DEPARTMENT OF COMMERCE
BUREAU OF FISHERIES

REPORT

OF THE

UNITED STATES COMMISSIONER OF FISHERIES

FOR THE FISCAL YEAR 1927

WITH

APPENDIXES

HENRY O'MALLEY
Commissioner

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Report of the United States Commissioner of Fisheries

ERRATA NOTICE

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DEPARTMENT OF COMMERCE

BUREAU OF FISHERIES

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REPORT OF THE COMMISSIONER OF FISHERIES[1]

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[1] Bureau of Fisheries Document No. 1017.

DEPARTMENT OF COMMERCE,
BUREAU OF FISHERIES,
Washington, July 1, 1927.

Hon. HERBERT HOOVER,
Secretary of Commerce.

DEAR MR. SECRETARY: I have the honor to submit the following summary of the major operations of the Bureau of Fisheries during the fiscal year ended June 30, 1927.

Perhaps the most noteworthy development of the year has been the growing appreciation of and expressed need for expansion of modern scientific research in the solution of fishery problems. This is shared by men in the fishery industries confronted by the many problems in the taking, merchandising, and distribution of fish and fishery products; by State and other officials interested in determining the condition and trend of each fishery and the need for and character of regulations necessary for the husbanding and wise use of our fishery resources; by Federal, State, and private agencies confronted with problems of large-scale fish propagation, the prevention of losses by fish diseases, and the development of the science of aquiculture; and by the thousands of organizations and individuals interested in having good fishing and enjoying the use of lakes and streams for recreational pursuits. It is believed that the bureau's present program of practical research and applied science is accomplishing much in inspiring confidence in and dependence on modern science for the solution of problems in fish culture, fishery administration, and technology. This also applies to the important duty of regulating and conserving the highly valuable fisheries of Alaska.

The concern felt for the future of such fisheries as those for shad, sturgeon, whitefishes, and lobsters, and the appreciation of the value of scientific research as a basis for wise administration of fishery resources, has caused demands to be made wholly beyond the scope of the scientific staff to cope with; and the same is true of demands for assistance from the bureau's technological staff in solving the problems of the commercial fishermen.

The bureau produced 6,481,073,000 fish and eggs for stocking various waters, an increase of more than 1,000,000,000 over the preceding year and the greatest production in the history of the bureau. Fifty-five cooperative fish nurseries assisted in rearing more fish from the fry stage to a length of 3 or 4 inches. Greater cooperation with State commissions helped to make this an unusually successful year; nevertheless present facilities are wholly inadequate for meeting the increasing demand for the trouts, basses, and sunfishes.

In 1926 the fishery industries experienced one of the most successful years in their history. The vessel landings at New England ports, which averaged about 170,000,000 pounds for the five-year period—1920 to 1924—had increased to nearly 217,000,000 pounds in 1925 and made a further increase to over 238,000,000 pounds in 1926. In large measure this growth is due to the growing demand for fish packed as fillets and steaks and to the unusually large catches of mackerel, which in 1926 exceeded 60,000,000 pounds. Landings of haddock (the principal fish sold in package form) averaged 73,000,000 pounds for the five-year period—1920 to 1924—increasing to nearly 92,000,000 pounds in 1925 and to more than 94,000,000 pounds in 1926.

A record pack of salmon was canned in Alaska, amounting to 319,000,000 pounds, valued at $46,000,000, representing an increase of 105,000,000 pounds as compared with 1925. In California the production of canned sardines was the largest in the history of that industry, amounting to over 100,000,000 pounds, valued at $7,807,000. The total pack of salmon was 359,450,000 pounds, valued at $56,219,000; of canned sardines in Maine and California, 143,415,000 pounds, valued at nearly $14,535,000; and the total value of canned fishery products and fishery by-products approximated $100,000,000. Our annual fishery harvest now exceeds 3,000,000,000 pounds, valued at $109,000,000 to the fishermen.

Highly efficient service on the part of the bureau's personnel has made possible the record of achievements given in this report.

INTERNATIONAL RELATIONS

NORTHERN PACIFIC HALIBUT CONVENTION

Under the terms of the convention with Great Britain, ratified October 21, 1924, provision is made for an international fisheries commission, whose duty it is to have made a thorough investigation into the life history of the Pacific halibut and to make recommendations as to what regulations are deemed necessary for the preservation and development of this fishery. The scientific staff, under the able direction of Will F. Thompson, has vigorously prosecuted the work and completed the first phase of it, which relates to the development of means and methods of research, the crystallization of plans of procedure, and beginning the active prosecution of such work. A preliminary report has been made to the commission.

A thorough statistical study has been made of market landings and fishermen's logs. From the pilot-house logs of the fishing vessels a record has been obtained of the vessels' movements, the amount of gear fished day by day, the locality of capture, and the estimated weight of the fish taken. For 1926, records were taken for nearly 260,000 units of gear, which took 19,400,000 pounds of halibut, or 35 per cent of the total Pacific coast catch. These records indicate a shifting of the center of fishing operations from Hecate Strait in 1910 to Portlock Bank in 1926. The log records also are valuable as a measure of abundance of the fish supply and the rate of decline of the catch. In Hecate Strait, for example, the catch of fish per skate of gear in 1906 was 450 pounds, declining to 143 pounds in 1914 and 47 pounds in 1926. The evidence is plain that the southern and older fishing banks are becoming steadily less productive and that the proportionate number of smaller fish in the catch is increasing.

Nearly 9,000 halibut have been tagged. Of the fish tagged on the southern banks in 1925 and 1926, about 16 per cent have been recovered. The migrations on these banks appear small, the average extent of movement being less than 20 miles. The evidence indicates that the immature fish do not migrate to any extent. On the offshore banks of the Gulf of Alaska and on the Aleutians, where the fish are more mature, indications are that the mature fish become more migratory. Thirty-three fish recovered from nearly 1,800 fish released averaged 275 miles, with 865 miles as the maximum. This enables us to get an idea of the exceeding complexity of the problem and the need for painstaking research to establish the facts.

The scientific staff has collected a fund of information along biological lines, which later will be found to be of great use when there has been opportunity to work over it thoroughly. This includes racial measurements, rates of growth, study of the eggs and larvæ of the halibut and their drift with the currents, and effectiveness of large and small gear and their effect on the fishery. The biological results fully corroborate the results obtained from tagging, as far as migration is concerned, but, of course, present many other facts. Intensive laboratory work must follow to bring out these facts.

On February 23, 1927, the fishing schooner *Scandia*, under charter by the commission, was hurled onto a reef half a mile off Kodiak Island, in the midst of a high sea and a blinding snowstorm, and wrecked. Through the prompt and courageous action of the captain and crew of the seine boat *Duncan I*, the scientific staff and crew of 15 men were saved, but the equipment and gear were lost. The loss of the *Scandia* was the climax of an exceedingly hard winter, during which the halibut investigations had been conducted with great difficulty, much of the work having been done virtually in intervals between storms. The catch of Pacific halibut (United States and Canada) in 1926 was 53,780,389 pounds, as compared with 49,843,967 pounds in 1925, an increase due to more intensive fishing.

FISHERIES CONVENTION WITH MEXICO

The convention between the United States and Mexico to prevent smuggling, and for certain other objects, which was ratified on March 18, 1926, contained a section devoted to the fisheries, quoted in full in the last annual report. Upon the initiative of the United States Government, the convention was terminated on March 28, 1927, or at the end of a year after it came into effect. During the life of the International Fisheries Commission, provided for under the terms of the treaty, a program of scientific investigations was drafted and preliminary investigations were begun.

A study of the record of the California Fish and Game Commission with respect to the receipts of fish from waters off the coast of Mexico, 1920–1925, inclusive, disclosed that of the total landings of the catch from the waters off both coasts at California ports the following percentages came from waters off the coast of Mexico: Yellowfin tuna, 79; spiny lobster, 70; black sea bass, 48; barracuda, 33; skipjack, 33; white sea bass, 26; bonito, 25; and yellowtail, 21. The investigative program, therefore, was to concern mainly these species.

Statistics of the fish, mollusks, and crustaceans landed in California during the calendar year 1926, as reported by the California Fish and Game Commission, show 371,648,275 pounds, of which 23,058,741 pounds were taken in Mexican waters. During the year about 750 American fishing boats operated off the coast of Lower California, Mexico, with 11 vessels, of 75 to 100 tons each, acting as tenders, and 4 or 5 barges. The investment of American capital in boats, fishing gear, and cannery capacity dependent upon the Mexican supply of fish is estimated at $10,000,000, exclusive of the investment in fresh-fish markets.

Although most of the fish of the Mexican coast are caught outside the 3-mile limit, it is necessary for the boats to enter Mexican territorial waters for shelter and to take sardines and other small varieties used in the live-bait operations. Also, the safest and most direct course for home brings the boats within 3 miles of the shore and under Mexico's jurisdiction. Therefore it is necessary for American fishermen to clear for Mexico rather than for the "high seas," to take out Mexican fishing permits, and pay the export fees on dutiable fish in observance of that country's regulations.

When the canneries and fresh-fish markets of the United States first began to draw upon the marine life off the coasts of Mexico, that country considered this resource of relatively little importance. Difficulties arose in the administration of fishery affairs, unfortunate practices crept in, and general dissatisfaction with existing conditions increased. When these matters were brought to the attention of the central Government, interest was aroused in the fisheries. More stringent regulations were put into effect, and higher rates of duty were imposed. It was this unsettled state of affairs that led Mexico to propose the fisheries section to the convention under discussion.

The abrogation of the convention came before the constructive program planned could accomplish any real benefits. There is urgent need for the adoption of a program of conservation that will insure the perpetuation of this important resource. This must be preceded by scientific studies to disclose the condition and trend of each fishery as a basis for the adoption of regulatory measures. There is also need for an impartial agency to prevent dissension and to promote harmonious working agreements between the two countries in the handling of fishery matters.[2]

NORTH AMERICAN COMMITTEE ON FISHERY INVESTIGATION

This committee, composed of delegates from Canada, Newfoundland, and the United States, held two meetings during the year—one at St. Johns, Newfoundland, on July 9, 1926, and the other at Washington, D. C., on April 28, 1927.

The fisheries statistics of the various countries that fish the banks of the northwestern Atlantic are being correlated so as to make it possible to follow the entire fishery of the banks of that region. A summary of the total annual catches of cod of the region taken by Newfoundland, France, Portugal, Canada, and the United States during the past 40 years or more shows that the cod fishery has furnished about 1,000,000,000 pounds of fish annually, ranging from 850,000,000 to 1,350,000,000 pounds. Although there have been considerable fluctuations, these have been upward as much as downward, so that there is no evidence of any definite decline in the fishery or of any depletion of the stock.

Studies of the cod off the coast of the United States reveal that fish that live off Cape Cod in the summer migrate to the New Jersey coast during the winter and return in the spring. Fish tagged at Mount Desert, Me., have been found to move chiefly eastward to both coasts of Nova Scotia, only an occasional one moving westward and reaching as far as Cape Cod.

[2] Based on a report by Miss Geraldine Conner, American secretary.

Growth studies of the cod in Canadian waters indicate that the scales do not grow in the same degree as the fish throughout the year, but grow relatively more rapidly at one time and relatively less rapidly at another. Of 275 cod tagged off Halifax, Nova Scotia, in 1925, and 3,747 off Shelburne, Nova Scotia, in 1926, more of the former lot were recaptured in the following year than during the year in which they were tagged, being retaken only along the coast and at no great distance, but going more to the southwestward (nearly to Liverpool, Nova Scotia) in the second year. The Shelburne cod showed very little movement, and that chiefly to the eastward, going as far as Liverpool, Nova Scotia, during the season, but reaching farther eastward (to Halifax) during the succeeding winter.

Investigations of the haddock off the Canadian coast reveal that the haddock population of the Bay of Fundy, particularly of the New Brunswick shore, failed to receive any considerable number of young for a series of years, with a resultant decline in the fishery. Then the young came in suddenly, and in a year or two the fishery greatly increased and has continued at a high level.

The haddock grows more rapidly in the early years of its life in the warm water of Passamaquoddy Bay, New Brunswick, than in the cold water on the outer coast of Nova Scotia near Lockeport; but this rapid growth falls off in later years in the warm water more than in the cold. The rapid growth of the year is limited to the months August to October. In 1926 2,540 haddock were tagged near Shelburne, Nova Scotia. They showed very little movement southwestward along the coast but considerable movement northeastward, as far as Halifax and Sable Island Bank—twice as far as the cod tagged simultaneously with the haddock.

The Canadian investigations of the mackerel have shown that it spawns in negligible amount in the Bay of Fundy and without success in producing fry, and on the outer coast of Nova Scotia the eggs fail to develop into fry. In the Gulf of St. Lawrence, however, spawning is extensive and very successful. Late in the summer the fry are to be found passing out of the gulf, around Cape Breton Island. The eggs have been found to require warm water for successful development. Studies of the mackerel of the Canadian coast reveal evidence of differences between those of southwestern Nova Scotia and those of the Gulf of St. Lawrence. In 1925 and 1926, in Canadian waters, 2,382 mackerel were tagged. The returns from those tagged at Yarmouth show a movement northeastward to the Gut of Canso, northward into the Bay of Fundy, and westward to the coast of Maine. Fish tagged at the Magdalen Islands in 1925 showed a movement to Prince Edward Island in the same season, and in the next year some of them returned to the coast near Halifax and in Massachusetts.

Mackerel tagged in 1925 at various points from Buzzards Bay, Mass., to Casco Bay, Me., spread in both directions along the coast from the point of tagging but did not migrate far. In the following year those recaptured were taken on the whole to the southwest, along the coast from where they had been tagged the previous year. one tagged on the coast of Maine being taken at Fire Island, N. Y. One of the mackerel tagged off Delaware and Maryland in 1926 was recaptured several months later near Cape Cod.

GREAT LAKES FISHERIES

The evidence at hand clearly indicates a decline in the Great Lakes fisheries, so marked as to cause grave concern for the future of these fisheries. The very existence is threatened of the bluefin in Lake Superior, the blackfin in Lake Michigan, the bloater in Lake Ontario, and the sturgeon in all the lakes. In less than half a century the catch of whitefish has declined from 21,000,000 to 4,000,000 pounds, and the sturgeon from 7,500,000 pounds to less than 100,000 pounds per annum. The aggregate catch has been maintained at a fairly fixed level by the substitution of more rough fish as the supply of the choicer species declined, and by greatly increasing the number and effectiveness of the units of gear employed.

The problem of fisheries administration is a most difficult one, in view of the fact that jurisdiction is divided between eight States and a Canadian Province. The questions are not alone State, but national and international. Jurisdiction over Lake Michigan is divided between four States; that over Lake Erie between four States and the Province of Ontario. There is a growing appreciation of the need for a better understanding of the problems and of better laws and their enforcement. Under such a division of authority it is difficult to get concerted action.

At the invitation of the Governor of Ohio to representatives of the States bordering Lake Erie, the Province of Ontario, and this bureau, a conference was held at Columbus, Ohio, on February 16, 1927. The purpose of the conference was to attempt to secure coordinated action in conserving the fisheries of Lake Erie. Resolutions were adopted, which, if enacted into law, would afford greater protection to the fisheries. Subsequent progress toward the enactment of such measures holds forth little hope of immediate action to meet the serious situation that exists.

At the call of the Governor of Michigan on March 3, 1927, at Lansing, a conference of fishery officials from the States bordering the Great Lakes and from the bureau was held to consider ways and means for conserving the Great Lakes fisheries. Only measures of general application to all the lakes were considered, and proposals with respect to fishing gear, sizes of fish, and the taking of spawn were made by the several States and the Province of Ontario.

UPPER MISSISSIPPI RIVER WILD LIFE AND FISH REFUGE ACT

Regulations for the administration of the upper Mississippi River wild life and fish refuge act of June 7, 1924, were signed and issued jointly on June 24, 1927, by the Secretary of Agriculture and the Secretary of Commerce. These regulations prescribe the conditions under which hunting, fishing, and other recreational activities will be permitted. Areas of overflowed bottom lands along the Mississippi in the States of Illinois, Iowa, Wisconsin, and Minnesota, from Rock Island, Ill., to Wabasha, Minn., are being acquired by the Department of Agriculture as rapidly as possible.

There are many sloughs and bayous within the limits of the reservation, some of which are navigable to boats of light draft, which may be utilized for growing fishes for restocking streams, and to be inoculated with the glochidia of the fresh-water mussels, thus helping to perpetuate this important industry.

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PROPAGATION AND DISTRIBUTION OF FOOD FISHES

The fish-cultural operations of the bureau present a picture of yearly production being increased to meet a constantly growing demand. The increase in the number of applications received has been greater than the increase in facilities for production.

During the past year no new hatcheries have been put in operation, so that the larger output has been brought about by redoubling efforts to utilize present facilities to their utmost capacity. The general conviction that fish 3 or 4 inches long or larger are essential for the successful repopulation of our waters has resulted in an intensive effort to produce more fish of this class. The output of commercial food fishes has been increased materially, particularly on the Atlantic coast.

COOPERATIVE FISH-CULTURAL WORK

The older conception of the division of fish culture as an agency for delivering so many fish upon order, as if this were a manufactured product the ultimate disposition of which was of little interest to the manufacturer, is disappearing. The real task is to restock the waters, and cooperative efforts are doing much to accomplish this.

The outstanding work along this line has been the cooperation with the sportsmen's clubs, which have received fry for rearing to fingerling size. Fifty-five of these nurseries are in operation, the majority in Pennsylvania and Wisconsin. Many more are awaiting completion of arrangements or are under consideration. In many cases the clubs are holding the fish received in the spring of 1926 for liberation this autumn at an age of 18 months. A new project has been undertaken this year, which exceeds in magnitude the leading nursery projects of last year. The Utica chapter of the Izaak Walton League of America has taken over a discontinued commercial hatchery at Barneveld, N. Y., which the bureau is operating. An initial stock of over 200,000 young fish has been supplied, and the project will be conducted so as to produce eggs from a brood stock of adult fish.

The bureau also has furnished advice to individuals and clubs desirous of raising fish individually. Further cooperation has been effected by the utilization of privately owned or controlled waters as egg-collecting stations. The bureau's employees take eggs from bodies of water in which a stock of fish has become established, the owner receiving a sufficient quantity to maintain the stock. A number of lakes in Colorado have yielded a fair quantity of rainbow and brook trout eggs under such arrangements.

An output of 6,481,073,000 fish and eggs represents the greatest production in any year since the bureau began its fish-cultural activities. Increased collections of four marine species—cod, haddock, pollock, and winter flounder—are largely responsible for the increase of over 1,000,000,000 more than the figures of last year. Large yields were obtained in some of the other classes, including an appreciable increase in the output of game species. The failure to equal the records of past years in the production of fingerlings is due to a shortage in one of the important groups—the Pacific salmons—and to limited collections from the Mississippi River. Inasmuch as all fish from the latter source are of fingerling size, limited collections make themselves evident in this class.

As an indication of the relative proportions of the various classes of fishes of this total, it may be pointed out that it included 5,473,378,000 fry and eggs of commercial marine species, 120,213,000 of the commercially important Pacific salmons, 548,535,000 of the commercial species of interior waters, and 247,313,000 of the anadromous forms, also of commercial significance. The game fishes were represented by 51,523,000 trout and salmon and 36,222,000 of the warm-water pond species.

RELATIONS WITH STATES AND FOREIGN GOVERNMENTS

Cooperation with the various States has been an important part of the bureau's fish-cultural work. The bureau has been of assistance by furnishing the advice and supervision of its experienced employees, by assigning eggs and fry to the States, and by assisting in the collection of eggs. The States have reciprocated by permitting the collection of adult brood fish, allotting funds for carrying on work of joint benefit, and by assisting in the distribution of fish. The Bureau of Fisheries and the States of Vermont and Pennsylvania operated the Swanton (Vt.) pike-perch station jointly. Over 1,000,000 trout eggs were incubated for the State of West Virginia at the White Sulphur Springs (W. Va.) station. Similar relations have been maintained with the State of South Dakota. The propagation of buffalo fish in conjunction with the State of Louisiana was undertaken. The bureau furnished the services of a man for shad propagation undertaken by the State of New Jersey. Extensive cooperative work has been initiated in Arkansas, where suitable areas have been taken over as nurseries for bass and other pond fish. Ponds have been stocked, and a number of others are being prepared for this purpose.

A total of 84,586,000 eggs was furnished to 24 States during 1927 The pike perch, yellow perch, whitefish, and cisco comprised 61,900,000 of this number, while the remainder consisted of various species of trout and salmon.

Arrangements have been perfected with the United States Forest Service whereby improved distribution practices will be followed and rearing ponds established. Generous allotments of fish and eggs have been made for stocking waters in the forest areas, notably in Wyoming and in the Sawtooth National Forest in Idaho. Inspections have been made of pond sites in the Ouachita National Forest and the Unaka National Forest.

Requests for the shipment of eggs of various species to foreign governments have been complied with as far as possible. This included the distribution of 2,227,000 eggs and 19,500 fish to five countries, Canada, Costa Rica, Italy, and Switzerland receiving rainbow trout, while Japan was assigned rainbow trout and whitefish.

PROPAGATION OF PACIFIC SALMONS

The work in the Pacific States and Alaska has been marked by improvements at certain points. It has been the rule to hold a maximum number of fingerlings at each station throughout the season, planting when for lack of space it has been absolutely essential to dispose of some of the stock.

Light has been thrown on the problem of power dams in salmon streams by a study of the operation of a fish ladder in the Baker River near Concrete, Wash. The dam, over 200 feet high, has a fish ladder of the common Cail type, together with a mechanical elevator for hoisting cars of fish over the crest. As a result of practical experiments it is expected that the science of developing a satisfactory fishway will be advanced materially.

In Alaska continued destruction of predatory trout has resulted beneficially in the vicinity of Afognak and Yes Bay. At the Yes Bay (Alaska) station the fingerlings have been placed in feeding ponds, from which they are permitted to work out gradually. It is believed that they become better adapted to conditions in natural waters in this way than by a sharp transition from the hatchery to the lake. Not until the entire hatch of salmon fry can be reared to fingerling size will the maximum benefit be attained from these fish-cultural operations.

MARINE SPECIES OF THE NORTH ATLANTIC COAST

Operation of the bureau's marine stations at Woods Hole and Gloucester, Mass., is contingent upon commercial fishing operations in the vicinity. Cod, haddock, and pollock eggs are taken largely by spawn takers on the fishing vessels. Only a small percentage of the eggs is obtained by independent spawn-taking operations conducted by the bureau. A substantial increase over the previous season's figures for this work resulted. Minute variations in the water, particularly in its specific gravity, affected the success of artificial incubation, and in such cases it has been found necessary to plant the fertilized eggs on the fishing grounds. Concomitant with the augmented market utilization of haddock, the number of eggs of this species handled by the bureau has been more than doubled. The hatching of winter-flounder eggs has been centered largely at the Boothbay Harbor (Me.) station, and the collection has been increased by about 800,000,000 over that of last year. The station makes its own collection of brood fish, operating in near-by waters. For the first time in a number of years the Boothbay Harbor station has handled cod eggs. As difficulty was encountered in incubating the eggs at the hatchery, the majority were fertilized and planted on the adjacent spawning grounds.

ANADROMOUS FISHES OF THE ATLANTIC COAST

This work comprises the hatching of shad, river herring, and Atlantic salmon, with such propagation of yellow perch as may be carried on in conjunction with the shad operations. The decline in the catch of shad has limited the bureau's efforts in this field to the stations at Bryans Point, Md., and Edenton, N. C. An increased number of eggs was obtained by unusual effort at Bryans Point. The take of shad and herring eggs in Albemarle Sound waters was negligible, in spite of a heavy run of fish. The run of shad was preponderantly of male fish, and very few of the females yielded ripe eggs.

There is the ever-increasing possibility of a light run of fish, due to overfishing, pollution, obstructions, etc., and the further chance that no eggs can be secured, even though the fish may be obtainable. The same situation applies in general to the propagation of the river herring. Shad work conducted on the Delaware River in cooperation with the State of New Jersey yielded very few fish, and no eggs were obtained. Previous to the opening of the shad season on the Potomac a large number of yellow perch were hatched at the Bryans Point station. A blizzard in March destroyed the fishermen's nets and seriously curtailed the output of the species in Albermarle Sound. A number of Atlantic-salmon eggs, obtained through exchange from Canada, were hatched and the fry distributed in Maine waters.

COMMERCIAL FISHES OF INTERIOR WATERS

Whitefish, cisco, lake trout, and pike perch, the main species supporting the extensive commercial fisheries of the Great Lakes, are the objects of attention in this field. As the eggs are secured as a by-product of the commercial fisheries, any adverse weather which retards fishing restricts the take of eggs. The various species frequent different localities and have different spawning periods, so that the causes that diminish collections of one species do not affect the others necessarily. There was an increase in the collection of lake trout and cisco eggs as compared with 1926. Whitefish and pike-perch collections declined in comparison with the previous year. Resumption of the practice of penning whitefish at some of the Great Lakes stations has effected a salvage of eggs that would otherwise be lost. A marked increase in the percentage of hatch has followed such practice. Where the eggs are taken by the bureau's experienced employees better quality is assured than when the fishermen themselves take and care for the eggs. The action of the conferences called in Ohio and Michigan urging that the taking of spawn by the fishermen in a proper manner be made a requirement of law should prove beneficial in increasing the output of the stations and in saving the fisheries from further depletion.

Pike-perch operations at Swanton, Vt., were not as satisfactory as heretofore, low water making the penning of adult fish difficult. Work with this species on the Great Lakes was successful, however. Hatching of buffalo fish at Plaquemine, La., was a virtual failure.

SALVAGING FISHES FROM OVERFLOWED REGIONS

Unusually low water during the spawning season, when the fish normally would migrate to the marginal areas and become landlocked, acted as a barrier to such movements. Later in the season, when seining operations have been conducted in other years, high water hindered the rescue work, so that it was difficult to obtain the fish that migrated. As a consequence, the collection of fish from this source was very small and a considerable number of applications for them were left unfilled.

FISHES OF INTERIOR WATERS

Waters well stocked with sport fishes are an important asset to any community, attracting anglers, and thus bringing wealth into the community in many ways. Good trout streams are especially sought after. The bureau finds it necessary to obtain a large percentage of its brook-trout eggs from commercial producers, but most of the rainbow and other trout eggs have been secured from wild fish or from hatchery brood stocks. The bureau's collecting stations for rainbow eggs in the Meadow Creek (Mont.) territory and the Lost Creek and Sage Creek (Wyo.) fields were notably successful, while other smaller projects of a similar nature in the Rocky Mountain territory have been developed. The Meadow Creek field also yielded an increased number of Loch Leven trout eggs during the past year, this immigrant having become more firmly established in the esteem of the angling fraternity. A station for collecting rainbow eggs was established in New Hampshire during the past season under the supervision of the Nashua (N. H.) station. The White Sulphur Springs (W. Va.) station has a fine brood stock of rainbow trout, and the fish have yielded eggs of excellent quality.

Statistics of the collection of black-spotted trout eggs in the Yellowstone National Park cover parts of two fiscal years. The close of the spawning season brought a harvest of eggs surpassing that of the previous year, but not equal to the standard set during the early years of the operations. Glacier Park, as well as the Yellowstone, has received the attention of the bureau.

The operation of the bureau's pond stations, situated chiefly in the Southern States, has resulted in an output surpassing all previous records at several points, particularly at the Cold Spring (Ga.), Tupelo (Miss.), and San Marcos (Tex.) stations. The Louisville (Ky.) station is of especial interest in that it is particularly successful in the production of small-mouthed bass, a species unusually difficult to raise in hatcheries. Some slight damage, not of a serious nature, was suffered at the Mammoth Spring (Ark.) station from spring floods. The superintendent of the Cold Spring (Ga.) station reported considerable success in feeding adult pond fish on shrimp heads, a waste product of a coastal fisheries.

DISTRIBUTION OF FISH

The carrying capacity of the fish-distribution cars has been increased greatly through the introduction of improved equipment, which has made it possible to handle the increased output of the hatcheries. During the fiscal year these cars traveled 63,300 miles, and detached messengers covered 363,565 miles.

The construction of at least one more steel distribution car is absolutely necessary for handling the increased output of fish, as well as for economy and safety in making the distribution. The cars and messengers are now carrying twice as many fish in a single shipment as were carried 10 years ago, so that there is little opportunity for effecting further savings by larger shipments.

COMMERCIAL FISHERIES AND FISHERY INDUSTRIES

REVIEW

According to the most recent statistics available, the fisheries and fishery industries of the United States and Alaska employ about 190,000 persons; their properties are valued at about $210,000,000; the annual sales of fish and fishery products by fishermen are about 3,000,000,000 pounds, for which they receive about $109,000,000; and the output of canned fishery products and by-products is valued at nearly $100,000,000.

With but one important exception, in 1926 the fishery industries may be said to have experienced one of the most successful years. Vessel landings at New England ports were the largest on record; Seattle landings were better than in the previous year; and the fish-canning industry had the most valuable output in recent years.

The exception to the generally successful conditions was the menhaden industry. In recent normal years this industry has an output valued at more than $6,000,000. In 1926 the value was less than $3,500,000, and the resulting condition in this industry is most acute. This is a repetition of what happened in 1924 and is most likely to be repeated frequently as long as no remedial steps are taken. The reduced output was due, of course, to a failure in the supply of menhaden, and the resultant loss was far greater than ordinarily would be expected, as the operating costs are about as high for a $3,500,000 output as for a $6,000,000 output. The reason for the high operating costs in poor years is the failure to foresee such a condition.

It is necessary to keep on full crews at the plants and on the vessels in order to take care of the large catches, which in poor years fail to materialize. This condition might be remedied by investigations of the fluctuations of menhaden, which would permit forecasting the extent of the supply, and technological research to develop more efficient methods in the menhaden plants. These two projects are considered of great importance. Unfortunately, no work on the fluctuations and only a little work on technological processes have been possible with the present personnel and funds.

The bureau's work most directly touching upon the fisheries industries is prosecuted by its division of fishery industries. The operations of this division include the collection, compilaton, and publication of statistics, technological research, and the dissemination of practical information to the industry.

