Indian Key.—One and one-fourth miles SE. by E. ½ E. of Indian Key; depth, 6 feet. Bottom hard mud. No clams.

Chokoloskee Pass.—One mile WNW. of mouth of pass; depth, 4 feet. Bottom hard. No clams. Mouth of pass; depth, 1½ to 5 feet. Places were found with hard bottom and without eelgrass where no clams were located. Other places where the bottom was somewhat softer and on which eelgrass was growing contained an abundance of clams.

Rabbit Key.—One and one-fourth miles NW. by W. of Rabbit Key; depth, 6 feet. Bottom hard with light stratum of silt; eelgrass sparse. Clams fairly abundant. One-fourth mile NW. by N. of Rabbit Key; depth, 5 feet. Bottom hard. Clams scattered. One-eighth mile SW. by W. of north end of Rabbit Key; depth, 5 feet. Bottom hard mud and broken shell; eelgrass. Clams abundant.

Pavilion Key.—Two miles northwest of Pavilion Key; depth, 4½ feet. Bottom varies from hard to rather soft mud; eelgrass. Clams abundant. One and one-half miles NW. by N. of Pavilion Key lies a bar 1 mile long and one-half mile wide which contains clams in great abundance. The depth of water varies from 1 to 3 feet, mean ebb tide, and clams can be dug by hand during low tide. The bottom is of sticky mud and eelgrass, which easily bears the weight of a person. One mile N. ½ W. of the north end of Pavilion Key. In this general locality the clam dredge has been working for several years. Although thousands of bushels of clams have been dug, they appear to be abundant still. One-half mile west of the center of Pavilion Key; depth, 5 feet. Bottom hard. No clams. One and one-half miles southeast of Pavilion Key; depth, 5 feet. Bottom hard with light stratum of silt. Clams very scattered. Two miles southeast of Pavilion Key; depth, 7 feet. Bottom hard, with stratum of silt. Clams fairly abundant. Two and one-half miles southeast of Pavilion Key; depth, 7 feet. Bottom rather hard with stratum of silt; eelgrass. Clams abundant.

Clam Point.—One mile WSW. of Clam Point; depth, 6 feet. Bottom rather hard with stratum of silt; eelgrass. Clams abundant. In and about the shore of Clam Point clams are very abundant. The bottom is of sticky mud and eelgrass. At low tide parts of the bar are almost uncovered and the clams can easily be dug by hand. Here the writer obtained 200 clams in 1 hour with but little effort.

Turkey Key.—One-half mile WNW. of Turkey Key; depth, 5 feet. Bottom sticky mud; eelgrass. Clams abundant.

Seminole Point.—One-half mile southwest of Seminole Point; depth, 5½ feet. Bottom of firm mud; eelgrass. Clams abundant.

Alligator Point to Porpoise Point.—Clams are very abundant nearly everywhere in this territory. An extremely prolific bar lies about three-fourths of a mile off Alligator Point, and it is here that the Key West boats obtain their clams. A white house, one of the few landmarks to be seen on the long stretch of coast adjoining the clam bar, is located on Porpoise Point, locally known as Wood Key.

Lossmans River.—One mile SW. ½ W. of the mouth of Lossmans River; depth, 2 feet. Bottom of mud, broken shell, and eelgrass. Clams fairly abundant. One and one-half and 2 miles southwest of the mouth of Lossmans River; depth, 3 to 7 feet. Bottom rather hard mud; small broken shells. Clams widely scattered. Dead clamshells were very plentiful.

Highland Point.—One and one-fourth miles southwest of Highland Point; depth, 6 feet. Bottom sticky mud; eelgrass. Clams abundant.

Rodgers River.—One and one-half miles west of Rodgers River; depth, 4½ feet. Bottom sandy mud. Clams abundant. Two miles southwest of Rodgers River; depth, 5 feet. Bottom sandy mud. Clams fairly abundant.

Shark Point.—One mile W. by N. of Shark Point; depth, 5½ feet. Bottom sticky mud. Clams scattered. Two and one-fourth miles SSW. of Shark Point; depth, 5 feet. Bottom hard sand. No clams.

Along the coast of the Ten Thousand Islands the shore slopes very gradually into the Gulf. At 1 mile offshore the depth varies from 4 to 7 feet at mean low tide, and from there to the 5-mile line the slope is about 2 feet per mile. Because of this small depth of water the clams can readily be taken over the entire bar. The offshore part of the bed, however, has never been worked, for clams are to be found in great abundance near shore where the water is very shallow and protection is afforded from the sea.

The bottom of most of the clam bed is of rather firm gray mud, on top of which is a stratum of silt several inches in depth. Eelgrass thrives in nearly all places where clams are abundant. In most places where this grass is absent few or no clams are present.

Two methods are used in procuring the clams—hand digging and dredging. No tongs are used in this region, for the clams are too abundant and accessible to require such apparatus. Furthermore, the consistency of the soil, which is a sticky mud, would render tonging difficult.

Digging clams by hand was the sole method used before the advent of the dredge. After the dredge came into use hand digging was resorted to from time to time only when the dredge became temporarily disabled. From 1919 to 1922 considerable hand digging was done owing to frequent breakdowns of the dredge and its inability to supply the two canneries with sufficient clams. During this time from 10 to 15 diggers were employed. They received 40 cents for a 5-peck basket of clams and could dig, according to the individual, from 10 to 20 such basketsful a day.

Hand digging can be done at all times except, perhaps, when the tide is at its highest point. The diggers keep pace with the tides, working away from shore during the ebb and toward the shore during the flood. To work with any degree of comfort, the maximum depth of the water should not be much greater than an arm's length.

The clams are located by wading about in the water, for which reason this method is sometimes called "treading clams." The clams are so plentiful that a digger can work within a small area for days at a time. When a clam is located with the foot it is removed from the mud with a 2-tined fork having a 6-inch handle. Each hand digger is equipped with a small flat-bottom boat, in which the clams are deposited after they are dug. The boat is pushed along with one hand and affords a means of balance while the operator stoops over to disembed the clams. When a boat becomes loaded, it is poled or pushed to shore, where the clams are cached in shallow water to await the arrival of a " run boat," which brings them to the canneries. During the course of a day a hand digger makes several trips to shore with clams.

Dredging is by far the most efficient method of procuring clams. The dredge used in the Key West region is of a unique type, one that is not used in any other part of the world. The first dredge was operated about 1905, but some years afterwards it was destroyed by fire. Later a new dredge was built and was still in use at the time of this writing. In September, 1922, a second dredge was put in operation to supply the increasing demands of the canneries. After the second dredge began working hand digging ceased entirely, for the two dredges have been able to dig sufficient clams to supply all demands. The new dredge has not been observed by the author, but it is understood that aside from a few improvements it was built on the same general plan as the old one, a description of which follows.

In general appearance the dredge resembles a houseboat. It is about 90 feet long and 20 feet wide and has two stories. Dividing it into thirds, the digger is situated in the middle, the machinery and tool room on one end and storage space for the clams on the other end. The second story is devoted to sleeping quarters and mess room.

The machinery is gasoline driven, a 36-horsepower engine being used, and heavy chain belts drive the various wheels and gears. The digger itself is a rather powerful machine. It has 10 rows of teeth, each row being separated by a distance of about 2 feet. The teeth are detachable in series of two and are attached by bolts to heavy strap iron, 18 teeth forming a complete row. The ends of the strap iron are attached to the chain belt, which revolves the digger. Each tooth when new is 6 inches long and curved, and a complete series of 18 digs an area about 6 feet in width.

The digging apparatus, which resembles a thick rectangular figure rounded on each end where the cogwheels are located, is set at an angle, allowing one row of teeth to dig at a time. The position of the digger is regulated to the depth of water by two heavy counterweights, which are placed at the extreme end of the dredge. The clams, soil, etc., are carried up by the curved teeth, and on the downward turn they are deposited on a moving wooden escalator or conveyor, which is provided with raised strips of wood at convenient intervals to prevent the clams from rolling back into the water. This escalator is an unique appliance—it might better be called a wooden belt conveyor. That part of the conveyor upon which the clams are deposited is under water, so that when the clams reach the pickers they are partially cleansed of mud.

At the top of the wooden conveyor two or more men pick the live clams, which are thrown into baskets. One man is employed to remove the filled baskets and to replace them with empty ones, as the pickers can not move from their positions without missing some clams, which would be carried over and into the water by the conveyor on its downward turn. When three baskets have been filled they are placed on a small car and rolled to the end of the dredge, where they are piled up until transferred to the run boat.

From two to four men are required to pick the clams from the conveyor, which moves at a speed of about 1 foot per second. At times a moment will pass when there are no clams, but suddenly a dozen or more will appear in a cluster. The pickers are generally kept continuously busy, and they are very skilled in picking out the live clams from the masses of débris and dead shells. The fact that all undesired material is automatically cast back into the water, without the slightest physical effort, is one of the principles that made this type of dredge a success. A full crew consists of a captain, engineer, cook, rope man, four clam pickers, and one man to care for the baskets as they are filled.

The dredge moves slowly while digging, traveling 1,200 feet in about one and one-half hours. This slow movement is accomplished by drawing in on a 1,200-foot cable attached to an 800-pound anchor. The distance traveled when the full length of the cable has been drawn aboard and the dredge reaches the anchor is termed a "run." With the anchor as a center each run of the dredge compares with the radius of a circle. Upon the completion of a run the cable is released and the dredge drifts back with the wind and the tide, and because of their variation the dredge never digs over the same course twice except possibly near the anchor where all the radii meet. Because of the great abundance of clams it is said that the dredge has been able to dig in one locality for several months at a time without shifting its anchor.

It has been claimed that large mounds of mud are left on both sides of the strip of bottom that is being dug over, but from the mechanism and operation of the machine this would seem very improbable, as the soil is not dumped to one side or the other but is merely worked over and deposited again more or less uniformly. The teeth of the dredge dig an area about 5 inches deep and nearly 6 feet wide. As the teeth strike the bottom, part of the muddy soil passes through the interspaces, while whatever mud adheres to the teeth is partly washed away before it reaches the wooden belt conveyor. The conveyor casts the residue back into the water, breaking it up still further before it reaches the bottom, and much of the mud settles back evenly on the bottom from which it was taken. For this reason it is not believed that clams or other animals are smothered by becoming buried beneath a heavy layer of soil and débris.

The majority of the clams dug by the dredge are from 2½ to 5 inches in size, measured from the hinge ligament to the farthest opposite point. Very few small clams are dug, but it is possible that they pass between the teeth of the dredge or are otherwise lost before reaching the wooden conveyor. About 3 per cent of the clams are broken by the digger, and are discarded as they would be decomposed by the time they reach the canneries.

The dredge digs from 80 to 120 five-peck baskets of clams on one run, and from 350 to 450 baskets during a day. As there are now (1923) two dredges in operation, this quantity of clams is utilized by each of the two canneries every working day. During 1922 the one dredge in operation worked about 300 days, digging continuously throughout the year except during part of August and September, which is known as the "gale season."

During 1918 the dredge dug about 28,000 baskets of clams (35,000 bushels). In 1919 it dug 34,439 baskets (43,049 bushels) and hand pickers dug 4,000 baskets (5,000 bushels), making a total of 48,049 bushels for this region. In 1922 one dredge dug 112,500 baskets (140,625 bushels); the new dredge dug about 22,000 baskets (27,500 bushels) during October, November, and December, and hand pickers secured about 30,000 baskets (37,500 bushels) during the year. This total of 205,625 bushels is by far the greatest number of clams ever taken from the waters of Florida in one year.

With the exception of the few brought to Key West, all the clams dug in this region are utilized by two canneries, one of which is located at Marco and the other at Caxambas, Lee County. The Marco cannery has an annual capacity of 100,000 cases of clam preparations, but the Caxambas factory is somewhat smaller. The Marco factory canned to its full capacity during 1922 and has continued to pack 2,000 cases a week up until the time of this writing (August, 1923). The following preparations are canned:

"*Little-neck*" *clams.*—These clams are not as small as the little-neck variety of the North but they usually measure less than 3¼ inches from hinge ligament to the farthest opposite point. They are packed in No. 1 cans, 2 and 4 dozens to the case, and in No. 2 cans, 2 dozens to the case.

"*Steamed*" *clams.*—These are the larger clams, measuring 3¼ inches or more, and they are packed in No. 1 and 2 cans, 2 dozens to the case.

Minced clams.—These are the larger clams that have been chopped up for use in preparing chowder, soups, fritters, etc. Minced clams are packed like "little necks."

Clam chowder.—Minced clams enter into the preparation of clam chowder. Most of the vegetables used in making the chowder are obtained from New York via Key West. Even the potatoes used are shipped from the North, as it is said that the Florida potatoes fall to pieces and do not hold their shape when diced and cooked.

Clam juice, plain.—This is the pure liquor of the clam, and it is packed in No. 1 cans, 2 and 4 dozens to the case, and in No. 2 cans, 2 dozens to the case. It is also packed in glass bottles, 1 dozen to the case.

Clam juice, concentrated.—Packed the same as clam juice plain.

The Marco clam cannery commenced operation in 1909, but was replaced by a more modern structure in 1919. The new building is constructed of corrugated galvanized iron with a cement floor. Within the building has been built a large concrete cistern to hold rainwater, which is obtained from the broad expanse of the roof. Thus far attempts to locate an adequate and dependable supply of good fresh water have met with failure. Considerable water is needed to prepare the various clam products, making the conservation of the supply furnished by the heavy rains during the summer of great importance for the successful operation of the cannery.

The cannery has been equipped with the most modern and efficient machinery peculiar to its needs. The general routing of operations embraces a good example of straight-line production, as the raw material is received at one dock and in the course of preparation passes through the building in an undeviating line and is delivered at another dock in the form of the finished product, packed and ready for shipment. The various methods of procedure will be briefly described.

When the clams are received aboard the run boat from the dredge they are deposited in a heap on deck, and the baskets are retained by the dredge. The run boat generally starts on the homeward journey about midnight, arriving in the vicinity of Marco about daybreak, and delivery is made early in the morning. A reserve supply of clams is rarely kept on hand, and the cannery, therefore, depends upon a fresh supply from day to day.

The population of Marco in 1919 was about 150 persons, and aside from a small amount of fishing and hunting the cannery furnished the only means of support to the inhabitants. Because of weather conditions and an occasional breakdown of the dredge it is never certain on which days work will be available, and for this reason as soon as a load of clams is sighted from the village the factory whistle is blown to notify the people that they should come to work.

When the run boat arrives at the receiving dock, the clams are unloaded as quickly as possible. This is accomplished with very little labor by an endless-chain bucket conveyor. The clams are shoveled into a short, heavy, iron chute, which reaches the deck of the boat and is adjustable to the stage of the tide. The clams are gathered up by elongate V-shaped iron buckets and are carried overhead, about 10 feet above the dock, where they are deposited in a large wire-meshed cylinder set at an incline. The cylinder revolves in a tank of water and finally carries the cleansed clams to a chute that empties into iron cars similar to those used in oyster canneries. The dock is covered with a series of tracks and is equipped with a turntable that makes it possible to turn the cars at right angles when necessary.

Three cars at a time, loaded with clams, are pushed into the interior of the cannery and placed inside a large iron cylinder. The cylinder is then sealed by a massive iron door fitted with heavy lugs, after which the steam is turned on in order to kill the clams. The clams die quickly and the shells open and lose their liquid contents, which collects at the bottom of the long cylinder and is carried away by an underground porcelain-lined pipe, emptying into a large galvanized-iron tank set below the floor's level in another room. The liquid is collected from this tank for use in the various products.

After the clams are killed the cars containing them are rolled out of the cylinder. The meats are then removed from the shells, put into buckets, and dumped into a large spray and washing machine, which is used to thoroughly cleanse them of grit. The washer consists of a large cylinder built of heavy mesh galvanized wire, which revolves in a tank of water, and it also has a spiral track that gradually carries the clams to the exit. Upon leaving the washer the clams are deposited through a short chute upon a wide rubber belt conveyor, which looks like a table with a moving top. Four operators on each side of the conveyor sort the clams. Some of them pick out the small white clams while others select the large dark ones. The sorted clams are thrust into a short offset spout, placed beside each operator, through which they are deposited in buckets beneath. Since the clams are used for different preparations, as already explained, sorting is necessary.

Next to the sorting table lies the clam mincer, which is a large food chopper operated by electricity. The large dark clams, used for chowder and canned minced clams, are minced in this machine. The potato peeler is situated next. After peeling, the potatoes are diced by hand as are the other vegetables. Onions and seasoning are also prepared by hand.

The various cookers, retorts, filling machines, capping machines, etc., are similar to those used in any modern vegetable or fruit cannery. The chowder is cooked in a 400-gallon glass-lined iron cooking pot and is kept stirred by a glazed propeller that reaches nearly to the bottom of the pot. The canned whole clams are cooked in six large steam retorts, each of which has a capacity of 900 No. 2 cans. After the canned product has been cooled in a tank of water the cans are labeled, packed in boxes, and brought to the opposite end of the building for shipment. The cases of clam products leave the cannery on a ball-bearing declined roller track which delivers them to a freight boat to be carried to Key West for shipment via coastwise steamship.

The State of Florida levies various taxes on the catching and preparing of clams. Besides a tax of 2 cents per barrel on all clams removed from the waters of the State, taxes are payable each year on runboats, dredges, process kettles, etc. The shellfish laws are published in booklet form, and are obtainable from the shellfish commissioner, at Tallahassee, Fla.

The clam resources of southern Florida can bear considerably more fishing. The chief drawbacks at the present time to the further utilization of the product and the expansion of the industry are the inaccessibility of the beds to transportation lines and their remoteness from northern markets.

In the Northeastern States the quahaug has been gradually declining in abundance and rising in value. Along our North Atlantic coast the small clam beds have been far from adequate to keep pace with the ever-increasing demands for this popular mollusk in the fresh state. The large clam beds of the Ten Thousand Islands, Fla., however, are practically virgin and await development.

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PROPAGATION AND DISTRIBUTION OF FOOD FISHES, FISCAL YEAR 1923.[1]

By GLEN C. LEACH, *Assistant in Charge, Division of Fish Culture.*

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PART I.—FISH PRODUCTION: PROPAGATION AND RESCUE WORK.

[1] Appendix XIII to the Report of the U. S. Commissioner of Fisheries for 1923. B. F. Doc. No. 964.

PART 2.—DISTRIBUTION OF FISH AND FISH EGGS.

INTRODUCTION.

During the fiscal year ended June 30, 1923, the bureau's fish-cultural activities were confined necessarily to certain well-established fields, it being impossible to extend the work into new territory because funds were not available for the purpose. Unless increased appropriations are allowed for the propagation and distribution of food fishes, the work of the division can hardly be enlarged beyond its present limits, and prospects at this time point to a gradually declining output. Up to the present time the pre-war record of the bureau has been more than maintained without any increase in the funds applied to the work. However, this high standard of efficiency can not be continued indefinitely in the face of an increase in the cost of all materials and labor entering into the work, the prices of practically everything used in connection therewith being approximately 67 per cent higher than in 1917.

FISHES OF INTERIOR WATERS.

The demand for fish for stocking interior waters of the country increases at the rate of about 10 per cent a year. The value of these interior fisheries can hardly be overestimated. They add millions of pounds annually to the Nation's food supply, and in many localities constitute the only source of fresh fish supply available. They make possible the extension of the fisheries and the establishment of fishing in many formerly unproductive waters. They afford a splendid means of recreation to millions of people, bringing them into contact with the great outdoors.

The increasing use of the automobile and the fact that almost every automobile tourist is a fisherman have had an almost disastrous effect on many waters, however. With their existing facilities the States have not been able to cope with the situation, but in anticipation of future conditions many of them have made preparations for a great increase in their operations. In this respect the State of North Carolina probably leads. The opening up of its wonderful mountain regions through the construction of good roads is sure to result in an influx of tourists and the consequent depletion of many of its waters unless fish-cultural work is prosecuted on an extensive and systematic basis. In recognition of this outlook the State now has plans in contemplation for the establishment of a system of hatcheries and the enactment and enforcement of adequate fishery laws.

The bureau has taken the lead in fish-cultural work, and the activities of the various States along this line have, for the most part, been patterned after its work. In many instances the States have succeeded with their plans by employing the bureau's skilled and experienced men at higher salaries than the bureau has been able to pay. In view of this situation it is felt that the bureau is little more than a training school for fish-culturists, and that in turning the services of such men over to the States it is doing a public work of great value. It is fully recognized that the fish-cultural experience of the bureau is for the public benefit, and the results of this experience are constantly being disseminated through the issuance of reports and bulletins and also in letters on special subjects.

COMMERCIAL FISH CULTURE.

While the cultivation of fish for stocking interior waters is an important phase of the bureau's activities, its work in the propagation and distribution of the so-called commercial fishes has a much greater significance so far as its economic value to the country is concerned. This work has probably attained its highest efficiency on the Pacific coast, and especially in Alaska, where the salmons constitute one of the most important natural resources. Had it not been for the combined efforts of the bureau and the States to conserve this valuable asset, it is probable that its value would by this time have declined to a point where it would neither have interested the white man as an investment nor served as a means of sustenance to the Indian.

In many instances the spawning beds of the salmon have been ruined by logging operations, while in other cases the ascent of the salmon to suitable spawning grounds has been cut off by the erection of insurmountable power dams. The salmon congregate at the entrance of certain coastal streams at a particular season of the year, and if they find ascent to their natural spawning grounds in the headwaters cut off by a barrier, the parent fish die, their eggs are wasted, and the supply of salmon is reduced to that extent.

It is part of the work of the bureau's hatcheries to seine these fish from below the barriers and to remove their eggs and incubate them. The vitality and fertility of the salmon egg is wonderful. If carefully handled and cared for, approximately 95 per cent of them will hatch. The young fish resulting from the eggs are held in ponds and troughs in such numbers as is practicable and are fed artificially until they have attained a length of 2 or 3 inches, when they are liberated. Shortly after liberation they descend to the sea and, with the exception of one species, which returns in two years, they remain in salt water for four or five years. At the expiration of that time they seek the headwaters of various coastal streams, where they reproduce and then die, completing the life cycle. It can readily be seen that hatchery work of this character is of the greatest importance if this valuable and extensive industry is to be maintained.

A somewhat different problem is presented by the fishes of the Great Lakes and Atlantic coast. Eggs from these valuable commercial species are taken only from fish caught for the market by men employed to go out with the fishing boats and salvage the eggs as the fish are removed from the nets. Were it not for this work, some three or four billion eggs would be wasted annually, being sent to market with the fish and discarded in the process of cleaning. This also applies to the shad, herring, and yellow perch.

In addition to the work of salvaging eggs for propagation in the hatcheries, experienced spawn takers are detailed to accompany the offshore fishing fleet operating from Gloucester, Mass., going out on the boats for trips of a week or two weeks' duration. As the eggs from such fish as the cod, pollock, and haddock can not be held until the return of the vessel, they are carefully removed from the fish, fertilized, and planted on the spawning grounds. As in the case of the other species, these eggs would be a total loss were it not for the bureau's intervention. Being exposed to the attacks of natural enemies, the percentage of eggs hatched of those thus treated must be far smaller than that attained in the hatcheries, but as they can not be handled in hatcheries, because of the inaccessibility of the latter, it is believed even the smaller percentage hatched fully justifies the time and money expended in the work of fertilizing and returning them to the spawning grounds.

COOPERATION WITH STATES, OTHER FEDERAL AGENCIES, AND FOREIGN GOVERNMENTS.

The division of fish culture has pursued its usual policy of working in conjunction with the States so far as possible. This cooperation consists in the interchange of fish and eggs, distribution of fish, joint production of fish, and joint operation of field stations for the collection of eggs. Sometimes State authorities are supplied with eggs of certain species and in return they fill applications for fish submitted to the bureau. In one or two instances eggs have been purchased by a State for incubation in the bureau's hatcheries, but the most important cooperation is probably in the distribution of fish, as it eliminates to a great extent what would otherwise amount to a duplication of effort in the stocking of waters. The bureau has rendered valuable assistance to the States by lending the services of its experienced men to aid in solving their fish-cultural problems and to give advice and assistance in the location and establishment of hatcheries.

Such governmental agencies as the Forest Service, Reclamation Service, and National Park Service have been of much assistance to the bureau in stocking waters with fish and protecting them. In many cases employees of these services have united in an effort to protect the fish life of streams and lakes and have assisted in the propagation of fish without incurring extra expense to the Government. Through these agencies fish are transported to remote sections of the public forests and parks and released in waters where they will be comparatively free from molestation for several years. As such waters become stocked the larger fish tend to work downstream, and in this way the stocking of larger bodies of water is effected.

The bureau's interest in the fish culture of foreign countries has not lessened with the passing years. In response to requests submitted through the State Department eggs of suitable species have been furnished in as liberal numbers as conditions would warrant, and exchanges of eggs have been made with Canada to the benefit of both countries, since it has been the means of replenishing the waters of both with desirable species of fishes not otherwise obtainable.

During the fiscal year 1923 cooperative fish-cultural operations in the waters of Lake Ontario were very satisfactory. The Canadian authorities permitted the force of the Cape Vincent (N. Y.) station to make collections of whitefish and lake-trout eggs in the Bay of Quinte, and the local fishermen were very glad to assist in the work, knowing that the resulting fry would be liberated in Canadian waters. It is the opinion of the bureau that much of the success attained in the Canadian fisheries is due to past activities of the Cape Vincent station. The fisheries of the lake had declined so that no eggs whatever were obtainable at any of the commercial fisheries, and every year the Cape Vincent hatchery was stocked by the transfer of eggs from other stations of the bureau, whitefish eggs being drawn from Lake Erie and lake-trout eggs from the Michigan fields. The bureau is convinced that the upbuilding of the Ontario fisheries has been brought about through the persistent stocking of the lake through the operations of the Cape Vincent hatchery. In recent years the Canadian authorities have generously permitted the bureau's employees to collect spawn in Dominion waters, but on the other hand the annual release of several hundred million fry from Cape Vincent station in this lake must have been a great factor in the upbuilding of the Canadian fisheries.

SENTIMENT IN FAVOR OF FISH PROTECTION.

One of the bureau's functions has been to impress upon the various States having inadequate fishery laws, or none at all, the necessity for taking steps to protect the fish life within their boundaries. It is felt that the bureau can not afford to make large plants of fish in the waters of States that have no laws providing for their protection. Such legislation should not only establish an adequate closed season so that the fish may spawn without molestation but should provide for regulations to cover a bag limit and a minimum size at which fish may be taken. It should rigidly prohibit the dumping of refuse in fish-cultural waters, as the presence of waste matter drives the fish away, destroys their feeding grounds, and makes it difficult ever to restore fishing in waters that have been contaminated.

It is gratifying to note that country clubs and other associations throughout the country are taking more interest in protection than ever before. In many instances such organizations have leased large tracts of land and have incurred considerable expense in stocking the waters located thereon. Some have gone so far as to maintain small hatcheries, while others have sought the aid of the bureau in their fish-cultural ventures, with the understanding that after reserving a sufficient supply of the fish produced for their own use the remainder will be planted in public waters.

The effect of the growing sentiment in favor of protection has been far-reaching and beneficial. Large numbers of men and women in different sections of the country are at the present time forming organizations having for their object the adoption of measures for adequately conserving natural resources, and the good results of their efforts along this line are very apparent. This sentiment in favor of the preservation of fish life is probably stronger throughout the Mississippi Valley than anywhere else. The people of that section look upon fish conservation as a matter vitally affecting their personal interests. A diminishing supply means the cutting off of their only means of obtaining fresh fish for food, and they are very urgent in their demand that the fishes stranded in landlocked pools and lakes in the flooded regions of the Mississippi River be transferred to living waters. Before this river became obstructed by power dams it constituted a natural fish hatchery for the great Middle West, but, as these dams are recognized as a national necessity, their greater value than the fish life is not questioned. The construction of the dams has resulted in cutting off the ascent of the fish to headwaters and it is thought to be no more than just that fishes stranded in the overflowed sections should be rescued and returned to the parts of the rivers thus cut off.

The sentiment in favor of this salvage of fishes from the overflowed lands has become so great that the resources not only of the bureau but of the States of Minnesota, Iowa, Wisconsin, and Illinois, as well, have been severely taxed in an effort to increase the scope of operations. It is estimated that during the fiscal year 1923 approximately one million pounds of fish were thus saved from destruction.

Part 1.—FISH PRODUCTION: PROPAGATION AND RESCUE WORK.

TABULAR SUMMARIES OF OPERATIONS.

SPECIES OF FISHES HANDLED.

The work as conducted during the fiscal year ended June 30, 1923, involved 58 species of fish, as indicated in the accompanying list, each species listed being the subject of either artificial propagation or rescue work. The majority of the fishes rescued from the overflowed regions of the Mississippi River are not distributed but are returned to the river. These include some species of the catfishes, sunfishes, suckers, carp, and pike. Very few of the commercial species are supplied on application.

LIST OF SPECIES HANDLED.

THE CATFISHES (SILURIDÆ):
- Blue catfish (*Ictalurus furcatus*).
- Channel catfish (*Ictalurus punctatus*).
- Horned pout, bullhead (*Ameiurus nebulosus*).
- Mississippi catfish (*Ameiurus lacustris*).
- Yellow catfish (*Ameiurus natalis*).
- Black bullhead (*Ameiurus melas*).
- Mud catfish (*Leptops olivaris*).

THE SUCKERS (CATOSTOMIDÆ):
- Mongrel buffalofish (*Ictiobus urus*).
- Common buffalofish (*Ictiobus cyprinella*).
- Smallmouth buffalofish (*Ictiobus bubalus*).

THE CARPS (CYPRINIDÆ):
- Asiatic carp (*Cyprinus carpio*).

THE SHADS AND HERRINGS (CLUPEIDÆ):
- Shad (*Alosa sapidissima*).
- Glut herring (*Pomolobus æstivalis*).
- Skipjack (*Pomolobus chrysochloris*).

THE SALMONS, TROUTS, WHITEFISHES, ETC. (SALMONIDÆ):
- Common whitefishes (*Coregonus albus* and *C. clupeaformis*).
- Pilot fish (*Coregonus quadrilateralis*).
- Cisco (chiefly *Leucichthys artedi*).
- Chinook salmon, king salmon, quinnat salmon (*Oncorhynchus tschawytscha*).
- Chum salmon, dog salmon (*Oncorhynchus keta*).
- Humpback salmon, pink salmon (*Oncorhynchus gorbuscha*).
- Silver salmon, coho salmon (*Oncorhynchus kisutch*).
- Sockeye salmon, blueback salmon, redfish (*Oncorhynchus nerka*).
- Steelhead salmon (*Salmo gairdneri*).
- Atlantic salmon (*Salmo salar*).
- Landlocked salmon (*Salmo sebago*).
- Rainbow trout (*Salmo shasta*).
- Black-spotted trout, redthroat trout (*Salmo lewisi*).
- Loch Leven trout (*Salmo levenensis*).
- Lake trout, Mackinaw trout (*Cristovomer namaycush*).
- Brook trout (*Salvelinus fontinalis*).

THE SMELTS (OSMERIDÆ):
- Smelt (*Osmerus mordax*).
- Wilton smelt (*Osmerus mordax spectrum*).

THE PIKES (LUCIIDÆ):
- Little pickerel (*Lucius vermiculatus*).
- Common pickerel (*Lucius lucius*).

THE MACKERELS (SCOMBRIDÆ):
- Mackerel (*Scomber scombrus*).

THE SUNFISHES, BLACK BASSES, AND CRAPPIES (CENTRARCHIDÆ):
- Crappies (*Pomoxis annularis* and *P. sparoides*).
- Largemouth black bass (*Micropterus salmoides*).
- Smallmouth black bass (*Micropterus dolomieu*).
- Rock bass (*Ambloplites rupestris*).
- Warmouth bass, goggle-eye (*Chænobryttus gulosus*).
- Green sunfish (*Apomotis cyanellus*).
- Red-breasted bream (*Lepomis auritus*).
- Bluegill sunfish (*Lepomis pallidus*).
- Long-eared sunfish (*Lepomis megalotis*).
- Common sunfish (*Eupomotis gibbosus*).

THE PERCHES (PERCIDÆ):
- Pike perch (*Stizostedion vitreum*).
- Sauger (*Stizostedion canadense*).
- Yellow perch (*Perca flavescens*).

THE SEA BASSES (SERRANIDÆ):
- White bass (*Roccus chrysops*).
- White perch (*Morone americana*).
- Sea bass (*Centropristes striatus*).

THE PORGIES (SPARIDÆ):
- Scup, scuppaug (*Stenotomus chrysops*).

THE DRUMS (SCIÆNIDÆ):
- Fresh-water drum, lake sheepshead (*Aplodinotus grunniens*).

THE CODS (GADIDÆ):
- Cod (*Gadus callarias*).
- Haddock (*Melanogrammus æglefinus*).
- Pollock (*Pollachius virens*).

THE FLOUNDERS (PLEURONECTIDÆ):
- Winter flounder, American flatfish (*Pseudopleuronectes americanus*).

OUTPUT.

The combined work of the fish-cultural stations and the rescue crews during the year resulted in a gross output of 4,315,857,725 eggs, fry, and fingerling fish for distribution. Losses in transportation amounted to 998,696, leaving a net total of 4,314,859,029 fish and eggs actually distributed.

Summary, by species, of net output of fish and fish eggs, fiscal year 1923.

Species.	Eggs.	Fry.	Fingerlings.	Total.
Catfish			37,092,979	37,092,979
Buffalofish	163,169,500	5,925,000	9,429,838	178,524,338
Carp	29,000,000	115,000,000	14,226,110	158,226,110
Shad		16,971,000		16,971,000
Glut herring		150,000,000		150,000,000
Whitefish	148,041,000	208,675,000	3,000	356,719,000
Cisco	10,000,000	39,000,000		49,000,000
Chinook salmon	4,205,000	720,000	28,965,045	33,890,045
Chum salmon		8,274,830	14,997,900	23,272,730
Humpback salmon		396,950	1,915,435	2,312,385
Silver salmon	100,000	8,371,025	5,910,630	14,381,655
Sockeye salmon	10,678,400	31,582,000	50,949,400	93,209,800
Steelhead salmon	1,744,000	275,000	5,339,005	7,358,005
Atlantic salmon		451,000	40,038	491,038
Landlocked salmon	76,872	727,670	92,800	897,342
Rainbow trout	2,689,960	754,000	3,408,159	6,852,119
Black-spotted trout	10,127,100	2,160,100	1,492,700	13,779,900
Loch Leven trout			43,800	43,800
Lake trout	7,253,300	34,748,415	232,080	42,233,795
Brook trout	725,300	2,841,400	8,477,250	12,043,950
Smelt	16,280,000	28,000,000		44,280,000
Pike and pickerel			905,395	905,395
Crappie			35,602,522	35,602,522
Largemouth black bass		806,500	1,342,349	2,148,849
Smallmouth black bass		449,400	79,007	528,407
Rock bass			64,035	64,035

Summary, by species, of net output of fish and fish eggs, fiscal year 1923—Con.

Species.	Eggs.	Fry.	Fingerlings.	Total.
Warmouth bass			8,350	8,350
Sunfish			26,854,257	26,854,257
Pike perch	37,275,000	63,365,000		100,640,000
Yellow perch	3,680,000	136,325,000	936,295	140,941,295
White perch			675	675
Striped bass		16,341,000		16,341,000
White bass			40,085	40,085
Fresh-water drum			49,026	49,026
Cod	650,980,000	376,813,000		1,027,793,000
Haddock	104,400,000	2,960,000		107,360,000
Pollock	33,960,000	276,098,000		310,058,000
Flounder	229,345,000	1,058,781,000		1,288,126,000
Miscellaneous fishes			15,818,142	15,818,142
Total	1,463,730,432	2,586,812,290	264,316,307	4,314,859,029

EGG COLLECTIONS.

The bureau's principal source of egg supply is the commercial fisheries, where vast numbers of eggs of valuable fishes would annually be wasted were it not for the bureau's work. In most instances they are transported to the hatcheries for incubation; but in the case of the offshore fisheries on the New England coast the spawn takers sent out to salvage the eggs fertilize and plant them on the spawning grounds, as it is impracticable to hold the spawn until the vessels return to port. In some cases eggs are taken from fish caught in nets and traps and are artificially impregnated and incubated in the hatchery, this being done to insure a higher degree of fertility than would be possible under natural conditions of spawning.

A decrease of approximately 991,000,000 is shown in the total egg collections as compared with those of the previous year. This decrease is explained partly by the prevalence of unfavorable weather during the spawning season of some of the fishes handled, and partly by lack of funds necessary to take full advantage of the opportunities for obtaining eggs in one or two instances.

Comparison of egg collections, fiscal years 1923 and 1922.

Species.	1923	1922	Species.	1923	1922
Buffalofish	179,173,600	199,906,250	Loch Leven trout	98,130	109,870
Carp	160,500,000	98,000,000	Lake trout	77,775,890	67,426,500
Shad	17,877,000	82,579,000	Brook trout	19,109,040	17,986,250
Glut herring	313,422,620	116,920,000	Smelt	42,000,000	309,000
Whitefish	537,546,000	623,100,000	Mackerel		2,022,000
Cisco	76,800,000	429,900,000	Pike perch	230,070,000	254,717,500
Pilot fish	255,000		Yellow perch	151,010,000	277,501,870
Chinook salmon	30,889,000	64,756,100	Striped bass	22,084,000	48,745,000
Chum salmon	26,513,500	22,830,000	Sea bass		32,000
Humpback salmon	1,099,200	1,722,000	Scup		3,425,000
Silver salmon	15,159,800	13,618,500	Cod	1,279,709,000	587,426,000
Sockeye salmon	97,886,000	119,214,350	Haddock	109,220,000	543,110,000
Steelhead salmon	7,946,300	7,302,800	Pollock	420,536,000	507,270,000
Atlantic salmon		572,040	Winter flounder	1,391,411,000	2,312,029,000
Landlocked salmon	852,350	445,000	Pole flounder		5,090,000
Rainbow trout	11,488,410	11,210,500			
Black-spotted trout	16,655,820	9,220,300	Total	5,437,057,660	6,428,487,830

FISH-RESCUE WORK.