GENERAL STATISTICS

During the past year statistics on the landings of fish at the ports of Boston and Gloucester, Mass., Portland, Me., and Seattle, Wash., were collected and published monthly. Statistics of the cold-storage holdings of fish were collected by the Bureau of Agricultural Economics in the Department of Agriculture and were published monthly by the Bureau of Fisheries as in previous years. Statistics of canned fishery products and by-products for the year 1926 were collected and published early in 1927, and those on the production, holdings, and consumption of animal and vegetable oils in the fishery industries were collected quarterly and furnished to the Bureau of the Census for publication as in previous years. The annual canvasses of the shad fisheries of the Potomac and Hudson Rivers were made as usual.

The States of Maryland and Virginia were canvassed for general statistics on the personnel, investment, and yield of the fisheries and fishery industries for the year 1925, and, with their publication, statistics of this nature are available on the various geographical sections, as follows: New England States, 1924; New York, New Jersey, Pennsylvania, and Delaware, 1921; Maryland and Virginia, 1925; South Atlantic and Gulf States, 1923; Pacific Coast States, 1922; and the Mississippi River and Great Lakes, 1922.

As the result of State activities, there are available annual statistics on the production of the Pacific Coast States for the years 1922 to 1925, inclusive, and of the Great Lakes for the years 1913 to 1925, inclusive. Statistics on persons, investment, and yield of the fisheries of Connecticut also are available for the years 1924, 1925, and 1926. In these cases original collections were made by the States, and the compilations of the various sections were made by the Bureau of Fisheries. It is to be hoped that more States will undertake work of this nature, for it is on properly collected statistics that we must depend for the facts necessary for the proper conservation of our commercial fisheries. The States, with their direct jurisdiction over the fisheries, are the logical agencies for the collection of such statistics.

MACKEREL STATISTICS

The collection of special statistical data on the mackerel fishery was continued during the past year. A preliminary analysis of these statistical and biological data indicates that the causes of fluctuations in the mackerel fisheries are due primarily to variations in the success of reproduction from year to year. Thus the unusually large runs of mackerel in 1925, 1926, and the early season of 1927 have been due to the unusually large numbers of mackerel spawned and hatched in one year, provisionally determined to be that of 1923. Very few mackerel of other year groups were found in the catch, indicating that the other spawning seasons have been much less successful than that of 1923.

CANNED FISHERY PRODUCTS AND BY-PRODUCTS

The canned fishery products and by-products of the United States and Alaska amounted to $98,326,350 in value in 1926. The output of canned fishery products was valued at $86,193,240, and that of by-products was valued at $12,133,110. The total is the largest in recent years, exceeding 1925 by 3 per cent and 1921 by 79 per cent. The increase is due chiefly to the larger pack of canned salmon in Alaska. Among the canned products, salmon, as usual, was the most important item, contributing 65 per cent of the total value; sardines were next, with 17 per cent; the tuna followed, with 6 per cent; and oysters, shrimp, clams, and miscellaneous products contributed the remaining 12 per cent.

TRADE IN FROZEN FISH

The holdings of frozen fish in 1926 were somewhat less during the first seven months and considerably more during the last five months of the year than in the previous year, varying between 16,154,002 pounds in April to 75,034,255 pounds in November. The average monthly holdings during the year amounted to 45,906,276 pounds, an increase of 4.13 per cent, as compared with the average monthly holding in 1925, and was above the five-year average by 11.71 per cent.

NEW ENGLAND VESSEL FISHERIES

Statistics of the New England vessel fisheries at Boston and Gloucester, Mass., and Portland, Me., collected by the bureau's local agents, have been published monthly. Two annual bulletins were issued—one showing the catch by fishing grounds and the other by months. The total landings by vessels at these ports in 1926 was the largest on record, amounting to 238,426,223 pounds of fish, having a value to the fishermen of $9,068,573. This was an increase over 1925 of 9.94 per cent in the quantity and 11.74 per cent in the value of the products.

The principal species, in the order of their value, were haddock, 94,060,734 pounds, valued at $3,082,924; cod, 78,218,703 pounds, valued at $2,647,479; mackerel, 36,232,655 pounds, valued at $1,406,485; halibut, 3,430,957 pounds, valued at $671,150; swordfish, 2,441,679 pounds, valued at $492,629; and flounders, 6,778,965 pounds, valued at $324,398. Compared with the previous year, there was considerable increase in both the quantity and value of cod and haddock and a large increase in the quantity and value of the catch of mackerel and swordfish.

The total catch of mackerel by the American fishing fleet in 1926 was 304,490 barrels fresh and 5,380 barrels salted, an increase over the previous year of 100,529 barrels fresh and a decrease of 7,062 barrels salted.

FISHERIES AT SEATTLE, WASH.

In 1926 the quantity and value of fishery products landed at Seattle by fishing and collecting vessels was 32,418,430 pounds, valued at $3,598,741.

The catch by fishing vessels, which consisted largely of halibut, amounted to 13,371,610 pounds, valued at $1,896,677. Compared with the previous year, this is an increase of 2.9 per cent in quantity and 19 per cent in value of the products landed. The fish landed by collecting vessels amounted to 19,046,820 pounds, valued at $1,702,064, an increase of 9.5 per cent in quantity and 25 per cent in value.

SHAD AND ALEWIFE FISHERIES OF THE POTOMAC RIVER

In 1926 the shad fishery yielded 336,662 shad that weighed 1,034,206 pounds, valued at $217,461 to the fishermen. This is an increase over 1925 of 65 per cent in number, 48 per cent in weight, and 33 per cent in value. While the catch is not large, compared with many of the former years for which statistics are available, the fishery has, nevertheless, registered substantial increases since the exceptionally poor year 1924.

The catch of alewives amounted to 13,795,848 fish, weighing 5,518,930 pounds, valued at $55,366 to the fishermen. The catch shows an increase over 1925 of 76 per cent in number, 76 per cent in weight, and 48 per cent in value, and, with the exception of 1924, is the largest catch on record since 1909.

FLORIDA SPONGE FISHING

In 1926 the quantity of sponges sold at the sponge exchange, Tarpon Springs, Fla., was 367,745 pounds, valued at $666,093, of which 235,143 pounds, value dat $592,367, were large wool; 26,073 pounds, valued at $36,502, small wool; 55,205 pounds, valued at $22,682, yellow; 49,233 pounds, valued at $13,441, grass; and 2,091 pounds, valued at $1,101, wire. It is estimated that sponges to the value of $50,000 were sold outside of the exchange at Tarpon Springs. Compared with 1925, there was a decrease in the production of 66,927 pounds, or 15.4 per cent, in quantity, and $49,004, or 6.9 per cent, in value.

FISHERIES OF MARYLAND AND VIRGINIA

Compilation of the statistics of the fisheries of Maryland and Virginia in 1925 was completed during the fiscal year and published in summary form as Statistical Bulletin No. 745. The results show that the fisheries of these States gave employment to 39,091 persons, of whom 25,856 were engaged in fishing operations, 9,671 in the wholesale fish trade, and 3,564 in the canning, salting, smoking, and by-products industries. The investment amounted to $19,322,844, of which $10,635,397 were invested in vessels, boats, fishing apparatus, and shore and accessory property used by the fishermen; $4,259,205 in property and cash capital in the wholesale fishery trade; and $4,428,242 in property and cash capital in the canning, salting, smoking, and by-products industries. The products of the fisheries of these two States amounted to 333,205,769 pounds, valued at $13,948,060. The products of the canning and other fishery industries had a value of $4,936,664.

Oysters, with a production of 60,264,932 pounds, or 8,609,276 bushels, valued at $6,021,606, were the most important fishery product of these States. Other important products were shad, 7,363,856 pounds, valued at $1,636,879; menhaden, 150,492,623 pounds, valued at $1,434,706; crabs, 29,600,605 pounds, valued at $1,249,497; croaker, 25,252,156 pounds, valued at $711,416; squeteagues, 13,924,659 pounds, valued at $668,296; and clams, 1,190,272 pounds, or 148,784 bushels, valued at $468,784.

Compared with 1920, the last available statistical report, there was a decrease of 5 per cent in the number of persons engaged; an increase of 5.7 per cent in the amount of capital invested; and a decrease of 37.2 per cent in the quantity, with an increase of 9.5 per cent in the value of the products landed by the fishermen.

FISHERIES OF THE PACIFIC COAST STATES

During the past year statistics, as collected by the Pacific Coast States, were compiled and supplemented by the bureau's agents. These compilations included 1924 and 1925, and, with the statistics already published, there are available four successive years' data, from 1922 to 1925, inclusive.

On the basis of the most recent year, 1925, the fisheries of the Pacific Coast States employed 16,856 fishermen, 673 vessels of 13,361 tons, and 5,424 motor boats. The total yield amounted to nearly 611,000,000 pounds, valued at nearly $24,600,000. This is the largest yield on record.

The salmon fishery, by far the most important in value, yielded 139,848,020 pounds, valued at $10,149,961. Next in importance was the tuna fishery, which produced 54,776,970 pounds of albacore, tuna, skipjack, and bonito, valued at $4,558,183. Third in importance was the halibut fishery, with 19,256,185 pounds, valued at $2,177,125. The sardine fishery ranked fourth, with 315,294,986 pounds, valued at $2,087,756.

The total yield has increased successively from 405,000,000 pounds in 1923 to 474,000,000 in 1924 and to 611,000,000 in 1925. The value increased from $19,000,000 to $20,000,000 and to $25,000,000 in these same years, respectively. Most of the increased poundage was achieved in the sardine fishery, which almost doubled its yield during the three years. The sudden spurt in value between 1924 and 1925 is due to the unusually large catches of salmon and tuna.

FISHERIES OF THE GREAT LAKES

With the cooperation of the Tariff Commission, statistics of the yield of the Great Lakes fisheries originally collected by the States were compiled for the years 1913 to 1925, inclusive. During this period the United States yield fluctuated between 68,000,000 and 109,000,000 pounds. The average yield during the first half of this period (1913 to 1919) was 94,195,000 pounds per year, while during the last half (1920 to 1925) it was only 78,161,000 pounds. This marked decline has been especially noticeable among some of the most valuable and most sought-for fishes, principally whitefish, herring, chubs, ciscoes, and sturgeon.

TECHNOLOGICAL INVESTIGATIONS

In its technological work the Bureau of Fisheries is endeavoring to improve present practices and to develop new equipment, methods, and products within the fisheries industries and to bring about proper utilization of wastes and by-products. Investigations are made and science applied to the various problems. Results are then made available to the industry, and their application is directed until they become an integral part of the same. The fisheries industries offer a very fruitful field for work of this nature. Rapid progress in industry (and this applies particularly to the fisheries industries) depends largely upon such work, combined with the application of sound business principles.

Work to date has been confined largely to four major lines of research—utilization of by-products, nutritive value of fish and shellfish, preservation of nets, and improvements in merchandising fresh fish.

A method was worked out for decreasing losses of the protein and oil contained in press liquors now discarded in the manufacture of fish meal and oil. The method produces a better oil and should help materially in diminishing pollution from these liquors in our coastal waters. In this connection a careful study of the menhaden industry was made, which revealed that certain steps should be taken to lessen production costs and improve the products, the results of which have been given to the industry.

With the increasing demand for fillets, the quantity of waste that is collecting in certain fish markets has become considerable—sufficient to enable profitable by-products industries to be prosecuted with the development of suitable methods for handling the gluey waste from such fishes as cod and haddock. Such a method has been worked out, and the results of this work are being made available to those in the industry unable to overcome the present difficulty.

The bureau has issued a document on the nutritive value of fish and shellfish, with chapters by experts on the chemical composition, mineral constituents, vitamins, oils, and fats, and protein value of aquatic foods. This has been very helpful in creating a better realization of the place of fish and shellfish in the diet. To add to our knowledge of the value of the proteins in fish, the bureau is conducting an investigation at Johns Hopkins University under the direction of Dr. E. V. McCollum, which indicates that the proteins in herring and haddock have high nutritive value, comparable with meat. Extensive tests are now in progress regarding the nutritive and corrective values of selected grades of fish meals, as demonstrated by rat-feeding experiments.

Large-scale practical tests with copper oleate and copper paint mixture net preservatives have been conducted at points on the coast of North Carolina, Virginia, and New Jersey, in which trap nets and purse seines were used. In addition, experiments with a large number of new preservatives are in progress at the Beaufort (N. C.) station.

Perhaps the most fertile field for experimentation lies in improvements in the methods of handling fresh fish from the place of capture until the product reaches the consumer. Holding or ripening meat improves its quality; the opposite is true of fish. The bureau has made a most important contribution to this branch of industry through the issuance of a handbook on the refrigeration of fish. This includes a history of the industry and important scientific principles involved; changes that take place in the fish in the fresh state and during freezing and holding; design, construction, and equipment of fish freezers; practical freezing methods; methods of brine freezing; transportation of frozen fish; and many other points essential to the proper understanding of the industry, its problems, and the product as a food.

Experiments are now in progress to improve the quality of fish as landed by the fishing vessels and to reduce overhead expense through the adoption of labor-saving devices.

The bureau also is arranging to provide research associate facilities, whereby firms or groups having special technological problems to solve will furnish the investigator and pay his salary and incidental expenses, the investigation to be carried on under the direction of the bureau's experts and the bureau's equipment to be used so far as available. The bureau reserves the right to make public the results of all such cooperative investigations.

Because of the extreme difficulties confronting the menhaden industry, particular attention is being given to the problems of that industry, especially to the possibilities of developing improved methods of manufacture that will cut down the extremely heavy labor cost of present practices, yield high-grade oil and meal, and obviate losses in the process of manufacture.

Epoch-making progress characterized developments in the fishery industries. Machine processes are being developed; cleaning and cutting machinery, mechanical conveyers, and packing machines are replacing hand labor. The packing of fresh fish in cartons and packages permits of its wider distribution by retail grocery stores and is tending to distribute sales more evenly throughout the week. The value of carbon dioxide ice for icing refrigerator cars, as well as for preserving smaller shipments, is being demonstrated; and the development of means of freezing fish rapidly with brines indicates that such methods are rapidly approaching a state of perfection that will permit of their use in the large-scale production of frozen fish required by this important branch of fresh-fish preservation and distribution.

BIOLOGICAL INVESTIGATIONS

FISHERY RESEARCH

A brief survey of the year's work shows gratifying progress in many fields. The culmination of many years of salmon investigation in the formulation of a successful plan of protection of the salmon fisheries of Alaska and the promise of reliable forecasting of future years' runs is one of the most satisfying results of the efforts of the fisheries investigators. Oyster investigations have been expanded and are yielding fruits of inestimable value to a great industry reaching from Cape Cod to Texas. Not only have immediately applicable recommendations with regard to oyster culture been offered to the several States, but fundamental investigations on the biology of the oyster itself have been conducted, which will make possible a greater production of this valuable mollusk.

Notable progress also has been made in the conquest of fish diseases which have seriously curtailed the output of the many fish hatcheries scattered throughout the country. These investigations in the pathology of fish and experimental fish culture have gone far to increase the effectiveness of hatcheries and eventually may place the farming of fish in ponds upon a successful and lucrative basis.

The enthusiasm and energy of the investigators have been stimulated materially by a conference of the entire staff of the division of scientific inquiry held in Washington, D. C., in January.

As in previous years, many States have cooperated with the bureau's investigators, thus making possible a more effective and more extensive investigation than would otherwise be possible. Joint investigations by the bureau and the State governments include work on the oysters in Georgia, North Carolina, South Carolina, Mississippi, and Texas; salmon investigations in California, Oregon, and Washington; a study of food supply in lake waters in Michigan and Wisconsin; and mussel investigations in Arkansas.

Following is a brief résumé of the results of the more important activities of the division:

INVESTIGATIONS OF THE FISHERIES OF THE NORTH ATLANTIC

Tagging operations in the summer of 1926 were continued from August to October, the total number of cod, haddock, and pollock tagged amounting to 4,235. The work was carried on from the fisheries steamer *Albatross II*, chiefly in the waters south of Cape Cod, on Georges Bank, and off Mount Desert, Me. The tagging work was resumed in April, 1927, the program including further tagging on Georges, Browns, and Fippenies Banks as well as on the inshore grounds in Massachusetts Bay and along the coast of Maine. Three cruises were made before the close of the fiscal year, during which 3,602 cod, pollock, and haddock were tagged, bringing the total of the fiscal year 1927 up to 7,847, and for the entire experiment since 1923 to 43,699. The recapture of tagged fish during the present season has been satisfactory, but a greater proportion is expected during the autumn and winter.

During the spring operations an otter trawl was used with considerable success, even on rocky grounds, for taking the smaller cod and securing a better representation of the immature members of the population. An extensive collection of scales has been taken; many of them have been studied, and the intensity of fishing and the size and age composition of the stock on the grounds has been determined.

In order to determine further the interdependence of the various fishing banks, studies of the abundance and distribution of cod eggs in Massachusetts Bay have been continued, and a report covering the observations made during 1924 and 1925 from the *Fish Hawk* has been completed.

Through extensive observations of the commercial run of mackerel at several of the major ports, an understanding of the composition of the mackerel stock entering the commercial fishery has been gained. The studies of the spawning areas also have been continued. Observations on the southern fishing grounds, from Long Island to Delaware, were made during the spring of 1927, and through systematic tow-net collections of eggs and larvæ an attempt is being made to discover the relative success of spawning each year. At the same time the tagging experiments to trace the migrations of the fish have been continued, and it is confidently expected that through the early detection of successful spawning years, and from knowledge of the biology of the fish and its habits, the extent of future runs may be predicted.

Both fresh and salt water smelts are being studied. The salt-water smelts are suffering rapid extermination, and these studies of life history and habits, as interpreted by modern methods of fishery research, will provide the basis for definite recommendations for regulation of the fishery. In addition, extensive collections of trouts and chars, made in many localities through North America, are receiving attention with a view to distinguishing the many races and specifically determining which are most satisfactory for continued artificial propagation.

INVESTIGATIONS OF FISHERIES OF THE SOUTH ATLANTIC AND GULF COASTS

Fisheries investigations in the South Atlantic region are being centered at the Beaufort (N. C.) biological station. The fisheries receiving particular attention at present are those for mullet, other shore fisheries, the scallop, oyster, and terrapin. Tagging mullet to determine the limits of its migration was extended somewhat, about 1,000 fish being tagged and liberated in the vicinity of Beaufort, with results that corroborated last year's findings. Studies on the cape mullet to determine their origin and importance in maintaining the stock of local fish are also receiving attention.

During the past year systematic tow-net collections were made, both inside the sound, in the vicinity of Beaufort, and offshore toward the Gulf Stream, to aid in studying the spawning periods and localities and the early development of the more important commercial fishes of that region. Previously unknown larvæ of the spot, croaker, gray trout or squeteague, menhaden, pigfish, and many other species were taken.

The scallop investigations begun in 1925 were continued. The scallop fishery is of considerable importance, the only producing grounds in the South being in the vicinity of Beaufort, N. C. The yield is subject to considerable fluctuation, however, and the investigations aim to determine the intensity of fishing that can be practiced without completely depleting the beds. The rate of growth and the abundance of the new generations and the mortality of the adults have been determined accurately, and a basis for regulation has been established. New beds were discovered recently, and conditions favoring growth in other localities have been examined.

Experiments in terrapin culture at Beaufort, initiated more than 25 years ago, have resulted in developing a practical method of cultivation, which now is followed extensively. The State of North Carolina is cooperating with the bureau by furnishing breeding adult terrapin and by hatching thousands of young terrapin for distribution in the marshes. A closed season of five years was established in 1925 for the protection of the terrapin, and it is believed that the extended program of restocking waters will restore the North Carolina terrapin fishery to a productive condition within a few years. Many of the adult terrapin provided by the State in 1925 to form the brood stock of the station began laying in the summer of 1927.

Investigation of the shore fisheries of Texas has been continued vigorously in both field and laboratory. Fisheries on the coast of Texas are in a very backward state, due, according to different views, to depletion or to lack of development. State authorities have attempted to protect the fish on the spawning grounds. During the past year investigations have been designed to discover the exact spawning areas and also the outstanding facts of the life history of the important commercial sea fish—spotted trout, drum, and redfish—and a report on the subject is being prepared. In addition, a study of the fish fauna of the entire Texas coast is being made.

OYSTER INVESTIGATIONS

The oyster investigations were extended considerably during the last fiscal year and were as follows: (1) Experiments for increasing the collection of spat; (2) study of the factors controlling setting; (3) study of the spawning of the oyster; (4) surveys of natural oyster beds and reefs; and (5) study of the drill, chief enemy of the oyster.

Inasmuch as the principal cause of the decline of the oyster industry in northern waters has been the inability to obtain a yearly crop of seed oysters, the purpose of experiments carried on at Milford Harbor, Conn., and Wareham River and Wellfleet, Mass., has been to discover a practical method of producing this annual supply. A new method for the control and production of seed oysters has been developed, which consists essentially in the establishment of spawning beds in bays, harbors, and river mouths, and the planting of crates filled with shells in the vicinity of oyster beds for the collection of set.

The crates were triangular in shape, of spruce lath, having a capacity of 2 bushels, and each covering an area of 2 square feet. They were planted in various formations on the tidal flats, so as to determine their efficacy as seed collectors and the effect of their position and arrangement on the uniformity or intensity of the set. In Milford Harbor 300 crates collected an average of 2,000 spat per bushel of oyster shells. Fifty crates were set in Wareham River, Mass., and yielded from 1,900 to 45,000 spat per bushel. Setting occurs here between tide marks and was found to be heaviest about 1½ feet above the bar on which shells are planted by the local oyster men. In Wellfleet 97 crates were planted, and, though no set of commercial importance occurred, the crates in Herring River collected a fairly good set, ranging from 1,200 to 2,800 per bushel.

Additional experiments and observations on the factors controlling setting have been undertaken in Long Island Sound by means of drift bottles, tide gauge, current meter, and spat collectors.

The following practical applications of the experiments can be made: (1) In certain localities the oysters can be induced to spawn by adding sperm to the water, and (2) for successful spawning the oysters should be planted on the spawning grounds as densely as possible.

At the request of the States, surveys of the oyster grounds were made in Massachusetts, North Carolina, South Carolina, Alabama, Mississippi, and Texas, to ascertain the practical measures suitable for each region that should be adopted in order to prevent further depletion of the natural reefs and to maintain or, if possible, to increase the production of oysters.

It has been found that in certain regions in Massachusetts, as, for example, Wareham River, Onset Harbor, and Centerville River, the production of seed oysters can be increased considerably by adoption of a new method of spat collection and by restocking the depleted oyster beds (Centerville River). The other localities (Waquoit, Cotuit, and Chatham) are suitable as oyster-growing grounds only.

In South Carolina oyster production can be increased by transplanting seed oysters from the tidal flats to the bottoms below low-water mark, where setting does not occur. It has been recommended to return a greater quantity of shells to the natural beds, to extend the beds by planting shells on adjacent firm bottoms, to restore the depleted oyster beds by planting seed and adult oysters, to collect the set on brush and shells planted on tidal flats, and to transplant it on suitable bottoms below low-water mark.

The survey of Texas waters covered the region from Corpus Christi to Galveston and has shown that oyster reefs in these coastal waters produce enormous quantities of oysters, some of which have little market value. It was recommended that the overcrowded reefs be used as the source of an almost unlimited supply of seed oysters, and to plant them on the bottoms of the following bays: Aransas, Mesquite, Lavaca, north of Sandy Point, Kellers, Karankawa Reef, Trespalacios, and Matagorda between Portsmouth and Pallacios Points.

The work in North Carolina consists chiefly in a hydrographic study of Pamlico Sound with reference to oyster culture. The temperatures, salinities of the water, sedimentation and shifting of the bottom, and the distribution of the oyster set have received particular attention throughout the entire year. One of the most serious problems in planting oyster shells is the danger of the set being smothered with sand or silt by shifting currents. Studies on sedimentation and currents, therefore, are designed to discover the areas where cultch can be planted safely and where producing beds can be extended by artificial means. The State of North Carolina has cooperated actively by furnishing a vessel for this research work. Some of the studies were conducted at the Beaufort biological laboratory and some in the soils laboratory of the University of North Carolina.

In Mississippi Sound and in Mobile Bay observations on the hydrographic conditions that affect oyster culture in that region have been under way throughout the year. Experiments on the use of brush as spat collectors have been undertaken on a large scale, and favorable results through the coming growing season are anticipated. Present observations in Mississippi Sound tend to show that the productiveness of oyster beds can be increased by the planting of shells and brush in order to utilize the abundant natural set.

Because of the extensive depredations of the drill in the oyster beds of Chesapeake Bay, a study is being carried on at Norfolk, Va. (where a temporary laboratory has been established), with a view to finding an efficient method for combatting this pest. A thorough study of the life history of the drill is under way, including field and laboratory observations on the spawning habits, feeding habits, migrations, and distribution of the animals. If the abundance of the oyster drill in Chesapeake Bay can be reduced, a saving of thousands of dollars to the oyster industry will be effected.

A number of minor surveys and inspections of oyster grounds have been made. At the request of the National Research Council, observations were made in the vicinity of Tampa and Key Largo, Fla., for the purpose of determining whether conditions there were suited to the cultivation of the Japanese pearl oyster. Black Water Sound, Palmasola Bay, and Largo Sound were found to be suitable for experiments in artificial pearl culture.

At the request of the Alabama Fish and Game Commission, a brief survey of the oyster bottoms in Mobile Bay was made during April, 1927, to determine the abundance and character of oyster growth on the natural reefs, and particularly as to whether or not dredging oysters on certain reefs would be harmful. Observations indicated that dredging north of the line extending from Alabamaport to Fish River not only would do no harm but would improve the condition of the reefs and increase their productiveness, provided the culling laws were observed.

FISHERIES OF THE PACIFIC COAST AND ALASKA

Besides successfully discharging the duties of protecting and administering the salmon fisheries of Alaska, based on present knowledge of the life histories and biology of the various species, the bureau is making rapid progress toward a more complete understanding of the factors that regulate the abundance of salmon from year to year and in checking the depletion. The salmon fisheries of Alaska depend upon five distinct species of wide distribution, each of which is represented by an independent, self-perpetuating colony in every stream that affords suitable conditions for its existence. Each colony is independent of all others, and, inasmuch as it secures no recruits from adjacent streams, its maintenance depends on an adequate spawning reserve to produce the eggs for succeeding generations. The regulatory function of the Bureau of Fisheries, therefore, consists in adopting and enforcing regulations of the fisheries that will permit a sufficient number of adults to reach the spawning grounds of each salmon stream throughout the region.

A program of investigation was adopted in 1921 with the purpose of discovering how large a spawning reserve is necessary, and this program has been followed assiduously and has been extended under the auspices of the Pacific Salmon Investigation Federation to include the entire salmon fisheries on the Pacific coast. The essential part of the problem is to ascertain the complete returns from spawning colonies of known size. The Karluk and Chignik Rivers have been selected because of favorable natural conditions in which to conduct the studies. Weirs have been constructed, and investigators have been stationed at them to make necessary observations, and it is confidently expected that a reliable basis for the prediction of the magnitude of future runs of salmon will be developed. A report on this subject has been prepared.

In order to determine the migration routes of fish, extensive tagging experiments have been continued for several years. A report covering these operations in Alaska in 1926 adds much to our knowledge of the routes of travel of the salmon from the sea to their spawning grounds and indicates the source of supply. Plans have been made for the spring and summer of 1927 to extend the tagging of salmon caught by trolling in the ocean. The work will be conducted by representatives of the bureau in Alaska and various State authorities along the coasts of Washington, Oregon, and California. Specific studies on Karluk Lake have been instituted to determine the reason for the unusually rich production of salmon in the Karluk River system.

During the past 10 years the Bureau of Fisheries, in cooperation with the Oregon Fish Commission, has conducted marking experiments as a means of studying the life history of the salmon in the

Columbia River. Fingerlings have been marked by removing various fins and have been liberated under varying conditions in the river.

The herring fishery of Alaska has been receiving greater attention recently. The growing use of herring for food and manufacture into oil and meal has aroused considerable anxiety concerning the danger of depletion. Biological investigations of the herring begun in the spring of 1925 have been continued, and extensive studies of the segregation of the various races have been made. In addition to the studies of the physical proportions of the fish as a means of distinguishing the racial units of the fish population, which were made last year, a tagging program has been undertaken. During the spring of 1927, 3,000 herring were tagged, and studies of the early development were begun by making tow-net collections of larval herring.

The only other subject of detailed study by the bureau was the razor clam. Studies have been conducted on representative beds throughout the Pacific coast, and several reports already have been published outlining the general features of the life history of this clam. During 1926 and 1927 a comprehensive study on rates of growth, according to latitude, on the Pacific coast has been in progress, and data of direct use in regulating the fishery in Alaska have been collected. Thorough annual observations of the more important beds are made and the trend and abundance of the resource accurately determined, and regulations governing the fishery in Alaska for the following year are drawn up in accordance with actual needs.

FISHERIES OF THE INTERIOR

The investigations of the inland fisheries are centered at the fisheries biological laboratory at Fairport, Iowa, for the Mississippi River district, and at the University of Michigan, Ann Arbor, Mich., for the Great Lakes. Investigations at Fairport are concerned chiefly with the artificial propagation of fresh-water mussels, which provide the raw material for the manufacture of pearl buttons and novelties, and with studies on the pond culture of fresh-water food fishes.

The most important work along this line conducted at the Fairport laboratory in recent years consists in developing a nutrient solution that serves as a medium for the growth of larval mussels without passing a period of parasitic life on the gills of various fishes. In addition to the trough-cultural methods devised as a result of earlier studies, great numbers of fish rescued from overflowed lands in the Mississippi Basin are infected with the glochidia of mussels before they are returned to the river. This work of the bureau has received enthusiastic support from the button industry, as the increasing cost of labor and the scarcity of raw materials are proving a serious handicap to the industry.

The process of rearing larval mussels in a nutrient solution, evolved by Dr. Max M. Ellis, of the University of Missouri, promises greatly to simplify the propagation work of the bureau and tremendously increase the output of juvenile mussels at an age and stage of development that virtually insure survival. Moreover, it will permit their being planted in areas suited to their rapid development, and which can be controlled, thus making mussel farming on an extensive scale possible. Plans are being made for adapting the laboratory process to large-scale operations.