The part of the bureau's work dealing with the salvaging of stranded food fishes from the overflowed lands along the Mississippi River showed a considerable decrease in results as compared with that of 1922. The following table indicates by localities and species the total numbers of fish salvaged, the numbers restored to original waters, and the numbers delivered to applicants. The summary also shows the total numbers of each species handled in all fields and returned to native waters, and the total deliveries of rescued fishes to applicants.

Number and disposition of fish rescued, fiscal year 1923.

Station and species.	Delivered to applicants.	Restored to original waters.	Total.
Homer, Minn.:			
Black bass	48, 315	78, 715	127, 030
Buffalofish		24, 593	24, 593
Carp		1, 008, 875	1, 008, 875
Catfish	48, 525	5, 803, 030	5, 851, 565
Crappie	47, 800	10, 995, 470	11, 043, 270
Drum		18, 950	18, 950
Pike and pickerel		311, 710	311, 710
Rock bass		1, 010	1, 010
Sunfish	31, 830	7, 810, 430	7, 842, 260
White bass		20, 580	20, 580
Yellow perch	11, 350	518, 490	529, 840
Miscellaneous		534, 900	534, 900
Total	187, 820	27, 126, 753	27, 314, 573
Bellevue, Iowa:			
Black bass	52, 495	20, 735	73, 230
Buffalofish	150	5, 590, 900	5, 591, 050
Carp	290	7, 243, 830	7, 244, 120
Catfish	75, 855	4, 387, 225	4, 463, 080
Crappie	1, 449	6, 651, 926	6, 653, 375
Drum		194	194
Pike and pickerel	160	21, 110	21, 270
Sunfish	10, 058	2, 639, 635	2, 649, 693
Warmouth bass	80		80
White bass		2, 281	2, 281
Yellow perch	1, 950	3, 930	5, 880
Miscellaneous	740	7, 837, 392	7, 838, 132
Total	143, 227	34, 399, 158	34, 542, 385
La Crosse, Wis.:			
Black bass	131, 545	79, 195	210, 740
Buffalofish	480	2, 799, 655	2, 800, 135
Carp	176	4, 715, 154	4, 715, 330
Catfish	53, 030	18, 905, 345	18, 958, 375
Crappie	33, 135	13, 488, 460	13, 521, 595
Drum	1, 185	150	1, 335
Pike and pickerel		484, 815	484, 815
Smallmouth bass	94		94
Sunfish	21, 190	11, 474, 150	11, 495, 340
White bass		7, 002	7, 002
Yellow perch	5, 930	340, 385	346, 315
Miscellaneous		5, 841, 300	5, 841, 300
Total	246, 765	58, 135, 611	58, 382, 376
Marquette, Iowa:			
Black bass	61, 420	33, 135	94, 555
Buffalofish	90	473, 400	473, 490
Carp	75	896, 600	896, 675
Catfish	28, 204	5, 722, 046	5, 750, 250
Crappie	347, 100	3, 273, 500	3, 620, 600
Drum		16, 100	16, 100
Pike and pickerel		70, 850	70, 850
Rock bass		300	300
Sunfish	5, 660	2, 202, 130	2, 207, 790
White bass		1, 200	1, 200
Yellow perch	5, 545	44, 460	50, 005
Miscellaneous		369, 755	369, 755
Total	448, 094	13, 193, 476	13, 641, 570

Number and disposition of fish rescued, fiscal year 1923—Continued.

Station and species.	Delivered to applicants.	Restored to original waters.	Total.
Rock Island, Ill.:			
Black bass		5,125	5,125
Buffalofish		105,595	105,595
Carp		330,280	330,280
Catfish		784,090	784,090
Crappie		348,212	348,212
Drum		222	222
Pike and pickerel		16,690	16,690
Sunfish		691,765	691,765
White bass		777	777
Yellow perch		4,525	4,525
Miscellaneous		886,055	886,055
Total		3,173,336	3,173,336
Baton Rouge, La.:			
Buffalofish		4,750	4,750
Carp		885	885
Catfish	275	705	980
Crappie	2,572	8,028	10,600
Drum	500	4,000	4,500
Sunfish	3,700	10,000	13,700
White bass	100	325	425
Miscellaneous		188,000	188,000
Total	7,147	216,693	223,840
Simmesport, La.:			
Black bass	239		239
Buffalofish		22,550	22,550
Catfish		1,298	1,298
Carp		130	130
Crappie	500	4,225	4,725
Drum		7,725	7,725
Pike and pickerel		60	60
Sunfish	1,075	2,325	3,400
White bass		5,170	5,170
Miscellaneous		192,500	192,500
Total	1,814	235,983	237,797
Friar Point, Miss.:			
Black bass	6,520	440	6,960
Buffalofish	20	88,480	88,500
Carp		300	300
Catfish	3,525	310,760	314,285
Crappie	1,420	6,979	8,399
Rock bass	600	1,545	2,145
Sunfish	117,700	1,103,300	1,221,000
White bass		2,650	2,650
Total	129,785	1,514,454	1,644,239
Fairport, Iowa, and substations:			
Black bass		8,160	8,160
Buffalofish		96,575	96,575
Carp		29,565	29,565
Catfish	300	208,895	209,195
Crappie		78,590	78,590
Sunfish		205,630	205,630
Miscellaneous		11,200	11,200
Total	300	638,615	638,915
Summary by stations:			
Homer	187,820	27,126,753	27,314,573
Bellevue	143,227	34,399,158	34,542,385
La Crosse	246,765	58,135,611	58,382,376
Marquette	448,094	13,193,476	13,641,570
Rock Island		3,173,336	3,173,336
Baton Rouge	7,147	716,693	723,840
Simmesport	1,814	235,983	237,797
Friar Point	129,785	1,514,454	1,644,239
Fairport	300	638,615	638,915
Total	1,164,952	138,634,079	139,799,031

Number and disposition of fish rescued, fiscal year 1923—Continued.

Station and species.	Delivered to applicants.	Restored to original waters.	Total.
Summary by species:			
Black bass	300,534	225,505	526,039
Buffalofish	740	9,206,498	9,207,238
Carp	541	14,225,619	14,226,160
Catfish	209,714	36,123,394	36,333,108
Crappie	433,976	34,855,390	35,289,366
Drum	1,685	47,341	49,026
Pike and pickerel	160	905,235	905,395
Rock bass	600	2,855	3,455
Smallmouth bass	94		94
Sunfish	191,213	26,229,365	26,420,578
Warmouth bass	80		80
White bass	100	39,985	40,085
Yellow perch	24,775	911,790	936,565
Miscellaneous	740	15,861,102	15,861,842
Total	1,164,952	138,634,079	139,799,031

STATIONS AND SUBSTATIONS AND OUTPUT OF EACH.

During the fiscal year 1923 fish-cultural operations were conducted at 37 main stations and 34 substations, though at several of these work was confined principally to the rescue of stranded fishes from overflowed lands. The following table lists the main stations in alphabetical order, each of them being followed by its auxiliary substations, and includes the period of operation at each point and the number of eggs, fry, and fingerling fish distributed.

Stations and substations operated and output of each, fiscal year 1923.

[Asterisk (*) indicates that additional eggs were transferred to other stations for convenience in handling. See table, p. 17.]

Station and substation.	Species.	Eggs.	Fry.	Fingerlings, yearlings, and adults.	Total.
Afognak, Alaska	Humpback salmon			240,000	240,000
	Sockeye salmon	*10,678,400	15,882,000	30,451,000	57,011,400
Baird, Calif.	Chinook salmon			1,466,000	1,466,000
Battle Creek, Calif.	do			1,587,500	1,587,500
Mill Creek, Calif.	do			750,900	750,900
Baker Lake, Wash.	Sockeye salmon	(*)	14,200,000	975,000	15,175,000
Birdsview, Wash.	Chinook salmon			300,445	300,445
	Humpback salmon	(*)		188,645	188,645
	Silver salmon	*100,000	5,977,025	1,227,470	7,304,495
	Sockeye salmon	(*)		29,000	29,000
	Steelhead salmon			285,305	285,305
Duckabush, Wash.	Chum salmon		5,545,250	8,645,400	14,190,650
	Silver salmon			289,310	289,310
	Steelhead salmon			139,445	139,445
Quilcene, Wash.	Chum salmon		2,729,580	6,000,000	8,729,580
	Humpback salmon			1,483,790	1,483,790
	Silver salmon			752,275	752,275
	Steelhead salmon			545,555	545,555
Sultan, Wash.	Silver salmon	(*)	2,394,000	799,000	3,193,000
	Steelhead salmon			207,800	207,800
Berkshire, Mass.	Brook trout			238,500	238,500
	Pike perch		485,000		485,000
	Rainbow trout			30,900	30,900
Boothbay Harbor, Me.	Flounder		866,800,000		866,800,000
Bozeman, Mont.	Black-spotted trout	50,000	25,000	825,500	900,500
	Brook trout		312,500	594,450	906,950
	Rainbow trout	*25,000		131,100	156,100
Glacier Park, Mont.	Black-spotted trout	1,389,700			1,389,700
	Rainbow trout			165,000	165,000
	Steelhead trout			50,000	50,000
Meadow Creek, Mont.	Rainbow trout		275,000	131,500	406,500
Yellowstone, Wyo.	Black-spotted trout	*8,687,400	1,970,100		10,657,500

Stations and substations operated and output of each, fiscal year 1923—Con.

Station and substation.	Species.	Eggs.	Fry.	Fingerlings, yearlings, and adults.	Total.
Cape Vincent, N. Y.	Brook trout		445,000		445,000
	Cisco	10,000,000	39,000,000		49,000,000
	Lake trout	*490,000	1,676,000		2,166,000
	Pike perch		600,000		600,000
	Rainbow trout		69,000		69,000
	Whitefish	*78,201,000	85,375,000		163,576,000
	Yellow perch		800,000		800,000
Central station, Washington, D. C.	Black bass			385	385
	Catfish			4,000	4,000
	Chinook salmon	5,000	5,000	10,000	20,000
	Crappie			450	450
	Humpback salmon		3,350	3,000	6,350
	Pike perch		750,000		750,000
	Rainbow trout			18,400	18,400
	Sunfish			24,100	24,100
	Whitefish			3,000	3,000
Bryans Point, Md.	Shad		16,771,000		16,771,000
	Yellow perch		128,525,000	210	128,525,210
Clackamas, Oreg.	Black-spotted trout			17,000	17,000
	Brook trout			17,000	17,000
	Chinook salmon	200,000	716,000	3,935,000	4,851,000
	Chum salmon			95,000	95,000
	Lake trout		25,000		25,000
	Rainbow trout			59,000	59,000
	Silver salmon			16,000	16,000
	Steelhead salmon	90,000		25,000	115,000
Applegate, Oreg.	Silver salmon			2,423,800	2,423,800
	Steelhead salmon	*1,095,000		1,200,000	2,295,000
Big White Salmon, Wash.	Chinook salmon			6,000,000	6,000,000
Little White Salmon, Wash.	do	*4,000,000		12,427,000	16,427,000
	Chum salmon			257,500	257,500
	Silver salmon			9,000	9,000
	Sockeye salmon			50,400	50,400
Rogue River, Oreg.	Black-spotted trout			15,500	15,500
	Chinook salmon			980,000	980,000
	Silver salmon			80,000	80,000
	Steelhead salmon			2,241,000	2,241,000
Salmon, Idaho	Brook trout			99,000	99,000
	Chinook salmon			1,124,700	1,124,700
	Rainbow trout			236,000	236,000
Sandy River, Oreg.	Black-spotted trout			2,600	2,600
	Chinook salmon			383,500	383,500
	Silver salmon			313,800	313,800
	Steelhead salmon	125,000		438,000	563,000
Washougal, Wash.	do	*434,000	260,000		694,000
Cold Springs, Ga.	Black bass		216,500	55,475	271,975
	Catfish			12,750	12,750
	Crappie			1,500	1,500
	Sunfish			90,400	90,400
Craig Brook, Me.	Atlantic salmon		451,000	40,038	491,038
	Brook trout		354,000	497,800	851,800
	Landlocked salmon	*76,872	223,000		299,872
Grand Lake, Me.	do	(*)	316,190	91,400	407,590
Green Lake, Me.	Brook trout		110,000		110,000
	Landlocked salmon		178,480		178,480
	Smallmouth black bass			94	94
	Smelt	17,030,000	28,000,000		45,030,000
Duluth, Minn.	Brook trout			135,000	135,000
	Lake trout	*525,000	13,170,000	85,000	13,780,000
	Pike perch		7,630,000		7,630,000
	Rainbow trout			86,000	86,000
	Steelhead salmon		15,000	75,000	90,000
	Whitefish		2,700,000		2,700,000
Edenton, N. C.	Black bass		25,000	28,175	53,175
	Catfish			575	575
	Crappie			120	120
	Glut herring		150,000,000		150,000,000
	Shad		200,000		200,000
	Sunfish			9,050	9,050
Weldon, N. C.	Striped bass		16,341,000		16,341,000
Erwin, Tenn.	Black bass		39,500	15,635	55,135
	Brook trout			278,200	278,200
	Rainbow trout	2,000		657,770	659,770
	Rock bass			18,050	18,050
	Smallmouth black bass			7,450	7,450
	Steelhead salmon			600	600
	Sunfish			4,645	4,645
	Yellow perch		500,000		500,000

Stations and substations operated and output of each, fiscal year 1923—Con.

Station and substation.	Species.	Eggs.	Fry.	Fingerlings, yearlings, and adults.	Total.
Fairport, Iowa	Black bass			8,160	8,160
	Buffalofish			96,575	96,575
	Carp			29,565	29,565
	Catfish			209,195	209,195
	Crappie			78,590	78,590
	Sunfish			205,630	205,630
	Miscellaneous			11,200	11,200
Gloucester, Mass	Cod	277,500,000	245,140,000		522,640,000
	Flounder		68,760,000		68,760,000
	Haddock	104,400,000	2,960,000		107,360,000
	Pollock	33,960,000	275,410,000		309,370,000
Homer, Minn	Black bass			127,030	127,030
	Buffalofish	35,055,000		24,593	35,079,593
	Carp	21,000,000		1,008,875	22,008,875
	Catfish			5,851,555	5,851,555
	Crappie			11,043,070	11,043,070
	Fresh-water drum			18,950	18,950
	Pike and pickerel			311,710	311,710
	Rock bass			1,010	1,010
	Sunfish			7,842,460	7,842,460
	White bass			20,580	20,580
	Yellow perch			529,840	529,840
	Miscellaneous			534,900	534,900
Atchafalaya, La	Buffalofish	128,114,500	5,925,000		134,039,500
	Fresh-water drum			3,000	3,000
Baton Rouge, La	Buffalofish			4,750	4,750
	Catfish			980	980
	Carp			885	885
	Crappie			10,600	10,600
	Fresh-water drum			1,500	1,500
	Sunfish			13,700	13,700
	White bass			425	425
	Miscellaneous			188,000	188,000
Bellevue, Iowa	Black bass			73,230	73,230
	Buffalofish			5,591,050	5,591,050
	Carp			7,244,120	7,244,120
	Catfish			4,463,080	4,463,080
	Crappie			6,653,375	6,653,375
	Fresh-water drum			194	194
	Pike and pickerel			21,270	21,270
	Sunfish			2,649,693	2,649,693
	Warmouth bass			80	80
	White bass			2,281	2,281
	Yellow perch			5,880	5,880
	Miscellaneous			7,838,132	7,838,132
La Crosse, Wis	Black bass			210,740	210,740
	Brook trout			242,600	242,600
	Buffalofish			3,000,135	3,000,135
	Carp			4,715,330	4,715,330
	Catfish			18,958,375	18,958,375
	Crappie			13,521,595	13,521,595
	Fresh-water drum			1,335	1,335
	Pike perch		2,100,000		2,100,000
	Pike and pickerel			484,815	484,815
	Rainbow trout			43,000	43,000
	Smallmouth black bass			94	94
	Sunfish			11,495,340	11,495,340
	White bass			7,002	7,002
	Yellow perch			346,315	346,315
	Miscellaneous			5,841,300	5,841,300
Marquette, Iowa	Black bass			94,555	94,555
	Buffalofish			473,490	473,490
	Carp			896,675	896,675
	Catfish			5,750,250	5,750,250
	Crappie			3,620,600	3,620,600
	Fresh-water drum			16,100	16,100
	Pike and pickerel			70,850	70,850
	Rock bass			300	300
	Sunfish			2,297,790	2,297,790
	White bass			1,200	1,200
	Yellow perch			50,055	50,055
	Miscellaneous			326,055	326,055
Rock Island, Ill	Black bass			5,125	5,125
	Buffalofish			105,595	105,595
	Carp			330,280	330,280
	Catfish			784,090	784,090
	Crappie			348,213	348,213
	Fresh-water drum			222	222
	Pike and pickerel			16,690	16,690

Stations and substations operated and output of each, fiscal year 1923—Con.

Station and substation.	Species.	Eggs.	Fry.	Fingerlings, yearlings, and adults.	Total.
Homer, Minn.—Contd.					
Rock Island, Ill. (Continued).	Sunfish			691,765	691,765
	White bass			777	777
	Yellow perch			4,525	4,525
	Miscellaneous			886,055	886,055
Simmesport, La.	Black bass			239	239
	Buffalofish			22,550	22,550
	Catfish			1,298	1,298
	Carp			130	130
	Crappie			4,725	4,725
	Fresh-water drum			7,725	7,725
	Pike and pickerel			60	60
	Sunfish			3,400	3,400
	White bass			5,170	5,170
	Miscellaneous			192,500	192,500
Leadville, Colo.	Black-spotted trout		120,000	551,000	671,000
	Brook trout	*725,000	315,000	3,030,000	4,070,000
	Lake trout			120,000	120,000
	Loch Leven trout			12,150	12,150
	Rainbow trout			64,000	64,000
	Steelhead trout			50,000	50,000
Louisville, Ky.	Black bass			1,300	1,300
	Rock bass			1,750	1,750
	Smallmouth black bass		383,000	19,000	402,000
	Sunfish			26,800	26,800
Cairo, Ill.	Black bass			150	150
	Buffalofish			22,600	22,600
	Catfish			755,000	755,000
	Crappie			307,000	307,000
	Sunfish			123,000	123,000
Mammoth Spring, Ark.	Black bass			87,500	87,500
	Crappie			400	400
	Rock bass			17,600	17,600
	Smallmouth black bass			20,200	20,200
	Sunfish			14,000	14,000
Manchester, Iowa	Brook trout			445,545	445,545
	Rainbow trout	*2,000		98,685	100,685
	Rock bass			5,750	5,750
Nashua, N. H.	Brook trout			614,106	614,106
	Lake trout			21,000	21,000
	Landlocked salmon			1,400	1,400
	Pike perch		75,000		75,000
	Rainbow trout			39,700	39,700
	Smallmouth black bass		8,700		8,700
Neosho, Mo	Black bass			9,038	9,038
	Crappie			600	600
	Rainbow trout	746,460		258,065	1,004,525
	Rock bass			4,415	4,415
	Smallmouth black bass			38	38
	Sunfish			17,521	17,521
	Yellow perch	3,680,000	3,500,000	270	7,180,270
Northville, Mich.	Brook trout		110,000	197,000	307,000
	Lake trout		20,000		20,000
	Rainbow trout			15,000	15,000
	Smallmouth black bass		30,700	32,325	63,025
Alpena, Mich.	Lake trout	*1,958,000	610,000		2,568,000
	Whitefish	*17,440,000	600,000		18,040,000
Charlevoix, Mich.	Lake trout	4,250,000	19,000,000		23,250,000
	Landlocked salmon		10,000		10,000
	Whitefish	(*)	20,000,000		20,000,000
Orangeburg, S. C.	Black bass		101,000	299,146	400,146
	Catfish			180	180
	Sunfish			26,030	26,030
	Warmouth bass			8,200	8,200
Put in Bay, Ohio	Carp	8,000,000	115,000,000		123,000,000
	Pike perch	*37,275,000	51,800,000		89,075,000
	Whitefish	*52,400,000	100,000,000		152,400,000
	Yellow perch		3,000,000		3,000,000
Quinault, Wash.	Black-spotted trout		45,000		45,000
	Sockeye salmon			944,000	944,000
	Steelhead salmon			78,000	78,000
St. Johnsbury, Vt	Brook trout	300	956,000	274	956,574
	Lake trout	*300	151,969		152,269
	Steelhead salmon			8,000	8,000
Holden, Vt.	Brook trout		238,400	9,050	247,450
	Lake trout	30,000	95,446	6,500	131,946
	Rainbow trout			1,200	1,200
	Steelhead salmon			300	300
York Pond, N. H.	Brook trout			1,264	1,264
	Lake trout			80	80

Stations and substations operated and output of each, fiscal year 1923—Con.

Station and substation.	Species.	Eggs.	Fry.	Fingerlings, yearlings, and adults.	Total.
San Marcos, Tex	Black bass			251,918	251,918
	Crapple			4,310	4,310
	Rock bass			260	260
	Sunfish			14,508	14,508
	Warmouth bass			70	70
Saratoga, Wyo	Black-spotted trout			87,500	87,500
	Brook trout			138,100	138,100
	Rainbow trout	619,440		103,800	723,240
Lost Creek, Wyo	do		410,000		410,000
Spearfish, S. Dak	Brook trout			792,445	792,445
	Loch Leven trout	(*)		31,650	31,650
	Rainbow trout			35,360	35,360
Springville, Utah	Black-spotted trout			1,600	1,600
	Brook trout			282,450	282,450
	Rainbow trout	*5,000		357,000	362,000
Tupelo, Miss	Black bass		337,000	75,190	412,190
	Crapple			650	650
	Sunfish			80,100	80,100
Friar Point, Miss	Black bass			6,960	6,960
	Buffalofish			88,500	88,500
	Carp			300	300
	Catfish			314,285	314,285
	Crapple			8,399	8,399
	Rock bass			2,145	2,145
	Sunfish			1,221,000	1,221,000
	White bass			2,650	2,650
White Sulphur Springs, W. Va.	Black bass		87,500	2,680	90,180
	Brook trout			710,066	710,066
	Rainbow trout	*1,047,500		726,900	1,774,400
	Rock bass			930	930
	Smallmouth black bass		27,000		27,000
	Sunfish			1,250	1,250
Woods Hole, Mass	Cod	*373,480,000	131,673,000		505,153,000
	Flounder	229,345,000	123,221,000		352,566,000
	Pollock		688,000		688,000
	White perch			675	675
Wytheville, Va	Black bass			5,875	5,875
	Brook trout			257,750	257,750
	Catfish			2,000	2,000
	Rainbow trout	*243,000		168,100	411,100
	Rock bass			12,700	12,700
	Sunfish			5,250	5,250
Yes Bay, Alaska	Humpback salmon		393,600		393,600
	Sockeye salmon		1,500,000	18,500,000	20,000,000
Gross output		1,464,480,872	2,586,887,790	264,489,063	4,315,857,725
Loss in transit		750,440	75,500	172,756	998,696
Net output		1,463,730,432	2,586,812,290	264,316,307	4,314,859,029

Transfers of eggs between stations, fiscal year 1923.

Species.	Number of eggs.	From—	To—
Black-spotted trout	75,000	Yellowstone Park, Wyo	Clackamas, Oreg.
	1,332,000	do	Glacier Park, Mont.
	698,000	do	Leadville, Colo.
	50,000	do	Quinault, Wash.
	100,000	do	Saratoga, Wyo.
Brook trout	131,666	Craig Brook, Me	Grand Lake Stream, Me.
	500,000	Leadville, Colo	Bozeman, Mont.
	531,360	Springville, Utah	Do.
	230,000	do	Clackamas, Oreg.
	259,200	do	La Cross, Wis.
	259,200	do	Manchester, Iowa.
	26,400	do	Salmon, Idaho.
	259,200	do	Spearfish, S. Dak.
Chinook salmon	225,000	Little White Salmon, Wash	Central station, Washington, D. C.
	1,750,000	do	Clackamas, Oreg.
Chum salmon	5,501,000	Brinnon, Wash	Duckabush, Wash.
	1,800,000	do	Quilcene, Wash.
Cod	30,480,000	Woods Hole, Mass	Gloucester, Mass.
Humpback salmon	278,616	Afognak, Alaska	Birdsview, Wash.
	50,000	Birdsview, Wash	Central station, Washington, D. C.

Transfers of eggs between stations, fiscal year 1923—Continued.

Species.	Number of eggs.	From—	To—
Lake trout	50,000	Cape Vincent, N. Y	Holden, Vt.
	75,000	Duluth, Minn	Bozeman, Mont.
	25,000	do	Clackamas, Oreg.
	150,000	do	Leadville, Colo.
	108,000	Northville, Mich	Alpena, Mich.
	3,037,000	Alpena, Mich	Charlevoix, Mich.
	230,000	do	Northville, Mich.
	3,000,000	Charlevoix, Mich	Alpena, Mich.
	4,000,000	do	Cape Vincent, N. Y.
	6,000,000	do	Duluth, Minn.
	50,052	St. Johnsbury, Vt	Nashua, N. H.
Landlocked salmon	20,349	Craig Brook, Me	Do.
	20,349	do	St. Johnsbury, Vt.
	380,002	Grand Lake Stream, Me	Craig Brook, Me.
Loch Leven trout	10,350	Spearfish, S. Dak	St. Johnsbury, Vt.
Pike perch	500,000	Put in Bay, Ohio	Berkshire, Mass.
	1,500,000	do	Cape Vincent, N. Y.
	1,000,000	do	Central station, Washington, D. C.
	1,500,000	do	Nashua, N. H.
Rainbow trout	50,000	Bozeman, Mont	Neosho, Mo.
	25,000	do	Manchester, Iowa.
	77,000	Manchester, Iowa	La Crosse, Wis.
	25,000	Springville, Utah	Manchester, Iowa.
	50,000	White Sulphur Springs, W. Va	Nashua, N. H.
	50,000	Wytheville, Va	Central station, Washington, D. C.
	50,000	do	Craig Brook, Me.
	50,000	do	Nashua, N. H.
Silver salmon	3,025,000	Baker Lake, Wash	Birdsview, Wash.
	780,000	Birdsview, Wash	Duckabush, Wash.
	650,000	Sultan, Wash	Quilcene, Wash.
Sockeye salmon	25,000	Baker Lake, Wash	Birdsview, Wash.
Steelhead salmon	100,000	Applegate, Oreg	Duluth, Minn.
	100,000	do	Leadville, Colo.
	85,000	do	Trail, Oreg.
	50,000	Washougal River, Wash	Bozeman, Mont.
	35,000	do	Clackamas, Oreg.
	50,000	do	St. Johnsbury, Vt.
	50,000	do	Spearfish, S. Dak.
Whitefish	1,120,000	Cape Vincent, N. Y	Central station, Washington, D. C.
	35,935,000	Alpena, Mich	Charlevoix, Mich.
	200,000	do	Northville, Mich.
	1,000,000	Put in Bay, Ohio	Central station, Washington, D. C.
	20,000,000	Charlevoix, Mich	Alpena, Mich.
Yellow perch	9,165,000	Bryans Point, Md	Central station, Washington, D. C.
	750,000	Central station, Washington, D. C.	Erwin, Tenn.
	250,000	do	Wytheville, Va.

EGG-COLLECTING OR AUXILIARY STATIONS.

In many instances the eggs hatched at the main stations are obtained at points established as near as possible to the base of egg-collecting operations. All of these egg-collecting auxiliaries are temporary in character, many of them being mere camps with a tent for the operator to live in, which in many instances serves also as a place where the eggs may be packed for shipment. In other fields the operator may be quartered with the fishermen or at some hotel in the vicinity, in which case a fish house is used for packing operations. During the past fiscal year 75 of these egg-collecting stations were occupied for periods varying from two weeks to approximately three months. The following list of substations of this class shows in each case the main station from which operations were conducted, the period of operation, and the species handled.

Egg-collecting stations, period of operation, and species handled, fiscal year 1923.

Station.	Period of operation.	Species handled.
Boothbay Harbor, Me.:		
Casco Bay, Me	Mar. 14 to May 7	Winter flounder.
Ebenecook Harbor, Me	Mar. 10 to May 1	Do.
Johns Bay, Me	Mar. 10 to May 10	Do.
Linekins Bay, Me	Feb. 27 to May 11	Do.
Outer Penobscot Bay	Mar. 16 to May 10	Do.
Seal Harbor, Me	do	Do.
Southport Coves, Me	Feb. 27 to May 19	Do.
Townsend Gut, Me	Mar. 10 to May 10	Do.
Cape Vincent, N. Y.:		
Bygotts Point, Ontario	Nov. 1 to Dec. 1	Cisco, whitefish.
Chaumont Bay, N. Y	Nov. 12 to Dec. 8	Do.
Deseronto, Ontario	Nov. 1 to Dec. 1	Do.
Fairhaven Bay, N. Y	Nov. 25 to Dec. 9	Cisco.
Grass Bay, N. Y	May 1 to 16	Yellow perch.
Pigeon Island, Ontario	Oct. 17 to Nov. 12	Lake trout.
Sodus Bay, N. Y	Nov. 25 to Dec. 8	Cisco.
South Bay, Ontario	Nov. 12 to 24	Whitefish.
Clackamas, Oreg.:		
Lemhi, Idaho	June to September	Chinook salmon.
Pahsimeroi, Idaho	September to October	Do.
Sunbeam Dam, Idaho	do	Do.
Craig Brook, Me.:		
Dobsis Lake, Me	Oct. 21 to Nov. 14	Landlocked salmon.
Ox Brook, Me	Oct. 21 to 23	Do.
Duluth, Minn.:		
Au Train, Mich	Oct. 16 to Nov. 3	Lake trout.
Bete Grise, Mich	Oct. 19 to Nov. 8	Do.
Fish Island, Mich	Oct. 18 to Nov. 25	Lake trout, whitefish.
Fishermens Home, Mich	do	Do.
Gay, Mich	Oct. 19 to Nov. 8	Lake trout.
Grand Marais, Mich	Oct. 20 to Nov. 5	Do.
Huron Island, Mich	Oct. 19 to Nov. 8	Do.
Keystone, Mich	Oct. 12 to Nov. 6	Do.
Long Point, Mich	Oct. 18 to Nov. 25	Lake trout, whitefish.
Manitou Island, Mich	Oct. 19 to Nov. 8	Lake trout.
Marquette, Mich	Oct. 17 to Nov. 9	Do.
Munising, Mich	Oct. 16 to Nov. 3	Do.
Ontonagon, Mich	Oct. 20 to Nov. 6	Do.
Portage Entry, Mich	Oct. 19 to Nov. 8	Do.
Portage Lake Canal, Mich	Oct. 20 to 31	Do.
Rock Harbor, Mich	Oct. 18 to Nov. 25	Lake trout, whitefish.
Siscowit Bay, Mich	do	Do.
Tobens Harbor, Mich	do	Do.
Todds Harbor, Mich	do	Do.
Traverse Bay, Mich	Oct. 19 to Nov. 8	Lake trout.
Washington Harbor, Mich	Oct. 18 to Nov. 25	Do.
Wrights Island, Mich	do	Do.
Leadville, Colo.:		
Carroll Lake, Colo	Oct. 29 to Nov. 18	Brook trout.
Engelbrecht Lake, Colo	Sept. 24 to Nov. 26	Do.
Fred Neal Lake, Colo	Nov. 17 to 26	Do.
Musgroves Lake, Colo	Oct. 26 to Nov. 22	Do.
Turquoise Lake, Colo	Oct. 19 to Nov. 29	Do.
Neosho, Mo.:		
Roaring River, Mo	Nov. 5 to Feb. 13	Rainbow trout.
Northville, Mich.:		
Cheboygan, Mich	Oct. 22 to 31	Lake trout.
Fairport, Mich	Oct. 26 to Dec. 2	Do.
Frankfort, Mich	Nov. 3 to 23	Do.
Gould City, Mich	Nov. 18 to 27	Whitefish.
Leeland, Mich	Nov. 3 to 21	Lake trout.
Manistique, Mich	Oct. 22 to Nov. 16	Do.
Naubinway, Mich	Nov. 18 to 27	Whitefish.
Northport, Mich	Nov. 1 to 21	Lake trout.
St. Ignace, Mich	Oct. 22 to Nov. 27	Do.
St. James, Mich	Nov. 1 to 22	Lake trout, whitefish.
Put in Bay, Ohio:		
Catawba Island, Ohio	Nov. 12 to Dec. 4	Whitefish.
Middle Bass Island, Ohio	Nov. 12 to Dec. 8	Do.
North Bass Island, Ohio	Nov. 8 to Dec. 8	Do.
	Apr. 15 to 30	Pike perch.
Pelee Island, Ontario	Nov. 28 to Dec. 4	Whitefish.
Port Clinton, Ohio	Nov. 1 to Dec. 4	Do.
	Apr. 12 to June 24	Pike perch.
Toledo, Ohio	Nov. 8 to 30	Whitefish.
	Apr. 15 to May 8	Pike perch.
St. Johnsbury, Vt.:		
Darling Pond, Vt	October and November	Brook trout.
Lake Dunmore, Vt	Oct. 25 to Nov. 5	Lake trout.
Lake Mitchell	October and November	Brook trout.

Egg-collecting stations, period of operation, and species handled, fiscal year 1923—Continued.

Station.	Period of operation.	Species handled.
Saratoga, Wyo.:		
Big Creek Lake, Wyo	October and November	Brook trout.
Canon Creek, Wyo	April to June	Rainbow trout.
Sage Creek, Wyo	do	Do.
Springville, Utah:		
Fish Lake, Utah	Nov. 3 to 28	Brook trout.
	May 2 to June 4	Rainbow trout.
Woods Hole, Mass.:		
Sandwich, Mass	Nov. 1 to Dec. 31	Cod.
Waquoit, Mass	Jan. 18 to Mar. 15	Winter flounder.
Wickford, R. I	Mar. 16 to Apr. 5	Do.

FISH FOOD USED AT HATCHERIES.

The following table indicates the amounts and kinds of food used at the fish-cultural stations of the bureau during 1923, with the cost per pound of each material used.

Pounds and cost per pound of fish food used during the fiscal year 1923.

PACIFIC SALMON STATIONS.

Station.	Beef liver.		Sheep liver.		Beef melts.		Canned salmon.	
	Pounds.	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*
Baird and substations, Calif	1,112	$0.10						
Baker Lake and substations, Wash	1,270	.0634	676	$0.08	3,360	$0.045	1,008 [1] 4,210	$0.06
Clackamas and substations, Oreg	770	.05			6,221	.039		
Total	3,152		676		9,581		5,218	

Station.	Salted salmon.		Fresh fish.		Salmon eggs.		Middlings.	
	Pounds.	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*
Afognak, Alaska	2,450	$0.0454	[2] 300					
Yes Bay, Alaska	1,725	.02			1,700	$0.015		
Baird and substations, Calif	9,000	.025						
Baker Lake and substations, Wash	1,313 [1] 250	.0215	[2] 120					
Clackamas and substations, Oreg	10,000	.011			4,420	.044	200	$0.028
Total	24,738		420		6,120		200	

ROCKY MOUNTAIN TROUT STATIONS.

Station.	Beef liver.		Beef hearts.		Sheep liver.		Hog liver.		Sheep plucks.	
	Pounds.	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*
Bozeman and substations, Mont	5,910	$0.075					6,883	$0.06		
Leadville, Colo			2,676	$0.0375						
Saratoga, Wyo	1,124	.05	1,754	.0425	550	$0.0425				
Spearfish, S. Dak	322	.12	1,146	.105	2,197	.07			2,200	$0.06
Springville, Utah	2,829	.04	9,594	.05	4,367	.06				
Total	10,185		15,170		7,114		6,883		2,200	

[1] Donated by State fish and game commission. [2] No cost.

Pounds and cost per pound of fish food used during the fiscal year 1923—Con.

ROCKY MOUNTAIN TROUT STATIONS—Continued

Station.	Paxton fish food.		Fishotine.		Lean beef.		Fresh fish.		Low-grade flour.	
	Pounds.	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*
Spearfish, S. Dak	39	$0.06	24	$0.08	14	$0.20				
Springville, Utah							6,225	$0.125	9,630	$0.0225
Total	39		24		14		6,225		9,630	

NEW ENGLAND TROUT AND SALMON STATIONS.

Station.	Beef liver.		Beef heart.		Sheep liver.		Pork liver.		Beef melts.	
	Pounds.	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*
Berkshire trout hatchery, Mass	364	$0.08							2,426	$0.05
Craig Brook, Me	892	.08					526	$0.06		
Nashua, N. H	1,149	.065	50	$0.045	3,274	$0.0425				
Total	2,405		50		3,274		526		2,426	

STATIONS PROPAGATING BOTH TROUTS AND POND FISHES.

Station.	Beef liver.		Beef heart.		Sheep liver.		Middlings.		Low-grade flour.	
	Pounds.	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*
Erwin, Tenn			5,580	$0.057	9,815	$0.0485	2,100	$0.0197	294	$0.027
Manchester, Iowa			3,182	.04	12,840	.036	400	.0175		
Neosho, Mo	1,684	$0.033	959	.0435	4,610	.0384	1,500	.016	3,705	.035
White Sulphur Springs, W. Va	113	.05	7,584	.05	20,036	.0471				
Wytheville, Va	4,609	.05	6,692	.06						
Total	6,406		23,997		47,301		4,000		3,999	

POND FISH-CULTURAL STATIONS

Station.	Beef liver.		Beef heart.		Fresh fish.		Fishotine.		Middlings.	
	Pounds.	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*	*Pounds.*	*Cost.*
Cold Springs, Ga., and substations					5,087	$0.10	373	$0.07	420	$0.10
Edenton, N. C	37	$0.20			172	.125				
Louisville, Ky	116	.10	437	$0.10						
Mammoth Spring, Ark			1,464	.052						
Orangeburg, S. C			1,864	.10						
Tupelo, Miss			1,688	.0926						
Total	153		5,453		5,259		373		420	

HATCHERY FISH-CULTURAL NOTES.

METHOD OF PREPARING FOOD FOR YOUNG SALMON.