At the request and with the cooperation of the Arkansas Game and Fish Commission, a brief survey was made of the more important rivers in Arkansas for the purpose of devising a more satisfactory code of fishery regulation to prevent overfishing and permit full utilization of productive mussel beds. A plan of alternately opening and closing certain sections was devised to afford maximum protection with minimum loss or inconvenience to the industry. Surveys of portions of the upper Mississippi River and certain rivers in Virginia also were made during the year to determine the state of the resource, so that recommendations for regulations could be made.

The need has been felt for more complete knowledge of the growth of commercially valuable mussel shells in order that localities where growth is rapid might be stocked heavily with the more valuable or more rapidly growing species. Satisfactory methods for determining age were worked out, and studies of the rates of growth of several important species were completed. A report on this work has been submitted.

An investigation begun by Dr. R. E. Coker in 1914 was taken up again by him and completed. This was a study of the effects of the dam at Keokuk, Iowa, on the fish population above and below the dam. A report that contributes much to our knowledge of the fish of this region has been completed.

A brief investigation of the pollution of the upper Mississippi River was conducted during the fall of 1926 at the request of the Joint Interim Committee of the States of Wisconsin and Minnesota. Plans were made for a joint sanitary and biological survey of the upper Mississippi River by the Public Health Service and the health departments of the States and the Twin Cities, and the bureau was requested to conduct the biological survey. Due to lack of funds and the short time available for completion of the report, only a limited program was undertaken. The abundance and character of the bottom life and of the plankton of the river were determined at various stations over a distance of about 200 miles, and observations on the fish life were made at the same time. A report of the findings showed that during the summer and fall the effects of pollution from the Twin Cities extends down the river for about 85 miles. Throughout this distance fish life suffered greatly and in areas of extreme pollution was entirely absent.

Plans for extending the investigations of the commercial fisheries in the Great Lakes, made possible through additional appropriations by the last Congress, have been made. In 1927 and 1928 the work will be confined to studies of conditions on Lake Erie to ascertain, if possible, the factors involved in the presumed depletion of certain species; to obtain an understanding of the nature of all biological and economic problems that affect the commercial fishing industry of the Lakes; to study the biology of the more important commercial and game fishes; and to acquire reliable data essential to drafting rational and uniform regulations for the fisheries of Lake Erie and, so far as may be applicable, of the other Great Lakes.

An agreement providing for extensive cooperation between investigators of the bureau and of the State of Ohio has been made for the conduct of experimental fishing, the study of the commercial catch, and studies on the environment of the fishes in Lake Erie. The State of Ohio will provide investigators to carry on a series of biological studies on the conditions of fish life in the lake. The bureau's staff, working in cooperation, will study the biological aspects of commercial fishing. In addition to these studies, the economic aspects of the regulation of fishing gear and the type of legislation required to restrict abuses in the fishery will be considered. The State department of agriculture, division of fish and game, will furnish and operate a vessel for the conduct of this work.

PATHOLOGY AND EXPERIMENTAL FISH CULTURE

Three important lines of investigation are being followed in the field of aquiculture—(1) pond culture of warm-water fishes, (2) experimental trout culture, and (3) pathology of fishes. Experiments in the production of basses and other food fishes of the Mississippi River region have been carried out in the ponds at the Fairport biological station in an attempt to increase the food supply through fertilization of the waters and to increase the production of fish through proper handling of the fish themselves. Detailed chemical and biological examinations of the ponds are carried on throughout the growing season to determine the conditions most favorable to fish growth; and an attempt is being made to develop a measure of productiveness by which natural pond and swamp areas throughout the country may be determined, so that those suited for the production of fish may be stocked and conditions in others improved. Experiments in producing forage fish, such as the black-head minnow, have been markedly successful, and the advisability of using forage fish as food for bass was clearly evidenced by a considerably increased yield of healthy fish. Through cooperation by the division of fish culture, arrangements were made to begin the pond-cultural experiments on a larger scale at the Neosho (Mo.) fish-cultural station; and in addition to cultivating largemouth bass, experiments in the rearing of smallmouth bass and trout were undertaken here in the spring of 1927.

The work at the Holden (Vt.) experimental fish hatchery has been devoted to the solution of problems arising in the culture of several species of trout. Feeding experiments have been conducted for several years, in which the value of various diets for trout fry has been determined. In an attempt to develop a superior brood stock, selective breeding experiments have been undertaken. A stock of select brood trout has been secured from various places and tagged for future identification. The eggs from the various types of fish were segregated and the young reared in separate pools. It is believed that such qualities as rapidity of growth, strength and vitality of young, resistance to disease, and fecundity can be improved materially in hatchery-reared trout. The capacity of the experimental hatchery at Holden has been increased by additional ponds and raceways, and the whole station has been brought up to a high level of efficiency.

Closely related to the work on pond culture and experimental trout culture is the study of fish diseases. Heavy annual mortality at the Holden station has been overcome through treatment of diseases and parasites, and a study of the cestodarian parasites of bass has been undertaken at the Fairport station and at the Neosho (Mo.) hatchery.

The isolation of several microorganisms that cause diseases in fish and the devising of methods of control were accomplished during the past year, and reports on this work are almost completed. Through the conquest of disease, it is anticipated that a marked increase in the output of the many State, Federal, and private hatcheries throughout the country will result, for fish culturists generally are recognizing the fact that fingerlings held in hatcheries for a long time have a greater chance of survival after planting than those planted in the fry stage. To avoid heavy losses in many hatcheries, the fish are planted in early stages of development and thus fall prey to many enemies when least able to care for themselves. Reducing hatchery diseases, therefore, will increase the output of fingerling fish, and hence the effectiveness of fish-cultural stations.

ALASKA FISHERIES SERVICE

ADMINISTRATION OF FISHERY LAWS AND REGULATIONS

In administering the fisheries of Alaska in 1926 there was no marked departure from the general conservation policy adopted upon passage of the act of June 6, 1924, which expanded the authority of the Secretary of Commerce to denote the time, place, and manner of commercial fishing operations. During the progress of the season's operations some extensions of the regulations were necessary to prevent overfishing in certain places and to meet unusual conditions that arose. The Commissioner of Fisheries was in Alaska during much of the active salmon-fishing season to give immediate attention to necessary changes in the regulations.

The act of June 18, 1926, reenacting and expanding section 1 of the act of June 6, 1924, further broadened control over the fisheries of Alaska by giving the Secretary of Commerce authority to permit the taking of fish or shellfish, for bait purposes only, at any or all seasons in any or all Alaskan Territorial waters. This made possible more satisfactory regulatory measures for the taking of herring for bait purposes in the halibut fishery.

Under date of December 22, 1926, there was a general revision of the fisheries regulations to be effective in 1927. The chief change was the closing to commercial fishing for salmon of 14 localities, in addition to the 99 previously closed. Three of the latter were opened part of the season, and in two others fishing with limited gear was permitted in specified periods.

With few exceptions, the 1,200 or more streams ascended by salmon had good escapements to the spawning grounds. The constant aim and purpose is to secure full compliance with that part of the act of June 6, 1924, which declares it to be the policy of Congress that there shall be an escapement to the spawning grounds of at least 50 per cent of the runs of salmon. The effect of the existing regulations upon the escapement can be gauged satisfactorily by maintaining weirs, through which salmon can be counted, and then checking the results with the commercial take of salmon in the vicinity. In 1926 such weirs were maintained in eight streams in Alaska. Additional weirs will be constructed from time to time as funds and facilities permit.

There was a further expansion in 1926 of the patrol for the protection of the fisheries of Alaska and the enforcement of the laws and regulations. Identified with this work were 13 regular and 145 temporary employees, exclusive of those on the bureau's 11 vessels and the 12 chartered boats, or an increase of 13 persons and 2 vessels over the previous season. In addition, a number of small launches were used for varying periods. This expanded patrol was of particular value as a deterrent to violations, for with few exceptions there was satisfactory observance of the fishery laws and regulations. Before another season the bureau will have added two new patrol vessels to its Alaskan fleet, both of which will be capable of offshore duty when necessary.

SALMON HATCHERIES

The Federal Government operated fish hatcheries at Afognak and on McDonald Lake, at which 52,010,000 red-salmon eggs were collected in 1926. In addition, several million steelhead-trout and humpback-salmon eggs were secured. Two privately owned hatcheries took 41,420,000 red-salmon eggs, and in addition one of them obtained 6,640,000 humpback-salmon eggs.

The Alaska Territorial Fish Commission maintained hatcheries at Ketchikan, Cordova, and Seward. At the Ketchikan hatchery 3,337,760 red-salmon eggs, 1,660,000 humpback-salmon eggs, and 2,000,000 king-salmon eggs were collected and received. At the Seward hatchery 3,164,000 red-salmon eggs were collected. No eggs were taken at the Cordova station in 1926.

SPECIAL STUDIES AND INVESTIGATIONS

During the season of 1926, 13,530 salmon were tagged and released for the purpose of securing further information in regard to migration routes. Scientific investigations of the life history of the salmons were conducted in various parts of Alaska, chiefly in the Karluk River region. Extensive observations were made on various salmon-spawning grounds to determine the adequacy of the salmon escapement and to supplement the information obtained at the counting weirs. Conditions were generally satisfactory, but in some instances the number of spawning salmon appeared to be insufficient.

Additional scientific studies were made in regard to the herring and clam fisheries.

PRODUCTS OF THE FISHERIES

The pack of canned salmon in Alaska was the largest in the history of the Territory, amounting to 6,652,882 cases. Compared with the preceding year, the pack of red salmon increased more than 100 per cent, humpbacks about 58 per cent, cohos over 25 per cent, and kings about 5 per cent. The pack of chums decreased about 16 per cent. The increase in the pack was due largely to a greater take of red salmon in western Alaska and of humpbacks in central Alaska.

The total value of the manufactured fishery products of Alaska in 1926 was $54,669,882. The value of the catch to the fishermen was approximately $14,500,000.

The entire Alaska fishery industry gave employment to 28,052 persons, as compared with 27,685 persons in 1925, and represented an investment of $74,557,522.

The extent and condition of the Alaska fisheries in 1926 and of the activities of the bureau under the laws and regulations for the protection of the fisheries are covered in detail in the annual report of the Alaska service for that year.[3]

ALASKA FUR-SEAL SERVICE

GENERAL ACTIVITIES

Activities at the Pribilof Islands during the year continued in general along the lines heretofore followed. The take of sealskins was satisfactory, exceeding somewhat that of the previous year, and the usual annual computation showed a substantial increase in the size of the herd. A sufficient number of 3-year-old males was marked and reserved for future breeding requirements. Foxing operations progressed satisfactorily.

Good progress was made in the construction of new buildings and in other improvements, including roads. The new buildings are largely to replace former structures, which through age have deteriorated so that they can no longer be kept in repair. The desirability of shortening seal drives and the advantages to be derived from the use of motor-driven vehicles make suitable roads a matter of much importance.

Food, fuel, clothing, shelter, and medical and educational facilities were provided 344 native inhabitants of the islands. The issues of food and other necessaries of life were supplemented by cash payments on the basis of 75 cents for each sealskin and $5 for each fox skin taken, in return for which the natives perform the general work at the islands. Additional small payments were made for certain special services. A staff of white employees supervises all work at the Pribilof Islands.

Through the courtesy of the Navy Department, the general supplies for the fiscal year 1927 were transported from Seattle to the Pribilof Islands by the United States steamer *Vega*, and the sealskins were shipped from the islands on that vessel. The bureau is also indebted to the United States Coast Guard for many services rendered by vessels on the fur-seal patrol.

SEAL HERD

On August 10, 1926, the Pribilof Islands fur-seal herd was computed to contain 761,281 animals. This was an increase of 38,231, or 5.29 per cent over the corresponding figure for 1925.

TAKE OF SEALSKINS

In the calendar year 1926 there were taken on the Pribilof Islands 22,131 fur-seal skins, of which 16,231 were from St. Paul Island and 5,900 from St. George Island. This was an increase of 2,271 over the number taken in 1925.

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[3] Alaska Fishery and Fur-Seal Industries in 1926. By Ward T. Bower. Appendix IV, Report United States Commissioner of Fisheries for 1927, pp. 225-336, 15 figs. Bureau of Fisheries Document No. 1023. Washington.

MARKING OF RESERVED SEALS

In 1926 the bureau marked 9,565 3-year-old male seals to be reserved for a future breeding stock, of which 7,558 were on St. Paul Island and 2,007 on St. George Island. In addition to the seals marked, there were remaining at the end of the year the 3-year-old males that never were taken up in driving operations. The method of marking was to clip a patch of fur from the upper part of each animal so that it might readily be distinguished thereafter.

SALE OF SEALSKINS

In the fiscal year 1927 two public-auction sales of fur-seal skins taken on the Pribilof Islands were held at St. Louis, Mo. The first sale was held on October 11, 1926, when 6,767 black dyed, 1,250 logwood-brown dyed, 54 golden-chestnut dyed, and 3 dressed skins, a total of 8,074, were sold at a gross price of $308,844. At the same time 181 Japanese fur-seal skins were sold for $4,402, of which 151 were dyed black and 30 were raw salted. These 181 skins were the United States Government's share of sealskins taken by the Japanese Government in 1924 and 1925. In 1926 the Government received 132 skins as its share of Japanese sealskins. There were also sold one confiscated sealskin (black dyed) and four pieces of confiscated dressed and dyed sealskin for $42.

At the second sale, held on May 23, 1927, 11,611 black dyed, 1,526 logwood-brown dyed, and 91 faulty skins, a total of 13,228, were sold at a gross price of $436,566.20.

Special sales of sealskins in the fiscal year 1927 consisted of 68 raw salted, 50 black dyed, and 7 logwood-brown dyed skins at a gross price of $4,324.04. All were taken at the Pribilof Islands.

FOXES

Fox feeding was continued on both St. Paul and St. George Islands in the winter of 1926–27. Specially prepared food was used, and in addition preserved seal meat was fed on St. George Island.

There were sold at public auction on October 11, 1926, at St. Louis, Mo., 465 blue-fox skins taken at the Pribilof Islands. The gross price realized was $24,740. Three hundred and forty of these skins were taken in the season of 1924–25, and 125 in the season of 1925–26. There were also sold at the same sale, for $1.50, three skins taken from foxes that died in course of shipment from the Pribilofs.

In the season of 1926–27, 118 blue and 27 white skins were taken on St. Paul Island and 610 blue and 3 white skins on St. George Island, a total of 758 skins. During the season of 1926–27, 125 males and 108 females were marked and released for breeding purposes on St. Paul Island and 205 males and 202 females on St. George Island. The stock actually reserved for breeding was larger, because a considerable number of animals are never caught at all. In order to improve the herds on each island, 10 pairs of foxes from St. Paul were released on St. George Island, and a similar transfer was made from St. George Island to St. Paul Island.

FUR-SEAL SKINS TAKEN BY NATIVES

By the provisions of the North Pacific Sealing Convention of July 7, 1911, natives of the Pacific coast may, under certain restricted conditions, take fur seals at sea. Before sealskins secured under these conditions can enter into commerce, they must be authenticated as having been taken lawfully. One thousand and seventy-five sealskins taken in the sealing season of 1926 have been authenticated by the Government, 40 of which were taken in the offshore waters of southeast Alaska and 1,035 from waters off the coast of Washington. Through the courtesy of the Interior Department, the latter skins were authenticated by the superintendent of the Neah Bay Indian Agency.

FUR-SEAL PATROL

An adequate patrol of the waters frequented by the Pribilof Islands fur-seal herd was maintained by vessels of the United States Coast Guard, supplemented in southeast Alaska by one of the bureau's fishery patrol vessels.

PROTECTION OF SEA OTTERS, WALRUSES, AND SEA LIONS

The protection of sea otters, walruses, and sea lions was along the usual lines. The killing of sea otters is prohibited at all times, both in Territorial and extraterritorial waters. The extreme scarcity of this valuable and formerly numerous animal will necessitate years of thorough protection to enable its reestablishment in even limited numbers as compared with its abundance of former times. The present regulations prohibit the killing of walruses and sea lions in Alaskan waters until April 30, 1928, except for purposes of securing food or clothing; and in the case of sea lions, except as may be necessary for the protection of property or while such animals are actually engaged in the devastation of runs of salmon.

VESSEL NOTES

The investigation of the fisheries of the Gulf of Maine, in which the *Halcyon* has been employed, was undertaken this year by the *Albatross II*, the former vessel having been laid up. The reconditioning of the latter steamer was sufficiently advanced to permit of her going to sea early in August, and the investigation was carried on as continuously as available funds would allow. The steamer cruised 4,291 miles and made 69 oceanographic stations, and 7,785 fish were caught, tagged, and liberated. Some faults have developed in the ventilating system, but these will be corrected during the coming year.

The *Gannet* and the *Halcyon* were not operated, but the other two steamers and motor vessels carried on the usual fish-cultural and biological work on the Atlantic coast and interior waters.

In the fiscal year 1927, 11 vessels of the Alaska service cruised more than 67,000 nautical miles. Of these, the *Brant* made over 17,000 miles and the *Eider* about 11,000 miles.

In addition to general patrol work in the waters of southeastern and central Alaska, the *Brant* was detailed during part of the winter to certain duties off the coast of California. This vessel, which is 100 feet in length and equipped with a 225-horsepower Diesel engine, was built in 1926 and has proved a highly satisfactory addition to the fleet.

The *Eider* continued as local tender for the Pribilof Islands, with base at Unalaska, and rendered some service in connection with salmon-fishery conservation.

In southeastern Alaska the *Widgeon*, *Murre*, and *Auklet* were engaged on fishery protective work. The *Kittiwake* was similarly employed in the Cook Inlet region, the *Blue Wing* in the Kodiak section, the *Ibis* at Chignik, the *Merganser* in the Alaska Peninsula region, the *Scoter* on Bristol Bay waters, and the *Tern* on the Yukon River.

The *Petrel* was at Seattle, Wash., pending arrangements for the installation of a new engine. The *Red Wing*, a power vessel approximately 40 feet in length, acquired by transfer from the Department of Agriculture, will be used in the Kodiak region after certain alterations.

An additional vessel for the Alaska service, which has been given the name *Teal*, was under construction at North Bend, Oreg., at the close of the fiscal year 1927. This vessel is to be 78 feet in length and 18 feet in breadth and will have a 150-horsepower full Diesel engine. The *Teal* will be assigned to duty in coastal waters of central Alaska.

APPROPRIATIONS

The regular appropriations for the bureau for the fiscal year 1927 aggregated $1,814,253, as follows:

Salaries, office and field	$688,378
Miscellaneous expenses:	
Administration	3,900
Propagation of food fishes	427,000
Maintenance of vessels	120,000
Inquiry regarding food fishes	57,475
Fishery industries	25,000
Protecting sponge fisheries	2,500
Protecting seal and salmon fisheries of Alaska	340,000
Upper Mississippi River fish-rescue station	25,000
Power vessel for Alaska fisheries	50,000
Nashua (N. H.) fish hatchery repairs	25,000
Establishment of auxiliary stations:	
Georgia	30,000
Colorado	20,000
	1,814,253

Very truly yours,

HENRY O'MALLEY,
Commissioner of Fisheries.

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ARTIFICIAL PROPAGATION OF PIKE PERCH, YELLOW PERCH, AND PIKES[1]

By Glen C. Leach, *Assistant in Charge of Fish Culture*

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PIKE PERCHES

DESCRIPTION

The pike perches (Stizostedion) include the largest members of the perch family inhabiting American waters. They may be distinguished readily from other fresh-water fishes by the long, rather pike-like body, with two dorsal fins, the first consisting of spines and the second of soft, segmented rays. The presence of a spinous dorsal serves as a ready means of distinguishing the pike perches from the pikes (family Esocidæ), which include the pickerel and muskellunge. The pikes have but a single dorsal fin of soft rays situated on the posterior part of the body. As the pike perches are members of the perch family, it is advisable to adopt this name and thus overcome much of the confusion of the species of the two families. Three species are found in our waters—the yellow pike perch (*Stizostedion vitreum*), the blue pike perch (*S. glaucum*), and the sauger or sand pike perch (*S. canadense griseum*). Of the three,

[1] Appendix I to the Report of the U. S. Commissioner of Fisheries for 1927. B. F. Doc. No. 1018.

This document represents a revision and enlargement of the chapters on "Muskellunge" and "Yellow Perch" 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, in the Report of the U. S. Commissioner of Fish and Fisheries for 1897 (revised edition published in 1900).

the yellow pike perch is the most abundant and important commercially.[2]

The body of the yellow pike perch is rounded instead of being compressed, the greatest width being about three-fourths of the greatest depth. The body is elongate, not as elevated as it is in the yellow perch, the greatest depth being about one-fifth of the distance from the tip of the snout to the base of the tail fin. The length of the head, from the tip of the snout to the hind margin of the gill cover, is contained about three and one-fourth times in the total body length, exclusive of the tail fin. The snout, measured from its tip to the anterior margin of the orbit, is contained about three and one-half times in the length of the head, and is rather larger than the horizontal diameter of the orbit (the latter contained about four and one-half to five and one-half times in the head). The mouth is rather large, the gape extending to approximately under the middle

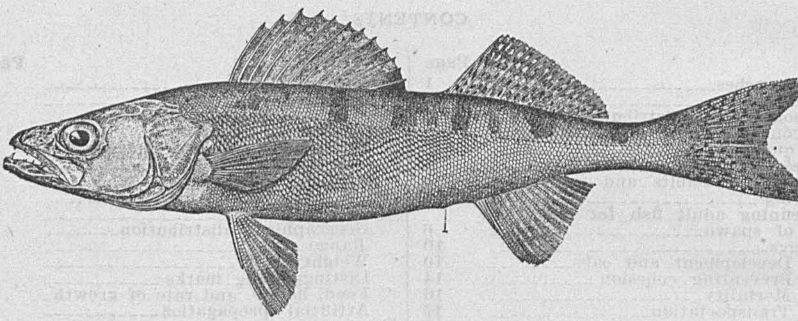

FIG. 1.—*Stizostedion vitreum.* Yellow pike perch

of the eye. The jaws are provided with brushlike bands of small teeth, and in addition some comparatively long canine teeth. The two dorsal fins are separated, the first consisting of 12 or 13 spines (frequently one or two spines more or less), while the second dorsal consists of 19 to 22 soft rays. The anal fin has two spines and 11 or 12 soft rays. The dorsal begins over the base of the pectoral, and the base of the ventral fin is but a little distance behind. The anal is placed entirely under the second dorsal. The tail fin is forked. The scales are rather small, there being about 90 oblique rows from the gill opening to the base of the tail.

The body is of a yellowish color, blotched with darker shades. The second dorsal fins usually are spotted, the small spots frequently being arranged in more or less regular rows. The first dorsal is irregularly blotched or spotted, and there is always a definite dark blotch on the membrane connecting the last two or three spines.

The blue pike perch was formerly considered a color variety of the yellow, but it never reaches so large a size and matures earlier. The body is grayish blue in color, without yellowish mottlings, and the lower fins are bluish white instead of yellow. The eyes are larger and close set.

[2] A Check-list of the Fishes of the Great Lakes and Tributary Waters, with Nomenclatorial Notes and Analytical Keys, by Carl L. Hubbs. University of Michigan, Museum of Zoology, Miscellaneous Publications No. 15, July 7, 1926, p. 58.

The sauger is distinguished from the other species by the larger number of pyloric cæca—5 to 8 (instead of 3)—its fewer dorsal rays (17 to 19), and absence of black blotch at the posterior end of the spinous dorsal.

The yellow pike perch attains a maximum size of 40 pounds, the average being from 5 to 10 pounds. The blue pike perch occasionally may reach a weight of 5 pounds, but averages under 1 pound. The sauger seldom exceeds a length of 18 inches and a weight of 2 pounds.

The yellow form usually is found in the larger streams, and in the Great Lakes seeks water 10 to 40 feet deep, while the blue form prefers water 30 to 75 feet deep.

GEOGRAPHICAL DISTRIBUTION [a]

The pike perch prefers clear water, with rock, gravel, sand, or hard-clay bottom. It is not often found in streams or lakes with bottoms of mud. The center of its abundance is Lake Erie, though it is one of the most widely distributed of our fresh-water fishes. Its range extends along the Atlantic seaboard from Connecticut as far south as North Carolina; thence to the northern portions of Alabama, Georgia, Mississippi, and Arkansas on the south, with Kansas, Nebraska, the Dakotas, and the Assiniboine River its western limits and the Hudson Bay its northern boundary.

Over the greater part of this vast area it is fairly abundant, and in all of the waters of the Great Lakes region, the Mississippi Basin, and the southern portion, at least, of the Hudson Bay system it is commercially important. In New Hampshire, Connecticut, New Jersey, and eastern Pennsylvania it is not indigenous. Its adaptability to suitable new waters is shown by its acclimatization in the Susquehanna and Delaware Rivers in Pennsylvania and in many small lakes in Michigan, where it has multiplied rapidly and is a great favorite with anglers and epicures.

The range of the sauger is less extensive. It extends from the Red River of the north and the Assiniboine River through the Great Lakes region, west to the upper Missouri and south to Arkansas and Tennessee.

ECONOMIC VALUE, FOOD AND GAME QUALITIES

The pike perches are among the most valuable of the fresh-water fishes. The following table shows the number of pounds and the value of the pike perches taken in the Great Lakes region during 1922:

Lake	Pounds	Value	Lake	Pounds	Value
Superior	23,298	$3,268	Ontario	153,850	$29,637
Michigan	132,948	21,185	Lake of the Woods and Rainy Lake	831,558	71,761
Huron	1,260,374	171,102			
St. Clair	38,620	5,741			
Erie	22,357,996	1,285,399	Total	24,798,644	1,588,093

[a] The blue pike perch has only recently been described as a distinct species, and its geographical distribution, habits, etc., have not as yet been definitely differentiated from those of the yellow form.

Throughout its range it is taken nearly the year round, and in spite of the zeal with which it is pursued, on account of its fine food qualities and the ease with which it is captured, it appears to be maintaining its numbers well, a condition that may be attributed, perhaps, to its hardiness and the facility with which it responds to artificial cultural methods.

As a table article it ranks high. The smaller fish are delicious fried, broiled, or boiled, while the larger ones, weighing from 5 to 15 pounds, are excellent when baked. The flesh is firm and well flavored, even in the warmest weather. Few fish stand shipment, holding, or freezing better than pike perch. It is not so well adapted to salting as some species, but this is not important, as the demand for it is so great that the supply is always disposed of fresh or frozen. The abdominal cavity is comparatively small and the head medium, so that little loss occurs in dressing. The bones are somewhat numerous, but they are generally large and easily separated. The gray and yellow varieties are considered superior to the blue for food, and are also better game fish.

The pike perch, although capricious, is readily caught with baited hook, artificial fly, spoon, etc., and deserves high rank as a game fish. About 100 tons are taken annually with hook and line through the ice about the Bass Islands, Lake Erie; large quantities are also thus caught near Buffalo, N. Y., in Saginaw Bay, Mich., and elsewhere. In ice fishing small minnows are generally used, the bait being taken near the bottom.

FEEDING HABITS

Although the pike perch is predaceous, observations would seem to show that it devours fewer desirable species than any other predatory fish. Its main food in Lake Erie the year round is a small cyprinoid, usually called lake shiner, which abounds in these waters, with occasionally crawfish in the winter and the larvæ of insects and the insects themselves in the warmer months. A pike perch weighing 16½ pounds has been caught containing a bullhead, which, in its partly digested condition, weighed 9 ounces. The stomachs of hundreds have been opened at all seasons of the year and under various conditions, and the examinations have as yet failed to disclose one containing a whitefish, black bass, or other valuable fish. Usually the stomach was empty, so far as the unassisted eye could discover, except for a thick, tough, greenish-yellow slime.

The pike perch does not generally inhabit the depths of waters frequented by the black bass, preferring the deeper portions of the shallow parts of the lake. Excepting the blue-pike variety, it is not found in deep water, which is the home of the whitefish during all the year except for a short period in the fall during its reproductive migrations. And even the blue pike does not inhabit the deep waters where the whitefish and cisco spend most of their lives.

SPAWNING HABITS AND SPAWN-TAKING

The pike perch is not a nest-builder, as are the basses and sunfishes. The female discharges her spawn in shoal waters, the male following and emitting milt in proximity to the eggs. The spawning time varies greatly in different localities, extending from the last of March with the yellow and gray varieties to the latter part of May. The blue pike has not been hatched by fish-culturists, and comparatively little is known of its spawning habits.

The work of collecting eggs for artificial propagation generally begins about the 10th of April and extends to the 25th of that month. The eggs are obtained from fish taken by commercial fishermen. Half or more of these are hatched into vigorous fry and deposited in public waters, and but for this work all the eggs thus saved would go to the market in the abdomens of the fish and be entirely lost.

The pike perch develops a greater number of eggs in proportion to its weight than the whitefish, and but a small percentage of them are fertilized under natural conditions. The eggs are 0.08 inch in diameter and average about 150,000 to a fluid quart. About 90,000 eggs would probably be a fair average per fish for Lake Erie, and as the spawning fish will average about 2 pounds each, 45,000 eggs to the pound weight of fish would approximate the true figures.

As the spawning time approaches spawn-takers are stationed at the various points on the lake where nets are to be fished. A spawn-taker accompanies the fisherman on his trips to the nets and examines the catch for ripe fish. His equipment is the same as that for white-fish,[4] except that he takes a quantity of swamp muck or cornstarch for use in preventing adhesion of the eggs. After he has selected and stripped a fish, it is returned to the fisherman. The eggs, after being fertilized, are either shipped directly to the hatchery or to some central collecting station.

The inner membranes of the egg are delicate and easily ruptured, and the greatest care is necessary, from the taking of the spawn to the hatching of the fry, and especially until they are cushioned by the filling of the membranes with water.