In connection with the salmon-rearing operations at the Oregon station and substations, considerable quantities of immature salmon eggs are used as a fish food with very satisfactory results. This spawn is taken in immense quantities in the commercial fisheries of the Columbia River and is held in cold storage until needed, when it is thawed by immersion in cold water. In preparing the material for food it is first passed through the coarse plate of a meat chopper and is then cooked in a single boiler for about 2½ hours, during which time it is stirred constantly. When cooked the food resembles granulated yellow cornmeal, and when introduced into the ponds and troughs it does not discolor the water.

TEST OF COPPER SULPHATE FOR ERADICATION OF FUNGUS.

The great difficulty experienced in preventing the development and growth of fungus on crappie held for distribution during the summer months impelled the district supervisor in charge of the Mississippi River rescue work to test the copper-sulphate treatment in an effort to find a cure for the trouble. Owing to the extreme weakness of very small crappie and sunfish in intensely warm weather, it was found that they would not survive even a weak solution of the chemical, those used in the test perishing in large numbers when subjected to it. The results demonstrated that it might be successfully applied to fishes of larger growth and to the stronger individuals among the younger fishes, and also that it is valuable for disinfecting and cleaning the troughs in which fish are held. Its use for such purposes will hereafter be resorted to at the holding and distributing stations in the rescue fields.

In this connection too much stress can not be laid upon the need for exercising care in the handling of fish to avoid abrasions, which serve as avenues of access for bacteria. In landing seines in the rescue fields special effort is made to prevent hauling the fish over low muddy places, thus filling the gills with mud. For the infection work, also, only the larger and stronger fishes are selected as hosts, all small and weak specimens being carefully culled out.

PARASITIC AFFECTION IN WHITEFISH JARS.

In connection with the parasitic affection that caused so much trouble in the whitefish jars at the Cape Vincent (N. Y.) station during the past season, it is the opinion of the bureau that the heavy losses sustained were very largely the result of the additional handling required in order to remove the growth from the jars. In investigating the underlying causes of a heavy loss of shad eggs at Windsor, Conn., Doctor Mitchell, of Brown University, found that a very large percentage of the loss was due not to lack of fertilization but to scratches and abrasions on the surface of the eggs. The raw surfaces caused by the abrasions formed a fertile ground for the multiplication of bacteria, and later on a white mold appeared, quickly coating the eggs. It is quite possible that the heavy mortality experienced in the incubation of whitefish and cisco eggs may be traced to injuries to the shell, many of them being caused by the constant screening and washing of the eggs. This may also explain the higher percentage of hatch attained by fishery employees of the State when using an inverted funnellike bottom on their jar tubes. The effect of this arrangement is to spread out the intake flow of water, thus imparting a slow movement to the eggs. When eggs in circulation are thrown violently against the jar bottoms they are liable to become more or less scratched, especially if the jars contain particles of iron rust, which is often the case. Heavy losses of brook-trout eggs have frequently been noted when they are massed during the expansion period. In the process of separating the eggs the protecting film of the shell is apt to be broken, forming a fertile field for bacterial growth. It is believed this subject is worthy of careful study in an effort to overcome the heavy losses of eggs annually occurring at most of the stations of the bureau.

HATCHING EGGS IN GRAVEL.

Some interesting experiments in the hatching of trout eggs in gravel were conducted in the course of the year at the Wytheville (Va.) station. On January 4, 6,600 eyed rainbow-trout eggs were buried in sand and gravel in one of the rearing ponds. This material was obtained from a neighboring creek and was not screened, though the larger stones were removed. No fish having been observed by February 27, the covering was removed and washed and all the eggs were found to be dead.

In another experiment, undertaken on January 5, a trough was prepared with crushed stone sifted through a coarse-mesh screen to exclude the fine particles. Four nests were made with the larger pieces of stone, and in each of these eyed eggs to the number of 944 were scattered and covered to a depth of about 3 inches with the sifted material. A few fry in the advanced stage were observed in the trough on February 10, and the remainder of the hatch came out of the nests within the next two weeks with the sac nearly absorbed. On February 20, when the nests were removed and the fingerlings counted, it was ascertained that 2,736 of the 3,736 eggs planted had hatched.

COMMERCIAL FISHES.

Of the 71 stations and substations engaged in the fish-cultural operations of the bureau, the work of 44 was devoted mainly to propagation and to the salvage of certain commercial species. Among the most important fishes handled, from a commercial viewpoint, were the salmons of the Pacific coast, the whitefishes, lake trout, and cisco of the Great Lakes, and the cod, haddock, pollock, and winter flounder of the Atlantic coast. Other species of lesser commercial value were handled on a smaller scale. The results of the work at these stations show a considerable decrease as compared with those of the previous year, most of the falling off occurring among the Atlantic coast species. The principal reason for the decline was the unusually severe weather prevailing during the spawning period. though lack of funds for the efficient prosecution of the work at all points was also responsible in some degree.

PACIFIC SALMONS.

Fish-cultural operations coming under this head are conducted extensively at 19 stations and substations located in Washington, Oregon, California, and Alaska. Operations at this group of stations are devoted almost exclusively to the propagation of the salmons of the Pacific coast, though small numbers of trout eggs, transferred from other stations of the bureau, are usually hatched annually at two or three points in Oregon to supply the local demands for fish of that character. The results attained in the salmon work during the year were fairly satisfactory, though the output of the stations in this class was somewhat smaller than that of the preceding year

AFOGNAK (ALASKA) STATION.

[F. R. LUCAS, Superintendent.]

The steady annual increase in the run of sockeye salmon to waters in the vicinity of the Afognak station, frequent mention of which has been made in previous reports, was maintained throughout the past year. Not only were the egg collections larger than in 1922, but fully half the fish counted into Letnik Lake could not be utilized in the propagation work owing to lack of facilities for handling the spawn. This gratifying situation is believed to be due solely to the bureau's efforts to build up and improve the run.

The spawning operations were begun August 1 and extended to the middle of September, by which time a sufficient number of eggs had been obtained to severely tax the fry-holding capacity of the station, the total amounting to 61,790,000, or nearly 8,000,000 in excess of last year's collection. During the month of September 10,678,400 eyed eggs were shipped in charge of an attendant, part of them being delivered at Juneau, Alaska, to fill the application of the fisheries commission of that Territory; approximately half a million were furnished to the fisheries authorities of the State of Washington, and the remainder was turned over to the Oregon State hatchery at Bonneville. From the eggs incubated at the station 47,569,000 fry, or 93 per cent of those retained, were produced, the hatching period extending from October 15 to April 25. All fry were held on trays until the sac was absorbed, when many of them had to be liberated as the rearing capacity under the present stacked-tray system is sufficient for only about 30,000,000. Those retained for rearing were held in open troughs and liberated from time to time, the last of them being disposed of shortly before the end of the fiscal year.

In response to a request from the Birdsview (Wash.) station for a consignment of humpback-salmon eggs, a collection of 600,000 of this species was made on August 23. Approximately 278,000 were shipped to that point in the eyed stage, and from the remainder 240,000 fry were produced and liberated in the fingerling stage in one of the branches of Letnik River.

A disquieting feature connected with the propagation work in this region is the presence of the Dolly Varden trout in large numbers. It has been conclusively demonstrated that these fish constitute a serious menace to the welfare of young salmon, which they have been observed to follow in their downstream migrations in May and June, returning with the run of brood salmon in July and later. A dam was recently constructed across Letnik River with the view of excluding this species and other undesirable fishes from Letnik Lake, which it is desired to retain exclusively for the sockeye work. As a result of the systematic attempts made to reduce the numbers of Dolly Varden trout, between six and seven thousand were captured during the year in seines and traps. Their flesh was used, so far as it was needed, for feeding the fingerling salmon.

In the course of the year a number of minor repairs were made to station buildings, roads, equipment, and vessels. A 32-volt, 850-watt Delco lighting system, equipped with storage batteries, was purchased and installed in an insulated room for furnishing light to the various buildings. A one-half-kilowatt radio transmitting set was also purchased and installed in one of the rooms in the bunk house. This set is capable of sending on a 300, 420, or 600-meter wave length, and has ample power to permit of communication with the naval radio station at Kodiak. A 5,000-meter crystal detector receiving set was also provided.

Most of the trays used in the stacked-tray system at this station are 1 inch high and are used in the troughs in stacks of four—three filled ones with an empty one at the top. As an experiment 1,000 trays three-fourths inch high with mitered corners were constructed, and were placed four filled trays to a stack. They were found to work just as successfully as the deeper ones, and by their use the capacity of a fry-holding trough is increased one-third.

YES BAY (ALASKA) STATION.

[JOHN W. GARDNER, Superintendent.]

The fish-cultural work at this important salmon hatchery during the fiscal year 1923 may be considered satisfactory. Notwithstanding the short egg-collecting period, which extended from September 5 to September 22, sockeye-salmon eggs to the number of 25,000,000 were taken, and approximately 500,000 eggs of the humpback salmon were obtained incidentally. On September 22 the fishing racks were wrecked by heavy drift washed against them during a sudden rise in the river. The collecting season was thus abruptly ended, though spawning fish in considerable numbers were ascending the river then and for some time afterwards.

For the first time since the general adoption of stacked trays for holding salmon fry through the yolk-sac absorption period a complaint has been registered against the system. The superintendent of the Yes Bay station reports that during the year a loss in excess of 29 per cent occurred among the fish thus held, while the death rate among the fry held in troughs was merely nominal. He attributes the abnormal loss to an unusual condition of the water supply; at least such a condition had never been observed previously at the station. He states that circulation was almost entirely precluded at times by the presence of quantities of slime, which covered the frames and wires of the trays, forming a jellylike substance. This slime is supposed to have come from the swampy tundra of the surrounding region. The superintendent suggests that the trouble might be overcome by the removal of the 14-inch mesh from the trays and the substitution of 10 or 12-inch mesh.

The year's output of the station consisted of 20,000,000 sockeye salmon, all but 1,500,000 being fingerlings No. 1; also humpback salmon fry to the number of 393,600, and upward of 4,000,000 sockeye fingerlings remained in the troughs at the end of the year.

Approximately 6,500,000 sockeye fingerlings were placed in McDonald Slough, an inclosed arm of Yes Lake about 4 acres in area, which has been used for several seasons as a rearing pond. Before placing the fingerlings in this inclosure all other fish that may have collected therein are removed with seines and gill nets and the entrance is screened to prevent their return. The salmon may then be given artificial food in addition to the natural food in the water, and held until such time as it seems desirable to release them.

During the winter months further trouble was experienced from anchor ice, and it appears important that steps be taken to correct this condition and thus avoid the threatened loss of valuable stock each season. During extended periods of cold the water at the intake end of the pipe line falls to a level where the pipe does not carry water to its full capacity. At such times anchor ice causes trouble, and there is always danger of the line freezing completely. Should this occur it would in all probability entail not only the loss of all eggs or fish on hand but it would be liable also to seriously damage the pipe line. As a corrective measure the superintendent recommends certain alterations to the dam at the intake, including an increase of its height to deepen the water at that point, and the protection of the pipe against frost by covering it throughout its entire length.

BAKER LAKE (WASH.) STATION AND SUBSTATIONS.

[J. R. RUSSELL, Superintendent.]

Satisfactory results were achieved in the fish-cultural work in this field during the fiscal year, the egg collections and output of fish eggs and young fish from all points comparing favorably with the work of past years, while the egg collections and output exceeded those of the preceding year by a substantial margin.

In this connection it should be taken into consideration that the Quinault station, which for some years has been an auxiliary of the Baker Lake station, is now being operated under the direction of an independent superintendent, and its output does not enter into the total of the Washington group of stations. A review of the year's work in the Quinault field is contained on page 29 of this report.

The Baker Lake field involves the work of six stations, all in the State of Washington, with the headquarters of the superintendent at Birdsview. Fish-cultural work in 1923 was addressed to the five species of Pacific coast salmon and the steelhead. Though the humpback salmon does not figure in the year's egg collections, the species is represented in the output by upward of 1,500,000 of advanced fry, these being the progeny of eggs collected in Alaska waters by employees of the State of Washington, and of a smaller shipment of eggs transferred from the bureau's Afognak station. These transfers were made with the view of effecting, if possible, the reestablishment of an annual run of humpback salmon in Puget Sound waters.

BAKER LAKE (WASH.) STATION.

Though it has been found more convenient in recent years to maintain executive headquarters at Birdsview, Baker Lake has always been considered the main station of the Washington group. It is the point at which the bureau first attempted fish-cultural work in the State of Washington, and it has continued to be the most important station as regards the value of its work to the great salmon industry of the surrounding region.

The construction work at this point during the year included the remodeling and rebuilding of the stable, some needed alterations and repairs to fishing and spawn-taking appliances at the retaining inclosure, and repairs to the trap. The trail and telephone line between the station and the railroad at Concrete, Wash., was kept open throughout the year. Because of the expense involved in packing supplies to this station from the railroad line, 18 miles distant, it has been found profitable to do a considerable amount of farming. Several acres of land adjacent to the buildings are under cultivation, and from this land upward of 6 tons of hay and a sufficient amount of vegetables to supply the station mess were produced. A storm channel was excavated for the diversion of flood waters from the creek flowing through the station grounds into a deep ravine, thus relieving the station of a flood menace of long standing.

There were on hand at the first of the year 5,400,000 sockeye-salmon fingerlings, all of which were distributed in July, 1922. From the operation of the trap at the outlet of the lake 7,080 adult sockeye salmon were taken between July 1 and August 14, and were held in the inclosure with the usual success until ready to spawn, all of them remaining in splendid condition throughout the period of confinement. Spawn taking was in progress almost daily from October 1 to November 21, and 11,040,000 eggs of excellent quality were obtained from the 3,499 female fish contained in the brood stock.

During the run of silver salmon—from September 25 to November 18—adult fish to the number of 2,924 were taken. Low water stages in Baker River were detrimental to the work, as large numbers of fish were unable or unwilling to ascend the shallow stretches of the river and deposited their eggs far below the usual spawning places. Between October 31 and December 15 the 1,033 females in the lot yielded 3,115,000 eggs. After being eyed, all of these were transferred to the Birdsview station for incubation.

In contrast to the statement of the superintendent of the Yes Bay station with reference to the use of stacked trays for rearing sockeye-salmon fry, the following is quoted from the annual report of the superintendent of the Baker Lake station:

> The fry were thoroughly cleaned when taken from under the baskets and were then placed on the trays, where they remained without further attention, aside from the regulation of the water, until they were swimming up. This would seem to indicate that if the fry are healthy when placed on the trays there is no need to molest them during the sac-absorption period, provided, of course, that no unfavorable water or other conditions are encountered.

Besides the 3,025,000 eyed silver-salmon eggs transferred to the Birdsview station, the distribution from Baker Lake included 15,175,000 sockeye-salmon fingerlings, with some 700,000 remaining on hand at the end of the year.

BIRDSVIEW (WASH.) SUBSTATION.

At the beginning of the chinook-salmon spawning season in September the protracted dry weather had reduced the water stages in Grandy Creek to such an extent that successful fish-cultural work seemed impossible. Late in October, however, the greatly needed rains came, bringing the streams to normal level, and from that date on conditions were generally favorable to good work. The egg collections were therefore successful, and more fish were produced for distribution than for a number of seasons past.

Between September 30 and October 4, while the drought still prevailed, 38,000 chinook-salmon eggs and more than 4,000,000 silver-salmon eggs were taken, the collecting season extending from October 4 to December 22. The steelhead work at this point also showed a satisfactory improvement over that of last season, the collections netting 847,000 eggs of excellent quality. No humpback salmon were in evidence in Grandy Creek during the year, but in October approximately 275,000 eggs of this species were received from the Afognak station. A small number was sent to central station at Washington, D. C., for exhibition, while the remainder was incubated and the young fish liberated locally in continuance of the policy of attempting the reestablishment of the run of humpback salmon in Puget Sound waters during the so-called "off year." No chum-salmon eggs were handled at the station during the year and no fish of this species were taken in the Grandy Creek trap, but it was observed that there was an excellent run in the Skagit River, large numbers of them appearing on the spawning grounds and apparently in excellent condition.

The output of all species of fish from this station amounted to 8,107,890 fry and fingerlings, and upward of 1,000,000 remained in the ponds and troughs at the close of the year.

BRINNON (WASH.) SUBSTATION.

This field station was opened on November 2 for the collection of eggs of the late run of chum salmon. During the spawning season—from December 4 to January 8—eggs to the number of 7,410,000 were taken. After being eyed these were sent to other stations on Hoods Canal to be hatched and the progeny were returned to the Dusewallops River in the advanced fry stage. While such transfers of eggs and fry involve some extra labor, they undoubtedly result in economy, as the expense of operating pumps and maintaining the Brinnon substation during the time required to incubate the eggs and develop the fry would exceed the cost of the transfers by a wide margin.

DUCKABUSH (WASH.) SUBSTATION.

There were distributed from this point during the year upward of 14,500,000 fry and fingerling fish, the species including chum salmon, silver salmon, and steelhead, and approximately 1,250,000 young fish were left in the ponds and troughs at its close.

In July and August a rack was installed in the Duckabush River near its mouth for the capture of spawning fish from the early run of chum salmon. Because of its low banks rack construction on this river is not an easy matter, and any barrier tending to impede the flow of the stream must be carefully watched to prevent damage from overflow on to adjacent agricultural lands. During the month of September 10,870,000 eggs were taken, and as this number, together with the eggs expected from the Brinnon collecting station, would fill all the hatchery space available, the collections were discontinued though spawning fish were still plentiful. Eggs received from Brinnon numbered 5,501,000, and late in December 80,000 eggs of the late run of chum salmon were taken at the trap on the station grounds.

While the run of silver salmon in Duckabush River appeared from all observations to be greater than that of an average season, the number of eggs secured would seem to indicate the contrary. This is explained by the unfavorable water stages, which interfered with the work to such an extent that only 97 female fish were taken. This stock yielded 260,000 eggs. An additional lot of 780,000 eggs of this species, an overflow from the Birdsview station, was also incubated. During the spring months 255,000 steelhead eggs were obtained from fish entering the traps.

QUILCENE (WASH.) SUBSTATION.

The egg collections from fields in the vicinity of the Quilcene station during the year amounted to 9,475,000, the species including chum and silver salmon and the steelhead. In addition to this stock, eggs to the number of 4,107,290 were acquired by transfer from other fields, 1,657,290 of them being humpback-salmon eggs taken in Alaska waters by employees of the State of Washington. All eggs handled were successfully incubated, and the aggregate output totaled 11,451,200 advanced fry and fingerling fish divided as to species as follows: Chum salmon, 8,729,580; humpback salmon, 1,483,-790; silver salmon, 752,275; steelhead, 545,555. In addition to the distributions made, 1,310,950 fingerling fish remained on hand at the close of the year.

SULTAN (WASH.) SUBSTATION.

As at the Birdsview station, low-water stages at spawning time seriously interfered with egg collections during the early fall. Thus only 79,000 chinook-salmon eggs could be obtained, these being taken between October 25 and November 4. As at Birdsview, also, the streams reached their normal level before the peak of the silver-salmon spawning season had passed, and under these improved conditions 4,065,000 eggs were taken, the collections being made between October 25 and January 13. This stock exceeded last year's collection by more than 1,700,000. Because of lack of hatchery space 650,000 of the eggs were sent to the Quilcene station for incubation. An average collection of steelhead eggs was made during the spring, the spawning season extending from April 8 to June 4.

QUINAULT (WASH.) STATION.

[PHILO B. HAWLEY, Superintendent.]

In accordance with plans previously outlined for this station, sockeye-salmon propagation, the principal item of the fish-cultural work, was omitted during the fiscal year 1923 except for the distribution of 944,000 fingerlings of that species which had been carried over from the previous year. The distributions also included 78,000 steelhead fingerlings, the product of the preceding year's egg collections, and 45,000 black-spotted-trout fry, the eggs of which had been transferred from the Yellowstone National Park. The only eggs collected for the station were 410,000 of the steelhead taken at the trap during May in connection with the salmon census. The progeny of these were still on hand at the close of the year.

The counting weir was installed and ready for operation by March 17, 1923. The first count was made three days later, and from then on to the end of June counting was a daily occurrence. The results of the work during this period, together with a record of the daily count for the corresponding portion of the preceding year, are indicated in the following table:

Daily count of sockeye salmon entering Quinault (Wash.) Lake during the fiscal year 1923, showing number of fish marked by gill nets each day.

Date.	1923		1922	
	Number of fish.		Number of fish.	
	Total counted.	Marked by gill nets.	Total counted.	Marked by gill nets.
Mar. 20	20			
21	34			
22	14			
23	14			
24	35			
25	7			
26	76			
27	23			
28	42			
29	65		65	
30	56		42	
31	42		185	
Apr. 1	91	5	200	
2	228	9	188	
3	55	3	349	
4	111	3	591	
5	132	5	860	
6	125	3	316	
7	75	1	194	
8	53	1	483	
9	120	2	197	
10	42	1	91	4
11	130	6	122	6
12	123	2	60	4
13	117	4	97	5
14	66	1	190	15
15	126	4	147	12
16	64	3	171	14
17	135	5	130	17
18	63	1	139	12
19	90	5	125	18
20	80	3	143	18
21	122	4	174	27
22	225	3	159	23
23	92		177	22
24	91	3	187	27
25	101	4	218	27
26	220	5	130	27
27	53	3	243	42
28	320	13	289	36
29	100	4	410	44
30	166	5	250	48
May 1	230	6	173	33
2	636	33	358	57
3	908	43	870	163
4	462	19	1,039	98
5	186	13	1,323	143
6	156	10	901	78
7	150	13	922	107
8	187	8	216	37
9	330	20	1,106	147
10	206	14	1,868	139
11	410	19	1,200	99
May 12	170	8	996	63
13	587	33	874	95
14	246	30	719	43
15	550	43	1,111	62
16	500	45	1,201	127
17	700	35	1,896	184
18	365	15	2,341	195
19	1,045	48	432	37
20	155	11	1,175	204
21	1,951	141	1,056	144
22	2,389	238	996	168
23	1,849	169	3,571	525
24	4,713	237	3,403	217
25	2,101	159	3,996	288
26	1,567	102	2,334	180
27	3,147	159	2,351	365
28	778	45	5,512	469
29	1,054	78	5,261	269
30	3,588	254	9,569	864
31	6,200	489	17,840	1,500
June 1	1,720	139	8,649	721
2	4,690	432	4,812	287
3	5,080	548	3,047	321
4	1,620	160	5,262	283
5	8,077	605	4,051	281
6	7,398	548	9,189	1,199
7	5,223	345	6,288	566
8	2,765	248	4,206	368
9	1,680	187	4,316	389
10	477	52	3,918	314
11	2,330	230	4,114	639
12	3,230	359	4,272	622
13	3,534	387	13,987	1,497
14	2,760	458	8,738	783
15	1,613	161	7,109	728
16	2,360	248	5,650	597
17	1,120	209	2,327	140
18	930	94	1,336	48
19	2,463	297	1,202	44
20	1,923	178	841	34
21	1,008	103	1,258	33
22	708	46	781	78
23	1,088	48	765	39
24	1,117	60	709	25
25	2,934	68	910	26
26	2,672	48	1,699	40
27	1,510	42	1,328	33
28	7,757	119	1,457	22
29	1,131	19	1,094	15
30	644	15	2,292	25
Total	123,022	9,088	199,489	17,735

Inasmuch as the run of sockeye salmon in Quinault Lake involves a part of two fiscal years, the total run for any one calendar year does not appear in the annual reports. Thus, during the calendar year 1922 fish were running and daily counts were made during the period from March 29 to September 13, 1922, inclusive, and during this time 49,466 salmon passed up the river. These, added to the count up to and including June 30, 1922, give a total of 248,932 fish entering the lake during the full period of the 1922 run. A table showing the daily count for this portion of the calendar year 1922 is herewith appended:

Daily count of sockeye salmon entering Quinault Lake, from July 1 to September 13, 1922.

Date.	Count.	Date.	Count.	Date.	Count.
July 1	1,886	July 27	818	Aug. 22	107
2	1,798	28	728	23	67
3	2,191	29	786	24	78
4	2,065	30	1,868	25	111
5	1,446	31	858	26	197
6	1,303	Aug. 1	1,502	27	473
7	1,015	2	1,542	28	496
8	1,228	3	750	29	254
9	779	4	682	30	120
10	1,092	5	774	31	135
11	738	6	458	Sept. 1	117
12	726	7	300	2	28
13	922	8	59	3	91
14	1,265	9	425	4	81
15	1,013	10	483	5	115
16	694	11	416	6	111
17	858	12	732	7	248
18	691	13	100	8	53
19	1,546	14	66	9	28
20	894	15	455	10	53
21	1,196	16	249	11	40
22	2,263	17	75	12	7
23	1,459	18	136	13	92
24	540	19	236		
25	1,065	20	158	Total	49,446
26	839	21	176		

An estimate of the probable number of fish that will enter the lake during the full term of the 1923 run, based on a comparison with last year's figures, would place the total for the calendar year 1923 at approximately 150,000, or about 61 per cent of the large run of the preceding year.

In the census for both the years referred to fully 7 per cent of the fish counted had been marked by the gill nets in use in the commercial fishery near the mouth of the river. Probably not less than 50 per cent of the fish marked were so badly scarred and lacerated that death before spawning time seemed inevitable. This means that one-half of the 9,091 net-marked fish passing through the weir between March 20 and June 30, 1923, constituted a total loss not only to the trade but to the work of propagation. Figuring at the current prices for marketable fish, this represents a monetary loss to the Indian fishermen of about $2,700.

The escapement for the calendar year 1922—very nearly 250,000—was probably as large as could reasonably be expected, and though comparatively little is known on the subject this number would seem to insure an ample return at the completion of the life cycle for the maintenance of the species in Quinault Lake, provided the fish find congenial spawning areas and the eggs and resulting progeny are not subjected to untoward conditions. The returns from the natural spawning of these years will be of interest to all observers.

During the spawning season of 1922 conditions were apparently not conducive to the best results from natural spawning. The customary fall rains were much restricted, and neither Quinault Lake nor its tributaries attained the normal high fall levels. At no time in the course of the spawning period did the lake rise to more than 3 feet above the average summer stage. As a result the spawning sockeyes were not induced to ascend to the upper reaches of the larger tributaries. Large numbers resorted instead to the smaller streams entering the lake, greatly congesting these limited spawning areas, while the more extensive grounds in the larger streams received only a comparatively few eggs. Never before in the history of the station has such a large number of spawning sockeyes entered Falls Creek, the small tributary on which the hatchery is located. It was estimated that not less than 10,000,000 eggs could easily have been taken from this stream alone.

Reports having reached the station during December that sockeyes in considerable numbers were returning to the ocean, an investigation was instituted, which indicated that Indians fishing near the mouth of the river for silver salmon and steelheads were taking from 30 to 40 sockeyes daily. All that were examined were typical spawners in a much emaciated condition. It was assumed that because of the low-water stages they had remained in Quinault River throughout the spawning season without entering the lake.

During November a five-day trip was made along the upper Quinault River and its tributaries for the purpose of ascertaining the number of fish that had resorted to those waters, the condition of the spawning beds, and other relevant information. Some 12 miles above Quinault Lake the so-called East Fork and the North Fork unite to form the upper Quinault River. The East Fork contains many small sloughs and shallow gravelly stretches, comprising very fair spawning beds. Sockeyes were noted working on these beds as far up as the junction of the Big South Fork with the East Fork, about 18 miles above the lake. At some distance above this point the river contains a succession of rapids and it is doubtful if spawning fish are able to surmount them.

The North Fork appears to be quite lacking in suitable spawning grounds, and no fish were seen in it beyond a distance of 2 miles above its junction with East Fork, though the examination was continued for a distance of more than 8 miles above that point.

It was estimated that perhaps 25 per cent of the fish reaching Quinault Lake resorted to the upper Quinault for spawning, and that not less than 75 per cent of this number remained in waters below the forks. During the progress of the investigation Big Creek, Merriman Creek, and Inner Creek, all tributaries of the upper Quinault River below the forks and from which egg collections are customarily made, contained large numbers of salmon.

Of special interest in connection with the natural reproduction of salmon in the upper Quinault River are the changing conditions brought about by the destruction of the forests. Local residents describe this river and its principal tributaries of 20 years ago as streams of moderate breadth flanked by heavy timber growth. At the present time this territory is subjected to ever-recurring floods, and the devastated area resulting from the shifting of channels varies in width from one-fourth to one-half a mile, and is noticeable throughout the entire distance of 12 miles to the main forks.

CLACKAMAS (OREG.) STATION AND SUBSTATIONS.

[HUGH C. MITCHELL, Superintendent.]

The "pack" of canned salmon from the Columbia River during the calendar year 1922 was one of the lightest in the history of the industry, and the supply of salmon eggs for artificial propagation fell off proportionately at all of the Columbia River hatcheries, both Federal and State, with the single exception of the State hatchery at Kalama, Wash. On the other hand, the number of salmon reaching the spawning areas in the vicinity of the bureau's stations was much larger than might have been expected in view of prevailing conditions.

The intensive fishing to which the Columbia River was subjected during the years 1915 to 1920, inclusive, and the comparatively large numbers of fish taken commercially in those years may have been factors in reducing the runs of the past two seasons. However that may be, there was a marked improvement in the commercial catch of chinook salmon at the beginning of the 1923 fishing season, and the greater measure of protection afforded immature fish in the ocean and river by the recent removal of purse seines therefrom may be expected to ultimately benefit the fishery.

With the Clackamas station as headquarters, fish-cultural operations were conducted during the fiscal year 1923 at 12 widely separated points in Washington, Oregon, and Idaho. Seven of these field stations are permanent, being in active operation throughout the year, while the others are merely eying stations or egg-collecting auxiliaries.

The aggregate egg collections of the group amounted to 35,371,000, as against 63,658,000 the previous year. Of this number 26 755,000 were chinook salmon; the remainder comprised such species as silver, chum, sockeye, and steelhead salmon, and the black-spotted trout. Besides the eggs collected in the various fields, 5,000,000 chinook-salmon eggs were transferred from the State hatchery at Kalama, Wash., and smaller consignments of brook, rainbow, and lake-trout eggs were received at Clackamas from other stations of the bureau.

The combined output of the Oregon group of stations in eggs, fry, and fingerling fish amounted to 30 540,800, this number including the fingerling fish carried over from the previous year. The output included three shipments of fish eggs to foreign governments, one of 200,000 chinook-salmon eggs being sent to the Netherlands and two of steelhead eggs going to Germany and Argentina. At the close of the year approximately 1,500,000 eggs, fry, and fingerling fish were still on hand.

The use of immature salmon eggs as food for fry and fingerling fish was continued throughout the year on an extensive scale, the station superintendent having found from past experience that this material, when properly cooked and mixed with beef spleen, makes a highly desirable food for young salmon. As its cost in the Oregon field is very low, arrangements have been made to hold in cold storage upward of 10 tons from the 1923 pack of salmon for the coming year's food supply. The superintendent has also found, after two seasons' trial, that feeding young fish only twice a day produces equally as good results in growth and vigor as are attained by the customary method of administering food more frequently. Aside from large quantities of immature salmon eggs, the principal food materials during the year consisted of salted salmon, canned salmon, and beef spleen.

CLACKAMAS (OREG.) STATION.

Seven species of salmonoid fishes are represented in the fish-cultural work of the year at this station—chinook, silver, chum, and steelhead salmon, brook, black-spotted, and lake trout. Egg collections from the Clackamas River were made between September 23 and November 17, 2,750,500 of the chinook salmon being taken, together with incidental collections of chum and silver salmon, the numbers amounting to 18,500 and 10,700, respectively. Transfers from other points included 220,000 brook-trout eggs from Utah, about 75,000 black-spotted-trout eggs from the Yellowstone National Park, 25,000 lake-trout eggs from Minnesota, 45,000 steelhead eggs from the Sandy River auxiliary, and 1,750,000 chinook eggs from the Little White Salmon substation. A high percentage of fry was produced from all eggs handled except those from Utah. On these a rather heavy mortality was experienced and the fry and fingerling fish resulting from them were below the average in vigor.

UPPER CLACKAMAS (OREG.) SUBSTATION.

In addition to the usual retaining rack constructed in the river just below the milldam, a second rack and a downstream trap were installed at Brions Eddy. Though there was a light run of fish and illegal fishing was prevalent, 857,000 salmon eggs were secured by means of this equipment, and from them a fair percentage of fry was hatched and successfully carried to the feeding stage. On the night of January 6, when the Clackamas River reached the highest stage ever recorded in this region, the hatchery site was practically washed away and the small remaining area covered with logs and débris. The station buildings suffered some damage and it became necessary to abandon the work pending the selection of a new hatchery site. The fish on hand at the time of the flood were all released in the river in good condition.

LITTLE WHITE SALMON (WASH.) SUBSTATION.

Considerable work in the line of improvements and repairs to station property was accomplished during the year at this point, the most important being the construction of a new hatchery on the site occupied by the two old buildings that have served in that capacity for a long term of years. Repairs of a rather extensive nature were also made on the water-supply flume, which had been damaged by snowslides during the past winter, when a serious loss of stock was narrowly averted. The floods occurring throughout the Columbia River Basin in January, 1923, caused some further damage to this flume and other property. The new hatchery is a frame structure, 40 by 140 feet in dimensions, on a cement foundation. It is equipped with 128 hatching troughs, providing holding capacity for upward of 30,000,000 salmon eggs during the incubation period.

In the fall of 1922 the usual fishing operations were conducted, and 14,261,000 eggs were taken between September 22 and October 14, practically all of them being chinook-salmon eggs, though small numbers of chum and sockeye eggs were also acquired. In addition to these collections 5,000,000 surplus chinook-salmon eggs from the Washington State hatchery at Kalama were handled. Excellent results attended the incubation and rearing operations, and the year's output amounted to 16,743,900 eggs and young fish. Of this number 12,427,000 were fingerlings from 1½ to 3 inches in length. Shipments of eyed eggs were made from the Little White Salmon hatchery to central station, Washington, D. C., to the State of Oregon, the University of Washington at Seattle, Wash., to the Netherlands Government, and to other stations of the local group.

BIG WHITE SALMON (WASH.) SUBSTATION.

A considerable amount of work in the line of improvement to property was also accomplished at this point. The hatchery building was moved to a more favorable site, remodeled, and thoroughly repaired. As reconstructed it consists of a frame building, 40 by 100 feet, on a cement foundation. It is equipped with 83 standard hatching troughs, having a capacity for approximately 20,000,000 salmon eggs.

During the spawning season, extending from September 22 to October 10, 6,237,000 chinook-salmon eggs were obtained from local spawning areas. Five hundred thousand eggs of the silver trout and 235,000 of the brook trout were incubated during the year for the Washington fisheries authorities, and the resulting fry turned back to the State officers for distribution. The total output of young salmon amounted to 6,000,000 fingerlings, ranging from 2 to 3 inches in length.

ROGUE RIVER (OREG.) SUBSTATION.

The usual difficulties were encountered in attempting to hold fishing appliances in the Rogue River during the freshets resulting from melting snow in the upper reaches, and conditions would not permit of really profitable work in egg collecting until August 9. From that time until the racks were destroyed by spring floods in the following May fishing operations were diligently prosecuted. The egg collections, including a small number taken in Elk Creek below the dam were:

	Number of eggs.
Chinook salmon	1, 235, 000
Steelhead	354, 700
Black-spotted trout	33, 900
Silver salmon	20, 500
Total	1, 644, 000

APPLEGATE CREEK (OREG.) SUBSTATION.

Fish-cultural operations at this point involved the silver salmon and the steelhead. The spawning season of the former extended from November 28 to January 16, while eggs were taken from the other species between January 16 and May 16, the collections amounting to 2,458,000 and 3,266,000, respectively. The changes made in the fishing racks during the past season proved highly satisfactory, and this improvement, together with the favorable climatic conditions prevailing throughout the season, made it possible to secure a very fair collection of eggs.

The usual transfers of eyed eggs were made, including steelhead eggs, to the Rogue River station, the Oregon State hatchery at Butte Falls, Oreg., and to eastern applicants. The retained eggs produced a remarkably high percentage of fry, all of which were successfully reared to fingerlings No. 1½ and No. 2 before releasing in local streams. About 600,000 fingerling steelheads remained on hand at the end of the year.

SANDY RIVER (OREG.) SUBSTATION.

The previous year's fish-cultural operations at the Sandy River site having proved eminently successful, it was deemed advisable to establish a permanent substation at that point. With this end in view a hatchery building, 29 by 58 feet, of frame construction on a cement foundation, a water supply line, and a four-room cottage were constructed and made ready for the work in advance of the spawning season.

The numbers of chinook and silver salmon reaching the racks were small as compared with last year's run, the decline being attributed to the diversion of a considerable portion of the river water supply to the operation of a hydroelectric plant in the vicinity. Notwithstanding this handicap, chinook-salmon eggs to the number of 461,900 were secured, the spawning season extending from August 22 to December 7. Water conditions in the river were improved during the spring months, and between March 31 and the end of the first week in June 832,600 steelhead and 330,600 silver-salmon eggs were collected.

The Sandy River substation is located near the base of Mount Hood, and the winters are sometimes so severe that slush ice occurs in the river. Taking this fact into consideration, provision has been made for the construction of a flume to conduct water from the river and also for an auxiliary flume between the hatchery and Spring Creek. By this means the possible failure of the water supply during periods of intense cold is guarded against.

Under normal conditions there is a good run of the highly prized chinook salmon, and also of the steelhead in Sandy River, and the site gives promise of fruitful results at a low cost for maintenance.

WASHOUGAL RIVER (WASH.) SUBSTATION.

This eying station was in operation during the spawning season of the steelhead, from April 13 to May 23, during which period 834,000 eggs were taken. A heavy run of fish passed up the river;

but, as in previous seasons, large numbers of them were not sexually mature. All immature fish taken were carried above the dam and released.

SALMON (IDAHO) SUBSTATION.

With the recently constructed buildings near Salmon, Idaho, as headquarters, temporary egg-collecting stations were established in this field on the Lemhi, Pahsimeroi, and Yankee Fork Creeks, and at Sunbeam Dam. The run of salmon was light at all points, but especially so at Yankee Fork, and the work there was abandoned early in the season, it being apparent that eggs could not be obtained in numbers sufficient to warrant the expense of maintaining racks.