The fish should be wiped so that slime will not drip into the spawning pan, as a very small portion will clog the micropile and prevent impregnation. The female is grasped firmly in the left hand just forward of the tail, with the back of the hand downward, the fingers outward and the thumb above and pointing upward, the head of the fish being held between the spawn-taker's right wrist and body, the right hand grasping the fish from below, just back of the pectoral fins, the fingers inward, the thumb outward. The anterior portion of the abdomen is thus firmly grasped and the pressure brought to bear on the eggs in the ovaries of the fish. A woolen mitten on the left hand allows a firmer grasp on the slippery body than is possible with the bare hand. The fish is now at an angle of 45°, the body forming a modified crescent, with the vent within 2 or 3 inches of the bottom of the pan. This position throws the pressure on the abdomen and facilitates the opening of the vent and the flow of the eggs. Gentle pressure is now maintained as long as the eggs come freely and in a fluid stream, probably over half of them being procured before the hand is moved, but when the flow slackens, and not until then, the hand should be moved slowly toward the vent without releasing the pressure and only fast enough to keep the eggs flowing in a continuous stream. When this stops the hand should be replaced and the

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[4]Artificial Propagation of Whitefish, Grayling, and Lake Trout. By Glen C. Leach. Appendix III, Report, U. S. Commissioner of Fisheries, 1923 (1923). Bureau of Fisheries Document No. 949, 32 pp., 42 figs. Washington.

process repeated until all the good eggs are procured. If the eggs do not start readily they should not be taken.

As soon as one female is stripped the milt is added, care being taken all the time to allow no water in the pan until the lot is finished or until the pan is half or two-thirds full of eggs. If males are abundant one is stripped for each female, and one for every two or three females in any event. When the pan is about half full, and before any water is added, the eggs are very thoroughly and carefully stirred with the outstretched, spread fingers, enough water is added to cover the eggs nicely, the whole being mixed again with the fingers and allowed to stand for two minutes. Next the milt of one or two more males and a little water are added, the mixture is stirred as before, and again allowed to stand for five minutes.

Impregnation can not take place unless the milt and eggs come into perfect contact, and as the milt dies two minutes after water is added, and as the eggs will not become impregnated after having been in water six minutes, it can readily be seen that the eggs and milt must be thoroughly and quickly mixed, both before and after the water is added. A tablespoonful of muck solution or cornstarch is now stirred into the mass and a pint of water added. The water is poured off after standing, and this process is repeated every half hour, as described on pages 15 and 16.

After the adhesion has subsided the eggs are placed in a keg nearly filled with water, and stirred every half hour, with a change of water at least every hour from the time the eggs are taken until they are delivered at the station. The stirring is thoroughly, but gently, done with a dipper, care being taken that the dipper does not strike the sides or bottom of the keg.

The eggs should never be exposed to the sun, and the water surrounding newly taken eggs should preferably be kept between 40° and 50° F., though experience has shown that even 35° is not harmful. Of course, all sudden changes of temperature should be avoided.

PENNING ADULT FISH FOR COLLECTION OF SPAWN

The plan of holding, in pens or other inclosures, adult fish taken prior to the spawning season has been tried with some success. This may be done to insure a sufficient and definite number of spawners, the collection of which during the fishing season is frequently interrupted by stormy weather or other causes. The method is sometimes followed at collecting stations where commercial fishing for the species is not followed and where many of the fish taken for cultural purposes have not fully matured their sexual products.

Contrary to expectation, pike perch proved more difficult to handle in this manner than most of the other species to which the method has been applied. Perhaps the higher water temperature at the time the work is conducted is an influence. The fish must not be crowded either while being transported or at any time during their confinement. Where injuries have occurred fungus is likely to set in much earlier than with the whitefish, and on this account great care is necessary in handling pike perch, as well as to prevent injury to eggs in the ovaries. While the male whitefish can be held and used repeatedly for two or three days, the pike perch can be used but once. When held for several days, especially late in the season, the milt comes from the fish thickened, as if taken from a dead fish, and is far from being at its best. However, this is true to a great extent with the fish taken fresh from the nets late in the season. Females that do not "ripen" within two or three days are likely not to furnish eggs at all, and if held even two or three days late in the season may yield eggs that will not hatch.

At the Put in Bay (Ohio) station pike perch are obtained in the same manner as whitefish—from the pound nets of the fishermen. They are sometimes taken directly into the tanks on board the steamer from the pound when it is raised, but more often are dipped into supplemental nets by an employee of the bureau, who accompanies the fishermen when the pound is lifted, and are held until they can be picked up at leisure by the steamer. This permits the gathering of fish from many nets, while if they were taken directly from the pound only one lifting boat could be followed at a time and comparatively few fish collected. The supplemental nets are placed at each pound net where fish are expected. They are 3 feet in diameter and 7 feet in depth, and are held open at top and bottom by rings of half-inch iron, the bottoms being provided with puckering strings to close them. The top ring is fastened to the outhaul stake and rim line of the pound, the lower one hanging free and acting as a weight to hold the end in place and also serving to keep the net open so that the fish will have plenty of room and not be scaled by chafing against the meshes. When thus located, the supplemental net is in a convenient position for receiving the fish when the pound is lifted. Rowboats transfer the fish in tubs to the steamer, where they are placed in tanks and transported to the pens. There they are counted and assorted as to ripeness.

The pens or live boxes used in the pike-perch work are the same as those used for whitefish. Stationary live boxes, supported by piling have been used, but as the water at Put in Bay becomes too warm for this the boxes are now made so that they can be towed like a raft into open waters, where the current is more vigorous and the temperature more uniform. Another advantage gained by this method is that an equal depth of water is maintained in the live boxes, the rise and fall in this section varying from 4 to 5 feet in a single day, according to the direction and velocity of the wind and the atmospheric pressure. The boxes are 16 feet long, 8 feet wide, and 8 feet deep, divided into two equal compartments 8 feet square, provided with false bottoms controlled by standards running in guides at the ends. The standards are pierced by inch holes at intervals of 6 inches, so that the false bottoms may be held at any desired place.

The pens, in groups of five, are fastened, end on, between booms, and the whole thus forms a raft. The booms are made of 4 by 8 hemlock joists, 2 feet apart on the outside, trussed at frequent intervals by diagonal cross braces and ties, on top of which are placed two tiers of 1-foot wide hemlock planks, thus making the booms, when completed, 52 feet long, 2 feet wide, and 1 foot deep, and quite strong and rigid, capable of withstanding seas of considerable violence. At

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each end and between all the crates are placed 2-foot plank walks, giving ample room for working on all sides, which is a great convenience in handling fish and procuring eggs, especially in stormy weather. The pens are now made of boards 3 inches wide, nailed 1¼ inches apart, which gives sufficient space for free circulation of water. The lumber is dressed on all sides and all inside corners are rounded, as the fish injure their noses on square corners in their attempts to escape. All parts of the pens are interchangeable and easily taken down for storage, being held in place by 4-inch log bolts. The pens are fastened to the booms by log bolts 6 inches long.

Much depends on the work of transporting either whitefish or pike perch from the nets to the pens, not only in moving the fish with the least possible injury but in the saving of time, so that greater numbers may be penned and the risk of holding the fish in the supplemental nets may be minimized. Tow cars have been used, but they retard the speed of the steamer fully one-half, and tanks on the decks of the steamers have therefore been adopted. It is better to have several smaller tanks than one large one, as the fish can be dipped more readily from the small tanks and the water is not so violently agitated during rough weather. A convenient size is about 6 feet long, 4 feet wide, and 3 feet deep. The tank has two lids, submerged about an inch, arranged to open crosswise of the center and held by lugs below and by pins above. The lids are made of 3-inch boards nailed firmly upon cleats on the upper side, with about one-fourth-inch space intervening. This prevents slopping in any weather when fish should be handled. The tank is smooth and has no obstructions inside. A 2-inch hole at the bottom at one end is provided for drawing off water, and one of the same size is made within 3 inches of the top for an overflow, when fresh water is being added. Fresh water must be furnished, the amount varying with the number of fish. This can be supplied with a donkey pump, the hose being carried from one tank to another as required. With three tanks of the dimensions given above, six or seven hundred pike perch of average size can be transported.

For coating these tanks inside, as well as all tanks and troughs about the hatchery, coal tar with about one-third its bulk of good spirits of turpentine, free from benzine, is applied as hot as it can be made. This forms a smooth, hard, strong, impervious coat, which lasts well and is cheaper than asphaltum varnish.

The use of a proper dip net in handling the fish is of great importance. The splitting of fins and removing of scales is to be avoided as far as possible where any species of fish is to be penned. The scales of the pike perch are not so easily abraded as those of the whitefish, but it suffers even more as the result of injuries, owing to the higher temperature of the water at the time it is penned. The ideal net would be made of cofferdam rubber of suitable thickness, perforated at frequent intervals so as to permit the free discharge of the water—that is, a rubber net—but where many are necessarily in use and subject to rough handling, especially in freezing weather, their expense would be considerable. The hoop of the net used at the Put in Bay station is of three-eighths-inch spring steel wire, that being the stiffest and strongest material of its weight obtainable. It is bent in the form of a parallelogram 22 inches long and 20 inches wide, with rounded corners. This is fastened into an ash handle about 6 feet long. The bag is of cider-press cloth (which is made of large, soft, twisted thread, loosely woven), with each alternate thread over a considerable space in the center of the net pulled out. The bag is fastened to the hoop with small copper wire, as twine is soon cut off in working around the nets and pens. The bag of the net is 8 or 10 inches, for if much more is given it will let the fish form a pocket against the wire and prevent an easy discharge.

Netting of 1-inch mesh and large thread has proved to be a failure, the tails of many fish being split by it. It is believed that netting with a very small mesh and the largest thread that can be woven will do the work well, the greatest objection being the knots, which injure tender species.

A frame made like a stretcher, with gunny cloth tacked on in such a manner as to bag about 2 feet, is convenient for holding fish preparatory to spawn-taking. It should be about 6 feet long and 3 feet wide, making the bag 3 by 4 feet, with handles 1 foot long at each end.

A gate made of light stuff as long as the pens are wide (8 feet) and 2 feet deep, covered by ordinary netting drawn taut and fastened by small staples, is useful in sorting the fish in the pens. The false bottom is lifted and fastened in place with the pins. There will now be about a foot of water over the floor and 1 foot of the top of the pen will be out of water. Beginning at one side, the gate is gently moved along until the fish are all confined in a sufficiently restricted space. They are sorted, the ripe fish placed in the "stretcher" preparatory to stripping them, the medium in a tub to be taken to the proper pen, and the hard fish, which, it is assumed, will be in the majority, are put back over the gate into the pen from which they were taken.

The pens are numbered and a careful memorandum kept of the fish, the number of males and females received from and turned back to the fishermen each day, the number stripped, and the number in each pen.

All unnecessary noise near the pens must be avoided, especially jars or discharge of firearms, and no one should go near them except in the performance of duty. The quieter fish are kept and the less and the more gently they are handled the greater the chances of procuring a large number of good eggs, while the opposite course will cause many "plugged" females and failure generally. In transferring the fish from one net or receptacle to another it is preferable to handle only one at a time, except when they are small.

Fish, particularly females, taken from a depth of from 30 to 35 feet often come to the surface of the water in the pens and can not descend, owing to the expansion of air in the swimming bladder. The pressure may be relieved without injury by inserting a small-sized aspirating needle, at an angle of about 45°, through the flesh of the fish into the bladder, about halfway between the middle of the spinous dorsal and the lateral line. The air can be heard escaping and when the sound ceases the needle may be removed.

EGGS

DEVELOPMENT AND CARE

When the eggs arrive at the hatchery they are held in 15-gallon cans for about 24 hours, with a gentle stream of water flowing into each can, this being considered better practice than to place them at once in hatching jars, as the motion is too violent for the green eggs. While thus held they are stirred every half hour. Kegs or cans, half filled with eggs, may be carried if properly cared for.

For the handling of all eggs except those intended for shipment 15-gallon pine kegs, painted on the outside, with iron hoops and iron drop handles, are preferred to tin cans at the Put in Bay (Ohio) station. They are cheaper and lighter than the cans, also more durable and convenient. The eggs are in full view when being stirred and when water is poured off or added. The most important point, however, is that the kegs retain the water at a more even temperature, being less affected by heat and cold than are the cans. All dishes and implements with which the eggs come in contact should be thoroughly scalded and cleaned at the beginning and at the close of each egg-taking season.

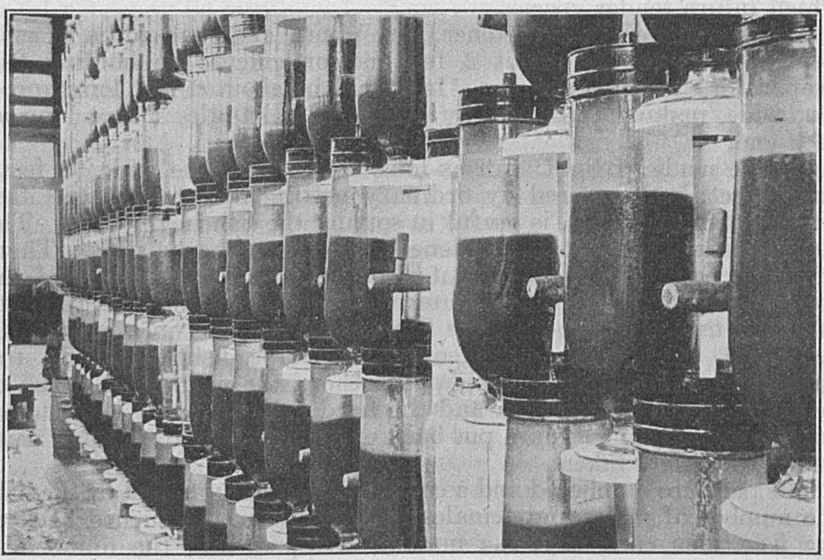

FIG. 2.—Pike-perch battery, Put in Bay, Ohio

For hatching pike-perch eggs, the open-top Downing or Chase jar generally is used. After the eggs have remained in the cans or tubs for the required length of time, as previously mentioned, they are measured into the jars by means of a dipper. The jar is first filled with water and a shallow funnel, with an outlet extending well into the water, is 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.

The jars are then placed on the battery. Tin tubes are inserted in the jars and connected with faucets that supply the water by rubber tubes. For convenience and economy of space and water, the hatching jars are arranged in tiers, constituting what is known as a battery. A Downing jar in operation and one showing the collecting tanks and battery at the Put in Bay (Ohio) hatchery are shown in Figures 2 and 3.

The troughs of the battery usually are 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

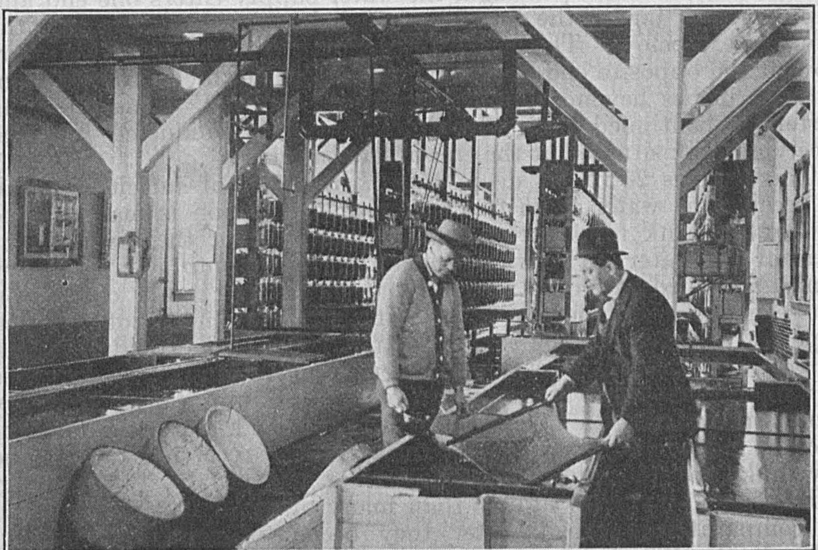

FIG. 3.—General view of pike-perch hatchery, showing method of removing fry from tanks

used freely underneath. The ends of the troughs are rabbeted in place, and the side pieces are nailed to the bottom. At one 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 ends 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 water to the trough next below. The length of the troughs varies 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 rubber tube 8 or 10 inches long and one-half inch in diameter. The tin tube is seven-eighths 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 inch timbers, so placed that a row of six jars can be accommodated between each set of stanchions. At the Put in Bay hatchery there are six rows of jars, making 36 jars between each set of stanchions. This type employs the stagger system in placing the jars on the battery, by which method each jar of the top row supplies the jar immediately underneath. The troughs are held together in the stanchions by one-half inch bolts, with nuts and washers at each end, which also act as supports to the trough.

Beginning at the top trough, the water supply enters one end and supplies each jar on the top row, which in turn discharge into the trough next 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 beyond the top trough at one end. This alternate system is continued until the water finally is conducted into the receiving tank situated at the end of the battery.

This tank is 24 inches deep, 3 feet wide, and of sufficient length to receive the water 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.

Pike-perch eggs are lighter than many others, and as they hatch in comparatively warm water they become fungused very soon after death. The hatchery water supply, therefore, should be clear. If it contains any considerable amount of sediment the defective eggs soon will become so loaded with it that they will attain the same specific gravity as the living ones and sink in the egg mass, forming lumps that can be removed only by screening, which is always more or less injurious. Even the live eggs will become coated with it, interfering with the proper working of the jars. Where clear water is used, the fungused eggs remain buoyant, float on top of the egg mass, and can be removed easily without loss or injury to the living ones.

With a water temperature above 55° F., and a moderately turbid water supply, it is difficult to maintain a proper circulation in the jars. Under such conditions fungus develops on the dead eggs so rapidly that it is impossible to prevent their mixing to some extent with the good eggs. The small percentage of living eggs contained in the mass of dead ones must then be drawn off and either planted in suitable outside waters or held in separate jars, known in fish-cultural parlance as hospital jars, until incubation is completed, only a comparatively small number of eggs being placed in each jar.

In order to secure perfect cleanliness, it is advisable, once or twice a year, to treat the whole system of troughs and pipes through which the water runs with a clear solution of chloride of lime, beginning with the supply tanks, which should be washed thoroughly inside, and following down until all have been cleansed, opening each faucet or cock during the procedure. In this way the system is freed at small expense from Infusoria and other forms, which at times are very troublesome and more or less destructive to the eggs. This work should be done just before whitefish eggs are to be placed in the jars in the fall, and again in the spring as soon as the whitefish eggs and fry are all disposed of and before the pike-perch eggs are received. If these periods overlap, one battery at a time can be treated. After treatment the tanks must be washed thoroughly and the whole system flushed for an hour or more. For this purpose chloride of lime is much more effective than common lime. The preparation is made by dissolving 5 pounds of chloride of lime in 10 gallons of water, and after it has settled the clear solution is decanted and added to approximately ten times its bulk.

When the eggs are placed in the jars 24 hours after taking, allowance is made for some additional swelling. Accordingly 3½ quarts of eggs are placed in each jar upon setting them up. These will swell to 4 or 4½ quarts at the end of three days, and this is the amount that can be worked to best advantage. The eggs are manipulated with the least possible amount of water that will keep them in motion throughout. More than this is harmful and will cause ruptured yolks. The jars are inspected daily, and any that are working too fast or irregularly are adjusted.

The eggs are semibuoyant and very adhesive. A single, large, spherical oil drop floats at the top of the yolk mass. The germinal disk is on the side of the yolk. The first cleavage of the disk ordinarily takes place in five or six hours in a water temperature of 45° to 50° F. Unequal division of the disk is rare, though it sometimes occurs, while with the whitefish and many other species inequality of cleavage is the almost universal rule.

In a water temperature of 45° to 50° the form of the embryo may be distinguished under a low-power magnifying glass within four days, and at the end of the sixth day the eye spots usually can be seen by the unassisted eye. By this time the pigment cells or color stars also may be seen with a microscope of low power, as well as the pulsations of the heart and the coursing of the blood through the vessels, the red corpuscles being distinguishable.

At this stage any monstrosities, malformations, and other deformities may be discovered easily. These consist of embryos with double heads (the most common form), more than the normal number of eyes, curved spines, and various others, some so slight as to be scarcely discernible.

The eggs hatch in from seven days at a mean water temperature of about 57° to 28 days at about 40°. At a temperature of about 48° the eggs will hatch in 18 to 20 days and produce vigorous, healthy fry.

As the fry of the pike perch are about three-sixteenths inch in length, very fine brass-wire cloth is required to hold them in the tanks. The screens in use at the several pike-perch hatcheries are made of brass-wire cloth, 60 meshes to the inch, tacked to a heavy frame. The cloth is pulled very tight before being fastened, so that it will present a smooth surface to the air or water 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.

It is exceedingly important that these screens be kept clear of the accumulation of egg shells and impurities in the water. This is accomplished preferably by means of air jets, although at some stations water jets are used. The air jet 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 1 inch distant from it. Half-inch galvanized iron pipe is used in the construction of air jets. The cross pipe should be perforated on one side with holes one-thirty-secondth 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 air jet one or more men must be employed to keep the screen clear. Moreover, many of the fry are unavoidably killed by being forced against the screens and by the men in keeping the screens 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 handled in troughs thus equipped.

The construction of a water jet is very similar to that described above except that a somewhat larger pipe is used and the holes in the cross pipe are larger. The water-jet system for keeping screens clear is not considered as efficient as is the air jet, one of the principal objections being that it adds more water in the trough without materially increasing the aeration.

The absorption of the food sac is governed by the period of incubation and by the water temperature. If 28 days have been required the sac will be absorbed in from five to six days, while if a shorter period, say 14 days, has been required approximately 10 days will elapse before the sac has disappeared entirely. Within a day or two after its complete absorption cannibalism will begin.

PREVENTING COHESION

Many experiments have been made from time to time to determine the best means for overcoming the tendency of pike perch eggs to cohere. This may be accomplished by stirring the eggs constantly from the time water is added until it fills the egg, when cohesion ceases. Time is lost, however, and a large percentage of the yolks inevitably are ruptured. Another method is to allow the eggs to agglutinate and stand thus until fully water-hardened, afterwards separating them by gently rubbing between the hands; but this also sacrifices time.

The date of the first use of foreign inert substances to prevent cohesion is uncertain. Fine clay dust and clay in solution have been used with success, and experiments with starch also have given good results. In each case the action is entirely mechanical. Having been found effective, cornstarch probably is more generally resorted to than any other substance, and most fish-culturists find it satisfactory and readily obtainable. Silt or swamp muck is strongly recommended for this purpose by the superintendent of the bureau's Put in Bay (Ohio) station. The following is his description of the method employed by him in its preparation and use:

In the spring of 1895 finely divided, washed, and screened swamp muck was tried at Put in Bay and has been used ever since, and recently with complete success, owing to a change in the method of application. The plan pursued up to 1899 was to add muck to the water in the kegs into which the eggs were poured after impregnation, and to wash them quickly. The washing was done quickly in order to prevent cohesion. This was effective, but it involved the use of too much muck, which was removed from the water with some difficulty and which smothered the eggs if left in too long in any quantity. Furthermore, it was difficult to get exactly the right quantity of the mixture. Careful experiments were therefore made in using the muck in the pan immediately after impregnation had taken place, and satisfactory results were obtained. At the present time the eggs are allowed to stand in the milt for about 10 minutes, with sufficient water barely to cover them, and are carefully stirred once or twice in the meantime. Then a tablespoonful of the muck mixture, of the consistency of thick cream, is added. Next the pan is nearly filled with water and the contents thoroughly stirred. It is then allowed to remain undisturbed for half an hour while another pan is being filled. Without moving pan No. 1 more than is necessary, the surplus water is poured off, the pan again filled, stirred, and left as before, while pan No. 2 is treated like the first. If the boat rocks so as to endanger the safety of the eggs it is better to pour them carefully into the keg and let them stand there, keeping only about an inch of water over them and pouring the water off and adding fresh water at intervals of not more than half an hour.

The important thing in preventing cohesion is to leave the eggs undisturbed until the particles of muck or the spermatozoa, in case the eggs are held in the milt without the addition of muck, have settled. The comparatively clear water is then poured off and a fresh supply added, at which time the eggs are gently agitated. It will be observed that most of the muck particles will have settled in one minute, the water becoming measurably clear. If the eggs are held in the milt, the water being very milky from the mixture, the water will become comparatively clear in three or four minutes. This is because the spermatozoa are slightly heavier than the water and settle to the bottom. In either case it is important to retain the particles in the remaining water and eggs until cohesion has ceased, in order to keep the eggs separated, for although the particles of muck or the spermatozoa, as the case may be, are adherent, sticking to the surface of the egg, they are easily washed off, thus permitting the eggs to come into contact and become fastened together. Aside from the washing off, the area of the egg membrane becomes constantly greater, removing the particles farther and farther from each other until finally the surfaces meet and cohesion takes place. This will not occur if the muck particles or the milt are left until cohesion has ceased or until the egg has become virtually filled with water—that is, has finished swelling.

While the eggs are soft and not cushioned by the absorption of water, the greatest care possible will not prevent the rupture of a considerable percentage of the sacs where the old method of constant working to prevent cohesion is pursued. By holding the eggs in the milt—which is better than the old way and requires less labor, but is not to be compared with the muck process—or by using muck, with reasonable care in all other directions, the loss may be measurably reduced.

The preparation of the muck solution is very simple, but should be carefully conducted, as follows:

At a suitable place in a swamp a depression is dug, which quickly fills with water. Muck is now suspended in this water by thorough beating and stirring until most of the muck particles are freely divided. Care is taken not to get the mixture too thick, as the sand will not settle out, nor can the mixture be screened freely. This is poured through a screen placed across a washtub until the tub is full, when the débris is knocked off the top of the screen and another tub is filled. The partially clear water is poured off of tub No. 1, it is again filled with muck, and this is continued until there are a few quarts of muck of the consistency of cream in the bottom of the tubs. The tubs are next filled with water, which is agitated thoroughly, and then allowed to stand a few seconds to give the particles of sand time to settle. The contents of the tubs are then emptied into kegs or cans, when the water may be poured off in an hour or more. This leaves quite a thick mixture of even consistency, as shown under the microscope. It should be free from sand, which would collect in patches in the bottom of the jars and interfere with the working of the eggs.

It is very necessary that the muck be now thoroughly cooked or scalded, otherwise Infusoria will develop on the eggs, causing much inconvenience and some loss. Finally, the muck is drained off, dried in any desired form, and held ready for use. It should be prepared before the egg-collecting season begins. The screen is about 20 by 30 inches and is made by tacking to a wooden frame a fine wire cloth of 40 meshes to an inch. The finest mesh that will let small particles of muck through is best. The cloth is bagged down somewhat, with the tack heads up, in order to present a smoother surface for the quick cleaning of the screen.

MORTALITY

With most species of fish that have been propagated artificially it is possible to secure a high percentage of fertile eggs, and the loss during incubation is slight. Under ordinary conditions such losses are frequently, perhaps generally, less than 10 per cent. The eggs of the pike perch are an exception, and most fish-culturists no doubt would agree that a 50 per cent hatch is a successful one.

This phase of fish culture frequently has been made the ground for investigation, but in all fairness it may be said that it has received but little detailed study and that no definite conclusion as to the causes of the unusually high death rate has ever been reached. The first cause of the remarkable mortality has been very generally ascribed by practical fish-culturists to failure of the eggs to fertilize, rather than to death of the eggs in the course of development. The assumption has been that a properly fertilized egg invariably would segment and develop normally, but this assumption has not been supported by certain investigations.

The methods of handling the brood fish and eggs are, in the main, very much alike at all stations where the pike perch is propagated. The less important details may vary to suit varying conditions or to meet the whims of the individual fish-culturist. It is highly probable that the admittedly crude but thus far unavoidable procedure of adding and actively stirring foreign matter with the eggs to prevent cohesion results in their injury, and the necessity for the utmost care in the application of this treatment can not be emphasized too strongly. Franz Schrader and Sally Hughes Schrader,[6] investigators for the Bureau of Fisheries, seem to disprove the theory that failure of impregnation is a direct cause of any large percentage of loss among pike-perch eggs.

These investigators point out that in the artificial insemination of the pike perch the eggs are immersed in milt that is but slightly

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[6] Mortality in Pike-Perch Eggs in Hatcheries. By Franz Schrader and Sally Hughes Schrader. Appendix V, Report U. S. Commissioner of Fisheries for 1922. Bureau of Fisheries Document No. 926, 11 pp., 23 figs. Washington, 1922.

diluted. The chance of a normal ripe egg remaining unfertilized therefore must be extremely small. Their studies further tend to show that failure of the eggs to segment is not necessarily related to lack of impregnation. They hold that it is impossible, even after 8 hours, to designate eggs as unfertilized when the absence of segmentation is taken as a criterion. The conclusions reached by these investigators may be summarized as follows:

The generally accepted theory that the high death rate in pike-perch eggs is due to lack of impregnation is unwarranted. The present methods of preventing cohesion of the eggs are responsible for a portion, but not all, of the losses. Approximately 50 per cent of the losses that occur in the eggs during incubation are due to the same agency that manifests itself in abnormal development. The cause in all probability is to be found in the practice of retaining adult fish in artificial inclosures for the development of eggs and sperm.

TRANSPORTATION

Shipment of pike-perch eggs a great distance can not be made successfully owing to the short incubation period. For short-distance shipments, as from a field or collecting station to the main station, the eggs ordinarily are carried in kegs or cans of water.

Where long distances are involved, the conventional shipping case or some modification of it is used, the eggs being spread in thin layers on trays, which are then stacked in a suitable container. The fundamental advantage of the case is that it gives sufficient insulation to maintain the eggs at an even temperature throughout the journey and protects them from any severe shock or concussion.

The egg trays in general use are 14 inches square inside and are constructed of material three-fourths inch thick by seven-eighths inch wide, the bottoms being covered with linen scrim or heavy cheesecloth. The egg cases are constructed of ¾-inch pine lumber and are built large enough to accommodate the tray and an inner compartment, in which the trays are placed. This inner compartment has a 2-inch space between it and the outer case, which is filled with ground cork or other suitable insulating material. An air space of one-half inch is provided between the stack of trays and the inner compartment, also, the trays being held in place by means of a ½-inch strip nailed in the middle of all four sides of the compartment.

In packing a shipment of eggs the trays are thoroughly soaked in cold water. The proper amount of eggs is then measured upon each tray, these having previously been covered with mosquito bar several inches wider than their outside dimensions. The eggs are carefully distributed over the surface of the tray, and the mosquito bar is brought in and lapped over the top of the eggs. Unless the shipments is to be in transit for a day or more 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 the eggs. The best moss for this purpose is known as sphagnum. It is well soaked in water before placing it upon the trays and the surplus water removed by squeezing a bunch of it between the hands.

When packed, the trays of eggs are placed upon a tray filled with moss, the upper tray of eggs also being covered with a tray of moss. The entire stack is then covered with an ice hopper, preferably of galvanized iron and with small drainage holes along the outer edge of bottom. Best results will be had if a block of ice, rather than chopped ice, is fitted into the ice hopper.

PLANTING THE FRY

In order to prevent loss from the fry preying upon each other, whenever practicable they should be planted before the sac is fully absorbed, but not for three or four days after hatching, since if they are so held they gain strength, and if they are to be transported some distance they become better fitted to withstand the hardships of a long journey. But with large numbers, running into hundreds of millions, lack of space makes it necessary to liberate them almost as fast as hatched. Darkening the tanks prevents cannibalism, but, owing to the absence of food and possibly to the darkness, the fry become weak and light colored in a day or two and will not stand transportation. They must, therefore, be transported before the sac is fully absorbed or large numbers will be lost by either cannibalism or starvation.

During the season of 1899 the water pumped from the lake for the supply of the fry tanks at the Put in Bay station literally teemed with Crustacea, such as Cyclops, Diaptomus, Daphnia, Alonopsis, etc., but at first, after the food sac was absorbed, the fry refused to partake of these, their supposed natural food, and preyed on each other instead. Three or four days later, however, a few hundred fry held for experimental purposes devoured these Crustacea greedily and throve upon them as long as the supply lasted. When cannibalism was at its height 50 fry were placed in a tin pan with myriads of Crustacea. In 10 minutes there were six cases of cannibalism. In each case one of the fry seized the tail of another and swallowed all it could. Close watching failed to discover any of these fry attempting to seize one of the Crustacea. It was also discovered that neither the fry of the whitefish nor of the pike perch, when later they began to feed on the Crustacea, would touch a Diaptomus, although the most showy of all the Entomostraca present and resembling very strongly the Cyclops, with which it is closely related. When a hungry fry would, as if by accident, seize a Diaptomus it would at once reject it and go about showing unmistakable signs of discomfort. Contrary to the general belief, the fry do not always die from the effects of eating other fry. The swallowed portion may be digested and the head and attached tissues finally rejected.

It has been customary to employ the same method in planting pike-perch fry as in planting whitefish fry; that is, the fry are dipped from the fry tanks of the hatching battery into cans or kegs and transported on a steamer to the points selected, where the cans are lowered into the water and the young fish allowed to swim out.

Toward the close of the season of 1899 an experiment was made of carrying fry to the planting grounds in a tank on board the steamer. The tank held 400 gallons, and was therefore equal in capacity to forty 10-gallon cans; but it was found in practice that a half more fry could be carried in this way, with a given amount of water, than in cans, as there was a continual stream going in through hose connected with a deck pump and out through screened siphons, whereas with cans some must stand while the water in others is being changed. Moreover, it is impossible to get a maximum number of fry in each can, so that some cans are carried with fewer fry than they should contain, while experience soon taught how many could be handled safely in the tank.

The fry were drawn from the fry tanks in the house direct to the tank on the steamer through a 1-inch rubber hose acting as a siphon, the suction end being held near the air supply, where fry collect in largest numbers. This required 10 to 15 minutes, while by the old method of dipping the fry into tubs and then distributing them into the kegs on board it would have taken more than an hour. This saving of time is very important when fry are hatching rapidly. Another advantage is that by passing the hose about close to the bottom of the tank nearly all the shells are removed with the fry, thus keeping the tanks comparatively clean. Examinations showed that the fry were not injured by passing through the hose, which is also an advantage over dipping them out with scoops.

On arriving at the field of planting, the fry and water are discharged through a section of hose about 10 feet long, leading from the bottom of the tank. The steamer is kept at a slow speed at the time, and the transfer of the fry to the water is accomplished as gently, at least, as would be the case in emptying them from kegs. Considerable time, as well as much hard work, is saved by this plan, and so far there appears to be no objectionable features in it.

YELLOW PERCH

DESCRIPTION AND RANGE

The yellow perch (*Perca flavescens*) is one of the best known and most abundant fresh-water fishes of the Atlantic and North Central States. It is one of the most strikingly marked of our common fresh-water fishes, though, like all fishes, it is subject to wide variation in color and markings. The general body color is golden yellow, the back greenish, and the belly pale. On the sides six or eight dark, broad vertical bars usually extend from the back to below the axis of the body, but, as stated, the colors and markings are greatly influenced by its environment. Sometimes the yellow is very bright, at other times pale; the bars are prominent in certain instances and indistinct in others. There is at times a coppery, reddish, or purple wash on the head and sides. The lower fins are largely red or orange, and in breeding males these colors frequently are brilliant. Some of the various names by which the fish is designated are American perch, raccoon perch, red perch, ring perch, and striped perch. It may attain a length of 10 to 14 inches and a weight of 1 to 2 pounds, though the average is probably somewhat lower.

The natural range of the yellow perch is from Nova Scotia to North Carolina in coastwise waters and throughout the Great Lakes region and the upper Mississippi Valley. It is primarily a fish of small lakes and ponds but is also found in streams in many parts of its habitat. Through the agency of man it has been successfully transplanted in nonindigenous waters and its geographic range thus greatly extended. At the present time it inhabits various lakes in Washington, California, and other western States, and is also found in the Ohio River.

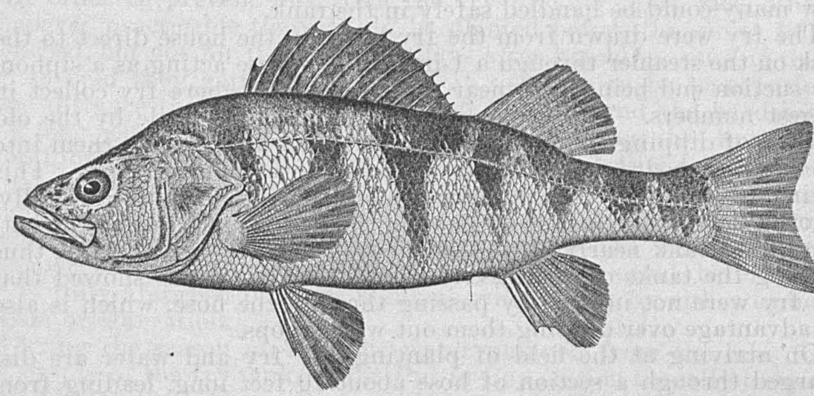

FIG. 4.—*Perca flavescens.* Yellow perch

FOOD AND GAME QUALITIES

The food qualities of the yellow perch are not surpassed by those of any of the fresh-water, spiny-rayed fishes with which it is usually classed. The flavor and texture of the flesh of all fishes, particularly the fresh-water species, vary with the environment. No fish can attain its highest excellence as to either food or game qualities in warm, sluggish, turbid waters. Taken from the clear, cool waters of a deep lake or pond, the flesh of the yellow perch will compare favorably with that of either species of black bass, the rock bass, or the pike perch.

As a game fish the yellow perch has much to recommend it. Its small size precludes its being a great fighter, and because of this it may be taken by even the most inexperienced fisherman. It may be captured with hook and line at almost any season of the year and with any sort of bait. It will rise freely on occasion to the artificial fly or trolling spoon, and if angled for in cold, clear water at a depth of 25 to 40 feet a 1-pound fish will make a fight that is well worth the time of the angler. Perhaps its most commendable feature is that it affords sport to women and children, who are often not sufficiently venturesome to seek the larger species of game fishes. Many inland summer resorts are rendered more attractive because the women and children find themselves able to bring in good strings of delicious yellow perch.

COMMERCIAL IMPORTANCE

Throughout most of its range the yellow perch occupies an important place in the commercial fisheries and is highly esteemed. From the Great Lakes, the Potomac River, and the smaller lakes of the upper Mississippi Valley large quantities are taken every year by means of fyke nets, gill nets, traps, seines, and lines and find a ready market. The annual catch approximates 5,700,000 pounds, valued at $384,000, about 86 per cent being credited to the Great Lakes.

SPAWNING SEASON AND CHARACTER OF EGGS

The spawning season of the yellow perch occurs on a rising water temperature in late summer or early spring. In the Potomac River this fish spawns in February, March, or April, depending upon climatic conditions. The eggs, which are of a light color and semitransparent, are remarkable from the fact that when deposited they are joined together in a greatly elongated, ribbonlike mass. One end of the mass, corresponding to the anterior end of the roe, is larger than the other end and bluntly forked. The length of the string varies from 2 to 7 feet, depending upon the size of the fish, but it may be much compressed lengthwise because of its arrangement in regular transverse folds, like the sides of a bellows. Upon deposition the eggs are in loose, globular form, but after being fertilized and water-hardened the mass becomes many times larger than the parent fish. It is recorded that a female yellow perch under observation in an aquarium deposited a string 88 inches long, 4 inches wide at one end, and 2 inches wide at the other. The weight of this mass after fertilization was 41 ounces avoirdupois, while the weight of the fish shortly before it had spawned was only 24 ounces. Throughout the entire length of the string there is a cavity, its walls being formed by the delicate membrane surrounding the eggs. Small apertures occur in this column at irregular intervals, their purpose apparently being to permit the free circulation of water to facilitate incubation.

At the Cape Vincent (N. Y.) hatchery, where a careful count was conducted, a quart of green eggs was found to number approximately 100,000, while the number per quart, after being fully swollen, was reduced to 36,000. These figures can not be adopted as standard, however, since there is a wide variation in the size of the eggs taken in different regions.

The incubation period in a mean water temperature of 47° F. covers about 27 days. The egg sac is absorbed in about five days.

ARTIFICIAL PROPAGATION

The source of egg supply of this species consists principally of adult fish procured from market fishermen and allowed to spawn naturally in tanks of running water or in floating boxes or pens. These boxes are made of seven-eighths-inch material and are about 8 feet long, 4 feet wide, and 4 feet deep. In their construction a solid board, to form the bottom, is fastened to four corner posts, The lowest of the tiers of boards that form the sides and ends o: box are nailed close against the bottom, but a 1-inch space is l between the remaining boards. In a stream that has an apprecial current it is advisable to cover the sides and ends of the boxes w wire cloth five meshes to the inch to prevent the eggs being wash through the openings.

During flood in many rivers and streams strings of yellow-per eggs may be found suspended from sticks and bushes along t banks. As the waters recede the eggs are exposed to the elemen and soon die. Large quantities of eggs are collected annually fro such places in the Missisquoi River in Vermont and are incubated the bureau's Swanton (Vt.) hatchery.

At the Bryans Point (Md.) hatchery on the Potomac River and some other stations of the bureau where the propagation of yell perch is conducted two methods are employed in developing the eg the one in more general use being to incubate them in jars similar those used in the hatching of whitefish eggs. Owing to the gre tendency of yellow-perch eggs to swell, and to their lightness as co pared with the eggs of shad or whitefish, it has been found advisal to apportion them in jars at the rate of only about 2 quarts to a j In some instances a wire screen of fine mesh is placed in the overfl of the jars. Great care must be exercised in regulating the flow water in the jars, as the current caused by too much water will fo the eggs to the top, where they will either clog the outlet screen in the absence of a screen, will pass out into the fry trough.

At several of the hatcheries wire hatching baskets, suspended a neighboring river or stream, are successfully used for the incub tion of yellow-perch eggs. These baskets are cylindrical, about inches in diameter and 20 inches long. They are made of fine-me wire cloth and are provided with a hinged door having a catch lock, to guard against loss of eggs during incubation. About quarts of eggs are placed in each basket, the door is fastened, and t basket is suspended in the water by means of floats or stakes.

A simple float, in a stream that is subject to sudden changes water level, is made of a 2-inch plank, 12 inches wide and from to 12 feet long, into which nails have been driven alternately intervals of 1 foot on each side. After tying the baskets to the na the plank is anchored in a suitable spot where there is no danger the baskets touching the bottom. The apparatus should be inspect by an attendant at least once a day, and each basket gently rais and lowered several times to free the eggs from adhering sediment.

PIKES

DESCRIPTION

The muskellunge, pike, and pickerels are all pikes in a gene sense. There are other fishes belonging to entirely different famili and, therefore, structurally different and distinct from the tr pikes, which, unfortunately, have the local names of pike a pickerel. The most common species thus designated belong to t perch family. The spinous dorsal fin possessed by these fish readily distinguishes them from the true pikes. They are mo "pike" part of these names, however, signifies only a resemblance, yet in certain localities the pike perch is called "pike" and in others "pickerel." This is altogether unfortunate, as it has caused regrettable confusion, particularly in compiling statistics of the fisheries.

The true pikes are characterized by having a rather long, broad, flattish snout; a large mouth extending about halfway the length of the head; the lower jaw is longer, and both jaws are provided with broad bands of teeth, which are coarse and rough, like wool

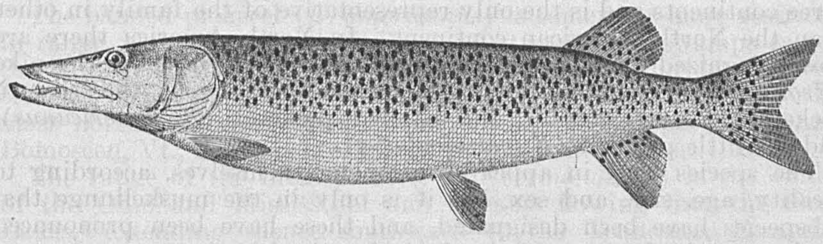

FIG. 5.—*Esox masquinongy.* Muskalonge

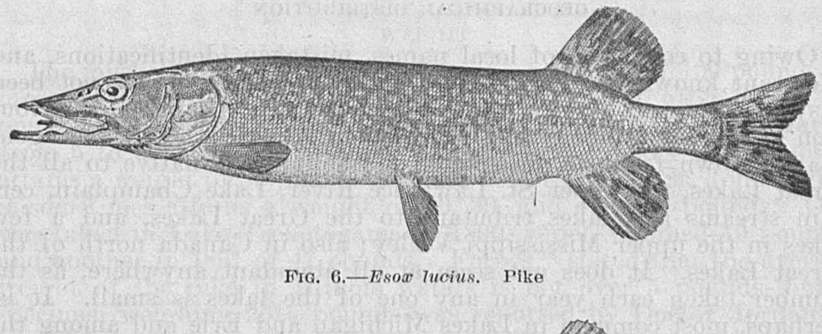

FIG. 6.—*Esox lucius.* Pike

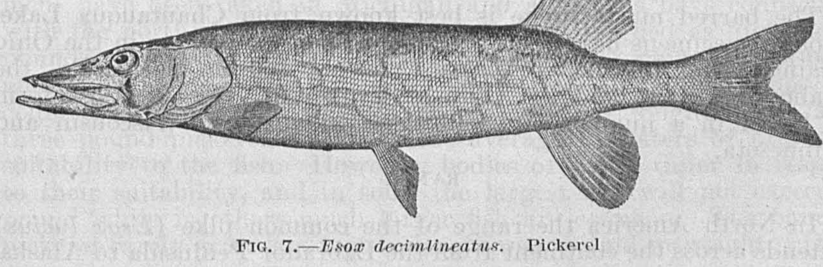

FIG. 7.—*Esox decimlineatus.* Pickerel

cards, and more or less movable. The dorsal and anal fins are situated near the tail and are similar and opposite. The ventral fins are abdominal.

The preceding characters serve to distinguish the pikes from the pike perches, and the following will distinguish them from all other fishes having abdominal ventral fins.

Body with ordinary scales; back without adipose fin but with a single dorsal fin made up of soft rays and not preceded by free spines; anal fin without distinct spines; tail forked; pectoral fin situated below the median line of the body, from tip of snout to base of tail; head more or less scaly; gill membranes not attached to the prolongation of the body forward between the gill openings; no barbels; maxillaries distinct; upper jaw not protractile, that is, its forward end is firmly joined to the snout; both jaws provided with sharp teeth, varying in size and arranged in broad bands; snout somewhat prolonged and depressed.

The pike family includes one genus only—Esox. The pikes are inhabitants of the fresh waters of the temperate parts of Europe, Asia, and America. The pike proper (*Esox lucius*) inhabits all three continents and is the only representative of the family in other than the North American continent. In North America there are now recognized five species, including the pike. These are the pike (*Esox lucius*), the muskellunge (*E. masquinongy*), the eastern pickerel (*E. reticulatus*), the banded pickerel (*E. americanus*), and the little pickerel (*E. vermiculatus*).

The species vary in appearance among themselves, according to locality, age, size, and sex, but it is only in the muskellunge that subspecies have been designated, and these have been pronounced distinct species by some ichthyological authorities.[6]

GEOGRAPHICAL DISTRIBUTION

Owing to confusion of local names, mistaken identifications, and the scant knowledge of the fishes of some regions, it has not been easy to decide positively regarding the exact geographical distribution of the muskellunge and the pike in America. The most generally known form of the spotted muskellunge is native to all the Great Lakes, the upper St. Lawrence River, Lake Champlain, certain streams and lakes tributary to the Great Lakes, and a few lakes in the upper Mississippi Valley; also in Canada north of the Great Lakes. It does not seem at all abundant anywhere, as the number taken each year in any one of the lakes is small. It is, perhaps, most common in Lakes Michigan and Erie and among the Ten Thousand Islands.[7]

The barred muskellunge is best known from Chautauqua Lake, though specimens have been reported from a few places in the Ohio drainage—for instance, in Lakes Conneaut and La Boeuf, Pa., the Mahoning River, and the Ohio at Evansville. The spotless form is found in a number of small lakes in northern Wisconsin and Minnesota.

RANGE

In North America the range of the common pike (*Esox lucius*) extends across the continent from the Labrador Peninsula to Alaska, northward to beyond the Arctic Circle, and southward to the St. Lawrence and Great Lakes Basin. It is found also in some waters in the United States south of the Great Lakes, as northern New York and the Mississippi and its tributaries, but it does not occur in Nova Scotia, New Brunswick, or (except by introduction) in that part of New England east of the Green Mountains.

[6] American Food and Game Fishes. By David Starr Jordan and Barton Warren Evermann. [The pikes, pp. 233–240.] New York, 1902.

[7] The Fishes of North and Middle America. By David Starr Jordan and Barton Warren Evermann. Bulletin, United States Museum, No. 47, pt. 1. [The pikes, pp. 624–630.] Washington, 1896.

The eastern pickerel (*E. reticulatus*) has a comparatively limited natural geographical distribution. It is believed originally to have been restricted to the fresh waters of the Atlantic seaboard, being commonly found everywhere east and south of the Allegheny Mountains from southwestern Maine to Florida. Aided by man, its range has been extended throughout the southern half of Maine and even farther north into the lower waters of the St. John River, into New Brunswick, and elsewhere. It has been reported in Missisquoi Bay, in the St. Lawrence River, and in one locality in Lake Ontario.

The banded pickerel (*E. americanus*) is somewhat more restricted in range, being found only in lowland streams and swamps east of the Allegheny Mountains, from Massachusetts to Florida, the westernmost record being from Escambia River at Flomaton, Ala.[7] The most northern locality from which it has been reported is Lake Bomoseen, Vt., but it is not known that it is indigenous there.

The range of the little pickerel (*E. vermiculatus*) is the valleys of the Ohio and Mississippi and streams flowing into the Great Lakes,[8] extending thence southward to the Tennessee, Escambia, and White Rivers,[9] and, according to Evermann and Cox,[10] to the Neuse River on the Atlantic slope.

WEIGHT

The muskellunge has been said to reach a weight of 100 pounds or more,[11] but the maximum weight is probably not often above 80 pounds and the average not over 25 or 30 pounds. The pike varies from 5 to 50 pounds in weight. In the larger lakes of Canada it attains a weight of 35 pounds or more. In the Lake St. John region it sometimes attains a weight of 20, 30, and even 40 pounds. One was taken in Lake Tschotogama in 1890, which weighed 49 pounds, and another in 1891 of 47 pounds. Forbes[12] stated that the average weight of the pike in Illinois waters is not over 5 pounds, but a specimen weighing 26½ pounds was reported by Doctor Jordan to have been caught in the Kankakee, and Tomlin[13] wrote that specimens have been taken in Michigan and along the bays connecting with the north shore of Lake Superior that weighed as high as 20 pounds. Eastern pickerel weighing as high as 8 pounds have been authentically reported, but such size is uncommon and fishes accounted large will not usually exceed half that weight. Two and three pound pickerel are about the average in waters of ordinary suitability to the fish. However, bodies of water differ in respect to their suitability, and in some the largest fish will not exceed a pound while in others much larger fish are common. The banded pickerel rarely exceeds a foot in length or a pound in weight. Her-

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[7] See Note 7 on preceding page.

[8] The Maskalonge of the Ohio Basin. By Tarleton H. Bean. Transactions, American Fisheries Society, pp. 145–151. Appleton, 1902.

[9] The Fishes of Illinois. By Stephen Alfred Forbes and Robert Earl Richardson. Natural History Survey of Illinois, State Laboratory of Natural History. The pikes, pp. 205–209. Danville, 1908.

[10] History and Present State of Ichthyology of New Brunswick. By Philip Cox. Bulletin, Natural History Society of New Brunswick, No. XIII, pp. 62–75. St. John, 1896.

[11] The Fishes of North and Middle America. By David Starr Jordan and Barton Warren Evermann. Bulletin, United States Museum, No. 47, pt. 1. (The pikes, pp. 624–630.) Washington, 1896.

[12] The Fishes of Illinois. By Stephen Alfred Forbes and Robert Earl Richardson. Natural History Survey of Illinois, State Laboratory of Natural History. (The pikes, pp. 205–209.) Danville, 1908.

[13] The Pike. By W. David Tomlin. *In* American Game Fishes, pp. 367–380. Chicago and New York, 1892.

bert[14] said that a pound was greatly above the average weight, which was probably not more than one-half pound. Similarly, the general statements regarding the size of the little pickerel are that it never attains a length of over 12 inches.

DISTINGUISHING MARKS

The genus Esox is divisible into three groups according to the squamation of the sides of the head, which easily separates the muskellunge, pike, and pickerels. The species may readily be identified in the following manner:

In the muskellunge the cheek, as well as the lower half of the gill cover (operculum), is without scales; with the pike the cheeks are entirely scaled but the lower half of the gill cover is without scales; all the pickerels have the gill covers and cheeks entirely scaled.

FOOD, HABITS, AND RATE OF GROWTH

The feeding habits of these fishes are similar; they all subsist largely upon other fishes. The muskellunge lurks among weeds or old tree tops that have fallen into the water, and will lie there for hours, perfectly motionless, awaiting his prey. Like all animals of prey, it is solitary in habit. Its breeding places are where the logs, stumps, and driftwood are thickest in shallow water, or flowage where dead limbs, logs, and brush have accumulated. It is said to begin to spawn a few days after the ice is out, and continues until the latter part of April in shallow water from 10 to 15 feet deep, on muddy bottom, usually going into the bays.

In spring and summer the pike haunts shallow inlets with weedy bottoms and shores overgrown with reeds and rushes. Toward autumn it betakes itself to precipitous, stony shores, which it again forsakes when winter is at hand and the inlets freeze. Most of the pike then return to their summer stations, but the larger ones seemingly follow the shoals of other fishes to the depths, being seldom caught during the winter in shallow water.

Not much has been written concerning the breeding habits of the American pike, and it is necessary to rely for information mainly upon what has been published respecting the European fish, which is specifically identical with habits supposed to be much the same. In the spring, before there is open water in the lakes, the pike commence to approach the shores, and breeding individuals, in particular, repair to those parts of the shore having inlets. When the spring is so far advanced that the lakes are free of ice, the brooks clear, and the low-lying meadows about the shores are under water, the larger pike make their way to those inundated places and begin to spawn. The spawning is of long duration, its season depending upon the age of the fish, the young spawning first. When these have finished the middle-sized pike begin, and the oldest and largest spawn last of all. In Illinois the pike spawns in March, selecting shore water about 1½ feet in depth; the eggs hatch in about 14 days. The rate of growth is about as follows, depending on the amount of food available: Pike 1 year old, 10 to 12 inches; 2 years old, 14 to 16 inches; 3 years old, 22 to 24 inches; 6 years old, 39 inches; 12 years old, 53 inches.

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[14] Frank Forester's Fish and Fishing. By Henry William Herbert. (Esocidæ, pp. 217–236.) London, 1849.

The eastern pickerel has more or less the same feeding and spawning habits as the pike. Its rate of growth is about as follows: One year old, 4.5 inches, weight about 0.5 ounce; 2 years old, 7 inches, weight 1.5 ounces; 3 years old, 10 inches, weight 4 ounces; 4 years old, 13 to 14 inches, 8 to 12 ounces; 6 years old, 20 inches, weight 40 ounces.

The pikes are valued greatly as game fishes, and there is in the United States a considerable fishery for them. The commercial catch is about 680,000 pounds per annum, valued at $58,000.

ARTIFICIAL PROPAGATION

The bureau has had but little interest in the propagation of the pikes, confining its efforts to some limited experimental work. They are now handled solely in connection with rescue operations. Other agencies, however, have been and are engaged in the culture of these species.

The State of Pennsylvania has been most prominent in the propagation of the pickerels and between the years 1905 and 1910 turned out a large number of fry. The eggs of the pickerels are deposited in strings, as are those of the yellow perch, and the same methods of incubation are applicable. Jars were utilized by the Pennsylvania Fish Commission, and the only serious difficulty appeared to lie in the proper regulation of the water flow to prevent clogging or smothering.

While the eggs can be taken from the ripe fish and fertilized artificially, the inability to find a sufficient number of ripe males and females at one time and the difficulty of feeding penned fish during their protracted spawning season have necessitated a reliance upon naturally spawned eggs for the main supply. These simply are collected from the spawning grounds by means of a scap net, placed in cans, and transferred to the hatchery. The incubation period varies from a week to 10 days, depending upon temperature. The eggs can as readily be handled in floating boxes and ordinary egg trays will serve for transferring them. Attempts to remove the débris and silt have an injurious effect.

The tiny fry must be distributed shortly after the disappearance of the food sac.

The culture of the muskellunge has been carried on by the New York Conservation Commission at its Chautauqua hatchery for some 30 years.[15] The process differs from that employed in Pennsylvania, in that eggs are secured by stripping the adult fish. These ripe individuals are captured by means of pound nets set in Lake Chautaqua in the spring. Incubation is carried on in jars of the Chase type. Conditions prevailing in this region generally cause a longer incubation period, ranging from a minimum of about 12 days to a maximum of 20 days. The temperature ranges are from 50° to 60° F. Immediate distribution after the absorption of the yolk sac is the practice with the muskellunge, as with the other species. The time required for this development is about 12 days. Little is known of the stages between this period and a length of 2 to 3 inches.

[15] Culture of the Maskinongé ("Muskellunge"). By Emmeline Moore. *In* Fifteenth Annual Report, New York State Conservation Commission, 1925 (1926), pp. 131–138, figs. 1–6. Albany.

EXAMINATION OF THE SUMMER FISHERIES OF PAMLICO AND CORE SOUNDS, N. C., WITH SPECIAL REFERENCE TO THE DESTRUCTION OF UNDERSIZED FISH AND THE PROTECTION OF THE GRAY TROUT CYNOSCION REGALIS (BLOCH AND SCHNEIDER)[1]

By Elmer Higgins, *In charge, Division of Scientific Inquiry,* and John C. Pearson, *temporary assistant, United States Bureau of Fisheries*

CONTENTS

INTRODUCTION[2]

DECLINE OF THE FISHERY

Many persons interested in the fishing industry of North Carolina are convinced that the supply of food fish in the waters of that State is insufficient to meet the demand. Despite the increase in catching power, brought about by the introduction of power vessels, the use of modernized gear, and the improvement of methods of refrigeration and distribution, the total yield of the fisheries of the State has not shown a corresponding increase during the past 45 years. The occasional statistics collected by the United States Bureau of Fisheries indicate that the average annual yield since 1880 of all aquatic food products, including fresh and salt water fish, mollusks, crustaceans, turtles, etc., but omitting nonfood fish, such as menhaden, has been 37,600,000 pounds. The total yield in 1880 amounted

[1] Appendix II to the Report of the United States Commissioner of Fisheries for 1927. B. F. Doc. No. 1019.

[2] The original report on this investigation was read by permission of the United States Commissioner of Fisheries, before the North Carolina Fisheries Commission Board at their regular meeting, Dec. 8, 1925, at Morehead City, N. C. The present paper contains all of the subject matter of the first report, together with some supplementary material resulting from further analysis of the original data.

to 32,249,000 pounds. This production rose to a maximum of 52,924,000 pounds in 1897, but since that time the available statistics show a continual though gradual decline until the period from 1918 to 1923, when the annual yield approximated 31,000,000 pounds, or about the same amount as that produced at the beginning of the period for which we have records. While the decline in total yield has not been disastrous to the industry, several important species have suffered serious decline. The most important of these are the shad and the mullet, although bluefish and striped bass also have shown a marked reduction. The total yield has been maintained only by the increased utilization of the cheaper and less desirable varieties of fish and by an increased intensity of fishing and improved methods of production.

This unsatisfactory trend of the fisheries of the State was forcibly pointed out by Dr. Hugh M. Smith in 1907,[3] when he asserted that the condition of the industry demanded the thoughtful consideration of the fishermen and lawmakers. He declared that:

The fisheries may be expected to deteriorate—

(*a*) Through failure of the State to provide prompt and adequate protection to those fishes which begin to show a decrease in abundance. The history of the sturgeon is an unmistakable indication of what will eventually happen to the shad, alewives, striped bass, and other species unless ample provision is made for the survival of a sufficient percentage of the annual run until spawning has ensued.