After being developed to the eyed stage, the eggs collected from the various streams in this region were transferred to the hatchery at Salmon for incubation. The year's distributions from this substation included 1,124,700 chinook salmon, 236,000 rainbow trout, and 99,000 brook trout, all fingerlings. The output of the two species of trout was the result of transfers of eggs made from other stations.

A further examination of the Salmon River district was made during the year, and from the evidence obtained on this and previous trips it appears certain that at least a majority of the sockeyes in the Columbia River originates in lakes in the Sawtooth Mountains. The species was first observed in the Salmon River, near Bay Horse Canon, in August, and at Sunbeam Dam some 10 days later. It was further noted that salmon entered most of the tributaries of the three rivers inspected. It is not probable that fish enter all these streams in large numbers, but at the time of the inspection each stream appeared to have a run.

BAIRD (CALIF.) STATION AND SUBSTATION.

[W. K. HANCOCK, Superintendent.]

The results of the year's fish-cultural work at all points in the California field were discouraging in the extreme, the egg collections and the output of young fish being the smallest since the inception of the bureau's fish-cultural operations in the State.

While extremely low water stages prevailed everywhere in this region during the spawning season, hampering the run of fish, and other climatic conditions were not altogether favorable, the very unusual scarcity of fish on their wonted spawning areas can hardly be attributed to natural causes alone. The principal reasons for the decline must, for the present at least, be the subject of conjecture. Among the theories advanced have been (1) excessive fishing by purse seines in the lower Sacramento River and (2) loss of fish through their entrance into the numerous irrigating ditches recently constructed.

Peculiarities noted in connection with the season's work at both the substations in the California field were the large size of the few spawning females taken and the excessive numbers of undersized and immature males present. However, at the Baird station, on the McCloud River, the mature females exceeded the males in number.

BAIRD (CALIF.) STATION.

During the month of April, 1922, racks were installed in the McCloud River with the object of securing for incubation eggs of the spring run of chinook salmon. Throughout the spring and summer there seemed to be no well-defined run of salmon, but a few fish reached the barrier every day during the season. Spawn-taking operations extended from September 8 to September 29, by which time 1,521,000 eggs of good quality had been laid down in the hatching troughs. This number compares favorably with the work of the past few years.

Because of the depth of water and the uneven nature of the bottom of the pool in which the fish were held pending the development of their eggs, it was not an easy matter to capture them for spawn taking. They refused to enter the traps, and gill nets were ineffective. Seining after dark proved to be the best method, though a considerable number evaded any method of capture that could be devised, and these were finally permitted to pass the racks to spawning sites of their own selection.

Even for that arid section of the State the season was an unusually dry one, and water for the hatchery through the gravity supply ditch was not available. To avoid the expense of pumping water from the river an improvised battery of troughs was set up on the grounds and supplied with water from a small spring. By careful management this small amount sufficed until the eggs had about completed hatching, by which time it became necessary to move the stock into the hatchery and start the pumps. From October 6 until the last of the fish had been distributed, in March, the pumps were kept in continuous operation, the necessary amount of water not being available from any other source.

At the close of the spawning season of the spring run of salmon the racks were removed from the river, as appearances did not indicate that the fall run would be of sufficient importance to warrant the cost of egg collections. Furthermore, after the customary fall rains set in it is only with the greatest difficulty that racks can be maintained in the McCloud River, and should the expected rains fail, as proved to be the case, the available water supply is sufficient only for the eggs already on hand. The racks were again installed during April, 1923, for the interception of the spring run of the succeeding season.

A close watch was kept on the dam in the Sacramento River near Redding, to note the effectiveness of the openings in the "splash boards" in permitting the passage of fish. The station superintendent has expressed the opinion that these openings probably serve their purpose as adequately as could the conventional fishway. He states that such fish as find the openings pass readily over the dam, but that a large number fail entirely to find them, and are thus prevented from reaching suitable spawning places.

During the year reports reached the superintendent to the effect that adult salmon in numbers were entering the irrigation ditches. Such reports could not be substantiated, however, and the several visits made to the points complained of indicated that the screens were intact and properly installed.

BATTLE CREEK (CALIF.) SUBSTATION

As at the Baird station, the season at this point was marked by scarcity of rainfall, with low-water stages in all the surrounding streams. The fishing racks were installed as usual, but active fishing operations, conducted from October 19 to November 28, resulted unsatisfactorily. Seining on the riffles in the Sacramento River below the mouth of Battle Creek proved equally unremunerative, and when the attempt was finally abandoned there were 1,587,000 eggs in the hatchery.

As previously mentioned, the season's run of fish was unique, both on account of its small size and because of the nature of the fish comprising it. The few sexually matured females taken were unusually large, yielding an average of 6,000 eggs per fish. However, the majority of the run was composed of immature males.

In past years attempts have been made to procure eggs of the spring run chinook salmon at various points on Battle Creek, but the attempts have never met with success. The early run appears in the stream in the spring or early summer, but the fish are not in spawning condition until late August or early September. The great difficulty thus far encountered in this field has been to find a suitable place with a sufficiently low water temperature for holding the fish through the hot summer months pending the maturity of their eggs.

It has been ascertained that the water temperature below the dam of the Coleman Power Co. plant, some 4 miles from the Battle Creek hatchery, averages from 5° to 6° lower throughout the entire summer than at any of the other points investigated. Because of this favorable condition it seems probable that successful work may be accomplished below the dam, and with the view of determining this point racks were installed late in May for holding a limited number of fish for observation.

MILL CREEK (CALIF.) SUBSTATION.

The total take of chinook-salmon eggs at this point amounted to 791,000, being the smallest secured since fish-cultural work was first inaugurated there. The reasons ascribed for the failure of the fish to appear have been mentioned, but they are far from satisfactory. The drought conditions extended to this station, but in August, when the racks were installed, the creek was entirely dry, all of the natural flow having been diverted for irrigation purposes. Spawn taking began October 29 and was continued to December 27. As at Battle Creek, practically the entire run of fish appearing at the racks in Mill Creek was composed of immature males.

GREAT LAKES FISHES.

The territory covered by the work in the propagation of the commercial fishes coming under this head extends from Lake Superior on the west to Lake Champlain on the east, and, with the possible exception of salmon propagation, it is the most important branch of the bureau's fish-cultural activities. The commercially valuable fishes of the Great Lakes are the lake trout, whitefish, cisco, and pike perch. In addition to these, carp and yellow perch have become commercially prominent and large numbers of their eggs are hatched annually and the product returned as fry to parent waters. The total egg collections of this group of stations in 1923 was approximately 1,082,000,000, showing a decrease of about 467,-000,000 as compared with this branch of the work last year. The largest part of this decrease occurred in the cisco and pike perch, and the principal causes for it may be attributed to unseasonably cold weather during the spawning period and lack of sufficient funds for prosecuting the work to its fullest extent in some of the fields occupied. Owing to the latter circumstance the pike-perch hatchery at Swanton, Vt., was not operated.

DULUTH (MINN.) STATION.

[S. P. WIRES, Superintendent.]

Collections of eggs of the lake trout for stocking the Duluth hatchery were made at the usual field stations in Lake Superior during the fall, the spawning period extending from September 25 to November 15. Eggs to the number of 16,132,000 were secured, and on November 25 this stock was increased by the receipt of 6,000,000 green eggs from the Charlevoix (Mich.) field. The eggs from Lake Superior were of good quality, but for some reason the transferred eggs were exceptionally poor. Eyed eggs to the number of 525,000 were furnished to applicants, and 250,000 were forwarded to other stations of the bureau; the remainder were hatched and the product returned to the spawning grounds in Lake Superior, the distributions aggregating 13,170,000 fry and 85,000 No. 1 fingerling fish.

The whitefish eggs handled during the year—5,060,000—were collected in connection with the lake-trout work at Isle Royale, Mich. Notwithstanding the fact that they were secured under rather unfavorable conditions, 2,770,000 fry of excellent quality were hatched from them and returned as fry to the native spawning grounds.

As a result of cooperative work between the station and the Minnesota Fish Commission in the collection of pike-perch eggs in the Rat Root River region of Minnesota, the station received as its share of the proceeds 25,000,000 eggs, 5,000,000 of which were eyed. The green eggs, received May 5, appeared to be in good condition on delivery, but within 48 hours after installation in jars it was discovered that the loss would be heavy as not more than 15 per cent were fertilized. From the entire stock 7,630,000 fry of good quality were hatched and distributed, going to applicants in Minnesota, Wisconsin, and Michigan.

The brook trout listed in the distributions from the Duluth station resulted from 147,000 eyed eggs acquired by purchase from a commercial breeder, while the rainbow trout were carried over from the hatch of the preceding year. A consignment of 100,000 steelhead eggs, received from one of the bureau's substations in Oregon on May 24, yielded a total of 90,000 fry and fingerling fish.

Of passing interest in connection with the incubation of the lake-trout eggs was the unusually large percentage of albinos resulting from a lot of eggs obtained at Isle Royale, Mich. These eggs—about

100,000 in number—arrived at the station early in October, and approximately 5 per cent of the 70,000 fry hatched from them were albinos. So far as could be learned there was nothing unusual in the appearance of the parent fish. The albinos were reared with the colored fish without undue loss.

NORTHVILLE (MICH.) STATION AND SUBSTATIONS.

[W. W. THAYER, Superintendent.]

NORTHVILLE (MICH.) STATION.

Distributions of smallmouth black-bass fingerlings Nos. 2 and 3 to the number of 14,475 were made during the first month of the fiscal year, and in October the brood stock of this species was increased to a total of 500 by the addition of 100 adult fish derived from collections in Lake Erie. In the spring, when the water in the ponds containing these fish was drawn down, only about 300 could be found. It is impossible to account for the shortage, as no such loss of brood stock has ever occurred heretofore. The available adults were installed in spawning ponds on May 3 and began nesting a few days afterwards. On the evening of May 8 a heavy snowstorm of 24 hours duration set in, causing a drop in water temperature from 65° to 41° and destroying all nests of eggs in the ponds at the time. As soon as the temperature returned to normal spawning was resumed, and in the course of the season 75 nests of eggs were deposited. At the close of the year 48,500 bass fry and fingerlings No. 1 had been gathered from these ponds and distributed, and it was estimated that about 50,000 were still available.

To relieve the conditions existing at the Alpena substation in connection with an unsuitable water supply, part of the green lake-trout eggs at that point were transferred to Northville and carried until they were near the hatching stage, when they were returned to Alpena.

During the winter 345,120 eyed brook-trout eggs were received from a commercial dealer in Massachusetts. These were of fine quality and produced a good percentage of healthy fry. All but 28,000 of these fish had been disposed of before the end of the year. The station also handled 126,000 eyed rainbow-trout eggs furnished by the Michigan fisheries authorities. The fry produced from these were still on hand at the close of June.

A brood stock of adult bluegill sunfish, collected from a lake near Vicksburg, Mich., was installed in a spawning pond early in May. A few nests were observed in this pond during the spring, but the results of the experiment can not be determined until the water is lowered in the fall.

CHARLEVOIX (MICH.) SUBSTATION.

In arranging for the collection of lake-trout eggs for filling the Charlevoix hatchery the procedure of past years was followed so far as was possible, experienced men being stationed at the best fishing ports on Lakes Michigan and Huron to instruct local fishermen as to the proper manner of taking spawn and caring for it during the early stages. However, a sufficient number of men experienced in the work could not be found to cover all fields and at some points local help had to be employed to perform this important duty. Under such circumstances it was impossible to secure a uniformly good grade of eggs, and while the season's collections—amounting to 55,640,000—were considerably in excess of the total of any year in the recent past, their quality was far below the desired standard. The collecting season extended from October 31 to December 22, and the incubation of the eggs was completed at the expiration of 140 days in a mean water temperature of 38.5°.

The salt-solution process was employed almost throughout the season for separating poor eggs from the good ones, thereby effecting a large saving in the employment of temporary help. In connection with the work it was discovered that good eggs were being carried out of the troughs with the discarded ones, and a method was at once devised and put in operation by the assistant in charge of fish culture, which conserved practically all good eggs.

Collections of whitefish spawn were made at various points in Lake Michigan between November 16 and December 30, the season's total aggregating 16,660,000. This stock was augmented in December by the receipt of the partially incubated eggs from the Alpena hatchery, though most of the transferred eggs were returned to that point just prior to the hatching stage. The incubation of the eggs was completed at the end of 180 days in a mean water temperature of 39°. In order to effect any considerable improvement in whitefish propagation in this region it will be necessary to provide penning facilities at suitably located points for the holding of the partially ripened fish until their eggs are fully matured. Some investigations are now being made with the view of establishing several of such stations as soon as funds are available for the purpose.

Early in April 15,827 eyed eggs of the landlocked salmon were received from the bureau's Craig Brook (Me.) station. They were hatched with not more than normal losses and carried in good condition until about the time when the sac was absorbed, at which period the water supply became polluted from the exhaust of the city water-works engine and one-third of the stock was lost. The remainder was delivered to an applicant for that species.

ALPENA (MICH.) SUBSTATION.

While whitefish and lake-trout eggs are collected annually in the Alpena field, for several years past no attempt was made to incubate them in the Alpena hatchery, as the city water supply, upon which the substation is dependent, was so heavily charged with chlorine as to be very injurious to eggs or fry held in it. Having received information that the conditions in this respect had improved somewhat, the hatchery was stocked by the bureau during the fall of 1922 with whitefish and lake-trout eggs secured in the immediate region. It quickly developed, however, that the water supply was still detrimental, and all stock on hand had to be transferred, being divided between the hatcheries at Charlevoix and Northville. Acting on advice from the city authorities that the contemplated operation of a filtration plant in course of construction would obviate the necessity of chlorinating the water after March 1, 1923, the eggs sent to other points earlier in the season were returned to Alpena just prior to the hatching stage with the view of effecting some economy in the distribution of the product. Owing to a delay in starting the plant the use of the chlorine was not discontinued, and to avoid the threatened loss of the entire stock all eggs and fry in the hatchery were liberated on March 23 on the local spawning grounds, after which the hatchery was closed.

PUT IN BAY (OHIO) STATION.

[S. W. DOWNING, Superintendent.]

The season's arrangement for the collection of whitefish eggs in the Lake Erie fields having been completed by early November, it was deemed advisable to place men in the collecting areas around Toledo and Port Clinton in advance of actual spawn-collecting operations to give instructions to the various fishermen as to the proper manner of taking the eggs and caring for them until they could be turned over to the bureau's agents. Between November 14, when the first eggs were taken, and the close of the season on December 4 the collections amounted to 242,720,000, approximately 143,000,000 less than were secured last year. Of this number 104,000,000 were obtained in the Port Clinton field; North Bass Island, the field of next importance, yielded 75,000,000; 17,720,000 were taken in the vicinity of Middle Bass Island; while collections only a little in excess of 15,000,000 for each field were secured in the neighborhood of Toledo and Catawba Island. Slightly more than 11,000,000 were taken in the vicinity of Put in Bay, while at Pelee Island, Canada, 3,440,000 were secured.

The comparatively poor results of the work are attributable to the natural conditions existing during the spawning season. The water seemed to contain a great quantity of slime, and the spawning fish and the eggs had a decidedly soft, slimy feeling. The eggs failed to harden properly even under the most careful treatment. Information was received to the effect that the same conditions were met with throughout the Great Lakes region, but the situation is believed to have been intensified in the Lake Erie fields, both by the unusually high water temperatures prevailing and by the steady westerly winds, the latter resulting in such low water stages at the western end of the lake that the sediment and slime at the bottom were washed up and mingled with the general supply. Late in the spawning season, after the winds had subsided, the water cleared and there was a noticeable improvement in the quality of the eggs taken during that period.

Of the eggs collected, 28,000,000 were shipped direct from the field to the Erie hatchery of the Pennsylvania Fish Commission, and 22,400,000 fertilized eggs were planted on reefs near the Put in Bay hatchery; 3,000,000 eyed eggs were forwarded to applicants and other hatcheries of the bureau, and from the remaining stock 100,000,000 fry were hatched and liberated on the spawning grounds. On account of the poor quality of the eggs as a whole, the percentage of hatch was about the lowest ever recorded at the station.

Early in the spring all prospects for a good collection of pike-perch eggs appeared favorable. The ice disappeared from the western end of the lake early in March, and for the first time in several years the fishermen were able to set their nets at the beginning of the open season. The weather turned cold a few days afterwards, however, and the anchor ice formed by the heavy winds and snow became attached to the nets in large quantities, causing them to float, and some of them drifted away with the current to such a distance that they were never recovered. The spawning season extended from April 19 to May 6, and the storms prevailing throughout this period injured the nets so badly that the time of the fishermen was largely employed in making repairs, to the detriment of egg collections. Of the season's total—aggregating 192,440,000—eggs to the number of 37,275,000 were delivered in the green state to the Ohio Fish Commission, and 4,500,000 eyed eggs were shipped on assignment. The fry resulting from the remainder—amounting to 51,800,000—were liberated in the vicinity of the collecting fields in Lake Erie.

In connection with the pike-perch work, 900,000 eggs of the sauger (*Stizostedion canadense*) were obtained from fish taken in a trap net. These were incubated in the hatching jars without any difficulty and almost without loss, yielding over 90 per cent of healthy fry. The eggs are heavy, slightly adhesive, and measure 17 to the linear inch after being fully water hardened. All previous experience with sauger eggs at this station has been with spawn from fish taken in gill nets, and though the eggs have invariably been handled with the utmost care, in no instance have any fry ever been hatched from them. This would seem to indicate that the manner of capturing the fish has much to do with the quality of the eggs. The season's collections also included 3,440,000 yellow-perch eggs, from which 3,000,000 fry were hatched and planted.

Very successful results were obtained in the propagation of carp. Eggs of this species were taken between June 1 and June 20 and a total of 160,500,000 was secured, this record exceeding that of any previous year since the inauguration of the work in 1918. The field of collection was extended to Sandusky Bay, where spawning fish were found to be very plentiful, and by this means a far greater number of eggs was secured than would have been possible from the Portage River alone. All eggs taken were of excellent quality and yielded a good percentage of fry. In making the distributions the fry were liberated over a distance of 12 miles in the Portage River, from Port Clinton to Oak Harbor.

A very unusual difficulty was encountered about the middle of December. Minnows in immense numbers, moving along the shores of the lake, were taken up in the water supply suction and carried against the screens of the tanks, which became so clogged with them as to be of no practical use. A few strokes of the pump would result in complete obstruction, and for three nights the entire station force was occupied in keeping the spigots free of minnows.

During the year the station steamer was placed in dry dock, all barnacles and rust removed, and the bottom painted with two coats of tar thinned with turpentine and applied with a common paint brush. This material has been used for several years for this purpose and has been found to be entirely satisfactory.

CAPE VINCENT (N. Y.) STATION.

[J. P. SNYDER, Superintendent.]

The repair work in progress at this station at the opening of the fiscal year was completed during the summer. Among the more important items accomplished were the following: Construction and installation in the fry building of two plank metal-lined tanks 17 feet long, 36 inches wide, and 30 inches high; removal of a defective hardwood supporting timber in the basement of the hatchery and replacing it with a new one; placing metal plates along the water line forward to protect the planking of the launch *Curlew*, and installing an electric-lighting plant on this launch. There being an excess of exhaust steam above the amount required for heating the hatchery, an underground exhaust-steam line was run to the residence and connected with the heating plant. The return pipes were carried back to the hatchery, where provision was made to use the hot condensed water in the boiler again.

A new 28-foot pound-net boat was purchased in advance of the fish-cultural season. This boat has a 9-foot beam and is equipped with a 14-horsepower, 2-cylinder, 4-cycle Regal motor. The shaft is fitted with a universal joint to permit the lifting of the wheel when running through shallow water.

The season's fish-cultural operations began on October 17 with the taking of the first lake-trout eggs in the Pigeon Island, Canada, field. The collections extended to November 12, and as they were conducted under favorable weather conditions more eggs than usual were secured, the total amounting to 1,281,000. Of these, 60,000 were shipped in the eyed stage, and the losses on the remainder to the time the resulting fry were distributed amounted to 11 per cent of the eggs retained for hatching. Very poor results were attained from a consignment of 4,880,000 green lake-trout eggs received in November from the Charlevoix (Mich.) substation. Nearly half of them were dead on arrival, and the losses continued heavy up to the middle of January. The output from this shipment amounted to 480,000 eyed eggs and 595,440 fry.

Permission having been obtained for the collection of whitefish spawn from nets operating along the Canadian shore of Lake Ontario, work was undertaken on the 1st of November at Bygotts Point and Deseronto, in the Bay of Quinte, and at a later period in the South Bay field. No eggs having heretofore been available on these grounds prior to November 3, it was assumed that the landing of the spawning crew on November 1 would be sufficiently early, but on the arrival of the men it was learned that the fish had been spawning for several days and that considerable numbers of eggs had been lost. No explanation can be offered to account for this spawning, as the season began later than usual in the field near South Bay, Ontario, and also in Chaumont Bay, in the New York waters of the lake. Notwithstanding these losses of eggs the jars in the Cape Vincent hatchery were filled to capacity before the season closed, and 77,009,000 additional eggs were furnished to the Canadian and New York fisheries authorities. The total collection for the season aggregated 228,650,000, of which 214,000,000 were obtained in the Canadian fields, and 14,650,000 in Chaumont Bay.

In the incubation of these eggs considerable difficulty was experienced from the presence of a parasitic or fungoid growth, which interfered with the proper separation of the dead from the living eggs. As the season advanced the eggs became so coated with this hairlike formation that they would not lie together closely in a uniform mass but were more or less suspended in the water current. To overcome this tendency the jars were taken down and the eggs screened and washed. This improved matters for a short time, but within a few days the treatment had to be repeated. This constant screening and washing, which had to be resorted to throughout the incubation period, not only involved much additional labor but it is believed also to have increased the percentage of mortality.

Cisco eggs to the number of 76,800,000 were collected between November 22 and December 9 in Fairhaven, Sodus, and Chaumont Bays, in New York waters, the first-named bay furnishing the bulk of the collections. Although the catch of cisco by commercial fishermen during the summer and early fall was above the average, for some unexplained reason the take during the spawning season was far below normal and egg collections were correspondingly reduced. On the development of the eggs to the eyed stage a shipment of 10,000,000 was furnished to the Michigan Department of Fisheries, and from the remainder 39,000,000 fry were hatched and distributed on the spawning grounds in Lake Ontario. Part of the losses on these eggs was due to the fungoid growth referred to in connection with the whitefish work.

During the winter the station received 553,000 brook-trout eggs from commercial hatcheries and distributed the product in the fry stage. A very satisfactory percentage of hatch was attained and the resulting fry did well up to the early part of April, when a weakness developed. Grouped together the young fish presented a whitish cast, and under the magnifying glass patches of mold or fungus became apparent. All except the more badly affected ones were restored to normal condition by applying a salt bath and then placing them in a village water supply.

In the course of the year the station received and hatched 100,000 eyed rainbow-trout eggs received from the Michigan Department of Fisheries, and 1,500,000 pike-perch eggs transferred from the Put in Bay (Ohio) hatchery. Under permit from the New York Conservation Commission several hundred brood yellow perch were captured in the St. Lawrence River and from them 1,000,000 eggs were collected, the adult fish being returned to the river at the end of the spawning season. The eggs were incubated in sunken wire baskets and the resulting fry were returned to the local spawning grounds.

BRYANS POINT (MD.) SUBSTATION.

[L. G. HARRON, Superintendent.]

Between the 4th and the 18th of March a total of 17,999 brood yellow perch was collected and installed in live cars near the Bryans Point station to serve as a source of egg supply for the hatchery. The fish spawned daily from March 18 to March 30, yielding 146,560,000 eggs, of which 9,165,000 were shipped, one consignment of 7,800,000 going to the Neosho (Mo.) station and the remainder being divided between the Wytheville (Va.) and Erwin (Tenn.) stations. From those retained 130,525,000 fry of excellent quality were hatched. With the exception of 2,000,000 fry, which were forwarded to a fish and game protective association at Phoenix, Pa., the entire output of the station was returned to the spawning grounds in tributaries of the Potomac River.

BUFFALOFISH.

ATCHAFALAYA (LA.) SUBSTATION.

[C. F. CULLER, in charge.]

The work of putting this substation in readiness for buffalofish propagation was taken up on January 17 by a force of detailed employees under the immediate direction of the field foreman of the Mississippi River rescue station. Eggs were taken from February 15 to March 5, but natural conditions in general were unfavorable. The spawning of the fish was retarded and the egg supply curtailed by the prevailing cold weather, and the quality of the eggs secured was impaired by the abnormally low temperature of the water in the hatchery, which at no time during the collecting season attained 56°.

Probably because of the unusually high water stages and the low temperatures prevailing, the fish deserted their customary spawning places almost without exception and sought new ones. On March 5 a considerable rise in the Ouachita River resulted in flooding the surrounding lowlands and polluting the hatchery water with the oily and alkaline substances with which this river appears to be charged. Under such conditions the run of fish in the Atchafalaya immediately ceased and the entire stock of eggs in the hatchery was killed. From that time to the end of the season all eggs taken were fertilized and immediately returned to the spawning grounds from which derived, the number thus treated—128,114,500—including the bulk of the season's collections. The total output of fry amounted to only 5,925,000, these being the product of the earlier eggs taken.

In the course of the season an attempt made to incubate eggs in water from the recently constructed artesian well at this station resulted in failure, the eggs proving a total loss within 24 hours after the test was started. The water appeared to be of an oily nature and was very roily. Its temperature at the well registered 72° F.

The experience gained as a result of two seasons' efforts on the Atchafalaya River would seem to demonstrate the advisability of abandoning the present site and relocating the station at some point where the quality of the water supply for the hatchery is more suitable and dependable. It is believed that such a site can be found in the section north of the Red River, and it is recommended that an inspection of this territory be made in advance of another spawning season.

MARINE FISHES.

At the stations engaged in the propagation of the marine fishes the work during the year was chiefly concerned with the cod, pollock, haddock, and winter flounder. The aggregate output of these species amounted to 2,733,337,000 fertilized eggs and fry, this number, as compared with that of the previous year, showing a shortage of about 570,000,000. Two important spawning grounds of the winter flounder—in the vicinity of Newport, R. I., and Nantucket, Mass.—were not occupied. Some collections have been made in the former field in the past, but in the absence of a suitable boat none was undertaken last season. No egg collections have ever been made in the Nantucket field, but the information at hand would appear to indicate that with proper facilities very profitable returns might be expected, as hundreds of tons of winter flounder are annually caught around Nantucket and shipped to the market.

Despite a tendency in some quarters to the belief that the artificial propagation of the deep-sea fishes is of little practical value, the general trend of opinion among the more prominent fishermen is favorable to a continuation of the work. Speaking generally, the fishermen are deeply interested and in nearly all cases they are zealous in their efforts to assist the bureau in its egg collections. Some years ago most of the fishermen of this region were opposed to the placing of spawn takers on their boats. Now they not only permit the presence of the spawn takers but assist them in many ways in the conduct of their work.

BOOTHBAY HARBOR (ME.) STATION.

[E. E. HAHN, Superintendent.]

As in past years, everything possible was done during the spawning season to secure eggs of various marine fishes but without success except in the case of the winter flounder. No pollock were obtainable from the Gloucester field, no haddock or cod could be found anywhere along the eastern Maine coast, while alewives came on to the fishing grounds in very small numbers and none of them was in spawning condition.

The usual preparations were made to take up winter-flounder propagation late in February, but all efforts to secure a brood stock at this time were rendered futile by heavy ice fields on the fishing grounds, abundant snowfall, and freezing weather, these conditions predominating up to the beginning of the third week in March. On March 20 the first capture of fish was made, and four days afterwards the first eggs were taken, the spawning season being fully two weeks later than in any preceding year since the station was established. From that time on the outlook brightened. Over 60 fyke nets were scattered over an area extending from Casco to outer Penobscot Bay and were vigorously fished to the close of the spawning period on May 10, the steamer *Gannet* attending the more distant nets, while those within easy reach of the station were looked after by motor boats and dories.

In the course of the season nearly 5,000 brood winter flounder were captured, and as the majority were of unusually large size the egg yield was good, amounting to 943,316,000. These were of uniformly good quality and from them 866,800,000 fry were produced and distributed, the percentage of hatch being a trifle under 92. The fry were sent out in ordinary transportation cans and planted by means of the station steamer and several motor boats on the spawning grounds from which the eggs were derived.

A peculiarity in connection with the work was the scarcity of winter flounder in Linekins Bay, heretofore the most prolific field covered by the station operations. This year practically no results were obtained from the nets set in the bay, while those in eastern waters yielded a large number of fish of greater than average size.

During the year a large amount of minor repair and improvement work was done on station buildings, boats, machinery, and other equipment, practically all of it being accomplished by the statutory employees attached to the station.

A most interesting and educational exhibit of the marine life of the region was maintained in the hatching room of the station during the summer months and attracted a large number of visitors. The exhibit was discontinued early in September to save fuel.

GLOUCESTER (MASS.) STATION.

[C. G. CORLISS, Superintendent.]

A number of important items of repair work were made at this station during the year. New joists and new double flooring were laid in the hatchery and the roof of the building was reshingled. The boiler and pump house was enlarged to permit of the installation of a new horizontal boiler and a better arrangement of some of the machinery. To increase the amount of working space two small wooden extensions set on concrete foundations and conforming in style to the old construction were annexed to the sides of this building, and a concrete pit, 4 by 11 feet in area and 3 feet deep, was built into the extension of the pump room for the condenser and circulating pump.

The outer end of the wharf was extended 9 feet along its entire front, thus giving greater stability to the entire structure and permitting of the projection of the suction line into deeper water. Other needed repairs were made to the foundation of the wharf, and several important changes were made in the steam plant with the view to increasing its efficiency and effecting economy in coal consumption.

In the prosecution of the pollock work the same adverse conditions contended with last year were again in evidence, operating in some respects with even greater force than in 1922, and as a result the collection of eggs was greatly reduced as compared with the average of recent years. There appeared to be an abundance of pollock on the inshore fishing grounds, but, owing probably to food conditions, the fish were constantly shifting about. This not only curtailed the daily catch of fish, but entailed a serious loss of time in resetting the nets.

The unusually small force of spawn takers available for making egg collections was compelled by circumstances to work on smaller fishing boats than formerly and with a few exceptions these boats were equipped with old nets, which had to be favored in bad weather, thus causing the loss of many days when fishing might have been profitably conducted had proper equipment been available. All these factors operated to reduce the egg collections.

The spawning season opened November 11, fully half a month before pending repairs to the steam plant could be completed, and during this period the 33,960,000 eggs taken had to be fertilized and returned to the spawning grounds. In all, 418,950,000 eggs were secured, the last collection being made on February 4, and from the 379,000,000 incubated 275,410,000 fry were hatched and released in suitable coastal waters.

Despite the fact that fishing operations were seriously curtailed by the severe weather prevailing during the winter and early spring, the collection of cod eggs was the largest ever made for the Gloucester station. Though small, the daily receipts throughout December, January, and February were fairly uniform. In March the supply was substantially increased, but the majority of the collections were received in April and May. Inshore fishing was much below the average in volume, the daily catches for the most part running small, but this decline was more than offset by the unusually large numbers of ripe fish taken. The receipts of eggs from the beginning of the spawning season (December 9) to the closing day of the collections (May 24) aggregated 605,960,000, besides consignments to the number of 32,970,000 surplus eggs transferred from the Woods Hole hatchery.

During the period of the spring freshets it became necessary to discontinue shipments from the collecting fields to the hatchery and plant the fertilized eggs on the spawning grounds. The number thus treated amounted to 277,500,000. Including the transfers from the Woods Hole station, 365,450,000 cod eggs were incubated in the hatchery, yielding a total of 245,140,000 fry for distribution.

The season's collection of haddock eggs, made between March 25 and May 11, was the smallest secured in several years. The causes responsible for this were (1) extremely cold weather during the early spring, (2) scarcity of brood fish on the inshore spawning grounds, and (3) the unusually small number of boats engaged in fishing. The spawning season opened extremely late, and while several large captures of fish were made late in March, no ripe ones were among them. At times during the season, weather conditions were so unfavorable that it was impossible to haul the nets for periods of three to five days at a time, and, when finally landed, all the fish taken in them were dead and their eggs a total loss.

Notwithstanding the many difficulties encountered, over 100,000,000 eggs were secured during April and early May, though most of them, owing to the unsuitable condition of the hatchery water at this time, had to be fertilized and immediately returned to the grounds where taken. Only 2,960,000 haddock fry were produced at the station in the course of the season, and these were released in waters near Cape Ann.

There was a great scarcity of winter flounders in Massachusetts Bay during the spring, and in the absence of commercial fishing for that species in the vicinity of Cape Ann, the station was compelled to rely upon fyke nets for its brood stock. The station nets were set as soon as the ice left the harbor, and by this method 194 gravid fish were taken between March 14 and April 27. This stock yielded 78,230,000 eggs, and from them 68,760,000 fry were obtained for distribution.

WOODS HOLE (MASS.) STATION.

[W. H. THOMAS, Superintendent.]

This station experienced the most successful year's work in its history in the propagation of cod, the egg collections of that species amounting in round numbers to 670,000,000, while the output of eggs and fry aggregated 505,153,000, or nearly three times the number produced the preceding year.

Much difficulty was experienced during the fall in effecting satisfactory arrangements for the delivery of brood cod as a source of egg supply. An extended search disclosed that all the fishing vessels heretofore performing this service had either been lost or had taken up other lines of work. However, a small vessel suitably equipped for the purpose was finally engaged to transport cod to be furnished by a trap owner on the commercial fishing grounds, and while the deliveries were sometimes delayed by storms the station secured by this means an exceptionally fine brood stock of 2,812 cod averaging 6.91 pounds in weight. In past years, when purchasing stock direct from the vessel owners making the deliveries, the bureau has found it expedient, in order to retain their full cooperation, to accept all fish landed regardless of sex. Under this year's arrangement it was deemed advisable to effect an agreement with the trap owner to furnish fish in the proportion of 2 males to 3 females. This plan worked so well that it will be followed hereafter.

During the spawning season, extending from late November to the middle of February, 555,584,000 eggs of good quality were realized from the brood stock, this being the largest collection ever made from fish spawning naturally in the station cod basin. In an effort to augment the egg supply, a force of temporary spawn takers was engaged to collect cod spawn in Cape Cod Bay. In connection with this undertaking the station steamer was utilized not only as living quarters for the men but to gather up the spawn and transport it to Sandwich, Mass., from which point it was conveyed to the hatchery by the station truck. As soon as the hatching season opened double service was performed, consignments of fry being taken to Sandwich on the daily trips of the truck and from there transported by the steamer to be planted on the natural spawning grounds from which the eggs were derived. Work in this field extended from October 30 to the end of December, and the egg collections aggregated 114,145,000.

Information was received early in the season to the effect that cod eggs in profitable numbers might be secured in the vicinity of Plymouth and at other points along the Massachusetts coast, but the limited funds available would not permit of the conduct of operations in these areas.

Every season for some years much additional labor has been entailed and unavoidable losses of cod eggs sustained through the clogging of screens on the inner hatching boxes, the trouble usually being much worse during January and February than at any other period. A careful examination conducted by the scientific assistant last season when the difficulty was at its height disclosed the presence in the water supply of immense quantities of diatoms and other minute organisms of many different forms. Enormous numbers of diatoms were found throughout this region, Buzzards Bay, and Vineyard Sound, and great numbers were carried into Great Harbor (Woods Hole) by the strong currents and winds. It was noticed that after a thaw or heavy rain a considerable increase in the number of diatoms occurred, while repeated observations indicated that this was not a mere coincidence. A possible explanation may be that the drainage from the land increases the necessary food products of the diatom in these local waters. The particular diatom (*Rhizosolenia alata*) that usually interferes with propagation of cod at Woods Hole does not ordinarily occur until the temperature of the harbor water drops to about 35° F. It is not possible to relieve the situation by changing the source of water supply.

The best results are obtained in cod propagation when the water temperature is from 42° to 47° F. Therefore it is proposed hereafter to heat the water used in cod propagation at times when the temperature falls below 47°, and to maintain the supply at a point 5° above the temperature of the harbor water until the cod work is completed. Owing to the arrangement of the heating pipes in the hatchery, this undertaking will entail no additional expense.

As in past years, operations were conducted in Waquoit Bay for the purpose of obtaining a brood stock of winter flounder, this work extending from January 16 to March 20. Though prosecuted with the utmost vigor, the efforts to this end were rendered almost negligible by the difficulties met with. Not only were weather and road conditions such that it was often impossible to attend the nets for several days at a time, but there were very few fish on the spawning grounds. It was ascertained that one 42-foot fishing boat operating just outside the entrance of the bay early in November, just at the time the fish were beginning to enter it, had cleared a profit of $1,400 as a result of 10 days' fishing. This boat must have taken approximately 7 tons of winter flounder, representing about 9,000 fish, and it is possible that to the operations of this and other vessels may be attributed the unwonted scarcity of fish in this field. The efforts to obtain a brood stock of this species were also extended to the Wickford (R. I.) field. Work there was undertaken on March 16, but the returns up to April 4 were so poor that the attempt was abandoned. The total collection of eggs from fish taken in these two fields amounted to only 369,865,000, less than one-third the number secured in 1922.

On February 17, when hatching operations were in full swing, the water supply was shut off by the freezing of the suction pipe. To meet the emergency thus created the Coast Guard steamer *Acushnet* agreed to furnish the water required to keep the hatchery in operation, but at the expiration of 24 hours' service the steamer was obliged to take up other duty and nothing remained to be done but liberate all stock on hand. The plants made at this time consisted of 115,897,000 green eggs, 102,354,000 eyed eggs, 10,000,000 fry, and 400 brood fish, all winter flounder.

The usual efforts were made during the spring to obtain eggs of the mackerel, scup, and sea bass. On several occasions a few eggs of the two first-named species were secured, but in the absence of a fertilizing medium they were of no value.

ANADROMOUS FISHES OF THE ATLANTIC COAST.