(*b*) Because of unnecessarily wasteful methods, such as the capture of larger quantities of food fishes than can be utilized or disposed of to advantage and the useless destruction of larger numbers of fishes of no present market value but of prospective importance.

(*c*) Owing to careless methods of packing and preserving the catch, and failure to keep abreast of the progress of the times in matters affecting the shipment and sale of fish.

The wisdom of his predictions is attested by the present condition of the fisheries, for the decline in abundance actually has occurred, and many of the conditions that caused this decline still remain to be remedied almost 20 years since the original warning.

The general shortage of fish has increased the rivalry between the operators of two dominant types of gear operated in Pamlico and Core Sounds—pound nets and haul seines—and endless discussion concerning the effects of these nets on the fish supply has resulted. As early as 1883, L. H. Hardy, a North Carolinian, wrote to the United States Fish Commissioner as follows:[4]

We have in Carteret County, N. C., a great many fish, and our people live by catching and selling them. For the last four years our waters, both in the sounds and ocean, have been obstructed by Dutch nets (pound nets), which have proved very destructive to our fish. Thousand of fish too small to be serviceable are caught by these nets and suffered to remain in them until they are dead and then turned out to drift upon the shore in numbers that would seem incredible to relate. * * * Thus millions of good fish are being destroyed yearly that are not worth a cent while so small. * * *.

In 1912, C. H. Sterling, a fish dealer of Washington, N. C., said:[5]

As to the pound nets, dragnets, and seines, some man has said that the pound nets are the root of all evils. I think he is mistaken. I have seen seines pull in hundreds of small fish that a pound net would not catch.

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[3] Fishes of North Carolina, by Hugh M. Smith. North Carolina Geological and Economic Survey, Vol. II, p. 412. Raleigh, 1907.

[4] Bulletin, U. S. Fish Commission, for 1884, p. 317.

[5] Report of the Fisheries Convention held at New Bern, N. C., Dec. 13, 1911. North Carolina Geological and Economic Survey, Economic Paper No. 29, p. 37. Raleigh, 1912.

In 1909, J. H. Potter, of Beaufort, N. C., said:[6]

I have been engaged in the fish business for 30 years. I commenced before the first pound nets were set in North Carolina, and was instrumental in putting in the first pound net. I have seen that net destroy more fish than have been caught in North Carolina since.

THE PROBLEM

As a result of this controversy there has arisen a general feeling that wasteful practices existed in these fisheries, which were in part responsible for the shortage of the fish supply. Many proposals for the regulation of the various types of gear have been offered by one faction or the other, and it was recognized by the State authorities that some regulation was necessary. Because of strong sectional feeling, it was impossible for the fishing interests to agree upon a method of regulation, and it finally became apparent that, in the interests of future constructive regulations, a comprehensive, impartial, investigation should be conducted. Three problems were presented for consideration:

1. To find the actual composition of both the pound-net and long-haul seine catches throughout the entire summer fishing season and the degree of competition between the two types of gear.
2. To ascertain the amount of destruction caused by taking undersized food fish by each type of gear.
3. To find a method of protecting undersized fish until they became valuable to the fishermen, to the fish dealers, and to the people of North Carolina.

With these problems in mind, the Bureau of Fisheries, with the full cooperation of the North Carolina Fisheries Commission, under Commissioner J. A. Nelson, undertook an extensive survey of these fisheries. Too much credit can not be given to Captain Nelson for the excellent assistance rendered. The launch *Neuse*, with crew under the able handling of Capt. J. R. Morris, was detailed to the field work, and the financial burden of its operation, as well as half of the incidental cost of the investigation, was borne by the State.

SUMMARY

The findings of this investigation may be summarized as follows:

1. Many lines of evidence indicate that the fisheries of North Carolina are undergoing depletion.
2. Wasteful methods in the fisheries are believed to be a contributing cause to the exhaustion of the supply. Pound nets and long-haul seines both have been accused as responsible for the decline in abundance.
3. Pound nets are stationary gear operating on deep muddy bottoms. Long-haul seines are dragged over shallow sandy bottoms.
4. The catch of pound nets consists chiefly of gray trout or squeteague (*Cynoscion regalis*) and starfish or harvest fish (*Peprilus alepidotus*). The catch of long-haul seines consists chiefly of croakers (*Micropogon undulatus*), spots (*Leiostomus xanthurus*), and spotted trout (*Cynoscion nebulosus*). Hence there is little competition between the two types of gear.
5. The two types of gear are highly selective in their action, pound nets catching smaller sizes of all species than do long-haul seines.

[6] Report of the Fisheries Convention held at New Bern, N. C., Dec. 13, 1911. North Carolina Geological and Economic Survey, Economic Paper No. 29, p. 184. Raleigh, 1912.

6. The average monthly destruction of undersized fish by long-haul seines is: Spotted trout, 4 per cent of the total number of that species caught; croakers, 8 per cent; and spots, 17 per cent. The average monthly destruction of undersized fish by pound nets is: Gray trout, 31 per cent; starfish, 59 per cent; butterfish, 6 per cent; croakers, 35 per cent; and spots, 51 per cent.

7. Pound nets are highly destructive; long-haul seines are not unduly destructive of undersized fish.

8. The greatest wastage of all pound-net fish occurs in June.

9. The greatest wastage of gray trout occurs in June and July and is most extensive on the northwest side of Pamlico Sound.

10. Two-year-old gray trout are less than legal size during June and July, but by August they have grown so that most of them are legally marketable.

11. Certain facts concerning the life history of the gray trout, ascertained in the course of this investigation, may guide our efforts at conservation. These are—

(*a*) Spawning in 1925 reached its height by June 1 and was completed by August 10.

(*b*) Gray trout approximately 5 inches long in June are believed to be 1 year old; when 8 inches long, 2 years old; when 10 inches long, 3 years old.

(*c*) Gray trout spawn for the first time when 3 years old.

(*d*) Immature fish remain in the sounds during the spring, summer, and fall.

12. The present regulation establishing minimum size limits does not operate to conserve the fishery, for many are destroyed in order to market the few.

13. Regulations increasing the size of mesh in pound nets or establishing areas closed to pound-net fishing are undesirable.

14. A closed season on pound netting in Pamlico Sound, from the end of the shad season until August 1, would prevent the destruction of undersized gray trout and protect the spawning fish. This regulation is recommended.

THE FISHERY

The fishery with which this investigation is concerned is conducted chiefly by pound nets and long-haul seines during the summer season, beginning in the latter part of May and continuing into November. The duration of the fishing season, however, depends upon the weather, for the gear is frequently destroyed by storms during October and is not replaced. Six species constitute the bulk of the catch, which consists, in order of their importance, of squeteague or gray trout, croakers, spots, spotted trout, starfish or harvest fish, and butterfish. All of these species are taken by both types of gear but in different quantities. While the same species are taken by other types of gear, such as stake gill nets, drop gill nets, and short-haul seines, by far the greater part is taken by the two gears under consideration.

The total yield of these species in the six counties surrounding Pamlico and Core Sounds amounted in 1923 to 8,225,000 pounds, valued at $337,475, or 58.5 per cent by weight of the total yield of all aquatic food products in the State.[7] The gray trout was the most

[7] For detailed statistics of yield and valuation see Fishery Industries of the United States, by Oscar E. Sette, p. 369 ff. Appendix II, Report United States Commissioner of Fisheries for 1925 (1926). Washington.

important of this yield and amounted in the same year to 2,954,000 pounds, or 21 per cent of the total yield of aquatic food products; croakers, 2,208,000 pounds, or 15.7 per cent; spots, 1,751,000 pounds, or 12.5 per cent; spotted trout, 845,000 pounds, or 6 per cent; starfish or harvest fish, 519,000 pounds, or 3.7 per cent; and butterfish, 298,000 pounds, or 2.1 per cent.

METHODS OF FISHING

Pound netting.—The pound net is a type of stationary fishing gear that operates by directing the fish into inclosures or traps by means of leads. While the principle of pound netting is always the same, the actual setting and arrangement of the gear varies in different localities. A typical pound-net rig used in the summer fisheries of Pamlico

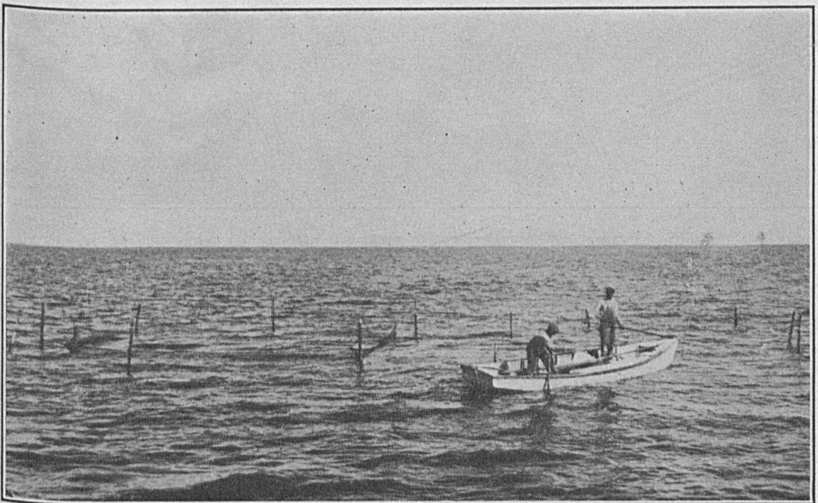

FIG. 1.—Pound-net fishing. Setting a net. The crib or pound is at the left; the men in the boat are setting the heart, and the lead extends off to the right

Sound and many of its tributaries consists of lead, heart, and pound. The lead is 175 to 300 yards long, having a depth of 17 to 20 feet, made of cotton webbing of 12-inch stretched mesh. It is supported in the water by stakes (pine poles) about 18 feet apart. This lead ends at a 9-foot opening into the heart—a semipound, which is usually 30 yards on each side, of the same depth as the lead, and made of webbing of a stretched mesh of 5 inches. At the end of the heart opposite the lead opening is a tunnel 20 feet square at the heart, tapering into a 34-inch square exit into the pound proper. This tunnel is about 12 feet long of 4-inch stretched mesh and the ends are held open by ½-inch iron-bar frames. The pound proper, into which the tunnel leads and which the fish finally enter, is about 27 feet square, having a depth of about 16 feet (depending upon the depth of water in which the gear is set), a stretched mesh of 2¼ inches, and is supported at each corner and at varying intervals by stakes. All parts of the rig, with the exception of the pound itself, must touch bottom and, of course, must rise above the level of the water for at least a few inches. The sides of the pound are usually at least 1 foot above the water level so as to prevent the trapped fish from jumping over. (See figs. 1 to 3.)

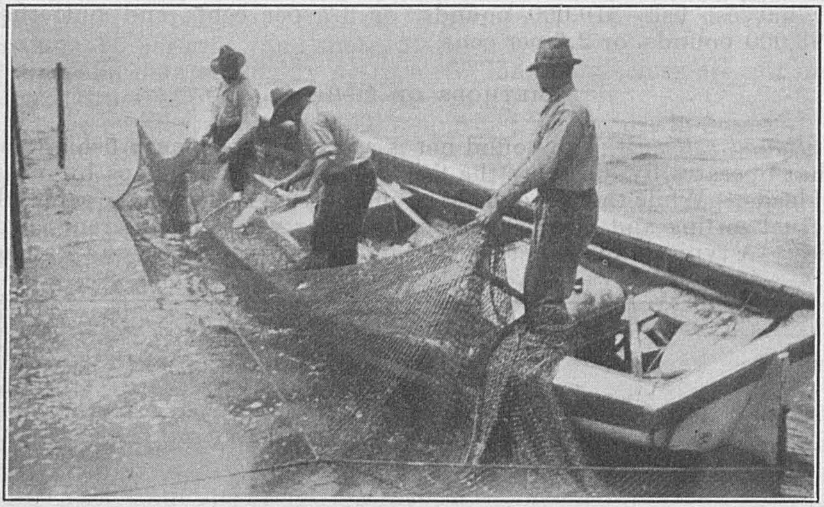

FIG. 2.—Pound-net fishing. When the fish are gathered into one corner of the net the catch is bailed into the boat with dip nets

As many as 8 or 9 pounds are sometimes set in a continuous row or stand, so that the entire distance covered by the leads, hearts, and

FIG. 3.—Pound-net fishing. Culling the catch. It is not feasible to sort the catch on the fishing grounds. All culling is done at the shore station when the fish are sorted for sale. Hence undersized fish are dead when discarded

pounds may be nearly 2 miles in length. Usually a stand consists of not more than four pounds, for this is the maximum that can be handled easily by the average pound-net crew.

A pound-net crew usually is made up of two men, but sometimes three, manning an open power boat, 25 feet long, 6 to 7 feet wide, and having a speed of about 7 miles an hour. The fishermen usually camp on some island or point within an hour's run from their nets, returning home only for the week-ends.

The pound net is fished by running the boat nearly over one side of the pound into the inclosure, and by means of a hook a side of the pound is raised and brought on board. The sides and bottom of the pound are then gradually taken up to the surface of the water until the fish are gathered or bunted into a small section of the side, from which they can be bailed into the boat. The entire process does not take the experienced fishermen more than 10 minutes in good weather, but hours are sometimes consumed in clearing the nets of small fish that have become gilled in the meshes. After fishing all their pounds

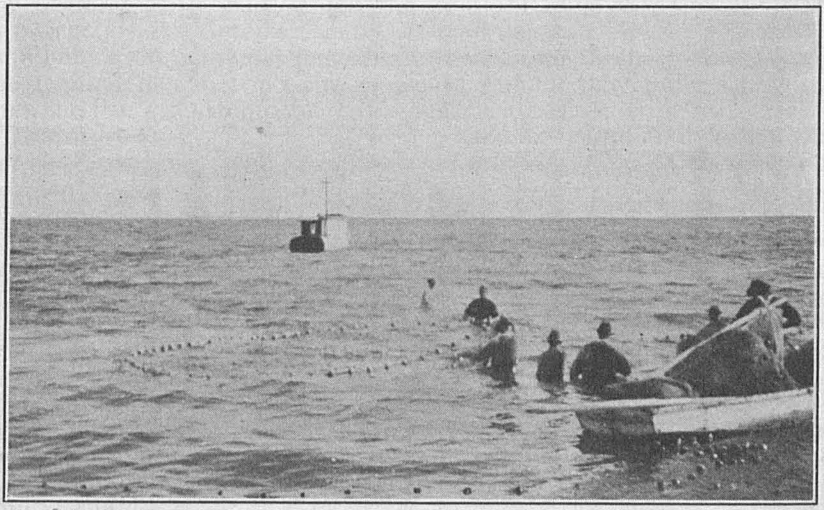

FIG. 4.—Long-haul seining. The seine has been removed and the men are now hauling the bunt net. The bunt net is used to inclose the fish so that they may be landed. Finer mesh and heavier twine in this net prevent the fish from rushing the net and escaping or becoming gilled in the meshes

the fishermen return to their camp and weigh and sell the catch to waiting buy boats sent by various wholesale fish dealers.

Pound nets are set in the deepest waters of Pamlico Sound, which are from 16 to 20 feet in depth. The gear is always set on a muddy bottom because of the necessity of a good holding ground for the stakes and because the fishermen believe that fish gather on this muddy bottom to feed.

Long-haul seining.—This is a method of fishing in which a seine is dragged between two power boats for a certain distance and then landed by hand in shallow water.

The nets consist of eight sections, each 150 yards long, and 12 feet deep, made of cotton webbing of a 3-inch stretched mesh. At the ends of each section are fastened 8-foot wooden staffs, leaded at the lower ends. A bunt net, 125 yards long and 100 to 125 meshes deep, with a mesh of 2½ inches, is also a part of the equipment. The more efficient boats are 30 to 40 feet long, drawing not more than 3 feet of water, and are powered with 16 to 20 horsepower engines. Each power boat has a crew of three men and tows a skiff about 20 feet long, which carries half of the nets.

In fishing the seine, the power boats first come together, join the ends of the sections of the seine, and commence to run in opposite directions, letting out the nets, section by section, until all eight seines—four from each tow skiff—have been let over the side. The seine is then slowly hauled in a shallow semicircle for approximately three-fourths of a mile. When the power boats reach the shallow water they come together and the staffs at the ends of the seines are fastened together, thus making a circle about 1,200 yards in circumference. (See figs. 4 and 5.)

FIG. 5.—Long-haul seining. The haul is here completed and the men are bailing the catch from the bunt net into the boats

After the circle is completed, two men in each of the tow skiffs untie the staffs that fasten the end pair of nets, the power boats take the ends of the second pair on each side, one at a time, and continue hauling to "cut out" or to remove the nets from the circle. Similarly, the second pair are replaced by the third pair, and the third pair by the fourth, so that the circle finally is reduced to a single pair of nets, each 150 yards long. The bunt net is then fastened to the farther staff of one of the last pair of nets and is laid out in the position of one of the fourth pair while that net is taken into the skiff. The remaining fourth seine is then hauled by power or by hand, depending on the depth of water, past the inward staff, until the two staffs of the bunt net are brought together. The final hauling of the net is performed by hand while one man holds down the lead line with his foot so as to keep the gap completely closed at the bottom. When the bunt net has been pulled in far enough (depending on the quantity of fish taken) hauling on the cork line is stopped and the lead line is hauled past the staff until all of it is landed in the skiff. This completed, the fish are secured beyond danger of escape, and they are easily bailed into one of the skiffs. Everything is landed except sharks and stingrays or occasional catches of large drum.

A modification of this method of hauling, called "swiping," is practiced by a few crews. This consists in merely laying out the nets, surrounding a given area of water, and then taking them in. There is no hauling done except to close the ends of the nets. This method is employed chiefly to save the expense of fuel used in hauling, which usually takes from three to four hours, but this is not the common practice.

The haul must be on a clean bottom, with the tide, and usually with the wind, otherwise the boats could not pull the seines because of the accumulating amount of floating grass. It must be made in a place where shallow water is at least a mile away and in which the nets can be removed both by power and by hand. Such shallow water in North Carolina generally consists of sandy shoals, and the suitable hauls are so well known and recognized that several crews frequently await their turns to fish a productive ground. Owing to the gradual process by which the nets are removed, the small fish apparently have time to escape. Often fish can be seen forcing the nets before the bunt net has been put out, and the presence of large-sized gilled fish in the pairs of seines removed by power indicates that the fish are attempting to escape during the cutting-out process. The bunt net serves a necessary purpose in preventing the frightened fish from rushing the net and gilling or escaping, and also serves to protect the fishermen from the attacks of stingrays, which are of frequent occurrence in the catches.

Owing to the relatively high cost of equipment for this type of fishing, which is valued at about $4,000, and to the relatively small number of haul areas available, there were not more than 25 crews operating in Pamlico and Core Sounds in the summer of 1925. Each crew usually sells to the buy boat of a fish dealer, who is under agreement to take the season's catch. The nets usually are laid out at about 6 o'clock in the morning, and the catch is aboard the buy boat by 2 or 3 o'clock in the afternoon. Some of the crews do not land their catch until later in the afternoon, while others, more energetic, may sometimes make two hauls in a single day, ending their last haul in the dark.

METHODS OF INVESTIGATION

To determine the actual composition of the catches of the two types of gear, it is obviously necessary to visit personally the various fishing areas and to inspect the unsorted catches of fish when taken. Representative areas should be chosen for examination, and the study should be continued during the whole fishing season.

In the sampling of the pound-net catch a route was selected covering as nearly as possible representative portions of Pamlico Sound, no pound netting being carried on in Core Sound; but choice of localities was limited by the fact that pound nets are fished only in the early morning, five days a week. (See fig. 6.) On this account, and on account of the distances to be covered, but one pound-net station could be visited daily. The following localities were visited regularly once each week, with the exception of one station that was discontinued because of lack of fish: Lupton, with 15 to 20 stands of nets set off Cedar Island; Brant Island, with 6 to 8 stands of nets off the mouth of the Neuse River along Brant Island Shoal; Gull

Rock, with 10 to 12 stands set along Gull Shoal; Portsmouth, with 1 to 12 stands about Royal Shoal (this place was visited during only one month because of discontinuance of fishing); and Point of Marsh, with 4 stands set along Brant Island Shoal. The only pound-net localities of any importance that remained were Ocracoke, with 6 stands, Hatteras, with 2 stands, Englehard, with 3 stands, and Stumpy

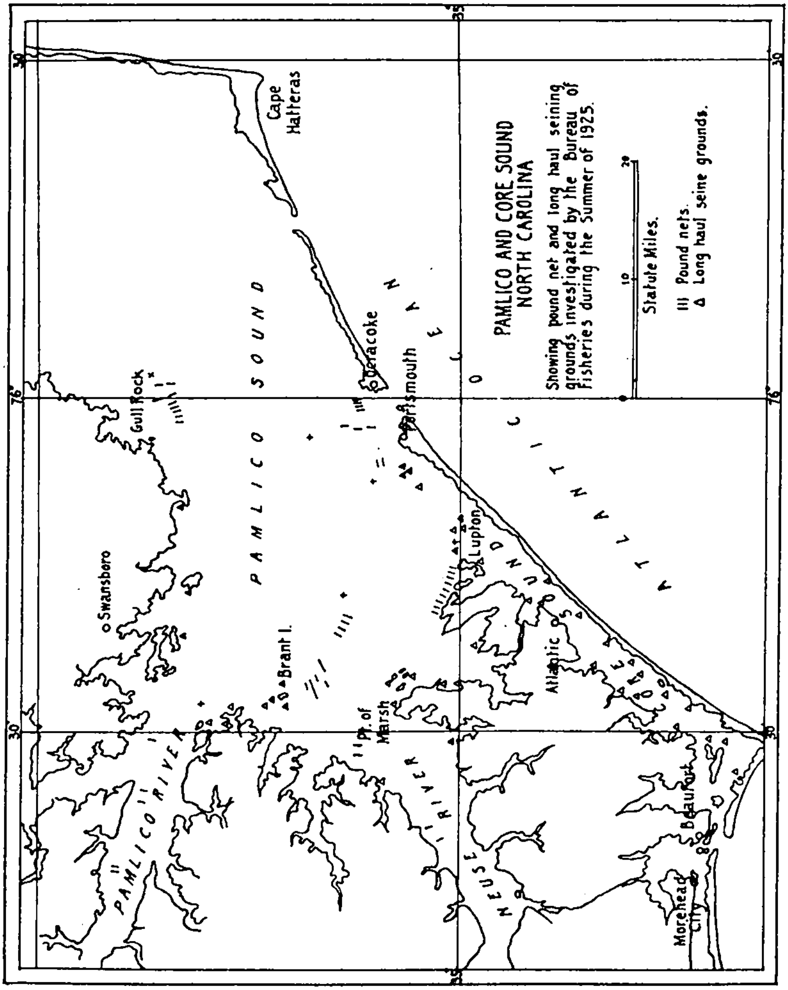

FIG. 6.—Pamlico and Core Sounds, N. C.

Point, with 20 stands. Lupton represented the southern end of the sound, Brant Island and Point of Marsh the western and central parts, Gull Rock the northwestern side, and Portsmouth the eastern part. The distance around the whole route was nearly 200 miles. Approximately 200 pound-net catches were sampled. Only a very few stations were omitted from the weekly visitation, and this was because of adverse weather conditions when very little fishing was carried on even by pound netters.

Long-haul seine fishing is conducted chiefly in the southern and western parts of Pamlico Sound and in the northern half of Core Sound. Moreover, this fishing is regulated greatly by weather conditions, so that the taking of samples was necessarily more irregular than was the case with pound nets. However, experience showed that samples could be procured more or less regularly while en route from one pound-net station to another, and since noon is the customary time for long haulers to end their fishing for the day, samples usually were secured as soon as the fish had been bailed into the skiffs. Samples were taken at varying intervals in virtually all the long-haul localities, 44 samples in all being studied.

Taking a random sample of about 50 pounds of unculled fish from each of three crews of pound-net fishermen, a total amount of approximately 150 pounds of fish was secured from each locality every week. The average daily catches of the crews seemed to be from 300 to 600 pounds of market fish to the crew, with the exception of Monday's catches, which were always larger than those of any other day because the pounds usually are not fished either Saturdays or Sundays. Personal observations were taken each morning on the majority of the catches brought in, and any unusual catch, both as to quantity and quality of fish taken, was noted.

A different problem was presented in obtaining samples of the catch of long-haul seines because of the variation in both quantity and quality, which ranged from 500 to 1,500 pounds of marketable fish. When the catch consisted chiefly of large fish, somewhat larger samples were taken than was the case when the catch was made up of small fish. In general, from 50 to 100 pounds of fish constituted the sample.

In obtaining all samples no hand selection was permitted, all fish being bailed, unculled, into a large bucket container by the fisherman, under the personal inspection of the investigator. The samples, once obtained, were sorted according to species, the species of scrap fish, such as pinfish and menhaden, alone being unseparated. The weights of certain food species and also the weights of scrap fish in the samples were secured. Each specimen of food-fish species was carefully measured on a rule constructed for the purpose,[8] each fish sexed, and the spawning or resting condition of the fish was noted. Scales were taken from many fish for the ultimate purpose of determining the age composition of the catch. Over 26,000 pound-net fish and 2,500 long-haul fish were thus measured during the 20 weeks, from the middle of June until the first of November, spent in actual field operations.

In analyzing the data collected by these means, length-frequency tables were constructed from the measurements of the samples obtained. While each sample was originally tabulated separately, frequency tabulations for the day were made for the three samples together. The day samples were then combined by months, by simple addition, and these monthly frequencies were then reduced to a percentage basis. In so far as the unweighted samples are representative, the actual composition of the commercial catch is accurately portrayed; but, because of the varying number of samples taken in the different months, it was deemed advisable to weight the

[8] The measurement of length used in this work is the projection of the distance from the snout, or point of the mandible, to the end of the middle rays of the caudal fin.

monthly frequencies to a constant number. Thus the conditions in each locality are represented by 12 separate samples taken on four occasions in each month.

The conclusions concerning the actual or total destruction of undersized fish, however, are subject to some criticism, from the fact that the total amount of the commercial yield at any time during the season is unknown. It is presumed that the fishery has a normal cycle of abundance, reaching a maximum at some period and dying away to a final end. Since the sampling was uniform throughout the season and the results are not weighted according to the total yield, a distortion of facts would occur from overemphasizing the early and late parts of the season, when the yield is presumably smaller, and underemphasizing the middle part of the season, when the maximum yield is supposed to occur. There are no statistics in North Carolina that can be used to weight our figures according to the total yield, and since it was not feasible, because of conditions in the field, to collect these figures at the time of the investigation, it is impossible to estimate the magnitude of this error. The authors believe that this error is negligible, however, because of evidence based on records of the catch of pound-net fishermen at Gull Rock. The actual yield of three different crews was obtained throughout the entire season. Since the nets are fished irregularly in this locality daily yields could not be obtained, but a table of total yield during each weekly period from each of the three crews was constructed. (See table 1.) During the period from June 28 to October 31, when all three crews were working without interruption, the average weekly yield does not vary more than 1,000 pounds, ranging between 2,000 and 3,000 pounds. If this condition obtains throughout Pamlico Sound, it is likely that maximum production is reached as early in the season as all the gear is installed and continues at a horizontal level until the removal of gear in early November.

TABLE 1.—*Pound-net catch of three fishermen at Gull Rock, N. C., in 1925, weekly totals of marketable fish*

Date	Crew No. 1	Crew No. 2	Crew No. 3	Total	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
June 7-13	1,219	708		1,927	
June 14-20	2,483	1,453		3,936	
June 21-27	2,398	1,065	244	3,707	
June 28-July 4	4,478	2,507	1,650	8,635	2,878
July 5-11	5,126	2,242	1,812	9,180	3,060
July 12-18	3,077	1,155	1,673	5,906	1,969
July 19-25	5,200	1,599	1,818	8,617	2,872
July 26-Aug. 1	1,828	1,092	1,657	5,577	1,859
Aug. 2-8	2,439	1,561	2,400	6,400	2,133
Aug. 9-15	3,049	1,651	2,837	7,537	2,512
Aug. 16-22	4,304	2,072	2,469	8,845	2,948
Aug. 23-29	2,958	222	3,183	6,363	2,121
Aug. 30-Sept. 5	2,669	2,706	3,372	8,807	2,936
Sept. 6-12	3,385	1,299	1,052	5,736	1,912
Sept. 13-19	2,502	1,926	3,110	7,538	2,513
Sept. 20-26	1,834	2,913	3,799	8,546	2,849
Sept. 27-Oct. 3	3,480	889	3,439	7,808	2,603
Oct. 4-10	2,802	1,720	2,921	7,443	2,481
Oct. 11-17	3,213	1,375	3,701	8,289	2,763
Oct. 18-24	3,523	1,163	2,605	7,291	2,430
Oct. 25-31	1,102	288	1,810	3,200	1,067
Nov. 1-7	303	380	435	1,118	
Nov. 8-14	224		628	852	
Nov. 15-21			549	549	
Total	63,596	32,028	48,164		

Since no further refinement in the analysis of the data is feasible, and since, on the basis of this evidence, the yield of the fishery appears to be quite uniform, it is believed that the conclusions drawn are not unwarranted because of the possible error of the method. This view is further supported by the internal evidence of uniformity of the data; for it appears, as is shown in the following tables, that the important features of the data are consistent among themselves.

COMPOSITION OF THE CATCH

As indicated in a previous paragraph, the yield of the pound nets and long-haul seines in Pamlico and Core Sounds comprises more than three-fifths of the aquatic food produced in North Carolina, and the species that make up this great catch, in order of importance, are the sea trout, croakers, spots, starfish, and butterfish. This estimate of relative importance is based upon the total weight of each species landed in the markets annually; but, from the point of view of wise regulation of the fishery, the total amount of fish *landed* is of less significance than the amounts actually *caught*, and in this case the disparity between the two figures is surprisingly great, for a tremendous waste of immature fish occurs in these fisheries. From the same point of view, the *weight* of the fish caught is of less significance than are the *numbers* of individuals taken, for an individual specimen, regardless of how young or how small it may be, barring the normal mortality occasioned by its enemies in the sea, has the potentiality of developing to a size that is of real value either to man as food or to the species as the brood stock of the future supply.

In the following discussion, therefore, the relative abundance of the different kinds of fish and of the various sizes representing each species is determined by calculating the percentage by number and not by weight in the entire unsorted catches of food fish in the different nets. Hence the following figures represent more fully the real stock of fish, as caught, than would any analysis of the catch as marketed. Let us examine the records, then, to discover what kinds of fish are caught by each type of gear and the relative importance of each species in the total catch.

SPECIES TAKEN

The following species, arranged in the order of importance, were observed in the catches of long-haul seines during the season. The common names are those in most general use in this locality. Those marked with an asterisk are marketed; all others are discarded as trash fish.

FISH TAKEN IN LONG-HAUL SEINES IN PAMLICO AND CORE SOUNDS, N. C., 1925

*Spotted trout	*Cynoscion nebulosus.*
*Gray trout	*Cynoscion regalis.*
*Croaker	*Micropogon undulatus.*
*Spot	*Leiostomus xanthurus.*
*Bluefish	*Pomatomus saltatrix.*
Pinfish	*Lagodon rhomboides.*
Menhaden	Brevoortia sp.
*Starfish	*Peprilus alepidotus.*
*Spanish mackerel	*Scomberomorus maculatus.*
*Red drum	*Sciænops ocellatus.*

Perch	*Bairdiella chrysura.*
*Hogfish	*Orthopristis chrysopterus.*
Stingaree	*Dasyatis say.*
Sea catfish	*Galeichthys milberti.* *Felichthys felis.*
Garfish	*Tylosurus marinus.*
*Mullet	*Mugil cephalus.*
*Pompano	*Trachinotus carolinus.*
*Sheepshead	*Archosargus probatocephalus.*
*Sea mullet	Menticirrhus sp.
*Flounder	Paralichthys sp.
Toadfish	*Opsanus tau.*
Bur fish	*Chilomycterus spinosus.*
Puffer	*Spheroides maculatus.*
*Rockfish	*Roccus lineatus.*

The following species, arranged in order of importance, were observed as occurring in the pound nets. The common names are those in most general use in this locality. Those marked with an asterisk were marketed, if large enough; all others were discarded as trash fish.

FISH TAKEN IN POUND NETS IN PAMLICO SOUND, N. C., 1925

*Gray trout	*Cynoscion regalis.*
*Starfish	*Peprilus alepidotus.*
*Croaker	*Micropogon undulatus.*
*Spot	*Leiostomus xanthurus.*
*Butterfish	*Poronotus triacanthus.*
Menhaden	Brevoortia sp.
Pinfish	*Lagodon rhomboides.*
*Flounder	Paralichthys sp.
*Bluefish	*Pomatomus saltatrix.*
*Porgy	*Chaetodipterus faber.*
*Spanish mackerel	*Scomberomorus maculatus.*
Cutlass fish	*Trichiurus lepturus.*
Lookdown	*Selene vomer.*
Sea catfish	*Galeichthys milberti.*
Stingaree	*Dasyatis say.*
Eel	*Anguilla rostrata.*
Nanny shad	*Dorosoma cepedianum.*
Garfish	*Tylosurus marinus.*
*Mullet	*Mugil cephalus.*
Olbacore	*Caranx hippos.*
Threadfish	*Alectis ciliaris.*
*Pompano	*Trachinotus carolinus.*
Sergeantfish	*Rachycentron canadus.*
*Spotted trout	*Cynoscion nebulosus.*
White perch	*Bairdiella chrysura.*
*Tripletail	*Lobotes surinamensis.*
*Hogfish	*Orthopristis chrysopterus.*
*Sheepshead	*Archosargus probatocephalus.*
*Red drum	*Sciænops ocellatus.*
*Sea mullet	Menticirrhus sp.
*Black drum	*Pogonias cromis.*
Foolfish	*Monacanthus hispidus.*
Puffer	*Spheroides maculatus.* *Lagocephalus lævigatus.*
Bur fish	*Chilomycterus spinosus.*
Sea robin	Prionotus sp.
Remora	*Echeneis naucrates.*
Toadfish	*Opsanus tau.*
Hogchoker	*Achirus fasciatus.*
Hairy back	*Opisthonema oglinum.*

Table 2 shows the composition, by species, of the catch of the pound nets and long-haul seines throughout the season. The average composition in each locality for each month is taken and from these figures the average composition for the season is calculated. Starfish constitute 45 per cent of the catch of pound nets, gray trout 40 per cent, spots and butterfish each 5 per cent, and croakers 4 per cent, while spotted trout are not taken in any appreciable quantity. Other species are taken, but in such insignificant quantities that they are omitted from consideration.

Long-haul seines, however, fail to catch many starfish or butterfish. Their catch consists of 38 per cent croakers, 18 per cent each spots and spotted trout, 7 per cent gray trout, and 19 per cent mixed fish, comprising many species in small but varying quantities, most important of which are bluefish, Spanish mackerel, and red drum.

TABLE 2.—*Composition of catch of different gear, by species, in Pamlico and Core Sounds, N. C., 1925. (In per cent, by number)*

	Gray trout	Spotted trout	Star-fish	Butter-fish	Croaker	Spot	Mixed	Total
POUND NETS								
June	39.1	....	35.7	9.4	8.0	7.9	....	....
July	40.8	....	38.6	7.4	8.1	5.0	....	....
August	32.3	....	58.4	4.0	2.0	3.2	....	....
September	34.3	....	59.1	2.1	1.8	2.8	....	....
October	53.3	....	35.2	.8	2.3	8.3	....	....
Average for season	40.0	....	45.4	4.7	4.4	5.4	....	99.9
LONG-HAUL SEINES								
July	2.4	15.6	....	....	55.9	20.3	6.0	....
August	7.5	10.6	....	....	44.1	20.4	13.8	....
September	10.4	21.4	....	....	28.4	12.3	27.3	....
October	7.6	24.0	....	....	22.9	19.0	29.0	....
Average for season	7.0	17.9	....	....	37.8	18.0	19.0	99.7

It is therefore apparent that the two types of gear supplement each other—pound nets yielding the valuable gray trout in large quantities, and long-haul seines providing spotted trout, which is highly prized. Starfish and butterfish would be absent from the markets if pound nets were not fished, and while both types of gear take croakers and spots, these fish form a larger percentage of long-haul seine catches than do any other species. Neither is there competition between the two types of nets in the locality fished, for the pound nets are confined to the deeper waters of Pamlico Sound and its tributaries, where the muddy bottoms are so soft that it is difficult to drag seines, while the long-haul seines operate on the shallow, sandy bottoms of Pamlico and Core Sounds, where conditions are unfavorable for pound netting. It would seem that both types of gear are desirable and necessary for yielding a balanced supply of fish to the markets.

SIZES OF FISH

The sizes of fish taken in the pound nets in Pamlico Sound are presented in Tables 3 to 7 and Figures 8 to 13 showing the length frequencies of the various species, month by month, during the season. Gray trout taken in pound nets range in size from 5.5 to

23.6 inches. One abundant size group is evident in this range, consisting of fish that are in all probability more than 2 years of age—that is, in their third year. The older groups are represented but scatteringly, and by the end of the fishing season a smaller size group also appears in moderate numbers. Starfish taken range in length from 2 to 8.3 inches and consist of two distinct sizes, which in all probability are separate year classes. The group of larger fish is taken during June and July, and the smaller size becomes abundant in August, September, and October, during which time the larger fish are absent. Butterfish range in length from 2.4 to 8.3 inches and constitute but one clearly marked size group. Spots range in length from 3.9 to 9.5 inches and are readily divided into two distinct size groups. The larger fish are more abundant in June and July and the smaller ones in August and September. Croakers range in length from 5.1 to 15.8 inches, but, as has been noted in other investigations, are separated with difficulty into distinct size groups. It is probable that two major size groups can be distinguished, but from our records it is difficult to assign ages to these groups. All sizes of fish are taken throughout the season, but the larger fish are notably reduced in relative abundance during October.

TABLE 3.—*Length frequencies of 9,497 gray trout taken in pound nets in Pamlico Sound, N. C., 1925, all localities. (In per cent of total number)*

Length, centimeters	June	July	Aug.	Sept.	Oct.	Length, centimeters	June	July	Aug.	Sept.	Oct.
14				0.09	0.08	39	0.18	0.97	0.31	0.88	1.15
15	0.27			.29	.23	40	.06	.33	.49	.40	1.06
16	.64			.20	.75	41		.18	.08	.20	1.36
17	.85	0.11		.62	2.47	42		.15	.12	.48	1.05
18	3.65	.33		1.05	4.39	43		.11	.13	.27	.94
19	8.68	1.25	0.17	1.24	4.40	44		.16	.21	.05	.72
20	13.62	3.94	.66	.71	3.25	45		.02	.37	.10	.78
21	15.78	10.27	1.87	.77	1.21	46			.08	.05	.26
22	10.20	13.92	7.79	1.46	.65	47		.03		.10	.38
23	4.20	11.54	13.51	5.01	.72	48		.04	.35	.06	.16
24	3.79	8.58	18.20	10.15	4.09	49	.05			.06	.18
25	7.19	6.24	12.38	14.68	7.08	50		.03		.11	.22
26	7.94	7.14	8.98	12.73	10.41	51					.30
27	7.33	8.28	6.75	8.53	9.52	52		.03			.18
28	4.32	6.05	6.19	7.65	6.54	53		.03			.22
29	3.20	4.79	5.51	6.11	5.63	54				.06	
30	1.61	3.23	4.20	6.26	5.02	55				.06	.06
31	2.18	2.88	3.45	3.89	5.19	58 [1]					.08
32	.67	2.03	1.87	4.14	3.81	59					.04
33	.17	1.81	1.85	3.12	3.79	60					.08
34	.84	1.36	1.23	2.60	3.37						
35	.91	1.11	1.42	2.77	2.63	Total	99.92	100.00	100.02	99.96	100.01
36	.18	1.25	.77	1.73	2.19						
37	.31	.54	.79	1.11	1.58	Number of fish	1,202	2,377	1,678	2,218	2,022
38	1.10	1.27	.29	.69	1.79						

[1] Indicates break in continuity of table.

TABLE 4.—*Length frequencies of 13,508 starfish taken in pound nets in Pamlico Sound, N. C., 1925, all localities. (In per cent of total number)*

Length, centimeters	June	July	Aug.	Sept.	Oct.	Length, centimeters	June	July	Aug.	Sept.	Oct.
5		0.11	0.54	0.03		16	6.23	13.86	6.61	.59	.16
6		.20	1.67	.18	0.03	17	2.03	7.54	2.49	.50	.14
7		.76	6.08	1.37	.63	18	.91	2.81	1.01	.23	.11
8		1.89	10.24	10.05	4.02	19	.14	.64	.58	.10	
9	0.16	1.96	12.07	23.20	18.05	20	.06	.38	.22	.02	.04
10	1.33	.15	20.79	24.40	37.69	21			.02	.04	.12
11	7.21	2.12	11.23	25.75	25.66						
12	15.90	6.34	2.39	10.37	11.12	Total	99.90	99.93	100.02	100.03	99.99
13	25.24	11.38	3.84	1.16	2.01						
14	27.04	22.40	8.12	1.08	.18	Number of fish	1,115	2,576	3,650	4,291	1,876
15	13.65	27.39	12.12	.96	.03						

TABLE 5.—*Length frequencies of 1,184 butterfish taken in pound nets in Pamlico Sound, N. C., 1925, all localities. (In per cent of total number)*

Length, centimeters	June	July	Aug.	Sept.	Oct.	Length, centimeters	June	July	Aug.	Sept.	Oct.
6	0.43					16	9.01	29.90	41.30	41.10	19.45
7	1.72					17	14.60	9.90	19.85	26.40	41.68
8	1.72					18	7.72	4.65	3.50	9.20	30.58
9	3.43					19	3.00	1.41	1.56	1.84	5.53
10	2.58	0.40				20		.20	.78	.61	
11	7.72	1.21	0.39			21		.20			
12	5.58	2.83									
13	13.30	4.85	2.34	3.07		Total	100.00	100.01	100.02	100.04	100.02
14	17.17	13.54	5.84	6.14	2.78						
15	12.02	30.92	24.46	11.68		Number of fish	233	495	257	163	36

TABLE 6.—*Length frequencies of 1,101 spots taken in pound nets in Pamlico Sound, N. C., 1925, all localities. (In per cent of total number)*

Length, centimeters	June	July	Aug.	Sept.	Oct.	Length, centimeters	June	July	Aug.	Sept.	Oct.
10		0.38				20	10.34	12.12	9.52	5.66	6.25
11		.38				21	3.45	10.61	8.33	6.92	10.42
12	1.15	.38	1.19	0.63	0.60	22		3.41	7.14	5.66	6.55
13		1.53	2.98	6.92	2.08	23		.38	1.19	2.52	3.87
14	4.60	3.03	11.90	7.54	11.01	24		.38	1.19	.63	1.19
15	16.75	2.27	14.28	14.45	9.82						
16	17.80	6.44	10.72	18.23	13.40	Total	100.04	100.02	99.98	99.97	100.00
17	14.94	15.90	3.57	16.98	21.12						
18	17.23	25.38	9.52	9.43	6.84	Number of fish	174	264	168	159	336
19	13.78	17.43	18.45	4.40	6.84						

TABLE 7.—*Length frequencies of 942 croakers taken in pound nets in Pamlico Sound, N. C., 1925, all localities. (In per cent of total number)*

Length, centimeters	June	July	Aug.	Sept.	Oct.	Length, centimeters	June	July	Aug.	Sept.	Oct.
13	0.82					29	2.88	4.63	5.66	4.90	0.81
14	1.23				0.81	30	1.65	1.09	1.89	3.92	1.62
15	4.53	0.27	1.89		.81	31	1.23	2.18	.94	4.90	
16	8.65	.54	.94	0.98	4.03	32	1.23	.82	3.78	1.96	.81
17	11.50	1.36		3.92	5.65	33	.41	1.64	1.89		
18	15.63	6.26	11.31	7.85	6.45	34	.41	.54	.94	1.96	.81
19	9.05	6.80	.94	3.92	12.09	35		.54	.94		.81
20	4.94	12.00	9.43	6.86	12.90	36	.41	.27	.94		
21	2.06	7.08	12.25	12.72	11.29	37	.41	.54	.94		.81
22	2.88	5.45	12.25	10.79	11.29	38		.54			
23	4.94	6.54	4.72	6.86	8.86	39					
24	7.40	11.70	1.89	.98	5.65	40		.27			
25	4.94	9.54	9.43	4.90	3.23						
26	6.17	7.08	6.60	3.92	4.84	Total	99.96	99.93	99.96	99.96	100.02
27	4.12	4.90	1.89	13.72	2.42						
28	2.47	7.35	8.50	4.90	4.03	Number of fish	243	367	106	102	124

In the long-haul seine catches (Tables 8 to 11) but scattering specimens of gray trout are found. Those caught range in length from 9.8 to 25.6 inches, and the more abundant sizes consist of fish that are in all probability more than 3 years old. The spotted trout taken range in length from 9.1 to 27.2 inches, but the size groups are not readily distinguished. The spots caught are from 4.3 to 10.6 inches in length. These also represent older fish than those taken in the pound nets, except in October, when the older fish are notably lacking; the same sizes are caught by both gears. Croakers range in length from 5.9 to 16.2 inches, and, as in the pound-net catches, the larger fish are abundant in the earlier part of the season but virtually absent in October.

TABLE 8.—*Length frequencies of 210 gray trout taken in long-haul seines, 1925, all localities. (In per cent of total number)*

Length, centimeters	Aug.	Sept.	Oct.	Length, centimeters	Aug.	Sept.	Oct.
25	2.02			41		2.60	5.88
26	2.02	3.90	2.94	42	4.04	1.30	5.88
27	3.03	9.09	8.82	43	2.02	5.20	2.94
28	3.03	6.50	8.82	44	1.01		
29	9.09	2.60		45			
30	8.08	2.60	8.82	46	4.04	2.60	
31	7.07	6.50	2.94	47	1.01		
32	8.08	2.60	2.94	48	1.01		2.94
33	5.05	5.20	2.94	49	1.01	2.60	
34	9.09	9.09	11.77	50		2.60	
35	5.05	7.79	14.70	55 [1]		1.30	
36	7.07	10.39	2.94	65 [1]	1.01		
37	2.02	5.20	2.94				
38	5.05	1.30	2.94	Total	99.99	100.06	99.97
39	7.07	3.90	8.82				
40	2.02	5.20		Number of fish	99	77	34

[1] Indicates break in continuity of table.

NOTE.—Only 15 specimens secured during the month of July.

TABLE 9.—*Length frequencies of 460 spotted trout taken in long-haul seines, 1925, all localities. (In per cent of total number)*

Length, centimeters	July	Aug.	Sept.	Oct.	Length, centimeters	July	Aug.	Sept.	Oct.
23				2.67	46	.90	1.67	.72	2.67
24				2.67	47	5.41		2.88	2.00
25				2.67	48	.90	5.00	.72	.67
26	0.90			3.34	49	1.80		1.44	
27	.90			2.67	50			.72	.67
28	3.61			2.67	51	.90		2.16	1.34
29	3.61	1.67		3.34	52		1.67		
30	7.21	3.44		2.00	53			.72	
31	6.30		1.44		54		1.67		
32	9.00	3.44	2.88		55				
33	6.30	8.34	1.44	.67	56	.90			
34	3.61	6.66	5.04		57				
35	9.80	8.34	7.91	1.34	58		1.67		.67
36	5.41	11.68	11.51	.67	59	.90	1.67		
37	3.61	8.34	8.63	8.00	60	.90		.72	
38	1.80	6.66	8.63	8.00	61	.90			
39	6.30	8.34	9.35	7.33	68 [1]			.72	
40	4.51	3.44	7.91	9.34	69	.90		.72	
41	3.61	5.00	9.35	6.00					
42	1.80	5.00	4.32	8.00	Total	99.91	100.37	100.01	100.06
43	2.71		2.16	6.66					
44	2.71	1.67	4.32	9.34	Number of fish	111	60	139	150
45	1.80	5.00	3.60	4.66					

[1] Indicates break in continuity of table.

TABLE 10.—*Length frequencies of 586 spots taken in long-haul seines, 1925, all localities. (In per cent of total number)*

Length, centimeters	July	Aug.	Sept.	Oct.	Length, centimeters	July	Aug.	Sept.	Oct.
11			0.81		22	11.10	31.61	25.00	8.96
12					23	6.17	11.61	12.10	4.14
13	0.61			2.07	24	.61	2.58	2.42	.69
14	1.23			.69	25		.65	.81	.69
15			2.42	4.83	26		.65		.69
16			4.84	12.40	27				.69
17	2.46	4.53	8.06	21.40					
18	10.50	5.16	6.45	14.50	Total	100.00	100.04	100.04	100.00
19	11.72	4.53	3.23	17.90					
20	20.40	14.20	10.50	4.83	Number of fish	162	155	124	145
21	35.20	24.52	23.40	5.52					

TABLE 11.—*Length frequencies of 1,303 croakers taken in catches of long-haul seines, 1925, all localities.* (*In per cent of total number*)

Length, centimeters	July	Aug.	Sept.	Oct.[1]	Length, centimeters	July	Aug.	Sept.	Oct.[1]
15				0.91	31	4.94	4.22	8.50	
16				.46	32	3.30	1.58	4.40	.91
17				.91	33	1.92	1.06	2.35	
18				3.20	34	.82		2.64	.91
19	0.27		0.29	7.30	35		.26		.46
20	1.37	0.26	2.35	16.45	36	.55		.88	
21	3.02	1.32	3.23	18.70	37	.27			
22	3.84	2.37	10.85	16.90	38			.59	
23	5.50	9.50	8.50	14.60	39			.29	
24	7.42	11.61	8.80	8.67	40		.26	.29	
25	9.34	12.66	5.87	2.74	41			.29	
26	12.60	17.94	7.92	4.10					
27	18.94	11.87	8.80	.91	Total	99.91	99.98	100.00	99.96
28	11.09	8.18	5.57	.46					
29	9.05	9.50	12.60	.46	Number of fish	304	379	341	219
30	5.76	7.39	4.99	.91					

[1] Includes collections on Nov. 2.

These data are all presented graphically in Figures 8 to 13, and for the benefit of the average practical reader, unfamiliar with graphical methods of analysis, Figure 7 is given to illustrate the method of construction of these curves and to make more complete the mental picture they are intended to convey.

SELECTIVE ACTION OF FISHING GEAR

It will be noted above that the size of fish taken in pound nets differs materially from those taken in the long-haul seines. Not only do pound nets catch the smaller fish, such as butterfish and starfish, which seldom appear in the catches of the long-haul seines, but the long-haul seines catch spotted trout, drum, rockfish, and other large species not frequently taken in pound nets. The sizes of fish of the same species are uniformly larger in long hauls than in pound nets. Thus, the maximum size of gray trout taken in long-haul seines is 2 inches greater than those taken in pound nets. The maximum size of spots is 1.1 inches greater, and the maximum size of croakers is 0.4 inch greater. The same disparity in sizes is shown in the minimum sizes taken, pound nets taking smaller fish of all species than are ever caught in quantities by long-haul seines. There is, therefore, a very evident selection of different sizes of fish by the two types of gear, which is more clearly illustrated by Figures 8, 11, and 12, showing the length frequencies of fish of the three species caught most abundantly by the two methods. Figure 8 shows the size composition of gray trout, and while the curve for the long-haul seine catch is quite irregular, due to the relatively small numbers it represents, it is quite apparent that fish under 25 centimeters in length seldom are caught by this gear. If we assume that the abundant size group found at 24 centimeters in August represents the 2-year-old fish, it is apparent that only fish 3 years and more of age are caught by long hauls. As the 2-year-old fish grow through the summer, the number of this group taken by the long hauls increases; but in all months of the season the older fish are taken in far greater relative abundance by long hauls than by pound nets. The same kind of size selection is shown by the catch of spots in Figure 11. If ages are assigned provisionally to the prominent size groups as shown in the graph, it is apparent that the III-group is taken far more abundantly in the early part of the season by long-haul seines than by pound nets. As the I and II groups grow, however, increasing amounts are taken by the long hauls until in October,

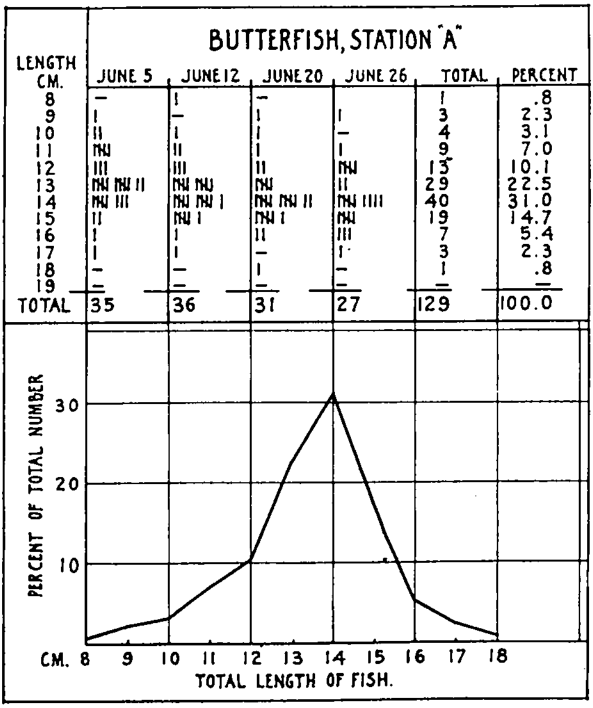

FIG. 7.—Illustrating method of tabulating length frequencies and constructing curves. At station A 35 butterfish contained in the gross sample obtained from the pound-net catch of one crew were measured and their lengths tallied on the record sheet opposite the correponding length in centimeters, as in the first column. On succeeding visits to this station (on June 12, 20, and 26) the butterfish taken were measured and tabulated. The total number of fish occurring at each centimeter length was then determined by adding together the samples, as shown in the total column. The number of fish at each length was reduced to a percentage of the total number, as shown in the per cent column, and comprise a length-frequency table corresponding to Tables 3 to 11. These figures were then used to plot the curve here shown by placing points at the corresponding heights on the vertical scale over the proper lengths on the horizontal scale. Fictitious and not actual figures have been used in this illustration

when the majority of the fish are above 15 centimeters in length, virtually equal numbers of the I and II groups are taken by both gears.

Figure 12 illustrates the catch of croakers. As was said before, the separate-age groups can not be distinguished readily, but it is again apparent that the larger fish are taken more abundantly by long-haul seines throughout July, August, and September, and that the smaller group appears in numbers only when the fish have grown beyond 19 centimeters in size.

No direct observations on the causes of this selection in sizes were made in the course of the investigation. It may be remembered, however, that pound nets operate in different localities than do long-haul seines and upon bottom of different character. It must also be remembered that the size of mesh used in the seines is much

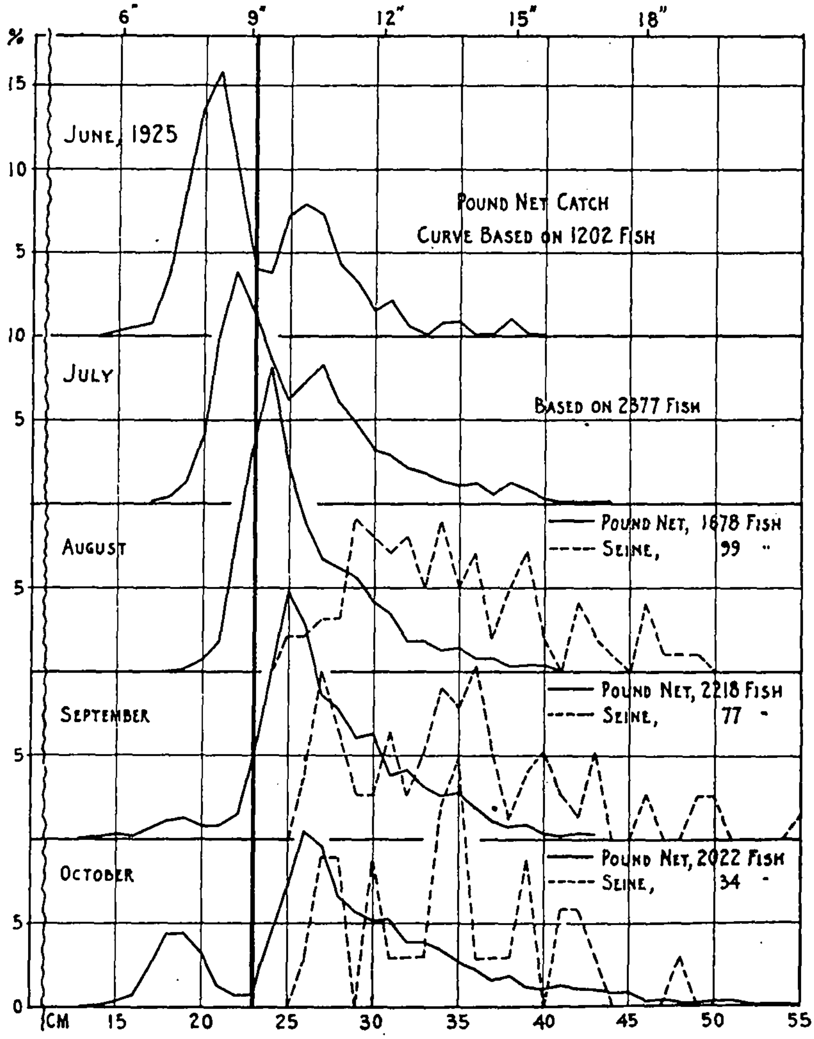

Fig. 8.—Length frequencies of gray trout from pound nets and long-haul seine catches in Pamlico and Core Sounds, N. C., 1925. The heavy vertical line is placed at the legal minimum size limit.

greater than that used in the crib of the pound net, and both of these factors, in all probability, are responsible. But whether this selection by pound nets and long-haul seines is due to the segregation of the size of fish according to the depth of water and character of bottom, or whether it is due to differences in size of mesh and in the method of operating the nets, is of little practical importance. That long-haul seines tend to catch more of the larger sizes of fish and that pound nets take greater quantities of the younger and smaller fish are facts of great importance. From this evidence alone, and unless counteracted by other undesirable features not discovered by this investigation, this selection of the larger species and of the larger fish in each species would warrant the encouragement of long-haul seining as being more efficient and less harmful to the fish supply than pound-net fishing.

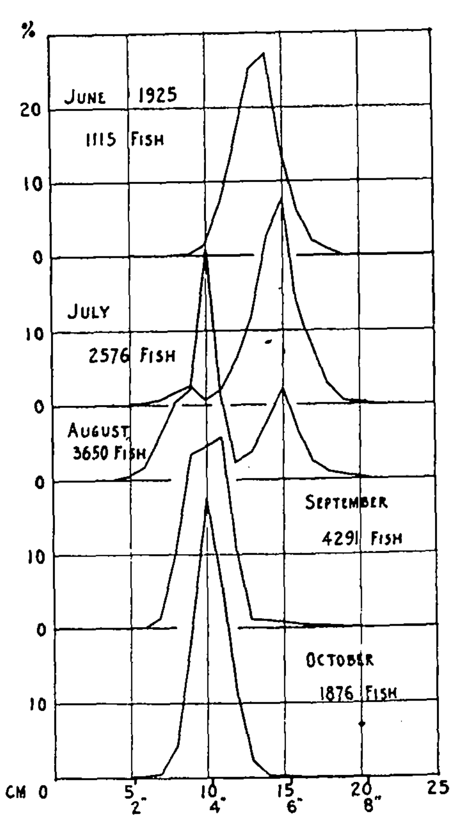

FIG. 9.—Length frequencies of starfish (harvest fish) in pound-net catches in Pamlico Sound, 1925

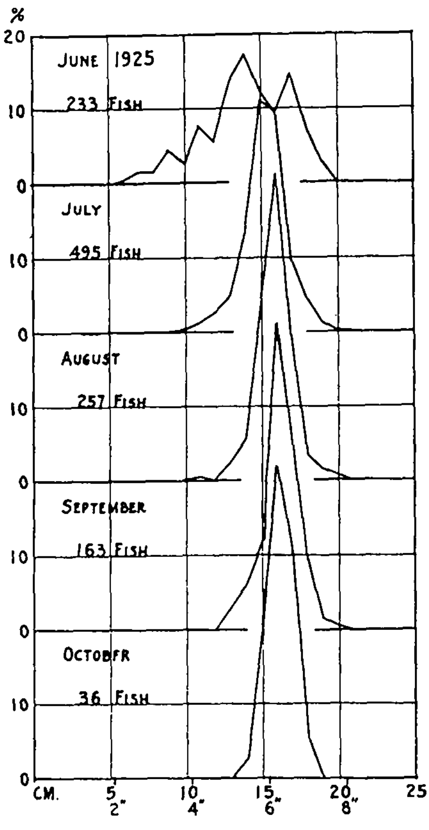

FIG. 10.—Length frequencies of butterfish in pound-net catches in Pamlico Sound, 1925

DESTRUCTION OF UNDERSIZED FISH

The Fisheries Commission Board of North Carolina has enacted regulations that prohibit the marketing, possession, or the unnecessary destruction of various commercial fish below a certain size. Rule 12, passed December 11, 1923, and published in "Orders, Rules, and Regulations" of the Fisheries Commission Board in 1925, provides the following minimum size limits: Gray trout, 9 inches; spotted trout, 11 inches; croakers, 8 inches; spots, 7 inches. Size limits are assigned also to other species not taken by pound nets or long-haul seines. Starfish and butterfish have no legal minimum size limit, but a very effective market limit of about 5 inches is placed upon these species by the dealers, for fish below this size are virtually worthless and are refused by the fish buyers.