The fish-cultural work coming under this head is conducted at three stations and one substation and includes operations with the Atlantic salmon, shad, the river herrings (*Pomolobus æstivalis* and *P. pseudoharengus*), the humpback salmon, and the striped bass or rockfish. The total output of these species during the fiscal year was 183,803,000, an increase of approximately 11,500,000 over that in 1922. The distributions of river herring were nearly doubled as compared with that year, but the production of shad and Atlantic salmon fell short of the usual numbers. This being the off year for the run of humpback salmon introduced in certain coastal rivers of Maine some years ago, no eggs of that species were taken.

SHAD.

BRYANS POINT (MD.) SUBSTATION.

[L. G. HARRON, Superintendent.]

Shad propagation at this station was undertaken under very unfavorable conditions. Cold stormy weather prevailed at the beginning and practically to the end of the spawning period, seriously curtailing the run of fish to the spawning grounds in the Potomac River. Only a comparatively few shad were in evidence when the collection of eggs was undertaken on April 20, but the work was vigorously and continuously prosecuted up to the middle of May, when it was recognized that the run was practically over. It is estimated that about 30,000,000 eggs were delivered at the hatchery, but as it was desired to pay for good eggs only no measuring or recording was done until the second day after their receipt, thus allowing sufficient time for the detection and elimination of any that might be of poor quality. The eggs paid for aggregated 17,627,000. Practically all were of fine quality and from them 16,700,000 fry were hatched, the losses during incubation amounting to only about 3 per cent. All fry hatched were liberated in good condition on the principal spawning grounds in the Potomac River.

During the year a bungalow 14 feet square and 8 feet high was constructed as living quarters for the superintendent. Four new live cars for holding brood yellow perch were built and various minor repairs were made to the hatchery and equipment.

SHAD AND RIVER HERRINGS.

EDENTON (N. C.) STATION.

[W. S. VINCENT, Superintendent.]

As the prevailing public sentiment in this region was in opposition to the issuance of licenses for the operation of gill nets for taking shad within certain restricted areas of upper Albemarle Sound, no permits of this character were issued during the spring of 1923. From the information at hand it appears that during the years when gill netters were allowed to operate on these grounds many unripe shad were taken and sent to the market which otherwise would have spawned naturally. In recent years these nets have constituted a very uncertain source of egg supply for propagation, as the State laws require their removal by April 25, just when the spawning season is at its height. In view of all the facts in the case it was deemed advisable to discontinue the issuing of licenses and await further developments. As a consequence of this decision the shad work of the Edenton station was limited to the incubation of 250,000 eggs, which were taken while a collection of material was being made for examination by the bureau's scientists. Two hundred thousand fry were produced from this lot and delivered to an applicant at Franklin, Va.

In lieu of the shad work, all efforts were concentrated on the propagation of the river herrings, of which two species, the branch herring (*Pomolobus pseudoharengus*) and the glut herring (*P. æstivalis*) are available. Owing to the cold late spring the spawning season began somewhat later than usual. Egg collections extended from April 9 to May 10, the largest numbers being taken on April 23 and 24. Variable winds kept the run of herring constantly on the move, the fish coming in with the southwest winds and running back with the offshore wind. Notwithstanding this handicap, however, over 313,000,000 eggs were taken, or nearly three times the number secured the previous year.

Very difficult conditions are encountered in the collection of herring eggs. While the owner of a fishing boat desires that the bureau obtain all ripe eggs available, his main object is to get the fish to market, and the spawn taker is sometimes obliged to work so fast that it is impossible to prevent the taking of some immature eggs with the ripe spawn. For this reason there is often a wide margin of difference between the number of eggs collected and the number hatched, and, while a hatch of 90 per cent was frequently obtained during the season, it was much below that taking the work as a whole.

The herring egg is adhesive during the earlier stages of incubation, and all attempts to overcome this adhesion by the use of the starch solution have been of no avail. For the first 24 hours, therefore, the eggs are held in open-top jars and must be stirred almost constantly with a feather to prevent their forming into a solid mass. By the end of that time the developing fish in the egg seems to overcome the adhesive tendency and an increase in the flow of water at this period will give all the motion required to keep the eggs in good condition until incubation is completed. During the past season the period of incubation was 57 hours in an average water temperature of 67°.

In addition to its work with the anadromous fishes the station produced limited numbers of the various pond species. Mention of this work may be found on page 84.

STRIPED BASS.

WELDON (N. C.) SUBSTATION.

[W. S. VINCENT, Superintendent.]

For several years prior to the striped-bass spawning season of 1923 the bureau's work in the propagation of this species had been directed by a temporary employee—a resident of Weldon. The methods pursued by him having aroused much dissatisfaction, it was decided to discontinue his services and detail one of the statutory employees of the Edenton station to assume charge of the work. It was discovered after the arrival of this employee that in past seasons the local fishermen had been paid at the rate of $20 per million for eggs furnished and had been allowed additional compensation for the time consumed in delivering them at the hatchery. He at once established a price of $20 per million for eggs delivered. This reduction in price, together with the change in management, incurred such ill feeling among the fishermen that they refused for a time to make any egg collections. However, after being thoroughly convinced that the station would be closed if they persisted in their refusal to cooperate, their attitude changed and they began furnishing eggs for propagation, the first delivery being made on May 5.

It was soon discovered, in connection with the prosecution of fish-cultural work at this point, that the waste matter discharged from a paper mill located at Roanoke Rapids was polluting the river water to such an extent that the fry succumbed soon after liberation. Egg collections were at once discontinued and the work was terminated as soon as the stock on hand could be disposed of. During the short period of operations—from May 5 to May 9, inclusive—22,084,000 striped-bass eggs were received at the hatchery and 16,370,000 fry produced and liberated.

ATLANTIC SALMON.

CRAIG BROOK (ME.) STATION.

[J. D. DE ROCHER, Superintendent.]

A small lot of young Atlantic salmon held over from the hatch of the previous year was carried through the months of July and August, 1922, and then liberated in Dennys River, Me., the distribution comprising 40,000 No. 2 fingerlings. Heavy April rains having washed away the barriers of the Dead Brook inclosure, where brood Atlantic salmon have heretofore been held awaiting the development of their eggs, it was decided to omit the customary purchase of adult stock during June, and, in view of the antagonistic attitude of the salmon-weir fishermen, it is believed that very few of them would have been willing to supply the fish even if the bureau had been in a position to take them. On March 10 a shipment of 500,000 eyed Atlantic-salmon eggs was received from the Canadian Government in exchange for an equal number of brook-trout eggs, this being the third successive year the station has received eggs from that source. Of the resulting fry 451,000 were liberated in tributary waters of the Penobscot River after the absorption of the food sac, and 14,820 were on hand at the close of the fiscal year.

RESCUE OF STRANDED FOOD FISHES.

[C. F. CULLER, in charge.]

With the Homer (Minn.) station as a central directing point, rescue operations on the upper Mississippi River were taken up early in July and vigorously prosecuted to the end of October, at which time shortage of funds compelled the discontinuance of the work though a considerable amount of territory was left wholly untouched. The field in general embraced all lowland areas lying between Prescott, Wis., and Andalusia, Ill. The Homer station and the substations at Marquette and Bellevue, Iowa, and at La Crosse, Wis., were employed as holding and distributing points for the fishes collected in their vicinity. A small amount of rescue work was also done in the State of Louisiana in cooperation with the Louisiana Conservation Commission, and at the Friar Point (Miss.) station under the immediate direction of the superintendent of the Tupelo station.

The number of fish handled at all points in the rescue field during the season amounted to 139,799,031, and all of them were released in suitable adjacent waters with the exception of 1,164,952, or less than 1 per cent of the whole. These were shipped to applicants in various parts of the United States by means of the bureau's distribution cars and messengers. The most prolific fields were in the vicinity of La Crosse, Wis., the substation at that point handling 58,135,611 fish in the course of the season and furnishing a material part of the output of rescued fish supplied to applicants. A table showing the number of fish of each species produced and the output from each distributing center may be found on page 11. The average cost of the work per thousand fish rescued was about 19 cents.

In accordance with an agreement entered into with the Louisiana Conservation Commission cooperative rescue operations were taken up in Mississippi River waters of the State on October 23, 1922. After removing the fish imprisoned in barrow pits near Baton Rouge, the men, boats, and equipment were transferred for further work to Bayou Sara, thence to Angola, and finally to the Atchafalaya River in the vicinity of Simmesport. After a careful survey of the conditions at this latter point it was decided that the probable results of the contemplated operations were too small to justify the expenditure involved, and on November 17 the bureau withdrew from the field. As a result of the cooperative work in this territory 451,487 fishes of miscellaneous species were removed from temporary waters and returned to the main channel of the river. For its prosecution the State furnished the use of a launch and a houseboat, to serve as living quarters, and the bureau provided the services of two experienced fish culturists.

The appreciable falling off from the output of the preceding year in the rescue field was the direct result of the natural conditions encountered in the work. Contrary to the usual experience, the flood stage of the Mississippi River was unduly protracted by continuous rains, and the lowlands where spawning occurs were not cut off from the main channel, as in other years, until after a large percentage of the young fish hatched had returned to it of their own accord.

The work was conducted to much better advantage than ever before, as the services of the special rescue personnel recently provided for by Congress were available throughout the season. Under present arrangements the work of the fishing crews detailed to various parts of the field can be personally supervised and directed by men trained in the rescue operations, thus insuring greater efficiency than has heretofore been possible and at the same time effecting a considerable reduction in cost.

MUSSEL INFECTION IN CONJUNCTION WITH THE RESCUE OF LANDLOCKED FISHES.

[H. L. CANFIELD, in charge.]

The infection of rescued fishes with the larvæ of commercial fresh-water mussels was undertaken on a large scale and resulted in the release of 2,048,977,910 larval mussels (glochidia) in a state of parasitism on the gills of host fishes. This total, representing by far the largest amount of mussel-infection work ever accomplished in a single year, was done at a very considerable reduction in cost as compared with that of the previous year, the average per thousand glochidia being only $0.0025. By combining the operations connected with the rescue and the mussel-infection work it has been possible to produce enormous quantities of juvenile mussels at a low cost, and the clam fishermen and others engaged in the industry have cooperated with the bureau to the fullest extent to make the work a success. The following table summarizes the mussel work of the bureau during the fiscal year 1923, showing the fields in which operations were conducted and the numbers and species of mussels handled in each.

Extent of mussel-propagation work in 1923, showing fields of operation and numbers and species of mussels handled in each.

Field.	Grass mucket. (*Lampsilis luteola.*)	River mucket. (*Lampsilis ligamentina.*)	Pocket-book.[1] (*Lampsilis ventricosa.*)	Total.
	Number.	*Number.*	*Number.*	*Number.*
Minneiska, Minn.	30, 209, 500	14, 506, 500		44, 716, 000
Winona, Minn.	70, 060, 000	13, 500, 000		83, 560, 000
Homer, Minn.	58, 338, 000	3, 235, 000	1, 798, 300	63, 371, 300
Dakota, Minn.	4, 082, 500	5, 343, 000		9, 425, 500
La Crosse, Wis.	61, 853, 750	860, 500		62, 714, 250
Brownsville, Minn.	67, 579, 750	21, 193, 350	36, 000, 500	124, 773, 600
Genoa, Wis.	97, 070, 000	121, 310, 000	64, 375, 000	282, 755, 000
Ferryville, Wis.	63, 800, 000	21, 350, 000		85, 150, 000
Lynxville, Wis.	614, 763, 000	68, 472, 500		683, 235, 500
Marquette, Iowa	13, 600, 000			13, 600, 000
Guttenberg, Iowa	20, 565, 000	28, 567, 500		49, 132, 500
Bellevue, Iowa	255, 635, 610	143, 451, 100	18, 243, 500	417, 330, 210
Rock Island, Ill.	67, 275, 500	35, 201, 550		102, 477, 050
Gordons Ferry, Iowa	26, 737, 000			26, 737, 000
Total	1, 451, 569, 610	476, 991, 000	120, 417, 300	2, 048, 977, 910

[1] This mussel is not first class in quality, and fishes are infected with it only when first-class mussels are not available.

FISHES OF MINOR INTERIOR WATERS.

Under this general head is included the work of the Rocky Mountain trout stations, the New England trout and salmon stations, the combination trout and pond fish-cultural stations, and that group of stations devoted exclusively to the production of warm-water pond fishes. The fishes propagated at these stations are, as a rule, distributed to applicants, but considerable numbers, especially of the black-spotted trout, are returned to the waters from which the eggs are derived. Since the advent of the automobile and the extensive opening up of roads in formerly inaccessible regions, many streams that originally teemed with game fishes have become practically depleted, while others would become so were it not for the efforts made by the bureau and the various State fisheries departments to keep up the supply. This depletion of fish life, especially of the brook trout, in so many of the streams of the country has increased the demands upon the bureau for eggs and fry of this species out of all proportion to its available supply.

In connection with its work of propagating the brook trout the bureau has found it necessary to purchase from commercial dealers the bulk of the eggs used for stocking its hatcheries. In many cases eggs from this source are of poor quality and the fry resulting from them lack the vitality inherent in fry derived from wild fish. In view of the situation the bureau has been endeavoring for the past year or two to establish, on a promising site at York Pond, N. H., a plant capable of producing sufficient brook-trout eggs to fill its needs. Work on this plant is being pushed to completion as fast as the available funds will permit.

Other fishes for which large demands are annually made are the black basses, both the largemouth and the smallmouth species. With the present facilities for their production it is practically impossible to produce them in sufficient numbers to meet the requirements, and the urgent need for the extension of this branch of the work is clearly apparent.

ROCKY MOUNTAIN TROUT STATIONS.

This important group is composed of eight stations and substations, located in the States of Colorado, Montana, South Dakota, Wyoming, and Utah. The year's work of the group was most successful, especially as regards the propagation of the black-spotted trout, the output of which was more than five times as large as that of the preceding year. The total output of these stations in eyed eggs and fry during 1923 aggregated 22,364,540, the species handled including black-spotted trout, brook trout, rainbow trout, and small numbers of Loch Leven and steelhead trout.

BOZEMAN (MONT.) STATION AND SUBSTATIONS.

[W. T. THOMPSON, Superintendent.]

Fish-cultural work at Bozeman station and its auxiliaries consisted in the propagation of brook, rainbow, black-spotted, and lake trout and the steelhead salmon. The majority of the eggs handled were taken in outside fields, only 1,610,000 being secured in local waters, while the year's output from this group of stations aggregated nearly 2,000,000 fingerling fish and 1,389,000 eyed eggs, the latter, at the request of the National Park Service, being deposited in waters of Glacier Park which it would be impossible to reach with fry owing to their inaccessible location.

BOZEMAN (MONT.) STATION.

During the year the Bozeman hatchery received from outside sources 1,285,000 brook-trout eggs, of which 250.000 were purchased from a commercial dealer. The remainder was contributed by the

Springville (Utah) and Leadville (Colo.) stations. From these eggs, together with 90,000 collected from brood trout in the station ponds, 1,271,000 fry were hatched, or nearly 92½ per cent of the original stock. Quite heavy losses occurred during the spring, due principally to the impossibility of securing fresh supplies of liver at all times. Notwithstanding this difficulty the output of brook trout exceeded 900,000, about two-thirds of them being fingerlings, and nearly 500,000 were on hand at the close of the year.

This station also received 1,450,000 black-spotted-trout eggs from collections made in the Yellowstone National Park, 338,000 rainbow-trout eggs from its Meadow Creek auxiliary, 75,000 lake-trout eggs from the Duluth (Minn.) station, and 58,000 steelhead eggs from Oregon. Of this stock eyed eggs of the rainbow and black-spotted trouts to the number of 150,000 were reshipped to applicants. The remainder was developed with not more than normal losses, furnishing an aggregate output of 981,600 fingerlings and fry and leaving on hand at the close of the year a material percentage of the original number to be reared to a larger size before distributing.

Quite extensive alterations were made to the ponds at Bozeman station during the year with the view of eventually reconstructing the entire system as funds permit. In pursuance of a carefully devised plan ponds Nos. 1 to 18, located in swampy ground, were converted into six rock and gravel-bottom inclosures, each approximately 90 feet long, 31 feet deep, and 4 feet 7 inches wide at the bottom, with a slope sufficient to give a width of 5 feet 7 inches at the top. These ponds are so arranged that when their dams are drawn all bottom sediment is swept by the heavy current toward the lower end, assisting very materially in cleaning operations. Screens extend across the entire pond areas and the outlet boxes in the sides are fitted with both screens and dams. It is intended later to lengthen these ponds to approximately 175 feet by throwing into them the space now occupied by the remaining 18 ponds of the old series. Each of the six ponds will then be provided with full-width dams and screens to form two or more inclosures at will, in accordance with the needs of the work. When the entire nursery system has been reconstructed the available supply of spring and creek water will be arranged to flow through the entire length of the ponds.

MEADOW CREEK (MONT.) SUBSTATION.

Rainbow trout operations at the Meadow Creek substation were greatly obstructed by the preparations being made by the Montana Power Co. to build a bridge across the stream. In connection with this project the water level in the creek was maintained at so low a level throughout the entire spring that many of the ascending trout were forced to turn back and seek spawning grounds elsewhere. Egg collections were therefore curtailed, the total amounting to only 1,520,000. The spawning season was from two to three weeks shorter than the average, extending only from April 23 to the end of May, and the losses of eggs were unusually heavy, only 810,000 or 54 per cent of the collection surviving to the eyed stage. Three hundred thousand of the eyed eggs were hatched at the substation with the view of returning the product as fingerling fish to the home

When the eggs had reached the eyed stage shipments to a total of 1,225,000 were forwarded to applicants and to other stations of the bureau, one consignment of 50,000 going to Alaska. The incubation period of those held in the hatchery was completed by the end of April, the number of fry produced amounting to 4,767,770, or approximately 88 per cent of the retained stock. In addition to the egg shipments the year's output of this species consisted of 3,345,000 fry and fingerling fish, and at the close of the year a considerable number of fingerlings were still on hand. The brook-trout fields occupied during the year, the number of eggs secured in each, and the dates between which egg collections were made were as follows:

Field.	Number of eggs taken.	Spawning season.
Carroll	443,000	Oct. 29 to Nov. 16.
Engelbrecht	2,193,000	Sept. 24 to Nov. 26.
Evergreen	6,000	Oct. 26 to Nov. 22.
Fred Neal	164,000	Nov. 17 to Nov. 26.
Musgrove	880,000	Oct. 26 to Nov. 22.
Turquoise	3,004,000	Oct. 19 to Nov. 29.
Total	6,690,000	

An output of 671,000 fry and fingerling black-spotted trout, the product of 750,000 eggs of that species received in the summer of 1922 from the Yellowstone Park station, was distributed during the fall to applicants in Colorado, Arizona, and New Mexico. The year's distributions also included 196,150 fingerling rainbow, Loch Leven, and lake trout, the output of the first two resulting from eggs secured in the brook-trout fields, while the lake trout were derived from a shipment of 150,000 eggs forwarded from the Duluth (Minn.) station the previous winter. From a shipment of 50,000 steelhead eggs forwarded from one of the bureau's Oregon substations 45,800 fry were hatched and were on hand at the close of the fiscal year.

YELLOWSTONE NATIONAL PARK (WYO.) SUBSTATION.

[C. B. GRATER and C. F. CULLER, in charge.]

The fish-cultural season at this station involves a portion of each of two fiscal years, and the part occurring in June, 1922, has been covered in the report for that year. From July 1 to the close of the season in September, 1922, operations were supervised by C. B. Grater, superintendent of the Leadville (Colo.) station. Very successful work was accomplished during the summer of 1922. The black-spotted trout egg collections aggregated 16,751,920, and a large proportion of the fry resulting from the eggs were liberated in various streams within the reservation. In connection with the fish-cultural operations a considerable amount of repair and improvement work was accomplished, among the most important items being the entire rebuilding of the trap on Clear Creek, which was located 18 inches deeper in the creek than was the one it replaced.

During the spring and early summer of 1923 the park work was directed by C. F. Culler, district supervisor. The Soda Butte hatchery was opened on May 23, as the first eggs of the season are usually obtainable in that field, and work at the main station was taken up two days later. At the close of the fiscal year 4,794,000 black-spotted-trout eggs had been secured, and the indications seemed to point to one of the most successful seasons ever experienced in this region.

SARATOGA (WYO.) STATION AND SUBSTATION.

[O. N. BALDWIN, Superintendent.]

The bureau's fish-cultural work in Wyoming consisted in the propagation of four species of trout—brook, rainbow, Loch Leven, and black-spotted—and, with the exception of the last-named species, all eggs handled during the year were collected either from domesticated stock carried in the ponds at Saratoga or from wild fish captured in the vicinity of its field auxiliaries.

The small number of brook-trout fingerlings on hand at the beginning of the fiscal year was distributed in September, and during the fall the brood trout at the station yielded 307,000 eggs. This stock was supplemented by the collection of eggs from wild trout taken in Big Creek Lakes, 90 miles distant. Though located in the Hayden National Forest, these lakes are at the present time under the jurisdiction of the Bighorn Land & Cattle Co. The manager of this company appeared to resent the bureau's activities, but through the intervention of local officials of the United States Forest Service an arrangement permitting the bureau to make egg collections in the lakes was finally effected. However, the work was interfered with later, the racks being removed by unknown persons and large numbers of brood fish allowed to escape. Through this occurrence the egg collections were curtailed from approximately 1,000,000 to 288,000. The output of this species for the year amounted to 138,100, and nearly 400,000 fingerlings were on hand at its close. It is the intention to return a substantial percentage of these to Big Creek Lakes with the view of building up the field as a future center for egg collections.

Shortly after the beginning of the fiscal year the rainbow-trout fry resulting from the cooperative work of the bureau and the Wyoming fishery department at the Sage Creek auxiliary were planted in suitable waters and the substation closed for the season. As soon as possible after its reopening in April, racks and traps for the interception of the early run of rainbow trout were installed in Lost, Sage, and Canon Creeks, but owing to the prevailing low water stages the run of fish was unusually light. Between May 1 and June 7 eggs to the number of 1,237,150 were taken, approximately 620,000 of which were furnished, when eyed, to the State fisheries departments of Wyoming and South Dakota. The remainder was developed at the substation with the view of replenishing and increasing the stock in parent streams.

The hatchery erected at Sage Creek last year is a log structure, 38 by 28 feet in dimensions, with hip roof. It is equipped with 24 wooden troughs, 16 feet long, 14 inches wide, and 9 inches deep, and each trough is divided into eight compartments by saw cuts and iron dams. The hatchery has a total capacity of 5,000,000 green eggs or 1,125,000 fry. As the water supply is derived from the heavy snowfall in the surrounding mountains, it is very roily at times. For this reason the tray system is used, it being necessary to handle the eggs almost daily.

A considerable amount of construction work will be required for the completion of this substation, and the racks and traps in all streams where egg collections are made must have concrete foundations. This part of the work will be done before the beginning of next season's fish-cultural operations, provided funds are available for the purpose.

In addition to its work with the brook trout and rainbow trout, the Saratoga station produced and distributed 87,500 black-spotted trout fingerlings, the product of approximately 100,000 eggs transferred from Yellowstone Park, and from a few Loch Leven trout held in ponds 15,000 eggs were taken and hatched. The resulting fingerlings are to be reared and retained for increasing the station brood stock of this species.

All available funds in the special appropriation having been exhausted by the building operations of the preceding year, no construction work other than minor repairs was possible though much still remains to be done to complete the Sage Creek hatchery and its water-supply system. The matter of improving the station grounds at Saratoga is one that urgently demands consideration. With the exception of a small strip of fenced land along the east side of the railroad these grounds still remain in their original wild condition, cattle roaming over them at will. The reservation should be inclosed by a substantial fence and the grounds planted in trees, shrubs, and grass.

SPEARFISH (S. DAK.) STATION.

[D. C. BOOTH, Superintendent.]

Construction work formed a very important part of the activities at this station during the year. The old plank ponds Nos. 1 to 12, which were built in 1899, had never given satisfactory service even when an abundance of spring water was available, and after the decrease in the supply of water on the upper level of the station reservation these ponds were of no value whatever. In order to provide space for storing water to be used during periods when a shortage in the city supply curtailed the amount delivered at the hatchery it was decided to tear out these unsightly plank ponds and utilize the space for the location of a suitable concrete reservoir. In pursuance of this plan ponds Nos. 1 to 8 were torn out, the space excavated to a suitable depth, and a substantial concrete wall, reinforced by one-half inch rods laid in cement, was constructed. This reservoir will hold 400,000 gallons of water, or a sufficient amount to tide the hatchery operations over for a period of several days in the event of an accident to the main water pipes or when overflow water from the city reservoir is not obtainable. Another important piece of construction work accomplished was the rebuilding of the large stone bulkhead wall along the southeast corner of the station grounds, the old one having been badly damaged by floods.

The results attained in the fish-cultural work were quite satisfactory, there being no disease among the stock and no abnormal losses. Brook, Loch Leven, and rainbow-trout eggs totaling 1,159,400 were incubated, from which 968,000 fry were hatched, the percentage of hatch being nearly 83½.

Of the brook-trout eggs handled 262,100 were collected from wild fish secured in local streams, 259,600 were transferred from the Springville (Utah) station, and 500,000 were obtained through exchange, the South Dakota fisheries authorities turning over to the station 500,000 eggs that had been purchased by the State from a commercial establishment in Pennsylvania, with the understanding that the State would be furnished an equal number of rainbow-trout eggs from another station of the bureau. These commercial eggs were of fine quality and the fry resulting from them were so exceptionally healthy and vigorous that 100,000 of them were selected and successfully used in the conduct of an experiment made for testing the comparative value of a certain commercial brand of fish food. The year's distribution of brook trout consisted of 792,445 fingerlings No. 1½, and 19,465 were on hand at the end of June.

Nearly 65,000 Loch Leven trout eggs were taken during the fall—12,300 from wild fish secured in connection with the brook-trout egg collection and the remainder from domesticated fish in the station ponds. During January 10,350 were shipped in the eyed stage to the St. Johnsbury (Vt.) station, and the young fish hatched from the remainder will be reared for increasing the station brood stock.

From domesticated rainbow trout held in the station ponds 72,900 eggs were taken, the spawning season extending from January 22 to May 9. Of the resulting fingerlings 35,360 were delivered to applicants late in June. The remainder of the lot was retained for later distribution.

The work at this station also included the handling of 50,935 steelhead-salmon eggs furnished from the Washougal (Wash.) field. This lot was hatched with a loss of about 7 per cent, and all of the resulting fry were being held at the close of the year for distribution in the fingerling stage.

SPRINGVILLE (UTAH) STATION.

[CLAUDIUS WALLICH, Superintendent.]

Fish-cultural work at this station was confined to the propagation of brook and rainbow trout, the output of which was considerably reduced in comparison with the output last year owing to the limitations imposed upon the bureau's operations in the Fish Lake field. Cooperative work between the bureau and the State was undertaken in this region in late October. On arrival there it was found that large numbers of brook trout had already assembled below the mouth of Twin Creeks, where most of the collections are made, but were prevented from entering the stream on account of the unusually low water level in Fish Lake. This condition was remedied by enlarging and deepening the mouth of the stream, after which racks and traps were installed. Spawn taking began on October 27, and from that date to the end of November eggs were taken almost daily, the total collection amounting to 8,250,000. The State turned over to the bureau 3,200,000 eggs, of which stock 1,500,000 in round numbers were shipped in the eyed stage to other stations of the bureau, over 500,000 going to the Bozeman (Mont.) hatchery.

A number of the stations receiving these eggs, including Springville, sustained unusually heavy losses prior to the hatching period, though the fry resulting from them appeared to be normal. The losses may be attributed in part to the fact that many of the eggs were taken late in the season. It has also been noted, with reference to this field, that eggs stripped from fish the second time are not of the best quality. Of the 522,000 eyed eggs retained at the Springville hatchery 83,000 were lost in the course of the incubation period, while the losses in the fry and fingerling stages aggregated 128,900. Shipments of fingerling brook trout to the number of 248,850, in the Nos. 2 and 3 stages, were made before the end of the fiscal year and 61,250 were carried into the succeeding year. The year's output of this species also included 33,600 No. 4 fingerlings, the product of the previous year's egg collections. These were distributed in July, 1922, most of them being returned to Fish Lake and its tributaries.

The stock of rainbow trout on hand at the beginning of the fiscal year included 637,000 fingerlings No. 3, which were distributed in July, 1922, and also 344,000 fry resulting from the spring egg collections. The fry did well until about the second week in August, when an abnormal mortality occurred and continued for some time. No definite cause could be ascribed for it. The entire lot was being carried in the hatchery, which was supplied with intake water, all surface water being excluded, and every effort was made to keep the stock in a sanitary condition. The food used was beef hearts, inspected, to which a small proportion of mush was added. The trouble first became evident through the fading of the fish to lighter shades. They gradually refused to eat, became emaciated, and assumed a heady appearance. The center of affection did not seem to lie in the gills. As a rule the losses were larger in troughs where water was being used a second time. The subsidence of the disease seemed to be coincident with the admission of surface water into the intake reservoir and the transfer of the stock to the concrete pond system, and by the middle of September, when the distribution of the fish was taken up, the survivors were in good condition. The output from the lot consisted of 169,300 fingerlings Nos. 2 and 3.

With the view to profiting by the experience gained the 508,000 fry resulting from the rainbow brood stock the following spring were transferred to the concrete pond system and subjected to the conditions that seemed to have afforded relief to the former lot, but without avail. Though a remarkably healthy and active lot of fish during the earlier stages of their growth, they were attacked by a somewhat similar epidemic when about 1½ inches long, but with this difference: Fish that apparently were in good health one day would be lying dead in windrows up and down and through the center of the ponds on the succeeding day. After continuing heavy for a few days the death rate would decrease, but almost every lot of the fish was similarly affected on attaining the length mentioned. The total losses on this stock amounted to 314,000. Of the remainder 124,000 were distributed as Nos. 2 and 3 fingerlings before the end of the year and 70,000 were on hand at its close.

Under an agreement effected with the Utah fisheries authorities the station participated with the State in the collection of rainbow-trout eggs from wild fish in the Fish Lake field during May and June and received one-fifth of the proceeds as its share. The quality of these eggs was about the average of the stock secured in this field. After shipping 25,000 eggs to the Manchester (Iowa) station the remainder was hatched, producing 310,000 fry, all of which were on hand at the end of June.

Complete failure attended the efforts put forth to collect eggs in the Kyune Reservoir, near Colton, Utah, where the bureau has recently been making annual plants of rainbow trout with the view to building up an egg-collecting source. The two trips made to this point—one in March and the other in May—failed to disclose the presence of any brood fish whatever. It is feared that this 13-acre lake is almost too small to warrant any profitable returns in eggs, but a few rainbow fingerlings will be liberated there annually for a while and a close watch kept on the results.

Having failed for two successive years to secure any results from the experiment undertaken some time ago with the object of determining the feasibility of holding a brood stock of native trout in the station ponds as a source of egg supply, it was decided to liberate the fish in suitable waters and abandon the attempt. The number of eggs taken in each instance was negligible and their quality was very poor.

NEW ENGLAND TROUT AND SALMON STATIONS.

Included under this head are the stations located at Hartsville, Mass., East Orland, Me., St. Johnsbury, Vt., and Nashua, N. H., together with their several auxiliary substations. During the past year the former station at Green Lake, Me., was reduced to the status of a substation and placed under the direction of the official in charge of the Craig Brook station at East Orland. Although the work in this field was interfered with to some extent by unseasonable climatic conditions the results attained at these stations were very satisfactory, their aggregate output being more than 100 per cent greater than in 1922.

BERKSHIRE (MASS.) STATION.

[W. A. CASLER, Superintendent.]

The year's fish-cultural work at this station consisted mainly in the incubation of eggs of the brook trout, rainbow trout, and pike perch, and the rearing and distributing of the resulting fish, the aggregate output of which amounted to 754,400 fry and fingerlings.

During the spawning season of the adult brook trout held in the station ponds 203,750 eggs were obtained, of which 149,260, or about 73 per cent, were hatched. This low percentage of hatch compares favorably with the results of recent years at this point and is attributed by the superintendent to the advanced age of the brood stock. A lot of 247,000 brook-trout eggs purchased from the establishment of a commercial trout breeder was apparently far superior in quality to those produced at the station, fry in excess of 240,000 being realized on the consignment. The two lots of fish were kept separate to the end of the fry stage, when they were thrown together owing to lack of space and because there appeared to be no advantage in their further segregation. For some time after commencing to feed the fish continued to develop normally, but in the latter part of March mortality suddenly increased, the daily death rate rising from about 134 per day to a maximum of 4,500 per day during April.

The disease could not be checked by any of the methods usually and sometimes successfully employed, and the losses up to the time the disease had run its natural course amounted to 151,255, or about 40 per cent of the fry hatched. No satisfactory explanation of this heavy mortality can be given, though the fish-culturist in immediate charge of the work has advanced the theory that surface drainage from the melting of an unusually heavy fall of snow may have carried into the spring supplying the hatchery water some substance deleterious to young fish. In support of this theory he cites similar conditions as to snowfall that existed in the fiscal year 1919. During that year disease broke out among the trout fry and caused an even greater mortality.

In December, 1922, two consignments of rainbow-trout eggs aggregating 108,500 were received from the Wytheville (Va.) station. Being of inferior quality these eggs sustained a loss of almost 40,000, or about 37 per cent, up to the hatching period, and subsequent losses among the fry and fingerlings so reduced the stock that only 45,900 fingerlings were realized, of which number 1,500 were on hand at the close of the year. Early in May a consignment of 500,000 eyed pike-perch eggs arrived from the Put in Bay (Ohio) station. Though delayed in transit the eggs were of exceptionally fine quality and from them 485,000 vigorous fry were hatched and distributed.

Nothing in the way of the much-needed repairs and alterations referred to in previous reports has been possible at this station, the only construction work accomplished during the year being of a minor routine character. Since the bureau acquired title to the Berkshire property in 1915 it has not been possible to divert a sufficient amount of the reduced appropriations from other and more important work to place the station in the condition in which it should be maintained. At the present time much of this property, especially the pond system, is very much dilapidated. The need is for sufficient funds to completely rebuild and rearrange the pond system, which was originally designed for private use and never intended for the production of fish or eggs on the extensive scale required in the bureau's work. While it is recognized that the work of this station can never be made to compare favorably with that of stations more advantageously located with reference to water supply and certain other essentials, it is apparent, nevertheless that if certain changes and improvements can be effected the station can, under skillful management, be made to play an important part in fish-cultural work and can be depended upon to produce for local distribution at a moderate cost certain species of fish that are now being furnished from more distant hatcheries at considerable expense and with some difficulty.

CRAIG BROOK (ME.) STATION AND SUBSTATIONS.

[J. D. DE ROCHER, Superintendent.]

That part of the fish-cultural work of the Craig Brook station that was addressed to the propagation of Atlantic salmon is discussed in connection with the anadromous fishes of the Atlantic rivers on page 55.

During late December and early January a total of 1,303,700 eyed brook-trout eggs was received from three commercial hatcheries located in Pennsylvania and New England. Of the first consignment, received from a hatchery in Maine, 131,666 eggs were reshipped to the Grand Lake Stream substation. The remainder of this lot—658,334—was incubated at the station, producing a hatch of 96 per cent. Later losses were large, however, over 9 per cent of the young fish having perished before the completion of the distribution in late June. From 210,700 eggs of fine quality received from a Massachusetts hatchery 202,651 fry were hatched. Of these, 155,800 were distributed in the advanced fry and fingerling stages and 24,995 were on hand at the close of the year. The eggs from the Pennsylvania hatchery were too far advanced for shipment when forwarded and some of them hatched on the trays en route. While the percentage of hatch on the remainder was nearly normal the subsequent losses were excessive, the mortality up to the time of distribution amounting to fully 50 per cent.

Fifty thousand rainbow-trout eggs forwarded in December from the Wytheville (Va.) station appeared, on arrival, to be in fair condition. It developed later that they were of poor quality, nearly half the lot being lost in process of incubation, while the fry hatched were weak and all of them perished within a short time.

During the month of March 380,602 eyed landlocked-salmon eggs were received from the Grand Lake Stream substation, of which number consignments aggregating 117,570 were reshipped to applicants in Vermont, New Hampshire, Idaho, and Michigan. From the remaining eggs 223,000 fry were hatched and distributed and 26,820 were on hand at the end of June.

All of the buildings at this station were wired for electric lights during the year.

GREEN LAKE (ME.) SUBSTATION.

Fish-cultural operations at this substation were concerned principally with the propagation of the landlocked salmon and the smelt, the latter including the American smelt (*Osmerus mordax*) and a subspecies (*O. mordax spectrum*) locally known as the "small smelt."

On November 1 traps were placed at the mouth of Great Brook for the capture of brood landlocked salmon, and between the 9th and the 22d of that month 193,000 eggs were taken. These were of uniformly good quality and from them 178,480 fry were hatched and distributed.

The egg collections of smelt were the largest in several years. The spawning season of *O. mordax* began on March 25 and ended April 15, while the spawning of the subspecies extended from the 5th to the 20th of May. In all, 46,300,000 eggs were taken, of which

42,000,000 were of the subspecies. Heavy rains and melting snow caused the bursting of the supply pipe of the smelt battery on April 29, necessitating the immediate planting of all eggs on hand. Fortunately, all of them had about reached the hatching stage and planting at that period therefore occasioned little loss.

One hundred adult smallmouth black bass, captured in traps in Green Lake during July, 1922, were held in the station ponds until fall and then delivered to an applicant at Norway, Me. These bass inhabit Green Lake in considerable numbers, and being considered undesirable on account of their tendency to prey upon the landlocked salmon their removal is generally approved of by residents of that section.

GRAND LAKE STREAM (ME.) SUBSTATION.

Approximately 93,000 landlocked-salmon fry were on hand at the beginning of the fiscal year 1923. Shortly before that date these fish had been placed in the recently constructed ponds in the canal, which was formerly used for the passage of boats in Grand Lake Stream, and immediately afterwards the death rate among them declined noticeably. The young fish were fed as frequently as they would take it readily on a mixture composed of two-thirds beef heart to one-third sheep liver finely ground, and late in July, after 45,000 of them had been liberated, it was observed that the remainder were obtaining sufficient natural food to satisfy them. They continued to grow rapidly and about the last of August all that remained in the ponds were liberated in Grand Lake Stream as fingerlings No. 3, the lot numbering 46,400. The first landlocked-salmon eggs from Grand Lake Stream were secured on October 31 and the last on November 18, while the collecting season at Dobsis Lake extended from the 1st to the 14th of November. In all, 423 female and 818 male fish were captured, from which eggs to the number of 659,350 were taken. Of these, two shipments, aggregating 380,602 eyed eggs, were forwarded to the Craig Brook station. On April 19 the Grand Lake Stream substation received 200,000 eyed landlocked-salmon eggs from the State hatchery at Caribou, Me., this shipment resulting from an agreement previously made with the Maine commissioner of inland fisheries and game to insure the return to parent waters of at least 75 per cent of the product of all egg collections. Owing to flood conditions following the breaking of the gate of the dam at the head of the canal on May 6, all salmon had to be disposed of in the fry stage, the plants being made in Grand Lake and tributary waters.

In addition to the work with the landlocked salmon the station handled a shipment of 131,666 commercial brook-trout eggs, which were reshipped early in January from the Craig Brook station. Owing to the accident referred to above all of them were liberated in the advanced fry stage in Grand Lake and other local streams.

The bureau's present policy of providing brook trout for Grand Lake and neighboring waters has already shown good results. It was very noticeable during the past season that good brook-trout fishing was to be had in all the streams in this section, such waters having formerly been denuded of that species. They now appear to contain young brook trout in abundance, to the intense satisfaction of the local public.

ST. JOHNSBURY (VT.) STATION AND SUBSTATIONS.

[A. H. DINSMORE, Superintendent.]

The fishes propagated at this station and its auxiliaries at Holden, Vt., and York Pond, N. H., included brook, lake, rainbow, and Loch Leven trout, landlocked salmon, and steelhead, the total annual output for the group amounting to nearly 1,500,000 eggs, fry, and fingerling fish. Owing to shortage in operating funds the propagation of pike perch at the Swanton (Vt.) substation was omitted.

ST. JOHNSBURY (VT.) STATION.

Of the 1,323,400 brook-trout eggs acquired for stocking the St. Johnsbury hatchery 450,000 in round numbers were purchased from a commercial trout establishment. The remainder was collected from fish taken in Darling Pond and Lake Mitchell, in Vermont, on the same terms as last year, the bureau collecting and incubating the eggs and receiving as compensation one-third of the eyed eggs produced. The fry resulting from the remainder were placed at the disposal of the owners of these waters. The work with this species also included the incubation of 100,000 eggs that were purchased and delivered at the hatchery by a local fish and game club whose members distributed the resulting fry in various waters of the region.

Other egg receipts were 238,350 of the lake trout, derived from collections at Lake Dunmore, Vt.; 20,350 landlocked-salmon eggs, transferred from the Craig Brook (Me.) station; 10,350 Loch Leven trout eggs, acquired by exchange from a commercial fish-culturist; and 49,500 steelhead eggs received from the Washougal (Wash.) collecting station. Some of the lake-trout eggs were reshipped to the York Pond auxiliary, and a consignment of 50,000 was forwarded to the Nashua (N. H.) hatchery. The remainder was hatched and distributed as fry in suitable local waters. The fry resulting from the landlocked-salmon eggs were transferred to York Pond to be reared, and the product of the Loch Leven and steelhead eggs was on hand at the close of the fiscal year.

On account of limited funds and the need of all possible additional help for the development of the York Pond substation, no work in the propagation of smallmouth black bass was undertaken during the year.

HOLDEN (VT.) SUBSTATION.

The outcome of the year's work in fish culture at this substation was very satisfactory. Only normal losses of stock were sustained and an entire absence of the affection that in recent years has caused such heavy mortality among the eggs and young fish gives ground for the hope that the difficulty has been solved through the application of the recently devised method of aerating the hatchery water supply.

The small stock of fingerling fish of various species on hand at the beginning of the year was distributed in the early fall, and during October and November the bureau and the State fisheries department were engaged in cooperative work in the collection of lake-trout eggs in Lake Dunmore. The returns from this work were the largest ever secured, the total collections amounting to 684,620 eggs, of which 580,600, or nearly 85 per cent, were eyed. Fifty thousand of the bureau's half of this stock were retained at the Holden station for development, and the remainder was forwarded to the St. Johnsbury station. Brook-trout eggs to the number of 250,000, purchased from a commercial fish-culturist and delivered in January, were held in brook water with a small admixture of spring water to keep them from freezing. From this consignment 238,400 healthy fry were hatched and distributed.

YORK POND (N. H.) SUBSTATION.

During the summer months a large amount of work was done at this substation in the way of improvements to the proposed pond system, with the view of developing it at the earliest possible date into a source of supply for brook-trout eggs for stocking various hatcheries of the bureau.

Diverting ditch No. 1 was continued along the south side and over the point of the separating ridge and then dropped into pond B. It is the intention to pass this water from pond B into the spawning race at the head of the main pond. In preparation for the coming spawning season, a raceway of planks, 6 feet 2 inches wide and extending 110 feet into the main pond, was provided for conducting water from pond A, a temporary diverting dike having been erected on the natural outlet to throw the water through the raceway. Twelve-inch drain tiling was laid from the kettle of pond A to York Pond, and 350 feet of cast-iron pipe, leading from the main lake to the hatchery, was installed. Races Nos. 1 and 2 were put in shape for rearing operations; the sidetrack grade, running up Cold Brook, was cleared and work started on a third rearing race, which, like all the others, will have spring water rising copiously in it, augmented by water from race No. 1, independent springs, and wells, and water diverted from Cold Brook. Below this race there is opportunity for the construction of a number of ponds, the flow from which will be to the hatchery flat, where there is space for further pond construction. A fourth raceway has been started along the hillside west of the hatchery flat, and this will later be extended some distance west of Cold Brook.

During the summer months fishermen were employed to catch trout in the closed brooks. These streams are so filled with driftwood and brush that no other practicable method has yet been devised for taking them, and it was found that by filing off the barbs of rather large hooks the fish are not apt to undergo material injury. Of 1,964 captured in this manner only 12 had been lost at the end of the season. The fish were held in a large inclosure prepared for them on the natural inlet and fed until spawning time, when an examination disclosed that only 254 were mature females. These fish were so small that only 42,450 eggs were secured, and to supplement the supply 100,000 brook-trout eggs and 25,000 lake-trout eggs were forwarded from the St. Johnsbury station.

It having become evident that the cement hatchery and pipe line from York Pond could not be completed in time to care for the eggs, a tent hatchery was installed on the run that is being converted into rearing race No. 3, and here the eggs were successfully held until the hatchery could be made ready to receive them.

The hatchery water-supply proved well adapted to trout incubation except that it contained large quantities of brown and green algæ, which gave serious trouble even though the eggs were mostly in an advanced stage when removed to the hatchery. After some losses and some experimenting it was discovered that the bad effects of the algæ might be overcome by placing the eggs, when just about to hatch, in the normal salt solution. Contact with the algæ appeared to toughen the shell so that the fish could not entirely emerge from it and the effect of the solution was to counteract the difficulty and restore the shell to its normal condition.

With the exception of 5,000 eggs planted in gravel in small brooks on the reservation no distributions of stock were made. All fish hatched were removed as sac-absorbed fry to the races, where they readily adapted themselves to their environment and began feeding readily. In addition to the fish hatched at the substation 77,000 brook trout and approximately 11,000 landlocked salmon were transferred from the St. Johnsbury hatchery.

NASHUA (N. H.) STATION.

[WALDO F. HUBBARD, Superintendent.]

The year's output from this station consisted of 675,000 fingerling fish divided as to species among the brook trout, rainbow trout, lake trout, and landlocked salmon; also 83,700 fry of the pike perch and smallmouth black bass. As in past years, most of these fish were the product of eggs forwarded to Nashua from other sources, the only brood fish maintained at the station being a few each of the brook trout and rainbow trout, which yielded 127,950 and 83,550 eggs, respectively. This stock was augmented during the winter by the purchase of 795,000 brook-trout eggs from a commercial fish culturist and the transfer of 50,000 rainbow eggs from the White Sulphur Springs (W. Va.) station. Heavy losses of both species were sustained in the egg and fry stages, greatly curtailing the distributions. Other transfers of eggs included 46,000 of the lake trout taken in connection with the field work of the St. Johnsbury (Vt.) station, 21,000 landlocked-salmon eggs shipped from the Craig Brook (Me.) station, and 1,500,000 eyed pike-perch eggs from Put in Bay, Ohio. Owing to a protracted delay in delivery the latter consignment was received in poor condition and yielded only 75,000 fry. The salmon eggs were successfully hatched and most of the resulting fingerlings were being held for later distribution at the close of the year.

An attempt during the first half of June to collect smallmouth black-bass fry from Lake Sunapee, N. H., for supplying applicants in that region was almost a failure, only 8,700 being secured. The outcome of such work in the Lake Sunapee field is very largely dependent upon weather conditions. If it is windy, as it is very likely to be, great difficulty is experienced in locating the nests and collecting the fry. Much trouble has also been encountered in holding the collections of fry even for the period of a day without incurring large losses.

In order to remedy a defect in the original planning of the pond system and to provide for a more economical consumption of water, a part of the year's fish-cultural allotment was diverted to the removal of the earth partitions at the ends of the ponds and rearranging the system so that the water supply will flow through the entire series of ponds instead of through only two, as under the former arrangement. It is planned to have this work completed in time for the beginning of fish-cultural work next season.

The conduct of fish-cultural work at the Nashua station is annually becoming more difficult and uncertain. Shortage in the station's allotment of funds for a long period of years has prohibited all possibility of necessary repairs and improvements, with the result that the hatchery, ponds, water-supply flume, and other equipment have now reached such an advanced stage of dilapidation that it is not considered entirely safe to attempt the handling of a valuable brood stock of eggs or fish. It is estimated that a special fund of at least $20,000 would be required to place the station in condition for the conduct of fish-cultural work on an efficient and economical basis.

COMBINATION TROUT AND POND STATIONS.

The stations included in this group are located in the States of Tennessee, Iowa, Missouri, and West Virginia. As compared with last year's production their output of brook trout and rainbow trout was substantially increased, but the unseasonably cold, late spring resulted in a serious reduction in the distributions of the pond fishes. Some of these stations also incubated yellow-perch eggs and used the product for the stocking of local waters.

ERWIN (TENN.) STATION.

[A. G. KEESECKER, Superintendent.]

Though eight species of food fishes figure in the output at this point the principal part of the station's production consisted, as in past years, of fry and fingerling rainbow and brook trout, the former species predominating in numbers. Other fishes included in the distributions were largemouth black bass, smallmouth black bass, yellow perch, rock bass, and bluegill bream.

During the period from October 26 to the end of the first week in February 1,309,000 rainbow-trout eggs were taken from the station brood stock, but owing, it is believed, to the abnormally mild weather prevailing prior to and throughout the spawning season their quality was impaired to the extent that the losses to the eyed stage amounted to fully 44 per cent of the original stock. From the 743,740 fry hatched 659,770 fingerling fish were reared and distributed. As the natural conditions at this station are unsuitable for the maintenance of a brood stock of brook trout, all work accomplished with that species must necessarily depend upon the transfer of eggs from other sources. A stock of 285,700 eggs purchased from a commercial brook-trout hatchery was incubated with a loss of only 2½ per cent, and from the resulting fry 278,200 fingerlings Nos. 1 to 2½ were reared and distributed.

The spawning of the largemouth and smallmouth black bass began about April 20 and extended well into June. Twenty-seven nests of the former species yielded 55,135 young bass, of which 15,635 were fingerlings No. 1, while the distributions of the smallmouth bass included 7,450 fingerling fish. An adverse feature of this work was the loss of a material number of adult fish of both species during the breeding season, greatly reducing the output. The most careful observation failed to reveal the cause of the mortality. So far as could be determined there were no unusual environmental conditions, and the dead fish appearing on the surface of the ponds had apparently not suffered from disease and bore no discernible evidence of bruises or injuries of any kind. The 500,000 yellow-perch fry entering into the year's distributions were derived from a consignment of 1,000,000 eggs supplied from the shad station on the Potomac River.

A number of items of construction work were accomplished during the year, among the most important being the enlargement and deepening of two of the ponds and the construction and installation of a 400-foot concrete flume to replace the old decayed wooden conduit for supplying the pond system on the lower level of the station reservation. The hatching capacity of the station was increased by the construction of a shed building, 40 by 42 feet in dimensions on an 18-inch concrete foundation wall and concrete flooring, to house a supplementary series of troughs. Eighteen additional troughs of galvanized iron were purchased and will be set up in this building as soon as the necessary pipe connections can be made.

MANCHESTER (IOWA) STATION.

[F. E. HARE, Superintendent.]

In the latter part of July, 1922, this station was subjected to a heavy downpour of rain, which flooded the reservation within an incredibly short space of time, transforming the entire pond system into one large lake and permitting the escape of a large percentage of the fish held therein, among them being many of the adult trout that were being counted on as a source of egg supply. One of the direct consequences of this loss was the reduction in the output of rainbow trout to less than one-half that of the preceding year, though the prospects up to the time of this occurrence had promised an increased egg production both of the rainbow and the brook trout. Moreover the quality of the eggs secured from the surviving rainbows was so inferior that only 98,685 fingerling fish were produced and distributed from the 354,700 collected. The greater part of the losses among this stock occurred before the hatching period. With the view of replacing the losses of brood fish, selected lots of young trout of both species are being reared, among them being 8,200 of the finest brook-trout fingerlings and the entire lot of fry produced from a consignment of wild rainbow eggs, the latter having been received during the spring from one of the western stations of the bureau.

The egg collections from the adult brook trout, amounting to 133,000, were supplemented by the purchase of 358,000 eggs from commercial trout establishments and the transfer of 235,000 eggs from stock collected for the Springville (Utah) hatchery. From this combined stock 649,250 fry were hatched, nearly 89½ per cent of the eggs handled, and the output for the year consisted of 445,545 fingerlings Nos. 1 and 2 with 30,400 still on hand at the end of the year.

Owing apparently to some peculiarity of the water supply, a disease of the gills has long been persistent among the brook trout held at this station and the many attempts to eradicate it have not thus far afforded much relief. In continuation of past efforts along this line a system of long narrow ponds with earth bottoms was recently constructed and provided with a good flow of water, plant growth, and other conditions in simulation of nature so far as might be possible. While the environment thus provided has not proved particularly effective in overcoming gill disease, it has been found that the ponds are much better adapted to the work of trout rearing than are the old rearing ponds on the reservation.

In additicn to trout culture, operations were conducted with the smallmouth and largemouth black bass and the rock bass, though, with the exception of a few thousand fingerlings of the latter, no fish of these species were distributed. Judging from the large numbers of fry observed in the ponds the results of the nesting season of the black basses were successful, but the actual outcome of the season at the close of the year was uncertain, the ponds not having been drawn down at that time.

The nesting of the rock bass did not meet with a large measure of success. The actual number of young fish of this species on hand at the end of June could not be determined, but it is doubted if the yield of fingerlings will justify the time and labor expended in their production. It is believed the brood fish have almost outlived their usefulness and steps will be taken to replace them with younger fish in advance of the next spawning period.

Owing to the necessity of conducting all operations on a reduced allotment no construction work other than minor repairs and improvements could be undertaken. However, in recognition of the importance of protecting the station against a recurrence of last year's disastrous flood preparations were in progress toward the end of June for the erection of a cement dike to run parallel to the streams running through the eastern end of the reservation, the actual work of construction to be undertaken in July. As planned, this barrier will extend approximately 2½ feet above the level of the ground and from 12 to 18 inches beneath the surface. It will be 7 inches in thickness, with a terraced embankment, to be filled in on the side nearest the hatchery.

NEOSHO (MO.) STATION AND SUBSTATIONS.

[Fred J. Foster, Superintendent.]

The scope of the work at this station was considerably enlarged during the year by extending its activities into new fields—in one case by the lease of property suitable for pond-fish culture, and in others by effecting agreements for the conduct of trout-cultural operations on a cooperative basis with private fish-culturists. One of the results of such extension has been the establishment during the year of a record collection of trout eggs, the total in round numbers amounting to 2,056,000, or 21½ per cent more than in any previous year in the station's history.

At the Neosho station 848,000 rainbow-trout eggs were collected between November 16 and February 19. This stock was materially reduced by losses, both in the egg stage and subsequently, and from it 181,965 fingerlings Nos. 2 and 3 were realized for distribution, with about 10,000 remaining on hand at the end of June.

It having been found that the best eggs at this station are the product of very young fish, a systematic policy of selective breeding and liberal feeding, with the object of increasing the percentage of early spawners, has been in progress for some time. The efforts in this direction are apparently bearing fruit, as the proportion of spawning trout under 2 years of age is steadily increasing, being now about double what it was before the experiments were instituted.

A slight deviation from past methods was made in the feeding of fry and small fingerlings. For the purpose of varying the diet the fish were given clabbered milk twice a day and beef heart three times a day. They took the milk readily and seemed to thrive equally as well as when fed exclusively on heart.

No definite cause could be assigned for a slight loss occurring in each lot of rainbow trout as they attained a length of 1¼ inches. A few of the fish showed what appeared to be an extremely minute threadworm in the intestines, but at 375 diameters these were hardly distinguishable. By immediately cutting off all food for a period of 24 hours and then giving nothing but clabbered milk for the succeeding four days the loss was reduced to normal proportions.

Late in April a more serious epidemic broke out in the troughs containing rainbow trout 2 or more inches in length, the more prominent symptoms being distortion of the head, faded-appearing gills, and an abnormally dark color, the latter being most pronounced among badly affected individuals. The kidneys showed disintegration with crystals. A careful examination by the bureau's pathologist failed to disclose the cause of the disease, but it is believed it may have been due to the presence of mineral substances in the water supply. There was no evidence of it among fish that had been removed from the hatchery to rearing ponds as fingerlings No. 1½, and thinning out of the young fish and early removal from the hatchery to rearing pools will hereafter be resorted to in the hope that a recurrence of the trouble may be averted.

The disease gyrodactylus developed in one pool of No. 2½ fingerling trout early in May, but was quickly dissipated by immersing the fish for a fraction of a minute in a 1:15 solution of pure cider vinegar. Ichthyophthirius made its appearance in one pond, but loss from this cause was prevented by immediately transferring the affected fish to another pond where they could be held in a good flow of running water.

Excellent results were attained in the hatching of a lot of 50,000 eggs from wild rainbow trout received on June 10 from the Bozeman (Mont.) station. The product of these eggs will be reared and reserved for a brood stock at Neosho and auxiliary stations.

The result of the season's work in the propagation of pond fishes at Neosho station was the poorest experienced in many years. This is attributed largely to adverse climatic conditions. An almost steady downpour of rain during May and early June, when the distributions usually occur, roiled the pond water to such an extent as to make the collection of fry impossible, and by the time the water had begun to clear the schools of fish had broken up and become dispersed among the dense vegetation in the ponds. Under such conditions it became necessary to carry over the entire crop for distribution as fingerlings in the fall.

An investigation conducted in May by the bureau's pathologist disclosed the prevalence of a parasitic affection among the pond fishes. The tapeworm (*Proteocephalus ambloplitis*) was found in the sunfish and in both species of black bass, the larval stage of this parasite heavily infesting the ovaries of some of the individuals examined. This trouble is believed to be one of the main causes for the poor success heretofore attained in the pond fish-cultural work at this station. So little is known of the nature of the organism, however, that prospects for its control do not seem bright, and in view of the circumstances it may be found advisable to discontinue the efforts to produce the two species of black bass and confine future activities in pond work to the propagation of the bluegill and green sunfish, which appear to be more resistant to the ravages of the parasite than any of the other species.

A consignment of 7,800,000 yellow-perch eggs was received late in March from the bureau's station at Bryans Point, Md. Of these eggs 3,680,000 were turned over to the Missouri State hatchery at Springfield, and from the remainder 3,500,000 fry were hatched and distributed to applicants for that species.

ROARING RIVER (MO.) SUBSTATION.

Work in this field, which is about 50 miles east of Neosho, was conducted on a share basis, the bureau receiving an equitable percentage of the eyed eggs obtained from the owner's stock of brood trout. The egg collections, made between November 27 and February 24, proved very disappointing, only 959,000, in round numbers, being obtained from a brood stock large enough to have produced at least twice that number. The small yield was attributed to underfeeding of the fish, and as this was a factor over which the bureau had no control, it was decided that the expense would not justify the results in future operations and the agreement was terminated at the end of the year.

BOURBON (MO.) SUBSTATION.

Bourbon is located in the eastern section of Missouri about 65 miles distant from St. Louis, and the property in which the bureau is interested belongs to the von Hoffman Press Association of that city. The cooperative arrangement entered into with this association stipulates that the bureau shall provide the services of a man to conduct fish-cultural work on the property, while the association will bear all expenses of construction and maintenance of the plant, including purchase of fish food and subsistence for the bureau's employees. The bureau is to receive at least two-thirds of all fingerling fish produced, with the understanding that they are to be liberated in Missouri waters.

The outcome of the first season's operations at this point was encouraging, nearly 250,000 eggs being taken from the 1,200 yearling fish comprising the brood stock. The fish had been well fed, and as regards both quality of eggs and number secured the results were far better than at Roaring River. The total cost of the work to the bureau was less than $115, and its share of the proceeds was 96,000 fingerling trout Nos. 2 and 2½, all of which were liberated in waters in the eastern section of the State. One of the most advantageous features of the work in this field is the saving effected in distribution cost, as the stocking of these waters with fish produced at Neosho station would necessarily involve heavy transportation expenses.

GREER SPRINGS (MO.) SUBSTATION.

This field station, also operated for the first time during the year, is located on land belonging to L. E. Dennig, of Oregon County, Mo., who desires the cooperation of the bureau in developing here a source of supply for rainbow-trout eggs. Apparently there is nothing to interfere with the success of this undertaking, as the flow of spring water is abundant, amounting to approximately 204,000,000 gallons per 24 hours, and the site appears to be well suited to fish culture in other respects.

Under the agreement effected with the owner the bureau is to supply not less than 50,000 rainbow-trout eggs annually, to be hatched and reared at his expense in pools which he has constructed, half the product in fingerling fish to be distributed locally and the other half to be at the disposal of the owner. Of the 70,000 fingerling fish resulting from 100,000 eggs developed at this point during the spring 30,000 were planted as fingerlings No. 1½ in Greer Springs Branch late in March. The remainder was held to the No. 2½ fingerling size and liberated early in June.

LANGDON (KANS.) SUBSTATION.

At this place, about 35 miles east of Hutchinson, Kans., the bureau recently leased from Eugene Catte a pond system approximately 6½ acres in area which had been successfully employed by him in past years in the production of black bass, bream, and crappie. These ponds having recently been used for goldfish culture, no brood fish of the various species desired were available, hence collections had to be made from wild fish and transfers arranged for from other stations of the bureau. By the 1st of April a brood stock consisting of 366 black bass, 391 sunfish, 425 crappie, and 58 rock bass had been assembled and installed in the ponds. Nesting and rearing activities progressed favorably to the close of the year, though some of the stock was lost during a heavy rain that flooded the pond early in June, washing away considerable numbers of fry and fingerlings. Owing to shortage of funds no distributions could be made from these ponds prior to the close of the fiscal year.

There are 13 other ponds belonging to farmers in the vicinity of Langdon, and with these men an agreement has been effected whereby the bureau is to collect at stated intervals the fish they are able to produce in their ponds, paying for them at a stipulated price per thousand.

WHITE SULPHUR SPRINGS (W. VA.) STATION.

[EDWARD M. HAYNES, Superintendent.]

The outcome of the year's fish-cultural work was the most successful ever experienced in this field, the distribution of eyed trout eggs being the largest in the station's history while the production of fish compared favorably with the record output established in 1922. In fact, the volume of the work has now reached a point where it can not be further extended without enlarging the hatching and rearing facilities of the station. The results secured were accomplished in the face of unusually difficult conditions. Lack of rain throughout the entire fall reduced the water supply in the hatchery and ponds to such an extent that a considerable number of the brood trout perished though every possible precaution was taken to save them. While this loss did not appear to reflect unfavorably on the egg collections, its full force will be felt in a considerable curtailment of the work next year because of the shortage of brood fish. The year's operations were also unfavorably affected by adverse weather conditions during the spawning season of the so-called pond fishes. Sudden and extreme temperature changes of air and water occurred repeatedly throughout the entire spring, causing the parent fish to desert their nests and resulting in heavy losses of eggs and fry.

The species handled were the rainbow trout, brook trout, largemouth and smallmouth black bass, sunfish, and rock bass, and the grand total of the distributions aggregated 2,653,826, of which number 1,097,500 were eyed eggs of the rainbow trout. With the exception of 114,500 black bass, which were distributed in the fry stage, all the remainder of the output consisted of fingerling fish of the various species mentioned, rainbow and brook trout predominating.

Notwithstanding the injurious effect of the abnormally low water stages upon the brood rainbows, some of which succumbed prior to the spawning period and others immediately after being stripped, the egg collections, amounting to 2,316,000, were the largest in the station's history. Their quality was also good, the percentage of hatch exceeding that of the previous year, while the reports on eyed eggs shipped to applicants were uniformly favorable. The output of fingerlings from this stock numbered 726,900. The fish were distributed somewhat earlier than in former years and to this fact is attributed the smaller losses sustained in shipment. The health of young trout is liable to become somewhat impaired when they are held for an extended length of time under the crowded conditions necessitated by the limited rearing facilities available at this station, and for this reason the practice of early distributions should be continued, the work to be started not later than the middle of March if possible.

All brook-trout eggs handled were purchased from commercial fish-culturists, no collections being made or transfers effected from other hatcheries of the bureau. The number received amounted to approximately 923,000, nearly half of them being paid for by the State of West Virginia with the understanding that the product hatched from an equal number of rainbow-trout eggs would be turned over to the State for distribution. Though the percentage of hatch was in excess of 96, the quality of the eggs as a whole was somewhat inferior and the losses of fry prior to the feeding stage were unusually heavy, especially on one lot that was badly affected by the disease known as "bluesac." The fish were distributed as fingerlings Nos. 1 and 2, the output amounting to 710,066 not counting 2,000 that were retained for future use as brood fish.

The output of black bass of both species amounted in round numbers to 117,000, or about 16,000 more than were distributed last year. Most of these were shipped in the advanced fry stage.

WYTHEVILLE (VA.) STATION.

[CHAS. B. GRATER, Superintendent.]

The output of this station amounted in round numbers to 695,000 eggs and fingerling fish, an increase of 63 per cent over the production of the previous year. About 25,000 of this number represented such pond fishes as the black bass, catfish, rock bass, and sunfish; 243,000 were eyed rainbow-trout eggs, and the remainder consisted of fingerling rainbow and brook trout.

On the stock of 1,044,000 eggs of the rainbow trout secured during the fall there was a loss of 347,500 owing to the presence of large numbers of defective eggs, known as "pinheads." Some of this heavy mortality was doubtless due to the advanced age of many of the brood fish, but it may also be attributed in large part to the poor physical condition of the brood stock as a whole, brought about by an insufficient water supply during the late summer and early fall when the flow from the spring was at a low ebb.

For the purpose of ascertaining the percentage of hatch a lot of eyed eggs was planted in a mixture of sand and gravel in one of the ponds. There were no results, but in another lot of the same age placed in nests of screened coarse crushed rock in a trough in the hatchery the mortality appeared to be very small, the fry emerging from the stones with the sac well absorbed within a period of two weeks.

At the beginning of the feeding stage two lots of fingerlings, equal as to numbers, size, and weight, were selected for the conduct of an experiment made to test the value of a commercial fish food composed of fish and cereal as compared with beef heart, the material in general use at this station for the feeding of fingerling fish. At the end of 60 days the lot that had been fed on beef heart showed an increased weight of 42.75 ounces as against a gain of 8.35 ounces for the fish receiving the commercial food. A second test was made with two equal lots of fingerlings that had been fed for a period of two weeks on beef heart. At the end of the 30 days' trial the lot that had been changed from the heart to the commercial brand of food showed a gain of only 12.75 ounces while the control lot had increased 24.75 ounces in weight.

Most of the adult fish at this station have been fed on liver and other slaughterhouse products in the past, but recently a change was made to beef heart mixed with varying proportions of mush. This diet has been found to result in a large production of eggs of good quality, and it is believed it will do much toward the eradication of thyroid tumor, which appears to have gained a foothold among the brood stock. The presence of this disease is believed to be due in large measure also to the method employed in cleaning the ponds. Under certain conditions it is necessary to wash all accumulations of sediment down through a pond containing fish to the outlet at a time when the depth of the water does not exceed 8 to 10 inches. This is not considered conducive to the health of the fish, since a large amount of the waste matter must pass through their gills.

With the view of improving the methods in this respect a bulkhead extending about 6 inches below the surface of the water was recently installed about 12 feet below the upper end of one of the ponds, with a gateway in the center of it. When cleaning this pond the water in the upper section is lowered and that portion cleaned first, after which a seine is passed around the fish, causing them to enter the cleaned portion; the gate is then lowered, and the remainder of the pond cleaned without subjecting the fish to insanitary conditions.

Acting on a suggestion from the fish pathologist, a small quantity of iodine solution was mixed with the food given to one lot of fish in the hope that it might tend to lessen, if not prevent, the development of thyroid tumor. Sufficient time has not yet elapsed to permit of any statement as to its effect upon the fish.

The pathologist discovered that a large number of ailing No. 1½ fingerling trout were infested with flagellate. It has been noted that the mortality among fingerling trout of this size is considerably greater than among older fish, and also that it is heavier in the spring than at any other season of the year.

The filtering system was used during the incubation period and up to the time the fingerling fish were distributed. By the use of a dropping device for the purpose of introducing sulphate of alumina in the water-supply tank, in varying amounts to meet the requirements, the turbidity of the spring water was greatly reduced, most of the sediment being precipitated to the bottom of the tank. This greatly lessened the work of caring for the eggs and fry and it is believed to have averted a large loss of fry, especially of the brook trout, which do not appear to be able to survive roily water. Considerable trouble was caused by the development of "pop-eye" among one lot of rainbow trout that had been held in water taken direct from the spring, but on transferring them to troughs containing water supplied by the filter the disease lessened and gradually disappeared.

The efficiency of the station was greatly increased during the year by the installation of 18 newly constructed troughs in the old hatchery building and arranging them so that the water supply can be drawn either from the filter or direct from the spring. These troughs have a capacity for 1,000,000 trout eggs, 750,000 fry, or 180,000 fingerlings No. 1.

The new hatchery has two hatching rooms. The one in the basement is equipped with 20 troughs arranged in a single series on iron-pipe supports, each trough being 13 feet 5 inches long, 14 inches wide, and 6 inches deep. The room on the floor above contains 40 troughs arranged in two series, and the water supply, which may be taken either from the filter or direct from the spring, is obtained from an open head trough. After passing through the first two troughs the water is carried into the waste ditch, and from there into the ponds containing the adult fish or directly into the creek, as may be desired. These two hatching rooms have a combined capacity for 3,540,000 eggs, 2,655,000 fry, or 590,000 fingerlings No. 1.

Early in the year arrangements were made for the thorough renovation of the bass ponds, which had become so filled with sediment and overrun with lilies as to have their usefulness greatly interfered with. A road scraper and team were employed so far as practicable to remove the sediment, which in many of the ponds was from 12 to 14 inches thick. In the ponds having soft bottoms it was found necessary to provide hard bottoms by first distributing a layer of coarse stones over the soil and filling the interstices with crushed rock.

Cement catch basins or kettles were installed in several of the ponds with the view of discontinuing the practice of drawing the small fish out into a screened box with the muddy water and then dipping them out with nets. This kettle, consisting of a cement basin about 5 feet wide and 12 to 14 feet long, with wide walls extending approximately 12 inches above the pond bottom, is set just ahead of the drain box. When the water has been lowered to a point level with the sides of the kettle all of it must then pass through the sluice gate cut into the side of the kettle next to the drain box. Following the water current, the little fish are naturally carried into the upper end of the kettle, where the water is comparatively clear.

POND FISH-CULTURAL STATIONS.

The output of the several stations composing this group was seriously curtailed by unfavorable weather conditions during the spawning season. Though unavoidable, this falling off is to be regretted as under the most favorable circumstances it has been found impossible to fully meet the demands for the so-called warm-water pond fishes, this applying especially to the two species of black bass. The aggregate output by species of these seven stations during the year was as follows:

Largemouth black bass	1,478,204
Smallmouth black bass	422,200
Sunfish	260,888
Crappie	6,980
Catfish	13,505
Rock bass	19,610
Warmouth bass	8,900

COLD SPRINGS (GA.) STATION AND SUBSTATIONS.

[CHARLES A. BULLOCH, Superintendent.]

The principal species produced at this station is the largemouth black bass and the pond space ordinarily devoted to the work is large enough to accommodate 800 brood fish. The persistent efforts made in advance of the spawning season to secure additional adult bass from various sources in Georgia and Florida to compensate for the losses that have occurred recently were unsuccessful, and in the face of a shortage of nearly 200 breeders two of the ponds were allowed to remain idle. The bass work was still further curtailed by a total lack of results in two other ponds that had been stocked with adult bass transferred early in the spring from Washington, D. C. Notwithstanding these discouraging factors, however, the station's production of fry and fingerling fish of this species exceeded last year's by 140,000, while the total output of the station and its Harris Pond auxiliary was nearly two-thirds larger than that of the fiscal year 1922.

Early in the year the pathologist made an effort to discover the cause of the heavy mortality occuring among the adult bass. No conclusion was arrived at, but it is the belief of the station superintendent that it is due to some deficiency in the food supply. Chopped mullet constituted the food supply of these fish during the year, and while the losses have been lighter than last year when beef heart was being fed to them, the mortality has, nevertheless, been much heavier than at other stations where the hearts are generally employed as a food for brood fish.

The year's production of crappie was almost negligible, only 1,500 fingerling fish being realized from one half-acre pond. For some unknown reason this species has never responded satisfactorily to artificial propagation at the Bullochville station.

Past experience at this station has demonstrated that ponds containing water throughout the year or remaining dry for only two or three months during the year are apt to produce large numbers of such injurious insects as Dytiscus, Gyrinidæ, and Hydracarina. With this in mind it was decided to drain all ponds immediately after completing the distribution in the late summer of 1922 and allow them to remain empty until late in February. Apparently this change was very beneficial. Not only were undesirable insects unusually scarce during the spring, but the ponds contained more daphnids, cyclops, chirinomids, and other natural food for young fish than ever before.

As the water from Cold Spring has always been pronounced too deficient in lime for the best results in fish-cultural work, an experiment was started in September with the view of ascertaining if this defect might be overcome by introducing lime in the supply. In a box 4 feet square and 2 feet high a false slat bottom was inserted, 1 inch of space being left below the slats. This was placed in one of the ponds, a layer of coarse gravel distributed over the slats, a 2-inch layer of sand over that, and finally a barrel of freshly slaked lime. A three-fourths-inch pipe was then installed in such a way as to force water up from beneath the slats and cause it to flow evenly through the gravel, sand, and lime into the pond. On May 1 when the box was removed it was found that all the lime had dissolved. As the results attained in this pond during the succeeding spawning season were not distinguishable from those in the untreated ponds, it is evident that the experiment had no beneficial effect upon the water supply.

In the course of the year Cold Spring, the main source of the station water supply, was covered with a shingle roof supported on 8-foot studding set in concrete blocks. The exclusion of leaves and débris was accomplished by inclosing the studding with wire poultry netting, and through the cutting off of the intense light to which the spring was subjected the growth of algæ will be largely prevented. In order to confine the water within the walls of the spring, which has always been difficult owing to the gravelly nature of the soil, a wooden bulkhead was set at a distance of 20 feet from the wall on the lower side and the intervening space filled in with red clay to a depth of 4 feet.

HARRIS PONDS (GA.) SUBSTATION.

Operations in this field extended from March 15 to the middle of October and consisted in the propagation of bluegill sunfish (bream) and catfish (*Ameiurus nebulosus*), the young fish being collected from the ponds in the Nos. 1 and 2 fingerling stages and transferred to Bullochville to be distributed with the fish shipped from that point. The outcome of the season's work was satisfactory, the production of sunfish exceeding that of any previous year, while sufficient numbers of catfish were distributed to fill all applications for that species. Fully 150 terrapin were captured in the ponds and destroyed during the season, and to this fact may be attributed a large measure of the success attained. However, a more serious menace to fish-cultural effort exists here in the form of numerous beetles of destructive species, and no successful method of combating it has yet been devised. The eggs of these beetles are deposited on the leaves of aquatic plants at or slightly above the surface of the ponds, where they are practically inaccessible. The supply of water from the springs is not sufficient to permit of changing levels during the spawning season, and the roiling of the water incident to wading into the ponds to cut the weeds would in all probability result in considerable losses through the smothering of the eggs.

At this field station the side ditches connected with the pond system were deepened and widened to exclude freshet waters and the shallow portions of several of the ponds were made deeper, the excavated material being utilized in the improvement of the division banks.

EDENTON (N. C.) STATION.

[W. S. VINCENT, Superintendent.]

In addition to the work concerned with the propagation of the anadromous fishes, mention of which may be found on page 54, the Edenton station produced the various pond fishes on a limited scale. Its output of such species during the year amounted to 62,920, of which the great majority were largemouth black bass fry and fingerlings. The remainder consisted of sunfish, catfish, and crappie, only negligible numbers of the two last named being produced.

LOUISVILLE (KY.) STATION AND SUBSTATION.

[CHARLES W. BURNHAM, Superintendent.]

Though pond fish-cultural activities at this station were concerned with four species of fish, the principal work, as in the past, consisted in the production of smallmouth black bass. Approximately 93 per cent of the year's distributions were of this species, the remainder being largemouth bass, rock bass, and sunfish, each of which was produced in about the usual numbers. Adverse weather conditions during the first half of April interfered with the spawning season, and shortly after nesting had begun a sudden cold spell occurred, killing all eggs that had been deposited. Aside from this the season was a normal one and, as four ponds had been devoted to the smallmouth bass work instead of three as in past years, the final results were larger by 57,000 than in 1922, the previous record year. This extension of the work was made possible by the receipt of 150 adult bass just prior to the spawning season from collections made in the Lake Erie field.

Adult bass for the enlargement and improvement of the brood stock have been received annually from Lake Erie collections for several years, some arriving in the fall and other lots in the early spring. During the past three years these various lots of fish have been segregated and special observations made with the view of determining whether those acquired shortly before the breeding season might be expected to produce as good results as the others. While no definite conclusion has been reached, it is the opinion of the station superintendent that this question is not a factor of particular importance, and that, other things being equal, spawning may be expected to occur regardless of the exact time the fish are received.

During the months of July, August, and September an aquarial exhibit of various species of fish collected from the Ohio River was maintained and proved a great attraction to the large numbers of visitors at the station.

CAIRO (ILL.) SUBSTATION.

The work at this point consists in salvaging food fishes that have become stranded in the sloughs or pools formed by the periodical flooding of the Ohio River. Owing to high water stages in these sloughs the collections could not be undertaken during the early fall. The work was started on November 13 and between that time and December 2 fish to the number of 1,207,750 were removed from temporary waters and returned to the river channel, the predominating species being catfish, crappie, and sunfish, in the order named. The total cost of the operations amounted to $415, or an average of less than 35 cents per thousand fish handled.

MAMMOTH SPRING (ARK.) STATION.

[Dell Brown, Superintendent.]

The work of repairing and improving the pond system, undertaken during the past fiscal year at this station, was extended well into the fall of 1922. Several unfinished pond banks were completed, a new levee was constructed to replace one that had been destroyed by muskrats, and 4-inch piping was purchased and installed to connect several of the ponds with the water supply. A sufficient amount of terra-cotta pipe for extending the supply to some of the unfinished ponds was also provided but not installed. During September and

October two abandoned ponds that had been allowed to grow up in weeds and bushes were cleared, and after plowing, harrowing, and leveling the soil, water was turned in and the bottoms thoroughly puddled by the use of a team and drag. The addition of these two ponds to the existing system will materially increase the pond fish-cultural facilities of the station. All buildings on the reservation, with the exception of the barn, were painted during the year, a number of minor repairs were made, and a considerable amount of grading and leveling was done on the grounds preparatory to sowing them to grass.

The corn received as rental for the use of a portion of the station reservation, together with the hay grown on the grounds and harvested by the station force, sufficed as feed for the station team practically throughout the year.

In view of the preparations made in advance of the spawning season for improving and enlarging the brood stock of the largemouth and smallmouth black bass, the results of the season's work were disappointing, the combined production of both species being but little in excess of 100,000 fingerlings. During the preceding fall and winter constant efforts had been put forth to acquire, by purchase and also by collections from open waters, all available adult bass not under 14 inches in length, and on April 15, when the collections ceased, the brood stock had been increased by the addition of 213 fish, giving a total of 500, of which 300 were largemouth bass. These fish had received as a regular diet throughout the fall and winter all the beef heart they would eat, in addition to about 50,000 common minnows obtained from neighboring streams. When apportioned among the breeding ponds their condition was most excellent.

The nesting of both species of black bass began on April 4 in a water temperature of 58°, and eggs were deposited freely throughout the spawning period in the four ponds devoted to the work. The spawning season of the smallmouth bass was completed by May 2, but eggs were deposited by the largemouth species up to and including June 10. The small results of the season's efforts were due to various adverse climatic conditions, among them being the cold, backward spring, sudden fluctuations in air and water temperatures, high winds, heavy rains, and muddy water. Suffocation of eggs and fry in the excessively muddy water experienced was probably responsible for the greater part of the loss sustained, taking the season as a whole, though starvation is believed to have been an important factor also, due to the inability of the fry to find sufficient natural food in the cloudy water. Moreover, it is reasonable to suppose that the natural food supply carried in the water during times of heavy rains and freshets is much smaller than when normal conditions obtain. The distribution of the smallmouth bass, consisting of 20,200 fingerlings Nos. 1 and 2, was completed in June, but collections of the largemouth species were still in progress when the year closed, the output up to that time amounting to 85,700 fingerlings. A compensating feature of the work was that all fish shipped were of fine quality, strong, and active.

From the single pond that had been devoted to the production of rock bass 17,600 fingerling fish were collected when the pond was lowered in October, 1922. The late fall distributions also included

14,000 sunfish (*Lepomis cyanellus*) and 400 crappie. The output of all of these fish was without doubt materially reduced through the ravages of a large number of pike, which were not discovered until the water was lowered to make the collections for distribution. These fish are believed to have gained access to the ponds through the supply pipe from the spring.

ORANGEBURG (S. C.) STATION.

[G. W. N. BROWN, Superintendent.]

The output of fish from this station, amounting in round numbers to 435,000, represents the most successful year in its history. The great bulk of the production consisted of fry and fingerling largemouth black bass, the distributions of which were in excess of 400,000. Most of the remainder were sunfish, with a few fingerlings each of the warmouth bass and catfish.

The most serious obstacle encountered during the year was the flooding of a portion of the pond system by the heavy rains occurring in July, 1922, and the consequent loss of a considerable number of young fish. Other than this, natural conditions were in the main favorable to fish culture and a change in methods is believed to have been a material influence in producing good results. Instead of confining the brood bass in two or three ponds during the winter, as heretofore, involving a second handling in the spring, the fish were apportioned among the breeding ponds immediately after the conclusion of the annual cleaning of the ponds, and were allowed to remain undisturbed to the end of the spring spawning. During the winter they were given all the food they would take, and their condition at the beginning of the spawning period was much better than under the old system of frequent transfer and handling.

A catfish pond, 3 feet by 30 feet in dimensions, divided by screens into three compartments to permit of a free circulation throughout its length, was constructed and 1 pair of catfish placed in each compartment, it being the intention to follow up the experiment of hatching in troughs instituted recently at the Fairport (Iowa) biological station.

The overflow of the levees early in the year necessitated prompt action, the work involving the excavation of a deep ditch and the construction of a levee in order to divert the flood waters and save the pond system. The levees between the two reservoirs were then raised to a height sufficient to guard against a recurrence of damage during periods of excessive rain. Two spillways were constructed—one at the outlet of the main reservoir leading into the drain and one at the small upper reservoir. The recent erection of a steel-wire fence around the reservation has added greatly to the appearance of the station and will afford pasturage for the station horse.

An interesting experiment was made during the breeding season to test the possibilities of artificial propagation as applied to the black bass. On March 5 a nest of approximately 4,500 freshly laid eggs was carefully removed from one of the ponds and placed in a trough on a cheesecloth-covered tray. The eggs were found to run

3,000 to the liquid ounce, measuring 17 to the linear inch. On March 7 the eye spot was visible and by the 10th all live eggs had hatched, the number of fry being estimated at about 600. The heavy loss of eggs indicated was doubtless caused by injuries received when they were counted. On March 23 the young fish rose from the tray as sac-absorbed fry and were soon feeding eagerly on beef heart that had been prepared for them by running it through a meat chopper several times, rubbing through cheesecloth, and finally converting it into a thin soupy solution by the addition of water. On April 9, one month and four days after the removal of the eggs from the pond, they were distributed as advanced fry, their number being 394.

SAN MARCOS (TEX.) STATION.

[MARK RILEY, Superintendent.]

There was a serious falling off in the production of fish at this station as compared with the work accomplished in 1922, the total distributions amounting in round numbers to 271.000, or considerably less than one-third of the record output established that year. The yield of the largemouth black bass, the most important species propagated, numbered 251,918, and 14,508 green sunfish (*Apomotis cyanellus*) were distributed. The other species handled during the year included crappie, rock bass, and warmouth bass, all of which were produced in negligible numbers.

The poor showing made in the year's fish-cultural work is attributed to excessive rains and severe cold prevailing prior to and during the early part of the spawning season. Weather conditions throughout the month of February were exceedingly unfavorable, and the sudden temperature changes experienced in March—the extreme range extending from 83° to 27°—proved very destructive to the nests of eggs. A determined effort was made to counteract these violent fluctuations of temperature by pumping into the ponds the warmer water of the San Marcos River, but it proved impossible to avert the disastrous losses of stock which occurred.

The station was compelled to cover the entire State, making many long trips that involved a much greater expenditure of funds than would have been necessary had the State fisheries authorities been able to cooperate as anticipated.

The inadequacy of the San Marcos station to meet the demands made upon it throughout the length and breadth of the State is every year becoming more apparent. Additional hatching centers are greatly needed. At the present time an undue proportion of the funds allotted for the work of the station is expended in shipping fish to applicants located at a great distance. Were it possible to eliminate the large expense annually incurred for transportation the funds thus saved would go a long way toward increasing the productiveness of the station.

In an effort to alleviate the situation the bureau has been negotiating with groups of interested citizens in different sections of Texas in an effort to secure financial cooperation in the construction of ponds where supplies of suitable fish may be raised to meet the demands of the immediate region, the management of such field work to be under Federal supervision. With this object in view two ponds have been constructed at New Braunfels, Tex., and funds sufficient for the construction of a small hatchery plant at Medina Lake have been contributed. Several other communities have expressed a desire to cooperate in fish-cultural work, among them being Fort Worth, where an abundant supply of water of good quality is available.

It is a matter of regret that the clear-water ponds at San Marcos are not adapted to the culture of crappie, the popularity of which in Texas is only second to that of the black bass. In an effort to respond in some measure to the urgent requests for this species the bureau has for some time been introducing crappie in cattle tanks belonging to stockmen located in various parts of the State, with the understanding that a certain percentage of the young fish produced therein shall be available for its distributions. While some success has been attained along this line the scheme is not an entirely satisfactory one owing to the liability of many of the waters to disappear entirely during the long periods of drought to which they are occasionally subjected.

For a number of years past water for the station ponds has been supplied by the San Marcos Utilities Co. at an annual expenditure of $500. The service was not entirely satisfactory and at the suggestion of the company the agreement was terminated. A pumping outfit was then installed by the bureau with the view of providing its own water supply and the results of the change have demonstrated its advantages over the old plan. During the last six months of the year the cost of keeping the ponds filled with water has amounted to $150.90, showing a saving of practically $100 for the period. It is also possible under the present arrangement to obtain water at any time, whereas 24 hours' advance notice had to be given the company under the former plan.

TUPELO (MISS.) STATION AND SUBSTATION.

[DAVID DAVIES, Superintendent.]

The Tupelo station produced a record output of fry and fingerling fish, the total amounting to 492,940, or more than 100,000 in excess of last year's output. This record was attained in spite of the heavy losses of eggs sustained late in March when a sudden cold spell and a drop of 17° in the water temperature caused many of the fish in the shallower portions of the ponds to desert their nests. All of the increase consisted in black bass, the production of both sunfish and crappie being somewhat smaller than in the previous year.

The new pond in course of construction during the past fiscal year was completed during the summer and fall and the pond was used for bass culture during the succeeding spring. This inclosure is of rectangular shape and covers an area of 2.14 acres. A considerable amount of repair work was done on the superintendent's residence and all buildings on the station were painted two coats of lead and oil paint, most of the work being done by the station force.

FRIAR POINT (MISS.) SUBSTATION.

On September 1 three employees of the Tupelo station with a temporary force of five men undertook the rescue of fish imprisoned in the shallow sloughs along the Mississippi River near Friar Point. Though unfavorable water stages delayed the operations fully 5 weeks beyond the usual time, and the work was hampered by inability to secure satisfactory auto-truck service, the number of fish secured during the season, which ended on November 23, was almost 100 per cent greater than in any previous year. The aggregate collections amounted to 1,644,239 miscellaneous fishes, the predominating species being sunfish, catfish, and buffalofish, in the order given. About 8 per cent of the collections were distributed to applicants and the remainder was returned to the main channel of the river.

CENTRAL STATION AND AQUARIUM, WASHINGTON, D. C.

[L. G. HARRON, Superintendent.]

Notwithstanding the limitations imposed upon the bureau's aquarial work in Washington, mention of which was made in the report of the division of fish culture for 1922, every possible effort was put forth to maintain as adequate a display of live fishes as the conditions would permit. So far as could be arranged for the methods of hatching employed at the different stations were illustrated, eggs for the purpose being forwarded to central station as

The following eggs were received during the

	15,000
	49,125
	24,515
	1,152,000
Pike perch	1,000,000
Total	2,240,640

A large percentage of hatch was obtained on the salmon and trout eggs, and the resulting fry were healthy and vigorous until January 6, when a fresh supply of chlorine was introduced into the city water supply by the health authorities. Two days afterwards it was apparent that practically all fish and eggs on hand were affected, but the mortality among the rainbow-trout fry was so heavy that the lot had to be disposed of and the fry were liberated in the west branch of the Patuxent River. The chinook and humpback salmon seemed to withstand the effects of the chemical much better for a time, but on January 12 they also began dying rapidly and all fry of both species in stock were at once delivered to the Maryland Conservation Commission, at Baltimore, Md. Two thousand eggs of the chinook salmon were held with the view of trying to eliminate the gas from the water supply, but the experiment failed, all fry perishing soon after hatching.

The whitefish eggs, which were of excellent quality, seemed to withstand the presence of the chlorine for about 10 days. A small mortality then occurred and continued until late in February, when it ceased, the eggs apparently having become immune. Of the 50,000 fry realized from this lot 3,000 were supplied to an applicant in New Jersey. The balance was held with the view of making observations as to their feeding habits, rate of growth, etc. The young fish eagerly took and appeared to thrive on a diet of pulverized beef heart, but in early May they began dropping off, the water temperature having become too warm. The last remnant of this lot survived until May 27, at which time they had attained a length of 1 inch.

A creditable display of adult fresh-water fishes was maintained during the early part of the fiscal year, but a few individuals included in a fresh lot of fishes brought in from outside sources were found to contain the parasite Ichthyophthirius. No heavy losses from this cause occurred during the winter, but with the rising of the water temperature in the spring the parasite multiplied rapidly and soon became so numerous that a large number of the fish were practically devoured by the ravages of the organism. Efforts directed toward the extermination of the affection through the application of strong limewater solutions were made and this work was progressing favorably at the close of the year.

Part 2.—DISTRIBUTION OF FISH AND FISH EGGS.

[E. C. FEARNOW, Superintendent of Fish Distribution.]

BRIEF REVIEW OF THE WORK.

The output of the bureau's stations (see table, p. 9) for the fiscal year ending June 30, 1923 (4,314,859,029 fish and fish eggs), was distributed throughout the States and a consignment of eggs of the black-spotted and rainbow trouts was sent to the Territory of Hawaii. Shipments of fish eggs were also made to the Governments of Canada, Argentina, Czechoslovakia, Germany, and the Netherlands. Approximately 90 per cent of the net output consisted of fish and fish eggs of commercial species which, except in instances where the eggs were shipped to State fish commissions (see table, p. 96), were planted in waters where the egg collections were made. The species handled in this manner were shad, glut herring, whitefish, cisco, salmons, pike perch, yellow perch, striped bass, cod, pollock, and flounder. The principal species available for stocking interior waters are as follows: Black-spotted, brook, and rainbow trouts, catfish, largemouth black bass, smallmouth black bass, rock bass, crappie, and bream. While only one-tenth of the bureau's output is diverted to inland waters, the importance of maintaining a supply of food and game fishes in the waters of the interior States is attaining greater significance with the increased cost of food and the desire of some 7,000,000 of the population for the wholesome recreation of fishing. The importance of this phase of the bureau's work is recognized by the leading railroad companies, which, in many instances, furnish transportation at a reduced rate for the movement of the bureau's distribution cars, and grant special courtesies to distribution employees carrying living fish in baggage cars.

Valuable aid is received from State fisheries authorities, fish and game associations, and public-spirited individuals who arrange for the transportation of the fish from the railroad stations to the waters where they are to be planted. A wholesome effect of such cooperation has been the development of a sentiment against the destructive methods of fishing common in some localities.

SUMMARIES OF DISTRIBUTION.

DISTRIBUTION TO ALL APPLICANTS.

The following table shows in summarized form the numbers and species of fish and fish eggs of the net output of the hatcheries for the fiscal year 1923 that were delivered to applicants:

Summary, by species, of distribution of fish and eggs to all applicants, fiscal year 1923.

[Asterisk (*) denotes eggs; all others are fry, fingerlings, or yearlings.]

UNITED STATES AND TERRITORIES.

State and species.	Number.
Alabama:	
Catfish	8,000
Buffalofish	20
Crappie	1,255
Largemouth black bass	426,400
Rock bass	550
Sunfish	94,800
Alaska:	
Humpback salmon	240,000
Sockeye salmon	71,444,936
Brook trout	*50,000
Arizona:	
Catfish	3,600
Rainbow trout	*5,000
Black-spotted trout	24,000
Brook trout	70,000
Largemouth black bass	1,165
Sunfish	210
Arkansas:	
Rainbow trout	16,800
Crappie	400
Largemouth black bass	60,700
Smallmouth black bass	3,200
Rock bass	19,075
Sunfish	18,525
Yellow perch	400,270
California:	
Chinook salmon	3,804,400
Silver salmon	*100,000
Black-spotted trout	*100,000
Lake trout	*100,000
Colorado:	
Catfish	3,750
Steelhead salmon	50,000
Rainbow trout	*25,000 64,000
Black-spotted trout	385,000
Loch Leven trout	12,150
Lake trout	*50,000 120,000
Brook trout	3,361,050
Crappie	1,400
Largemouth black bass	10,250
Rock bass	1,000
Sunfish	475
Yellow perch	900
Connecticut:	
Rainbow trout	10,500
Lake trout	*60,000
Brook trout	117,975
Smallmouth black bass	600
Pike perch	130,000
Yellow perch	105
Delaware:	
Largemouth black bass	3,731
Sunfish	5,355
Yellow perch	500,000
District of Columbia:	
Steelhead salmon	150
Largemouth black bass	75
Florida:	
Largemouth black bass	2,000
Georgia:	
Catfish	5,950
Rainbow trout	54,600
Brook trout	36,000
Crappie	645
Largemouth black bass	151,940
Rock bass	50
Sunfish	52,900
Idaho:	
Catfish	1,500
Whitefish	*1,000,000
Chinook salmon	1,100,700
Rainbow trout	190,000
Landlocked salmon	20,349
Black-spotted trout	*175,000 31,500
Brook trout	98,700
Illinois:	
Catfish	929,320
Carp	*3,000,000 347,910
Buffalofish	*22,230,000 157,975
Rainbow trout	485
Brook trout	545
Pike and pickerel	16,690
Fresh-water drum	222
Crappie	387,993
Largemouth black bass	8,390
Rock bass	100
Sunfish	739,530
Yellow perch	4,605
White bass	777
Miscellaneous fishes	886,795
Indiana:	
Catfish	7,380
Brook trout	60,000
Crappie	620
Largemouth black bass	22,155
Sunfish	9,020
Yellow perch	1,260
Iowa:	
Catfish	10,188,038

Summary, by species, of distribution of fish and eggs to all applicants, fiscal year 1923—Continued.

UNITED STATES AND TERRITORIES—*Continued.*

State and species.	Number.
Iowa—Continued.	
Carp	*18,000,000 8,152,470
Buffalofish	*12,825,000 6,108,685
Rainbow trout	*155,600 1,000
Lake trout	*75,000
Brook trout	5,875
Pike and pickerel	92,120
Fresh-water drum	16,294
Crappie	10,305,046
Largemouth black bass	68,854
Rock bass	750
Warmouth bass	80
Sunfish	5,695,870
Yellow perch	49,615
White bass	3,481
Miscellaneous fishes	8,174,647
Kansas:	
Catfish	600
Largemouth black bass	2,905
Sunfish	570
Kentucky:	
Catfish	755,600
Buffalofish	22,600
Crappie	307,125
Largemouth black bass	3,050
Smallmouth black bass	397,331
Rock bass	1,750
Sunfish	146,000
Louisiana:	
Catfish	2,278
Buffalofish	*128,114,500 5,952,300
Carp	1,015
Pike and pickerel	60
Crappie	15,456
Largemouth black bass	1,384
Sunfish	21,450
White bass	5,595
Fresh-water drum	12,225
Miscellaneous fishes	803,508
Maine:	
Atlantic salmon	491,038
Landlocked salmon	809,070
Lake trout	*50,000
Brook trout	913,900
Smelt	*16,280,000 28,000,000
Smallmouth black bass	3,169
White perch	675
Flounder	866,800,000
Maryland:	
Catfish	750
Carp	100
Shad	9,837,500
Whitefish	*192,000
Chinook salmon	*15,000 14,000
Humpback salmon	6,350
Rainbow trout	*115,000 39,800
Brook trout	3,450
Crappie	700
Largemouth black bass	3,564
Rock bass	600
Sunfish	580
Yellow perch	63,957,200
Massachusetts:	
Rainbow trout	17,900
Lake trout	*200
Brook trout	*200 243,156
Smallmouth black bass	9,000
Pike perch	355,000
Massachusetts—Continued.	
Cod	*650,980,000 376,813,000
Haddock	*104,400,000 2,960,000
Pollock	*33,960,000 276,098,000
Flounder	*229,345,000 159,032,000
Michigan:	
Catfish	2,700
Carp	30
Whitefish	*17,440,000 22,350,000
Cisco	*10,000,000
Steelhead salmon	40,000
Landlocked salmon	*15,825 10,000
Rainbow trout	62,000
Lake trout	*1,928,000 27,402,708
Brook trout	341,800
Crappie	2,625
Largemouth black bass	18,950
Smallmouth black bass	46,250
Sunfish	925
Pike perch	2,325,000
Yellow perch	300
Minnesota:	
Catfish	5,819,180
Buffalofish	24,593
Carp	1,008,865
Whitefish	1,025,000
Steelhead salmon	33,000
Rainbow trout	37,000
Lake trout	*200,000 1,595,000
Pike and pickerel	311,710
Brook trout	142,300
Crappie	11,018,770
Largemouth black bass	90,095
Rock bass	1,010
Sunfish	7,818,560
Pike perch	850,000
Yellow perch	519,740
Fresh-water drum	18,950
White bass	20,580
Miscellaneous	534,900
Mississippi:	
Catfish	313,085
Buffalofish	88,480
Carp	300
Crappie	8,524
Largemouth black bass	146,831
Rock bass	1,545
Sunfish	653,900
White bass	2,650
Missouri:	
Catfish	1,350
Rainbow trout	*463,360 115,290
Crappie	2,300
Largemouth black bass	41,378
Smallmouth black bass	17,038
Rock bass	3,240
Sunfish	13,171
Yellow perch	*3,680,000 2,000,150
Montana:	
Whitefish	*1,000,000
Steelhead salmon	*100,000 50,000
Rainbow trout	577,740
Black-spotted trout	*2,988,700 522,200
Lake trout	50,000

Summary, by species, of distribution of fish and eggs to all applicants, fiscal year 1923—Continued.

UNITED STATES AND TERRITORIES—Continued.

State and species.	Number.
Montana—Continued.	
Brook trout	*375,000
	849,450
Largemouth black bass	500
Nebraska:	
Catfish	454
Brook trout	54,000
Largemouth black bass	800
Yellow perch	450
Nevada:	
Steelhead salmon	*100,000
Rainbow trout	18,000
New Hampshire:	
Chinook salmon	*120,000
Steelhead salmon	*50,000
Landlocked salmon	*20,349
Rainbow trout	37,200
Lake trout	*50,000
	52,500
Brook trout	659,764
Smallmouth black bass	400
Pike perch	75,000
New Jersey:	
Whitefish	3,000
Steelhead salmon	*25,000
Rainbow trout	*100,000
Brook trout	27,000
Largemouth black bass	1,475
Smallmouth black bass	2,000
Sunfish	396
Pike perch	750,000
New Mexico:	
Catfish	9,900
Carp	180
Rainbow trout	*69,500
Black-spotted trout	*50,000
	284,000
Brook trout	*300,000
	180,000
Crappie	210
Largemouth black bass	2,050
Sunfish	1,040
Yellow perch	500
New York:	
Catfish	4,075
Buffalofish	30
Whitefish	*34,009,000
	85,300,000
Cisco	39,000,000
Steelhead salmon	*50,000
Landlocked salmon	1,400
Rainbow trout	*25,000
	92,800
Black-spotted trout	*10,000
Lake trout	*1,260,000
	1,696,000
Brook trout	607,600
Crappie	1,770
Largemouth black bass	15,710
Smallmouth black bass	7,394
Rock bass	2,000
Sunfish	1,880
Pike perch	600,000
Yellow perch	801,115
North Carolina:	
Catfish	575
Glut herring	150,000,000
Steelhead salmon	450
Rainbow trout	494,020
Brook trout	216,900
Crappie	120
Largemouth black bass	189,682
Smallmouth black bass	2,800
Rock bass	11,675
Warmouth bass	2,225
Sunfish	23,340
Yellow perch	500,000
Striped bass	16,341,000
North Dakota:	
Catfish	13,000
Buffalofish	1,110
Crappie	6,425
Largemouth black bass	1,800
Sunfish	1,965
Yellow perch	1,400
Ohio:	
Catfish	11,000
Carp	*8,000,000
	115,000,000
Whitefish	*22,400,000
	100,000,000
Steelhead salmon	*20,000
Rainbow trout	*60,000
Brook trout	18,000
Crappie	2,975
Largemouth black bass	8,150
Smallmouth black bass	4,475
Sunfish	3,650
Pike perch	*37,275,000
	51,100,000
Yellow perch	1,300,395
Oklahoma:	
Rainbow trout	119,000
Rock bass	200
Sunfish	1,860
Yellow perch	1,100,000
Oregon:	
Chinook salmon	*3,790,000
	6,038,500
Chum salmon	95,000
Silver salmon	2,633,600
Sockeye salmon	*5,045,000
Steelhead salmon	*410,000
	3,466,000
Rainbow trout	105,000
Black-spotted trout	*50,000
	27,500
Lake trout	25,000
Brook trout	25,600
Pennsylvania:	
Catfish	24,696
Buffalofish	50
Whitefish	*28,000,000
Rainbow trout	*831,060
	128,300
Brook trout	318,259
Crappie	2,354
Largemouth black bass	26,440
Smallmouth black bass	2,000
Rock bass	875
Sunfish	5,397
Pike perch	800,000
Yellow perch	1,201,920
Rhode Island:	
Flounder	32,949,000
South Carolina:	
Catfish	180
Rainbow trout	14,400
Brook trout	8,000
Largemouth black bass	227,864
Smallmouth black bass	1,900
Rock bass	274
Warmouth bass	5,975
Sunfish	17,410
South Dakota:	
Catfish	2,800
Rainbow trout	*310,440
	103,500
Loch Leven trout	25,650
Brook trout	593,400
Crappie	400
Largemouth black bass	7,650
Sunfish	570
Tennessee:	
Catfish	5,600

Summary, by species, of distribution of fish and eggs to all applicants, fiscal year 1923—Continued.

UNITED STATES AND TERRITORIES—Continued.

State and species.	Number.
Tennessee—Continued.	
Rainbow trout	*2,000
	86,110
Brook trout	18,800
Crappie	60
Largemouth black bass	48,133
Smallmouth black bass	2,750
Rock bass	5,400
Sunfish	10,275
Texas:	
Catfish	400
Rainbow trout	1,554
Crappie	4,300
Largemouth black bass	249,168
Rock bass	260
Warmouth bass	70
Sunfish	15,503
Utah:	
Catfish	28,400
Black-spotted trout	1,600
Rainbow trout	333,750
Lake trout	*150,000
Brook trout	270,400
Vermont:	
Steelhead salmon	*50,000
	8,300
Landlocked salmon	20,349
Rainbow trout	1,200
Lake trout	*130,100
	202,787
Brook trout	*100
	366,524
Smallmouth black bass	1,100
Virginia:	
Catfish	11,925
Carp	80
Shad	7,133,500
Rainbow trout	146,050
Brook trout	153,600
Crappie	225
Largemouth black bass	48,485
Smallmouth black bass	27,000
Rock bass	12,950
Sunfish	22,830
Yellow perch	64,568,750
Washington:	
Chinook salmon	*80,000
	18,727,445
Chum salmon	23,177,730
Humpback salmon	2,066,035
Washington—Continued.	
Silver salmon	11,648,055
Sockeye salmon	*534,484
	16,185,400
Steelhead salmon	*442,000
	1,963,105
Rainbow trout	53,000
Black-spotted trout	*105,000
	168,600
Brook trout	7,600
West Virginia:	
Catfish	1,275
Rainbow trout	*1,000
	583,600
Brook trout	667,066
Largemouth black bass	68,880
Rock bass	1,230
Sunfish	680
Yellow perch	300
Wisconsin:	
Catfish	18,930,221
Buffalofish	2,998,995
Carp	4,715,160
Rainbow trout	126,400
Lake trout	*3,000,000
	3,886,500
Brook trout	625,000
Pike and pickerel	484,815
Crappie	13,529,930
Largemouth black bass	170,945
Sunfish	11,475,595
Pike perch	6,380,000
Yellow perch	351,870
White bass	7,002
Fresh-water drum	1,335
Miscellaneous fishes	5,418,232
Wyoming:	
Catfish	5,400
Steelhead salmon	*75,000
Rainbow trout	*309,000
	531,160
Black-spotted trout	*6,331,400
	2,218,400
Lock Leven trout	6,000
Lake trout	*150,000
Brook trout	250,945
Largemouth black bass	7,400
Sunfish	25
Yellow perch	450

FOREIGN COUNTRIES.

Country and species.	Number.
Argentina:	
Steelhead salmon	25,000
Canada:	
Black-spotted trout	317,000
Steelhead salmon	400,000
Whitefish	44,000,000
Czechoslovakia:	
Rainbow trout	100,000
Germany:	
Rainbow trout	68,000
Netherlands:	
Chinook salmon	200,000
Rainbow trout	50,000
Total	45,160,000

ASSIGNMENTS OF FISH AND FISH EGGS TO STATE AND TERRITORIAL FISH COMMISSIONS.

The following table gives the numbers and species of fish and fish eggs delivered to State and Territorial fish commissions as applicants:

Assignments of fish and fish eggs to State and Territorial fish commissions, fiscal year 1923.

[Asterisk (*) denotes eggs; dagger (†) fry; all others are fingerlings.]

State and species.	Number.
Alaska:	
Brook trout	*50,000
Sockeye salmon	*5,098,936
California:	
Black-spotted trout	*100,000
Lake trout	*100,000
Colorado: Lake trout	*50,000
Connecticut: Lake trout	*30,000
Hawaii:	
Black-spotted trout	*50,000
Rainbow trout	*25,000
Idaho:	
Black-spotted trout	*125,000
Brook trout	900
Catfish	1,500
Rainbow trout	4,500
Whitefish	*1,000,000
Iowa:	
Lake trout	*75,000
Rainbow trout	*153,600
Louisiana:	
Black bass	24
Buffalofish	†1,200,000
Crappie	250
Sunfish	1,700
Maine: Lake trout	*50,000
Maryland:	
Brook trout	750
Chinook salmon	*15,000
Do	†4,000
Crappie	100
Humpback salmon	†3,350
Rainbow trout	400
Do	*114,000
Whitefish	*192,000
Michigan:	
Cisco	*10,000,000
Lake trout	†636,000
Minnesota:	
Black bass	600
Catfish	12,700
Crappie	17,900
Lake trout	*200,000
Sunfish	7,520
Yellow perch	100
Missouri:	
Rainbow trout	*50,000
Yellow perch	*3,680,000
Montana:	
Black-spotted trout	*1,599,000
Lake trout	*50,000
Steelhead salmon	*100,000
Whitefish	*1,000,000
New Hampshire:	
Chinook salmon	*120,000
Lake trout	*50,000
Landlocked salmon	*20,349
New Jersey:	
Rainbow trout	*100,000
Sunfish	88
New Mexico:	
Black-spotted trout	*50,000
Do	62,000
Brook trout	*300,000
Rainbow trout	*69,500
New York:	
Lake trout	*1,250,000
Whitefish	*31,885,000
North Dakota:	
Black bass	400
Buffalofish	1,110
Catfish	9,600
Crappie	5,550
Sunfish	1,330
Yellow perch	1,100
Ohio: Pike perch	*37,275,000
Oklahoma: Rainbow trout	119,151
Oregon:	
Black-spotted trout	*50,000
Chinook salmon	*4,000,000
Sockeye salmon	*5,045,000
Steelhead salmon	*370,000
Pennsylvania:	
Rainbow trout	*681,000
Whitefish	*28,000,000
Utah:	
Catfish	28,400
Lake trout	*150,000
Vermont:	
Lake trout	*130,000
Landlocked salmon	*20,349
Steelhead salmon	8,000
Washington:	
Sockeye salmon	*534,464
Steelhead salmon	*95,000
Do	50,000
West Virginia:	
Brook trout	352,000
Rainbow trout	500,000
Wisconsin:	
Black bass	8,350
Catfish	16,150
Crappie	7,800
Lake trout	*3,000,000
Do	†1,760,000
Wyoming:	
Black-spotted trout	*550,000
Do	†300,000
Lake trout	*150,000
Rainbow trout	*309,000
Total	*138,112,198 †3,903,350 1,219,973

METHODS OF DISTRIBUTION.

Each species of fish spawns at a certain time during the year and the resultant fry and fingerling fish are distributed as soon thereafter as practicable. The product of each season is distributed as the fish attain proper size for shipment, and only brood stock is carried over from year to year.

Applications for fish are filled in the order of their receipt, and the number that can be supplied for a particular body of water depends on the supply of the species desired and the size of the fish at the time of shipment. Owing to the greater value of fingerling fish for stocking purposes it is unnecessary to furnish them in as large numbers as fry. It is the policy in all cases to furnish a sufficient number of small fish to form a brood stock. The bureau refuses requests for black bass and allied predacious species for introduction into waters in California, Oregon, Idaho, Washington, Nevada, and western Wyoming, as their presence in such waters might prove harmful to the trout and salmon fisheries of that region.

Fish are delivered to the applicant's railroad station without expense to him. Formal applications to be properly executed should be indorsed by a United States Senator or Representative. Blanks on which application for fish may be made, together with full particulars concerning the bureau's method of distributing living fish, will be furnished upon request.

DISTRIBUTION OF FISHES OF INTERIOR WATERS.

CAR NO. 3.

[E. R. WIDMYER, Captain.]

On July 24, 1922, a carload of warm-water fishes was received from the La Crosse (Wis.) station and delivered to applicants in South Dakota, Nebraska, Wyoming, and Montana. On completing this trip the car proceeded to Bozeman, Mont., and took up the distribution of trout from the bureau's station at that place. After making 8 carload trips from Bozeman, the car was placed at the disposal of the Montana State Fish Commission for which it made 8 carload shipments. After completing the State work the car again returned to Bozeman, making a carload shipment of trout to Omaha, Nebr., from which point it proceeded to Dubuque, Iowa.

Owing to the fact that car No. 3 is of wooden construction, and that practically all main-line trains in Montana are of steel construction, the car was detached from trains frequently and left to lay over for from 12 to 18 hours at a time. However, all deliveries of fish were made in good condition, and from July 24 to October 29, the date on which it returned to Dubuque, Iowa, the car had made 9 trips for the bureau and 8 for the Montana Fish Commission, traveling 11,987 miles and delivering 2,981,650 fingerling fish.

In handling the Montana State distribution in conjunction with the Bozeman distribution great saving in transportaton can be brought about by cooperation of the Bozeman and State superintendents, and it is suggested that an advanced outline of their work for the season be furnished the captain in charge of the car.

In connection with the Montana distribution the Oregon Short Line was the only road that furnished free transportation for the bureau's car. The Chicago, Milwaukee & St. Paul Railway gave a 5-fare rate by special request only, all other roads charging 10 full fares.

The car was used in the distribution of warm-water fishes from October 29 until the close of the season, when it was placed in the Milwaukee shops for winter repairs.

The spring distribution of car No. 3 was begun on May 10, 1923, when a carload of trout was received from the La Crosse (Wis.) station and delivered to Wisconsin and Minnesota applicants. The car then proceeded to Duluth, Minn., where the distribution of trout and whitefish was taken up from the Duluth station. From May 13 to June 20 the car and its messengers shipped from the Duluth station 2,625,000 whitefish fry, 11,495,000 lake-trout fry, 7,630,000 pike-perch fry, 90,000 steelhead-trout fry, and 135,000 brook-trout fry, a total of 21,975,000 fish. On June 21 the car left Duluth for Manchester, Iowa, from which station a carload of fingerling trout was obtained for delivery to Minnesota and Wisconsin applicants, the car returning to La Crosse.

While engaged in the Duluth distribution the Fearnow pails were given a thorough trial and found to be far superior to the 10-gallon round-shouldered cans for transporting fish, and the car's equipment is being changed to carry a complete set of pails.

During the fiscal year ended June 30, 1923, car No. 3 traveled 14,815 miles and delivered 24,956,650 fish.

CAR NO. 4.

[FRED W. A. ENGELHARDT, in charge.]

On July 18, 1922, the initial trip of the season was made from Dubuque, Iowa, to Marquette, Iowa, where the car received consignments of river fishes for distribution en route to Malta, Colo. A part of the load was delivered at Burnham, Colo., but the bulk of it was distributed to applicants at Denver. The car then proceeded to Malta, from which point shipments of trout were to be made, arriving there July 25. Owing to the fact that the black-spotted trouts were not sufficiently developed, the distribution of that species was delayed until August 14. In the meantime the crew was engaged in making messenger shipments of brook and rainbow trouts to various points in Colorado.

During August, 1922, car trips with brook and black-spotted trouts were made from Malta, Colo., to Trinidad, Colo., and to Albuquerque, N. Mex. In the latter part of the month a washout in the road between Florence and Pueblo, Colo., caused a delay of 24 hours in the car schedule. In September a car trip with brook and black-spotted trouts was made from Malta to Las Vegas, N. Mex. While en route, the Colorado Fuel & Iron Co., at Trinidad, Colo., was supplied with an "owner's share" of brook and black-spotted trouts. Messenger trips with trouts to various points in Colorado were also made during the month.

While en route from Malta to Dubuque, Iowa, the car was detached from an all-steel train. This happens occasionally and sometimes causes a delay of 24 hours or more. During October car trips with river fishes were made from Marquette, Iowa, to Kansas City, Mo., and Williamsport, Pa.

The car then returned to Washington, D. C., to remain during the winter. During part of the time, however, it was at the Wilmington (Del.) shops undergoing repairs. In June, 1923, the car proceeded from Washington to Northville, Mich., in order to take up the distribution from that point. While at Northville the car crew made messenger shipments to various points in Michigan, and also assisted the station crew in collecting fish, raking moss, and cleaning ponds. Car trips with smallmouth black bass and trout were made from

Northville to Detroit and to Auburn, N. Y., messenger shipments being made en route.

After finishing the Northville distribution the car was prepared to make a trip to La Crosse, Wis., in order to take up the distribution of river fishes during the fiscal year 1924. The car was furnished with 140 Fearnow aluminum pails with which to carry on future distributions.

During the fiscal year 1923 it was impossible to secure any free transportation. In July, 1922, the Burlington Route agreed to handle the car from Omaha, Nebr., to Denver, Colo., for five full fares. The Denver & Rio Grande Western Railroad refused free transportation, but agreed to handle the narrow-gauge baggage cars that are used to distribute carload lots between Alamosa, Colo., and Durango, Colo., for five full fares.

During the fiscal year 1923 car No. 4 traveled 9,362 miles and distributed 46,355 river fishes and 1,080,500 trout.

CAR NO. 7.

[E. M. LAMON, Captain.]

On July 20, 1922, the distribution from the La Crosse (Wis.) station was taken up. Approximately 45,000 fingerling pond fishes were distributed in Wisconsin, Minnesota, North Dakota, and South Dakota, by messenger shipments from La Crosse. From July 20 to October 27, 128,825 fingerling pond fishes were distributed to applicants in Wisconsin, Michigan, North Dakota, South Dakota, Missouri, Illinois, Ohio, Indiana, West Virginia, Maryland, and New York. The car left La Crosse on October 25 on its last trip for the season with a carload of miscellaneous fishes for applicants in the vicinity of Washington, D. C., the shipment including a number of specimens for central station. The car arrived in Washington on October 27, and after the distribution work was completed it was placed in the United States Navy Yard for general repairs, and the messengers were detailed to stations for the winter to assist in fish-cultural work.

On March 2, 1923, the car left Washington to take up the trout distribution from the Erwin (Tenn.) station. Between March 2 and April 15, when the Erwin work was completed, 245,000 fingerling brook trout and 465,700 fingerling rainbow trout were distributed in Tennessee, North Carolina, South Carolina, and Georgia. From Erwin the car proceeded to Wytheville, Va., making a trip from the Wytheville station to Pennsylvania with 52,200 fingerling brook trout and 16,000 fingerling rainbow trout, returning to White Sulphur Springs, W. Va., and taking up the trout distribution from that station. Between May 1 and June 15, 249,850 fingerling brook trout and 156,100 fingerling rainbow trout were distributed from the White Sulphur Springs station in West Virginia, Maryland, Pennsylvania, and New York.

The work at the White Sulphur Springs station could be greatly improved if cooperation could be effected with the Chesapeake & Ohio Railway Co. and the bureau's cars given the same service by it that they receive from other leading railroads of the country.

The Fearnow transportation pails have been very successfully used during the year and the car is now fully equipped with them. A trip was made from Manchester, Iowa, to Madison, Wis., just before the close of the fiscal year, and 200 of these pails were very successfully transported on one trip. It is found that by using these pails instead of the standard 10-gallon cans the carrying capacity of the car can be increased over 50 per cent, with no increase in weight.

During the fiscal year 173,825 fingerling pond fishes, 614,200 fingerling brook trout, and 1,267,400 fingerling rainbow trout were distributed by the car in 23 trips, 18,685 miles being traveled.

CAR NO. 8.

[E. K. Burnham, Captain.]

At the beginning of the fiscal year fisheries car No. 8 was engaged in the distribution of brook and rainbow trouts from the Duluth (Minn.) hatchery; the season closed with the completion of the salmon and trout distribution from the Craig Brook (Me.) hatchery.

While the car was undergoing general repairs at the Washington Navy Yard during the winter its interior was sufficiently rearranged to permit of the installation of a small dining room capable of accommodating four persons at the table. The dining room has eliminated the annoyances attendant upon the former practice of setting up a table for each meal at the center of the car, thus blocking the aisle.

By the adaptation of the fish compartment on one side of the car for carrying 100 aluminum fish pails, the capacity of the car has been increased from 140 cans to 170 cans of fish. At the close of the fiscal year the fish compartment on the other side of the car was changed by the car crew to make the total capacity of the car 216 aluminum fish pails. Nearly all minor repairs and many of the changes and improvements in the car are made by the regular car crew while distribution work is not in progress.

The most important improvement made to the car during the year was the installation of an electrically driven air pump. This pump furnishes 5 cubic feet of free air per minute and is operated by a one-half horsepower electric motor, the electricity being obtained from the storage batteries of the car's electric lighting system. An important saving is effected by using this electricity for pumping air for the fish, as during the last fiscal year the car used approximately 8 tons of anthracite coal to generate steam for pumping air.

During the fiscal year 1923 the car was engaged in the distribution of fish from nine of the Federal hatcheries. Fourteen species of food fishes were distributed to suitable waters in 19 States, the farthest west being Utah. During the year the car handled over 1,500,000 fingerling and yearling fish. During the course of the year the car traveled on 19 different railroads, the total miles traveled being 18,823. Nineteen and one-half tons of ice were used during the year for maintaining a suitable water temperature for the fish.

CAR NO. 9.

[A. H. KERTH, Captain.]

Car No. 9 made 17 trips during the fiscal year 1923, covering a total distance of 18,275 miles, and supplying 1,076 applicants in the Middle Western, Southwestern, Eastern, and Southeastern States. The numbers and species of fish delivered during the year are as follows:

	Number.
Catfish:	
Fingerlings	33,100
Yearlings	1,200
Buffalofish, fingerlings	150
Carp, fingerlings	230
Rainbow trout, fingerlings	84,000
Brook trout, fingerlings	528,600
Pike and pickerel, adults	160
Crappie:	
Fingerlings	625
Yearlings	1,135
Adults	54
Largemouth black bass:	
Fingerlings	52,195
Adults	160
Smallmouth black bass, fingerlings	8,775
Warmouth bass, fingerlings	80
Sunfish:	
Fingerlings	9,790
Yearlings	5,240
Pike perch, fry	2,100,000
Yellow perch, fingerlings	3,250
Crappie and bream, yearlings (carload shipment)	9,000
Miscellaneous, assorted sizes, specimens	740
Total	2,838,484

No extensive repairs have been made to car No. 9 during the past year; neither has it been equipped with the Fearnow aluminum transportation pails (for description see U. S. Bureau of Fisheries Doc. 941, pp. 90–98), but a number of these pails are to be forwarded in the near future.

A new style aerator for use by messengers when carrying fish on detached shipments has been furnished by the Washington office (see description, p. 102) and has proven very satisfactory.

An aerating device of the jetting design has also given quite satisfactory results.

The total number of miles traveled by the car during the fiscal year was 18,275.

NEW EQUIPMENT FOR USE IN SHIPPING LIVE FISH.

ELECTRIC AIR COMPRESSOR.

During the spring of 1923 there was installed on fisheries car No. 8 an air compressor operated by a one-half horsepower electrically driven motor, connected with the storage batteries used for lighting the car. The entire outfit is only 28 inches long, 18 inches wide, and 2 feet in height, and is placed on a shelf in the boiler room. This device has been used successfully on a number of occasions for furnishing compressed air for aeration of the water in the fish containers, and obviates the necessity of using the steam boiler for this purpose during the summer months, thereby effecting a considerable saving in the amount of coal used. The device has been used to

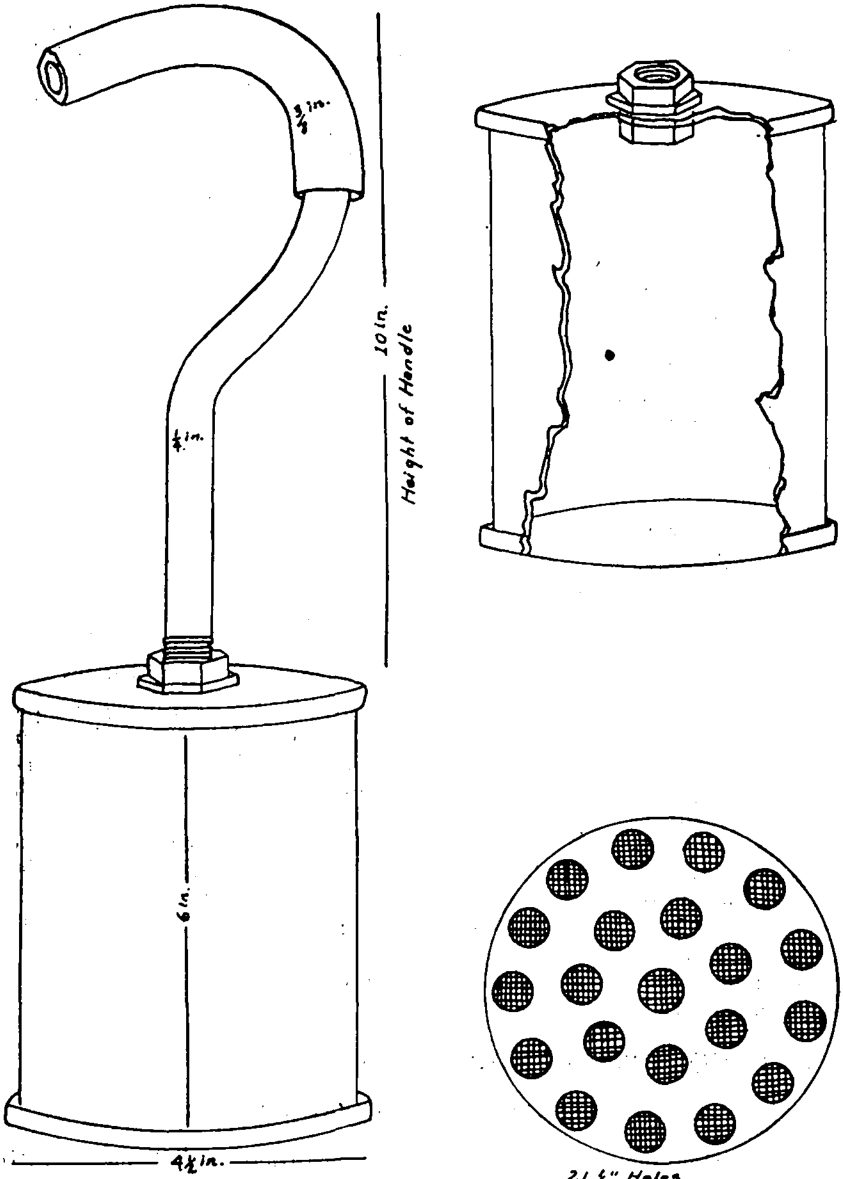

FIG. 1.—Improved device for aerating water in fish cans and removing sediment therefrom. The handle may be disconnected and the entire outfit carried in a small suitcase.

aërate 140 cans of fish for 14 hours without producing any apparent deterioration in the batteries, which have a capacity of 375 ampere hours.

"QUESTION MARK" AERATOR.

Within the last year the dipper that was used for aerating water has been largely replaced by the "question mark" aerator—so named on account of the bend in its handle—which is made of one-fourth inch pipe and serves as an air vent and means for suspending the aerator in a fish can when not in use. The cylinder of the aerator is made of galvanized rain spouting and is 4½ inches in diameter by 6 inches in length. The bottom contains 21 circular openings, which are screened to prevent fish from entering the cylinder. The handle may be unscrewed and the device carried in a small hand bag.

The device provides quick and efficient aeration, does not injure the fish, can be used to remove sediment or to lower the water in a container, and has a number of other advantages over the ordinary dipper. This aerator has met with general approval, as it seems to answer the bureau's needs better than any device that has been used heretofore.

JET AERATOR.

During the spring and summer of 1923 a new aerating device that circulates the water in the container and operates by air was used on the distribution cars to a limited extent and with very satisfactory results. This aerator was devised for the purpose of aerating the water and removing the carbon dioxide gas given off by the fish.

The device consists of a tube placed on the inside of a larger tube, care being taken to allow room enough to permit the water to be forced up in the space between the two tubes. Experiments with this device are still being carried on, and while its practicability is not generally perceived at the present time it is believed that it will be more fully appreciated when further improvements have been made in other transportation equipment.

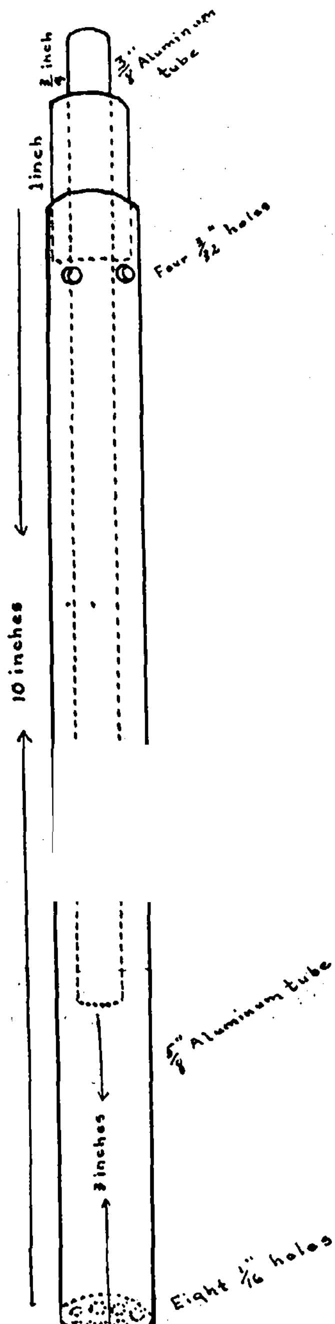

FIG. 2.—Device for circulating and aerating water in fish cans by means of compressed air.

AQUARIUM CLEANER.

The principle of the jet aerator may be successfully applied to a device for cleaning aquaria, as shown in Figure 3. It is necessary to use only a small amount of air in order to force waste material from the bottom of the aquarium to a receptacle on the outside. In fact, the air may be regulated so as to remove sand and gravel from the bottom of the aquarium. It is obvious that the lower end or intake should be provided with means for preventing the entrance of pebbles too large to pass through the outlet.

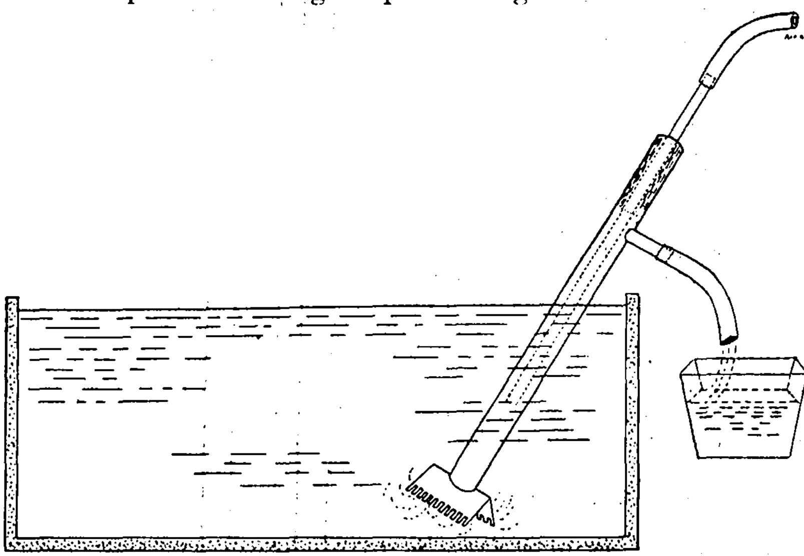

FIG. 3.—Aquarium cleaner operated by air pressure in the same manner as Figure 2.

COST OF DISTRIBUTION.

During the fiscal year 1923 the bureau honored 10,939 applications for fish, as compared with 10,376 in 1922. The following table gives comparative figures showing the cost of distribution for the fiscal years 1922 and 1923:

Fiscal year.	Number miles traveled.		Number of applications honored.	Cost of distribution.
	Cars.	Messengers.		
1922	77,128	306,215	10,376	$62,428.96
1923	80,118	345,387	10,939	58,751.71

During the past 20 years the output of the bureau's hatcheries has increased nearly 500 per cent, while the cost per thousand for transporting fish has been reduced 50 per cent during this period. In order to bring about this important reduction in distribution cost at a time when the cost of transportation, material, and supplies was unusually expensive, it has been necessary to adopt the most improved methods of carrying living fish and at the same time exercise the most rigid economy.

The following table shows the magnitude of the bureau's distribution problem and the gradual reduction of distribution expenses that has been made during the past 20 years:

Comparison of the number of miles traveled by the bureau's cars and messengers and the cost of distribution from 1903 to 1923, inclusive, exclusive of salaries of statutory employees.

Year.	Total output of fish.	Miles traveled.						Total cost of distribution.	Cost of distribution per 1,000 fish.
		Cars.			Messengers.				
		Paid.	Free.	Total.	Paid.	Free.	Total.		
1903	1, 226, 057, 475	52, 852	26, 526	79, 378	174, 535	85, 492	260, 027	$33, 437. 55	$0. 027
1904	1, 267, 343, 025	55, 028	15, 193	70, 221	150, 019	98, 957	248, 976	27, 923. 46	. 022
1905	1, 750, 475, 039	68, 532	14, 262	82, 794	184, 249	113, 701	297, 950	35, 405. 74	. 020
1906	1, 931, 834, 609	82, 308	11, 060	93, 368	216, 664	108, 757	325, 421	36, 999. 39	. 018
1907	2, 511, 597, 377	72, 014	11, 826	83, 840	182, 380	80, 816	263, 196	38, 520. 30	. 015
1908	2, 871, 456, 280	68, 495	8, 581	77, 076	299, 957	64, 913	364, 870	39, 008. 45	. 013
1909	3, 107, 131, 911	103, 476	5, 403	108, 879	309, 509	100, 085	409, 594	51, 825. 72	. 016
1910	3, 233, 012, 237	93, 413	2, 850	96, 263	332, 410	97, 943	430, 353	50, 155. 03	. 015
1911	3, 646, 294, 535	92, 993	7, 911	100, 904	336, 977	84, 281	421, 258	56, 543. 17	. 015
1912	3, 687, 921, 057	78, 957	13, 913	92, 870	359, 611	90, 661	450, 272	49, 308. 75	. 013
1913	3, 863, 593, 282	110, 823	12, 294	123, 117	392, 698	85, 837	478, 535	64, 148. 01	. 016
1914	4, 047, 643, 417	128, 156	3, 000	131, 156	387, 072	93, 463	480, 535	69, 255. 44	. 017
1915	4, 288, 757, 804	125, 553	20, 991	146, 544	395, 298	95, 874	491, 172	79, 922. 31	. 018
1916	4, 847, 202, 566	133, 825	15, 956	149, 781	521, 158	124, 563	645, 721	77, 984. 91	. 016
1917	5, 158, 963, 293	122, 778	15, 939	138, 717	474, 141	80, 456	554, 597	81, 383. 93	. 015
1918	4, 098, 105, 159	92, 306	10, 024	102, 330	413, 666	54, 578	468, 244	73, 559. 05	. 017
1919	5, 876, 985, 350	93, 891	3, 680	97, 571	421, 202	7, 740	428, 942	74, 599. 43	. 012
1920	4, 770, 355, 720	92, 419	------	92, 419	382, 891	10, 042	392, 933	73, 586. 40	. 015
1921	4, 962, 489, 405	84, 188	872	85, 060	353, 893	32, 095	385, 988	72, 176. 57	. 014
1922	5, 125, 101, 320	75, 032	2, 096	77, 128	285, 807	20, 408	306, 215	62, 428. 96	. 012
1923	4, 314, 859, 029	78, 595	1, 525	80, 118	307, 983	37, 404	345, 387	[1] 58, 751. 71	. 013

[1] $4,000 of this amount was spent for new equipment.

Method of distribution, by stations, species, number and size of fish, and costs.

DISTRIBUTION BY CAR MESSENGERS.[1]

	Species.	Number of fish.	Size.	Total cost.	Average cost per thousand.	Miles paid.	Miles free.
Bozeman, Mont.	Trout	23, 900	Fry	$13. 07	$0. 547	161	------
	do	70, 750	Fingerlings, 1-inch	48. 77	. 689	728	------
	do	216, 150	Fingerlings, 1 to 4 inch	241. 45	1. 112	3, 923	1, 471
Craig Brook, Me.	Salmon	682, 500	Fry	104. 55	. 153	1, 717	------
	do	40, 000	Fingerlings, 2-inch	81. 27	2. 317	919	56
	Pond fishes	96	Adult	54. 19	564. 468	690	92
	Trout	83, 200	Fry	13. 70	. 165	112	32
	do	469, 000	Fingerlings, 1-inch	101. 97	. 218	2, 070	------
	do	110, 200	Fingerlings, 1½-inch	41. 20	. 374	573	------
Duluth, Minn.	do	23, 000	Fingerlings, 1-inch	23. 12	1. 005	414	------
Erwin, Tenn.	Pond fishes	539, 500	Fry	92. 26	. 670	678	------
	Trout	190, 150	Fingerlings, 1 to 2 inch	137. 45	. 723	1, 604	------
Leadville, Colo.	do	462, 000	Fingerlings, 1-inch	365. 93	. 792	5, 528	------
	do	275, 500	Fingerlings, 1½-inch	140. 08	. 507	1, 615	------
	do	36, 000	Fingerlings, 2½-inch	78. 08	2. 169	907	------
Manchester, Iowa	do	72, 200	Fingerlings, 1 to 1½ inch.	56. 53	. 783	3, 666	------
	do	64, 800	Fingerlings, 1½-inch	68. 31	1. 064	668	------
	do	184, 600	Fingerlings, 2½-inch	166. 67	. 903	2, 157	------
Northville, Mich	Pond fishes	6, 000	Fingerlings, 1-inch	91. 03	15. 171	1, 377	712
	do	7, 200	Fingerlings, 2-inch	102. 00	14. 167	1, 325	------
	do	1, 575	Fingerlings, 2 to 3 inch	30. 21	19. 117	540	------

[1] Detached messenger shipments from cars. Cost in addition to "distribution by car."

Method of distribution, by stations, species, number and size of fish, and costs—Continued.

DISTRIBUTION BY CAR MESSENGERS—Continued.

	Species.	Number of fish.	Size.	Total cost.	Average cost per thousand.	Miles paid.	Miles free.
Upper Mississippi.[2]	Pond fishes	16,300	Fingerlings, 1-inch	$56.87	$3.428	1,016	------
	do	3,944	Fingerlings, 2-inch	49.32	12.505	560	------
	do	25,520	Fingerlings, 2 to 3 inch	242.31	9.137	2,781	176
	do	46,795	Fingerlings, 3-inch	362.21	7.740	4,878	------
	do	2,200	Fingerlings, 4-inch	34.26	15.573	--------	598
	do	103,053	{Fingerlings, 1-inch {Yearlings	831.55	8.070	11,729	------
	do	84,559	{Fingerlings, 1-inch {Adults	1,004.77	11.871	13,558	------
	do	496	Yearlings	21.45	43.271	294	94
	Trout	111,000	Fingerlings, 1-inch	59.27	.534	948	------
	do	28,800	Fingerlings, 1½-inch	23.21	.806	280	------
White Sulphur Springs, W. Va.	do	54,000	do	45.93	.851	561	------
	do	31,125	Fingerlings, 1½ to 2½ inch.	62.81	2.018	855	------
	do	231,200	Fingerlings, 2-inch	381.49	1.217	3,809	312
	do	750	Fingerlings, 3-inch	35.56	47.413	666	------
	do	43	Adults	27.64	642.791	490	------
Wytheville, Va.	do	10,000	Fingerlings, 1-inch	10.62	1.062	120	------
	do	51,750	Fingerlings, 1½-inch	48.54	.938	698	------
	do	17,500	Fingerlings, 1½ to 2½ inch.	25.42	1.452	195	------
	do	84,100	Fingerlings, 2-inch	104.32	1.240	1,460	26

DISTRIBUTION BY STATION MESSENGERS.[3]

Bozeman, Mont.	Trout	100,000	Fry	$31.95	$0.320	594	------
	do	133,000	Fingerlings, 1-inch	63.09	.474	1,148	------
	do	99,950	Fingerlings, 1 to 2 inch	72.16	.722	1,170	271
Cape Vincent, N. Y.	Lake herring	3,000,000	Fry	19.46	.006		
	Pike perch	600,000	do	26.65	.045	204	914
	Whitefish	10,190,000	do	43.71	.004		
	Trout	583,000	do	165.08	.284	1,172	4,153
Central Station	Pond fishes	2,000,000	do	23.15	.012	420	------
	do	6,000	Fingerlings, 1½-inch	24.95	4.159	511	------
	do	10,000	Fingerlings, 2-inch	50.97	5.097	794	------
	Trout	33	Adults	26.79	811.818	490	------
Clackamas, Oreg.	Salmon	6,000	Fingerlings, 1-inch	55.53	9.250	638	------
	Trout	218,500	Fry to fingerlings, 2½-inch.	43.24	.198	863	------
	do	122,000	Fingerlings, 1-inch	127.58	1.046	2,291	------
	do	102,000	Fingerlings, 1½-inch	101.17	991	1,614	------
	do	7,000	Fingerlings, 2½-inch	14.85	2.120	377	------
Craig Brook, Me.	do	40,000	Fingerlings, 1½-inch	35.34	.893	610	------
Duluth, Minn.	Whitefish	2,700,000	Fry	24.80	.009	--------	------
	Pond fishes	5,715,000	do	124.64	.022	1,845	------
	do	1,150,500	Fry to fingerlings, 1½-inch.	190.75	.165	2,869	------
	Trout	8,890,000	Fry	1,026.33	.115	406	------
	do	840,000	Fry to fingerlings, 1-inch.	72.71	.087	1,048	------
	do	115,000	Fingerlings, 1-inch	134.59	1.169	2,113	------
	do	56,000	Fingerlings, 1½-inch	65.85	1.177	1,015	------
Edenton, N. C.	Shad	200,000	Fry	10.52	.052	180	------
	Pond fishes	34,625	Fry to fingerlings, 1½-inch.	118.96	3.435	2,099	------
	do	9,600	Fingerlings, 1-inch	19.91	2.250	328	------
	do	13,450	Fingerlings, 1½-inch	72.71	5.406	1,157	------
	do	3,745	Fingerlings, 1½ to 4 inch	38.98	10.410	696	------
Erwin, Tenn.	Salmon	600	Adults	39.18	65.300	500	------
	Trout	39,800	Fingerlings, 1 to 2-inch.	17.40	.438	160	------
	do	23,500	Fingerlings, 2-inch	21.71	.924	208	------
	do	126,000	Fingerlings, 2½-inch	76.31	.616	836	------
	do	7,500	Fingerlings, 3 to 4 inch	71.86	9.580	805	------
	Pond fishes	43,862	Fingerlings, 1 to 4 inch.	361.47	8.240	5,785	------
	do	88	Adults	28.75	326.705	443	------
Hartsville, Mass.	do	325,000	Fry	27.29	.084	387	------
	Trout	261,400	Fingerlings, 1 inch	81.48	.031	1,169	------
	do	4,400	Fingerlings, 1½-inch	15.88	3.600	202	178

[2] La Crosse, Wis.; Bellevue, Iowa; Marquette, Iowa; and Homer, Minn.

[3] Distribution by station messengers includes cost of making distribution direct from the station without a car. This distribution is usually to near-by points.

Method of distribution, by stations, species, number and size of fish, and costs—Continued.

DISTRIBUTION BY STATION MESSENGERS—Continued.

	Species.	Number of fish.	Size.	Total cost.	Average cost per thousand.	Miles paid.	Miles free.
Leadville, Colo	Pond fishes	39,250	Fingerlings, 1-inch	$29.27	$0.746	434	
	Trout	375,000	Fry	215.29	.574	2,633	40
	do	1,377,000	Fingerlings, 1-inch	630.21	.458	7,895	785
	do	118,500	Fingerlings, 1 to 1½ inch	94.34	.796	1,122	
Louisville, Ky	Pond fishes	309,750	Fry	67.17	.217	1,263	
	do	63,100	Fingerlings, 1½ to 2 inch	203.49	3.224	4,121	
	do	1,800	Fingerlings, 2 to 3 inch	19.34	10.850	314	
	do	3,400	Fingerlings, 3-inch	26.77	7.930	518	
	do	3,000	Fingerlings, 4-inch	21.77	7.250	448	
Mammoth Spring, Ark.	do	121,000	Fingerlings, 1-inch	282.23	2.332	5,892	
	do	4,000	Fingerlings, 1 to 2½ inch	47.61	11.903	814	
	do	14,000	Fingerlings, 1½-inch	127.12	9.080	1,938	
Manchester, Iowa	do	4,130	Fingerlings, 1-inch; Yearlings	47.45	10.156	730	42
	do	143	Adults	87.66	365.454	1,434	
Nashua, N. H	do	8,400	Fry	43.15	5.137	747	
	do	4,300	Fingerlings, 1½-inch	18.31	4.258	334	
	do	7,100	Fingerlings, 2-inch	26.36	3.710	472	
	Trout	2,500	Fry	4.01	1.740	31	
	do	120,000	Fingerlings, 1-inch	31.10	.242	532	
	do	334,960	Fingerlings, 1½-inch	351.68	1.471	5,914	47
	do	17,700	Fry to fingerlings, 2 inch.	66.24	3.790	1,166	13
	do	580	Adults	46.36	79.930	862	
Neosho, Mo	Pond fishes	1,700,000	Fry	17.95	.010	831	
	do	3,600	Fingerlings, 2-inch	6.60	1.840	110	
	do	4,000	Fingerlings, 3-inch	41.97	10.493	837	
	do	17,774	Fingerlings, 1 to 4 inch	158.39	8.911	3,064	
	do	1,012	Adults	225.02	221.364	3,927	
	Trout	43,100	Fingerlings, 2-inch	98.47	2.284	1,818	106
	do	23,400	Fingerlings, 2½-inch	43.14	1.416	670	426
	do	13,000	Fingerlings, 1 to 4½ inch	42.51	3.270	780	119
	do	2,700	Fingerlings, 2-inch; Yearlings	9.30	3.460	143	
Northville, Mich	Whitefish	1,770,000	Fry	40.61	.023		1,423
	Salmon	10,000	do	15.83	1.583	224	
	Pond fishes	28,000	do	4.90	.179		686
	do	5,650	Fingerlings, 1-inch	18.31	3.241	50	424
	do	4,200	Fingerlings, 1 to 2 inch	8.75	2.083		454
	do	5,300	Fingerlings, 2-inch	26.50	5.000		1,620
	do	1,205	Fingerlings, 3 to 6 inch	23.94	19.870		329
	do	80	Adults	11.56	144.500		524
	Trout	432,500	Fry	122.45	.283	710	3,395
	do	48,500	Fingerlings, 1-inch	19.37	.399		861
	do	99,000	Fingerlings, 1½-inch	57.50	.581		4,246
Orangeburg, S. C	Pond fishes	93,150	Fry	93.85	1.007	1,346	84
	do	168,850	Fingerlings, 1-inch	258.33	1.529	3,273	78
	do	18,000	Fingerlings, 1½-inch	32.01	1.778	351	
	do	65,120	Fingerlings, 1 to 6 inch	295.07	4.531	3,748	160
St. Johnsbury, Vt	Salmon	11,018	Fry	1.75	.158		(4)
	Trout	734,000	do	184.60	.252	2,326	78
	do	6,500	Fingerlings, 2-inch	49.24	7.575	730	83
	do	9,200	Fingerlings, 2½-inch	45.84	4.983	743	5
	do	1,100	Fingerlings, 3-inch	12.87	11.700	60	
San Marcos, Tex	Pond fishes	33,900	Fry to fingerlings, 1 inch.	50.91	1.502	889	
	do	3,200	Fingerlings, 1½-inch	37.23	11.630	644	
	do	2,250	Fingerlings, 2-inch	(4)			
	do	7,442	Fingerlings, 3-inch	48.47	6.513	698	
	do	225	Fingerlings, 4-inch	(4)			
	do	235	Fingerlings, 5-inch	(4)			
	do	700	Fingerlings, 6-inch	29.61	42.300	584	
	do	225,442	Fingerlings, 1-inch; Adults	1,088.43	4.775	16,871	
	do	1,238	do	2.67	2.157	18	
Saratoga, Wyo	Trout	71,800	Fingerlings, 1-inch	17.34	.120	327	61
	do	36,000	Fingerlings, 1½-inch	22.31	.620	213	21
	do	14,100	Fingerlings, 1½ to 2 inch	11.21	.610	212	20
	do	40,000	Fingerlings, 2-inch	32.91	.919	544	96
Spearfish, S. Dak	do	649,500	Fingerlings, 1½-inch	165.68	.255	1,824	
	do	136,601	Fingerlings, 1 to 3 inch	65.12	.477	938	
	do	2,600	Fingerlings, 2-inch	(4)			
Springville, Utah	do	135,000	do	121.55	.901	1,395	2,629
	do	54,750	Fingerlings, 2½-inch	160.59	2.903	2,269	1,929
	do	10,700	Fingerlings, 1½ to 4 inch	25.28	2.362	275	266
	do	234,150	Fingerlings, 3-inch	202.07	.862	2,540	6,205
	do	27,000	Fingerlings, 4-inch	83.44	3.090	1,198	470

[4] Station delivery.

Method of distribution, by stations, species, number and size of fish, and costs—Continued.

DISTRIBUTION BY STATION MESSENGERS—Continued.

	Species.	Number of fish.	Size.	Total cost.	Average cost per thousand.	Miles paid.	Miles free.
Tupelo, Miss	Pond fishes	307,500	Fry	$205.61	$0.668	3,867	86
	do	112,200	Fingerlings, 1-inch	280.45	2.491	4,821	44
	do	15,600	Fingerlings, 2-inch	60.16	3.856	1,101	26
	do	176,841	Fingerlings, 1-inch; Adults	1,084.78	6.134	18,472	90
	do	140	Adults	33.35	238.210	701	......
Upper Mississippi.[3]	do	2,100,000	Fry	36.99	.017	722	......
	do	23,805	Fingerlings, 2 to 3 inch	232.17	9.753	3,875	......
	do	46,185	Fingerlings, 2 to 6 inch	288.76	6.252	5,648	......
	do	17,461	Fingerlings, 3-inch	145.99	8.361	2,211	......
	do	1,980	Fingerlings, 3 to 4 inch	64.99	32.166	1,148	......
	do	18,468	Fingerlings, 1 to 6 inch	86.37	4.677	1,128	......
	do	263	Adults	5.08	19.316	42	......
	Trout	144,000	Fingerlings, 1-inch	50.74	.345	598	......
	do	33,600	Fingerlings, 1½-inch	13.68	.406	238	......
White Sulphur Springs, W. Va.	Pond fishes	46,500	Fry	45.30	.975	724	......
	do	32,000	Fingerlings, 1-inch	31.47	.980	520	......
	Trout	31,500	do	11.81	.375	245	......
	do	42,500	Fingerlings, 1½-inch	64.01	1.506	1,056	......
	do	47,330	Fingerlings, 2-inch	90.15	1.925	1,370	......
	do	3,130	Fingerlings, 2 to 3 inch	46.13	14.738	869	......
	do	450	Fingerlings, 3-inch; Adults	28.22	62.711	572	......
Woods Hole, Mass.	Pond fishes	475	Fingerlings, 4-inch; Adults	47.29	99.547	391	622
	Flatfish	31,949,000	Fry	36.34	.001	460	......
Wytheville, Va	Pond fishes	15,562	Fingerlings, 1 to 3 inch	229.62	14.755	3,792	......
	do	800	Fingerlings, 2-inch	19.13	20.380	276	......
	do	8,725	Fingerlings, 2 to 3 inch	121.65	14.450	2,109	......
	Trout	54,000	Fingerlings, 1-inch	49.46	.916	760	......
	do	28,000	Fingerlings, 1 to 2 inch	40.57	1.449	694	......
	do	9,000	Fingerlings, 2-inch	11.77	1.307	222	......
	do	64,350	Fingerlings, 1½ to 2½ inch.	142.19	2.209	1,888	......
Warm Springs, Ga.	Pond fishes	163,800	Fry	254.49	1.553	4,169	......
	do	31,800	Fingerlings, 1-inch	113.68	3.575	1,557	......
	do	56,600	Fingerlings, 1½-inch	307.01	5.424	5,015	......
	do	73,425	Fry to fingerlings, 4-inch.	379.34	5.165	6,223	......

DISTRIBUTION BY CARS.[6]

Bozeman, Mont	Trout	974,150	Fry to fingerlings, 4-inch.	$2,165.53	$2.223	5,264	722
Bucksport, Me	Salmon	371,000	Fry to fingerlings, 1½-inch.	112.98	.304	258	......
	Trout	869,900	do	665.35	.763	1,976	......
Duluth, Minn	do	2,533,000	Fry	1,201.45	.474	2,671	1,523
Erwin, Tenn	do	710,900	Fingerlings, 1 to 2 inch	1,191.74	1.676	2,811	......
Langdon, Kans	Pond fishes	9,000	Yearlings	138.40	15.380	685	......
Leadville, Colo	Trout	1,050,500	Fingerlings, 1 to 1½ inch	1,405.99	1.340	4,250	......
Manchester, Iowa	do	536,000	Fingerlings, 1 to 2 inch	954.05	1.780	4,052	......
Northville, Mich	do	38,000	Fingerlings, 1 to 2½ inch	328.21	8.611	2,646	......
Upper Mississippi.[3]	Pond fishes	2,912,527	Fingerlings, 1-inch, to adults.	13,423.85	4.610	38,243	......
	Trout	156,275	Fingerlings, 1 to 2½ inch	359.00	2.290	1,080	......
White Sulphur Springs, W. Va.	do	439,450	Fingerlings, 1 to 2 inch	2,505.61	5.701	6,558	......
Wytheville, Va	do	257,650	Fingerlings, 1-inch, to yearlings.	1,061.30	4.119	2,709	......

[3] La Crosse, Wis.; Bellevue, Iowa; Marquette, Iowa; and Homer, Minn.
[6] Distribution by cars shows cost of transporting fish to destination or until delivered to car messenger.

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