The provisions of this rule regarding marketing or possession are undoubtedly well enforced in this State and are accepted without

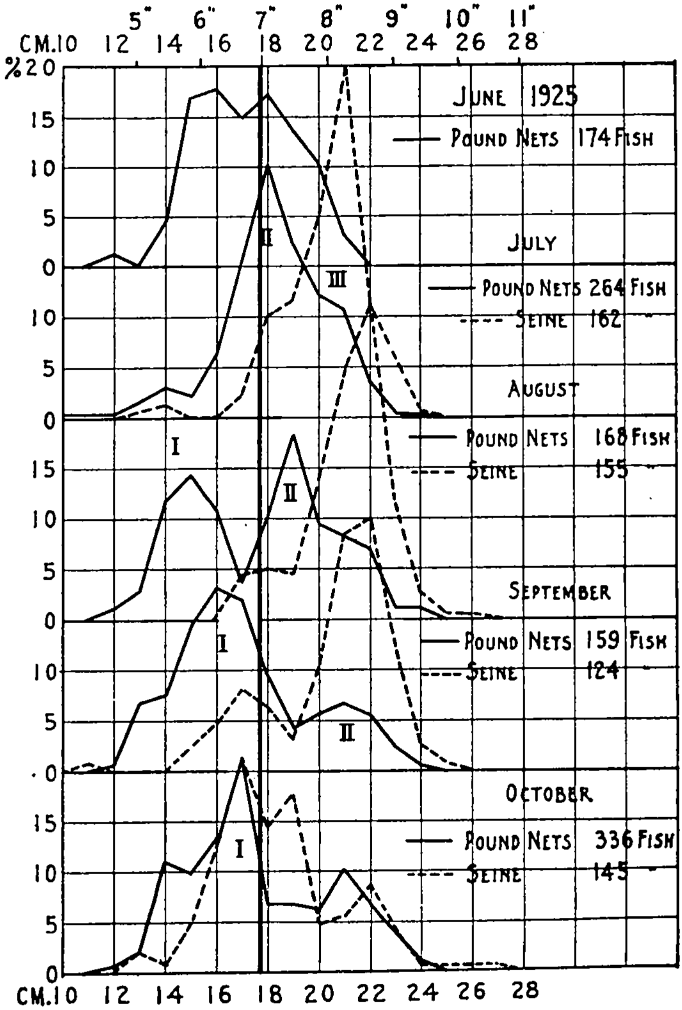

FIG. 11.—Length frequencies of spot in pound-net and long-haul seine catches in Pamlico and Core Sounds, N. C., 1925. The heavy vertical line is placed at the legal minimum size limit

protest by the fishing interests. Whether or not the third provision of the rule, concerning unnecessary destruction, is effective may be seen by an examination again of Tables 3 to 11, which show relative numbers of the various sizes of each species caught by the different kinds of gear. Table 12 summarizes the percentage, by number, of unmarketable fish—that is, fish below the legal or marketable size limit taken in the pound nets and long-haul seines during 1925. From the averages of destruction in different months it may be seen that long-haul seines waste no gray trout that are unmarketable,

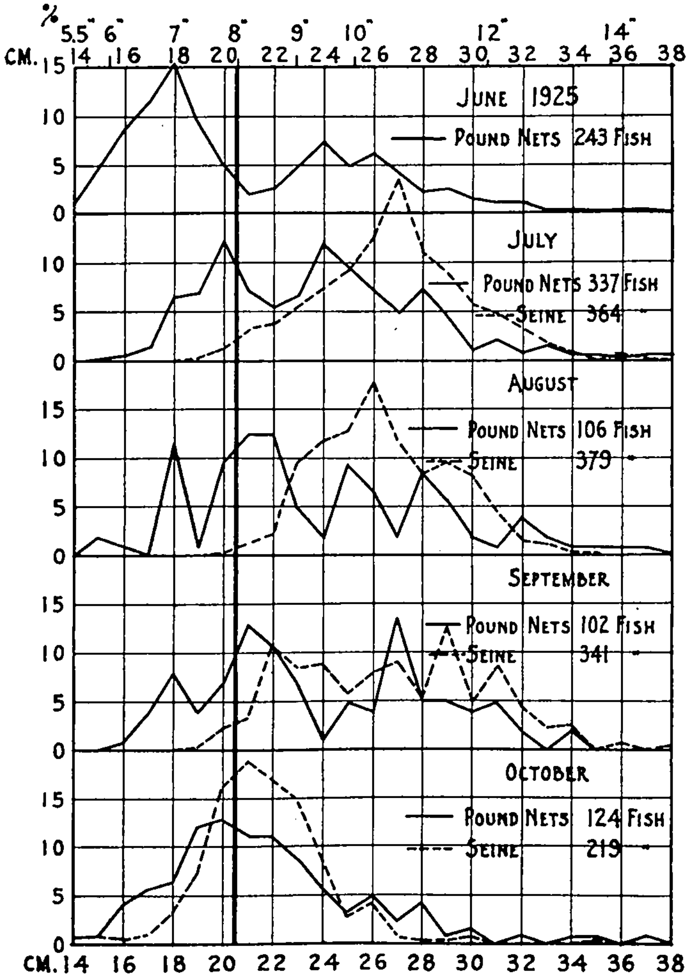

FIG. 12.—Length frequencies of croaker in pound-net and long-haul seine catches in Pamlico and Core Sounds, N. C., 1925. The heavy vertical line is placed at the legal minimum size limit

while pound nets waste, on the average, 30.6 per cent of the catch. Long-haul seines waste 4 per cent of the catch of spotted trout; pound nets destroy 59 per cent of the catch of starfish and 5½ per cent of the catch of butterfish.

TABLE 12.—*Percentage (by number) of unmarketable fish, Pamlico and Core Sounds, N. C., 1925, all localities*

Species	June	July	Aug.	Sept.	Oct.	Average
LONG-HAUL SEINES						
Gray trout	----------	0	0	0	0	0
Spotted trout	----------	1.8	----------	----------	14.0	4.0
Croaker	----------	1.6	.3	2.6	29.2	8.4
Spot	----------	4.3	4.5	10.1	41.4	16.6
POUND NETS						
Gray trout	57.9	41.4	24.0	11.4	18.2	30.6
Starfish	24.6	13.5	65.0	95.4	97.2	59.1
Butterfish	23.2	4.4	.4	0	0	5.6
Croaker	56.4	27.2	24.5	23.5	42.7	34.9
Spot	55.2	30.3	44.6	64.7	58.0	50.6

Long-haul seines waste 8½ per cent of the catch of croakers, while pound nets waste 35 per cent. Long-haul seines destroy 16½ per cent of the catch of spots, while pound nets destroy 50½ per cent. Long-haul seines also take appreciable numbers of mixed fish, but the numbers of each species is so small and variable that the percentage of destruction of small fish, such as rock or striped bass, drum, bluefish, and sheepshead, has not been reduced to exact figures; but of the total number approximately 12 per cent are below marketable or legal limit and are thus destroyed. It can be seen that long-haul seines destroy but small quantities of fish that are too small to market, while pound nets, on the other hand, are extremely destructive. A simple average of the percentage of waste by pound nets of each species shows a destruction of more than 36 per cent; but this is far under the real destruction of all fish taken, when it is considered that the destruction of the most numerous species—starfish—amounts to almost 60 per cent for the season.

The figures of size composition given in Tables 3 to 11 represent the size of fish landed in the boats. All of the fish below the legal or marketable size limit, indicated by the heavy vertical line in Figures 8 to 14, are utterly destroyed and wasted, for culling of these small fish from the marketable catch is not attempted in the case of the pound-net fishing until the boats have returned with the catch to the market places or waiting buy boats. They are then scooped up, sorted, and thrown overboard, where they float upon the water in great quantities, affording food only for gulls and crabs. (See fig. 3.)

Table 12 further shows that the destruction of the various species by pound nets varies throughout the season. The greatest destruction of gray trout occurs in June and declines through July and August, reaching the lowest point in September, with a slight increase in October. The destruction of starfish falls from June to July, but increases rapidly until the tremendous waste of 97 per cent occurs in October. Butterfish are wasted in appreciable quantities only in June, but the wastage of spots and croakers appears to be virtually constant throughout the season, with somewhat greater waste occurring in both species in June. The tremendous waste of croakers and spots is deplorable, but these species represent only 4 and 5 per cent, respectively, of the total season catch of the pound nets, while trout and starfish represent 40 and 45 per cent, respectively. Hence further consideration of undersized fish will be limited to a consideration of the pound-net catch of gray trout and starfish.

The previous figures, based upon observations at Portsmouth, Lupton, Brant Island, Gull Rock, and Point of Marsh, apply to the average conditions over the whole of Pamlico Sound. There is considerable variation, however, in the relative destruction of gray trout and starfish in the various localities. Table 13 gives the percentage destruction of small gray trout taken in pound nets in Pamlico Sound, according to month and locality.

TABLE 13.—*Percentage destruction of undersized gray trout by pound nets in Pamlico Sound, N. C., 1925, according to locality and month*

Locality	June	July	Aug.	Sept.	Oct.
Portsmouth	29.36	25.30			
Lupton	50.46	54.38	25.68	4.92	10.42
Brant Island	77.73	43.99	16.50	6.29	28.40
Point of Marsh		20.94	14.88	6.83	20.43
Gull Rock	74.17	53.16	38.93	27.76	13.28
Average	57.93	41.35	24.00	11.45	18.13

In the month of June the smallest fish are taken at Brant Island and Gull Rock, the number of unmarketable fish reaching 78 and 74 per cent, respectively while at Lupton virtually 50 per cent of the catch is below legal size. At Portsmouth less than 30 per cent are unmarketable, the bulk of the catch coming from the older spawning fish. In July the amount of destruction at Brant Island and Gull Rock has fallen somewhat and is exceeded by the destruction at Lupton, which amounts to 54 per cent. The amount of destruction at Portsmouth still remains low, although the preponderance of spawning fish is somewhat reduced. In August the destruction in all localities has fallen below 40 per cent, with the highest figure at Gull Rock. Fishing at Portsmouth has been discontinued until the very end of the season, but records are so scattering that they do not appear in our study again. The destruction at Gull Rock still remains high, but has fallen in September to about 28 per cent. This amount of destruction is largely due to the incoming of the smaller year class of trout, which scarcely appears in the catches at other localities. The total destruction at the other three pound-net localities is 5 or 6 per cent. In October the larger sizes of fish are relatively more important in all localities. The fish remaining below the legal limit have increased, however, to 20 and 28 per cent at Point of Marsh and Gull Rock, due to the increasing abundance of the youngest year class taken in commercial gear. If it can be assumed that conditions at Gull Rock are typical of the northwest side of Pamlico Sound, we may conclude that this region supports a population of very small fish with but a scattering of the larger sizes. The destruction of fish in this locality is, therefore, more severe than at any other place. Only the larger sizes are taken in the fishery at Portsmouth in June and July, hence the destruction of small fish there amounts to very little.

EFFECT OF GROWTH ON MARKETABILITY

Figure 8 shows the composition of the catch of gray trout in pound nets in all localities for the various months. The heavy vertical line at 23 centimeters marks the legal minimum size limit. It may be seen that in June two well-marked size groups are present in the range of sizes, one with a mode at about 21 centimeters and another with a mode at about 26 centimeters. The group above 23 centimeters is, of course, composed of marketable fish, while the smaller group lies entirely below the legal limit and these fish are wasted. In July the group of the smaller fish has grown to a modal or average length of 22 centimeters, when the larger members of this group are now beyond the minimum limit. In August the modal size of the same group has reached 24 centimeters, and in September more than 25 centimeters, with increasing percentages above the minimum size limit. Thus the decreasing destruction of the gray trout from June to September is explained by the growth of the most numerous year class, which passes from an unmarketable to a marketable size in the period of rapid growth during the summer. In October the percentage destruction rises somewhat because of the fact that the next younger age group has reached a size of 14 to 23 centimeters in length, which is large enough to be taken by the pound nets. They apparently are not very numerous, however, for they amount to but 18 per cent of the total number of fish taken.

The size composition of starfish taken in the pound nets during the season is shown in Figure 9. Here it may be seen that in June the market limit of 5 inches falls almost in the middle of an abundant year class with a mode at about 13.5 centimeters, hence the destruction of unmarketable fish is relatively great. This group has grown, however, by July so that but few remain below the limit. For some reason the smaller fish are not taken during the month of July, but in August a smaller size group becomes relatively abundant and the larger group diminishes in importance. Since this smaller group consists of fish from 5 to 12 centimeters in length, they are worthless in the market and hence are discarded from the catch. In September and October the catch consists almost entirely of this smaller year class, which apparently does not grow sufficiently to pass the minimum market limit. Hence, the destruction of this species reaches 95 and 97 per cent, respectively, in the latter months of the season.

THE PROBLEM OF CONSERVATION

It is now plainly evident that grossly wasteful and uneconomic practices exist in the pound-net fishery in North Carolina. From our records and from the statistics published by the State authorities it is not possible to estimate with any accuracy the total number of pounds of fish wasted, nor can any valuation be placed upon them, since they are all unmarketable. Despite this fact, the destruction of immature and unmarketable fish is a real economic loss to the fishery, and means should be devised to safeguard the supply against unnecessary strain, particularly when it is remembered that the supply is insufficient to meet the demand. Of the 8,225,000 pounds landed in Pamlico and Core Sounds in 1923, the landings of the two species of sea trout amounted to 27 per cent, butterfish 2.1 per cent, starfish 3.7 per cent, croakers 15.7 per cent, and spots 12.5 per cent. With the exception of spotted trout, these species bring the fishermen from 2 to 4 cents per pound. Spotted trout, however, are more in demand, bringing the fishermen 8 to 12 cents per pound. The trout, therefore, are a staple market fish in North Carolina; and although starfish are subject to a greater destruction of undersized fish, gray trout must be considered of greatest value as a natural resource.

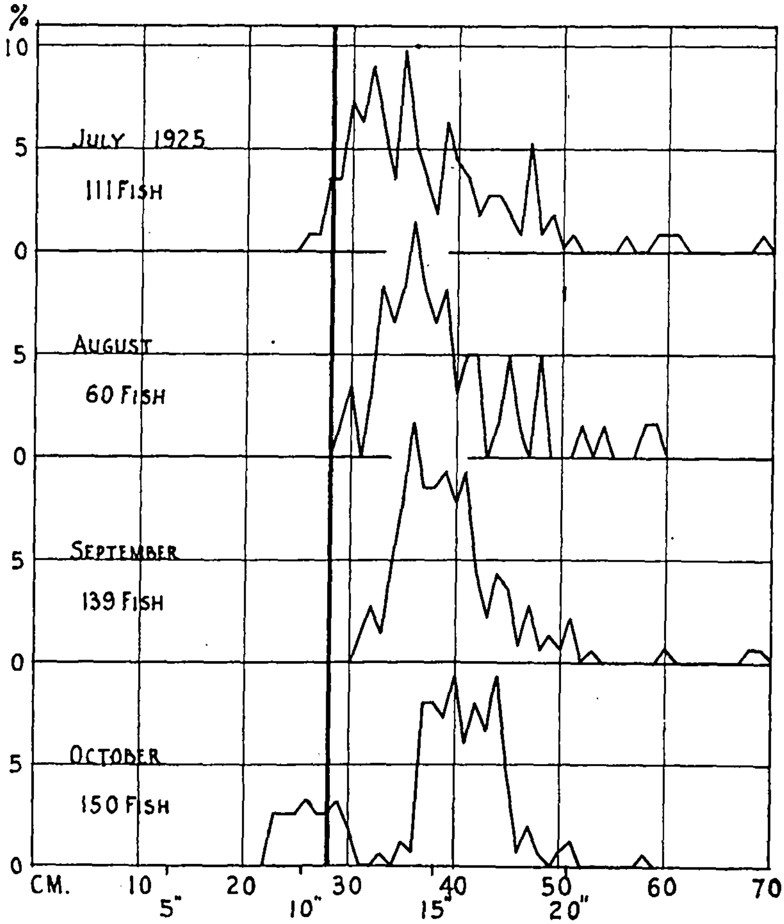

Fig. 13.—Length frequencies of spotted trout in long-haul seine catches in Pamlico and Core Sounds, N. C., 1925

We are faced, therefore, with the problem of affording the gray trout maximum protection from wasteful and excessive exploitation, at the same time disrupting as little as possible the operations of the fishing industry. The protection of the species, however, depends upon many facts in the life history and habits of the fish, which must be considered in drafting effective regulations.

LIFE HISTORY OF THE GRAY TROUT

In outlining the life history of the gray trout it must be admitted at the start that our knowledge is extremely fragmentary and quite inadequate in many directions. No complete or convincing study has been made of the details of the life history and habits of this species. The most useful contributions to our knowledge have been made by Taylor,[9] Welsh and Breder,[10] and Hildebrand and Schroeder.[11]

In the present investigation no attempt has been made to study the life history of the trout by means of scales, for it was felt that the major objects of the investigation would be served by employing less involved methods. All our discussions, therefore, concerning age and rate of growth, age at first maturity, etc., are subject to revision when more exact determinations of age are possible. Extensive collections of scales from the fish studied in this investigation have been retained for that purpose for subsequent treatment.

Spawning.—As has been noted by other authors, the spawning period of the gray trout occurs during the summer months, from May to September. Welsh and Breder state that the great majority of the fish spawn between the middle of May and the middle of June and that the season appears to be little affected by latitude. Spawning occurs from the Carolinas to Cape Cod.

Table 14 presents our data concerning the relative number of spawning fish among all mature females [12] taken in pound nets in Pamlico Sound. When our investigation began in the second week of June virtually all mature females were found to be in a spawning condition; that is, the eggs were large and distinct and the ovaries greatly swollen. In only a few, however, were free-running, ripe eggs discovered. Although there is variation among the different localities, it can be seen from the column of averages that the percentage of spawning fish fell rapidly during the season, from 100 per cent in early June to 0 by the end of the first week in August. This indicates that spawning in Pamlico Sound reached its height during June and was completed for that season by August 10. These facts are represented graphically in Figure 14.

TABLE 14.—*Percentage of spawning females among all mature females in pound-net catches, Pamlico Sound, N. C., 1925. (Average by weeks)*

Date	Portsmouth	Lupton	Brant Island	Point of Marsh	Gull Rock	Average
June 8–13	100					100
June 15–20	100	95	100			98
June 22–27	99	92	58		87	84
June 29–July 4	98	75	60		95	82
July 6–11	100	68	43		89	75
July 13–18		60	29		73	54
July 20–25		51	12	22	48	33
July 27–Aug. 1		18	4	28	52	26
Aug. 3–8		0	3	3	0	2
Aug. 10–15		0	0	0	0	0

[9] The Structure and Growth of the Scales of the Squeteague and the Pigfish as Indicative of Life History. By Harden F. Taylor. Bulletin, U. S. Bureau of Fisheries, Vol. XXXIV, 1914 (1916), pp. 285–330, Pls. L–LIX, 8 text figs. Washington, 1916.

[10] Contributions to Life Histories of Sciænidæ of the Eastern United States Coast. By William W. Welsh and C. M. Breder, jr. Bulletin, U. S. Bureau of Fisheries, Vol. XXXIX, 1923–24 (1924), pp. 141–201, 60 figs. Washington, 1923.

[11] Fishes of Chesapeake Bay. By Samuel F. Hildebrand and William C. Schroeder. Bulletin, U. S. Bureau of Fisheries, Vol. XLIII, 1927, Part I. (In press.)

[12] Mature fish, as shown in Table 15, are never less than 20 centimeters (7.9 inches) in length.

We have no observations upon the exact localities of spawning, but the fish are supposed to spawn in open water. They are known to spawn in Delaware and Chesapeake Bays, where the fish assemble in fairly deep water and spawn on the bottom. The fertilized eggs immediately float to the surface and are freely distributed by tidal currents. (Welsh and Breder.) It is not known whether conditions inside Pamlico Sound are favorable for spawning. Some slight evidence indicates, however, that the spawning individuals leave the inland waters and spawn in the Atlantic Ocean. Thus a scarcity of mature specimens was noted in June in experimental pound-net catches made in Beaufort Harbor in 1913 to 1916, and the early-spring run of large specimens is well recognized by the fishermen in the vicinity of Ocracoke Inlet. Figure 14 indicates that only ripe individuals were taken in the Portsmouth pound-net fishery

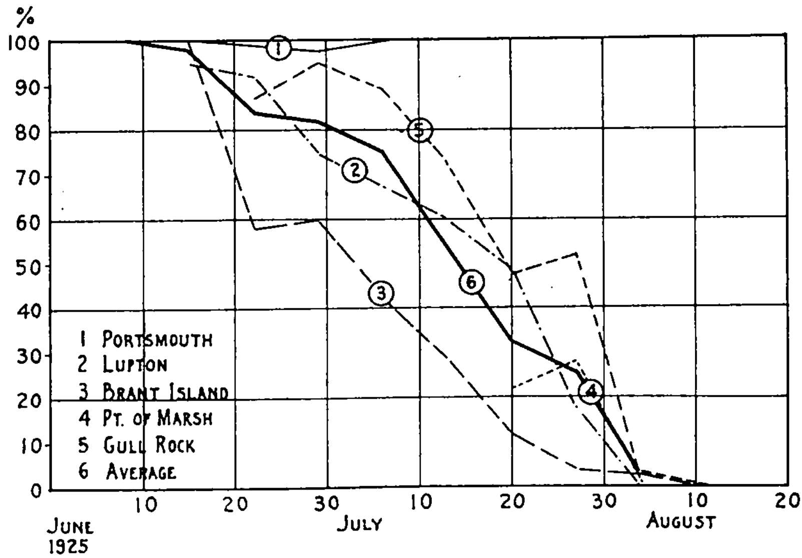

FIG. 14.—Percentage of spawning gray trout among all mature females occurring in pound-net catches in Pamlico Sound, N. C., 1925, computed by weeks during June, July, and August

until early July, when fishing operations were abandoned at that place. The proportion of spawning females is greater here than at any other locality in the sound, and it may be supposed that the outward migrating schools are intercepted by the nets at this locality.

Growth.—We have no knowledge of the early life of the trout in Pamlico Sound until they have reached the size large enough to be taken in the pound nets—that is, 14 centimeters in length. Some collections (Hildebrand) in the vicinity of Beaufort, N. C., however, include specimens ranging from 50 to 120 millimeters in length on August 1 and from 70 to 135 millimeters by October 15. Welsh and Breder also estimate that the length of trout at Cape May, N. J., is from 10 to 13 centimeters during their first winter. The smallest sizes taken in the pound nets in Pamlico Sound have a modal size of about 18 centimeters in October. We believe, therefore, that these fish are in their second year (I-group) and thus roughly agree with the estimate by Welsh and Breder of 21 centimeters in the second winter. By reference to Figure 5 the first size group in our length-frequency studies has a modal length of 21 centimeters in June. These fish, therefore, are the next older year group—the II-group—and are in their third year. Growth of this age group very clearly progresses to 22 centimeters in July, 24 centimeters in August, 25 centimeters in September, and to somewhat more than 26 centimeters in October. Welsh and Breder estimate that this group reaches a length of 28 centimeters in the third winter, and this is in fairly close agreement with our observations.

The next older year class in our series appears in June to have a modal length of approximately 26 centimeters. This figure, however, may be somewhat lower than the true average of the age group because of the evident selection of the smaller sizes in pound-net catches. The growth of this group can not be satisfactorily followed through the season because of the selective action of the fishing gear. An abundant size group occurs in the long-haul seine catch, which approximates 30 centimenters in length in August, and an estimate of growth during this period may therefore be made. Welsh and Breder estimate that a length of 33 centimeters is attained by the fourth winter, and this again agrees fairly well with our provisional estimate of age. This group, therefore, is the III-group and in the fourth year.

Based on these estimates by various authors, together with the imperfect evidence afforded by the separation of the length-frequency curves into distinct groups, the following estimate of size and age of the gray trout in Pamlico Sound appears to be warranted:

Age	Midwinter size
½ year	11 centimeters (4.3 inches).
1½ years	21 centimeters (8.3 inches).
2½ years	28 centimeters (11 inches).
3½ years	33 centimeters (13 inches).

Age at maturity.—Observations as to the state of maturity of the sexual products were made in all of the fish measured in this investigation. Trout containing swollen ovaries, in which the eggs were distinctly granular and which would obviously spawn during the present season, were considered mature, as well as those in which spawning was under way or in which the ovaries were partially spent. All others were considered immature. The males were not considered in this study, since it is difficult to judge the condition of the male organs. Some error occurred by classing fully spent fish with the immature, but since spent fish were early recognized and relatively scarce during the month of July the records for that month are reasonably accurate and a determination of maturity at each size is possible. Table 15 presents the relative maturity of female gray trout taken in pound nets in Pamlico Sound during July, in which the number of mature females at any size is shown as a percentage of all fish at corresponding sizes. These data are presented graphically in Figure 15, in which the average obtaining in the whole sound is shown superimposed upon a curve of length frequency of all fish taken. It is plainly evident that of the II-group but a relatively small percentage are mature females, but that the III-group is composed chiefly of mature females in July. From the appearance of the frequency curve it seems that there are but few of the older year classes present in the sounds; hence the future supply must depend chiefly upon the spawning of the 3-year-old fish. This condition differs from that reported by Welsh and Breder at Cape May, N. J., where the majority of the spawning fish were from 4 to 6 years old and the 5-year-old fish were the most numerous.

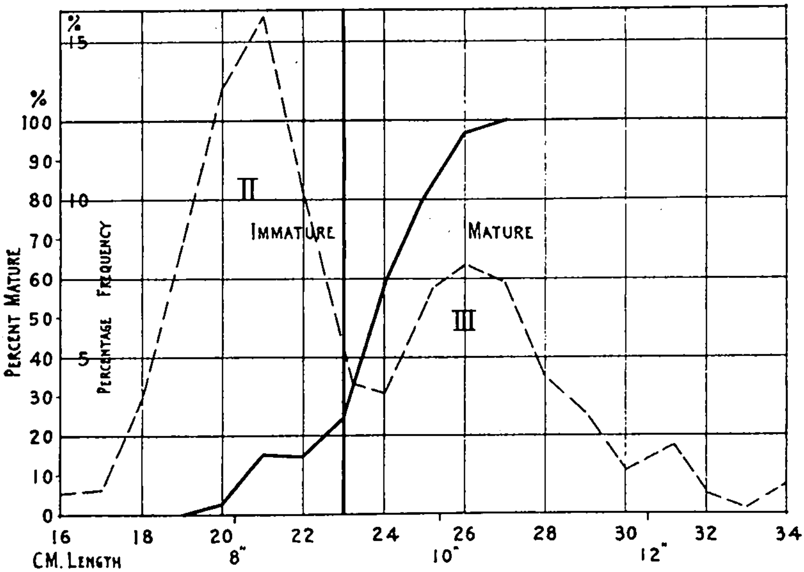

FIG. 15.—Relative maturity of female gray trout in Pamlico Sound, N. C., in July, 1925. The heavy curve rising from 0 to 100 represents the number of mature females occurring at any size, expressed in per cents of the total number of fish at that size. The length frequency curve of both males and females combined is superimposed. These data indicate that the II-group (fish in their third year) are largely immature, while of the III-group nearly all are mature, and that the fish larger than 27 centimeters in length are all mature females.

TABLE 15.—*Percentage of mature female gray trout occurring at any size in pound-net catches, Pamlico Sound, N. C., July, 1925* [1]

Length, centimeters	Lupton	Portsmouth	Brant Island	Gull Rock	Point of Marsh	Average
17	----------	----------	0	0	----------	0
18	0	----------	0	0	----------	0
19	0	----------	0	0	----------	0
20	0	0	0	11.1	----------	2.8
21	8.9	40.0	3.5	23.6	0	15.1
22	11.0	30.8	5.7	26.7	0	14.8
23	11.0	58.4	13.1	33.7	5.6	24.4
24	29.6	80.0	46.7	51.0	35.3	58.5
25	64.4	100.0	91.7	86.3	66.7	81.8
26	90.8	100.0	100.0	94.9	100.0	97.1
27	100.0	100.0	100.0	100.0	100.0	100.0
28	100.0	100.0	100.0	100.0	100.0	100.0

[1] Because of the difficulty (under the conditions obtaining in the field) experienced in determining the sex of the younger immature individuals, the percentage of mature females is calculated on the basis of the frequency of both males and females together.

Migrations.—Very little is known regarding the migrations of the gray trout. Welsh and Breder report that in the Chesapeake and Delaware regions the fish appear in April, move up the bays until brackish water is encountered, and then turn back and move seaward, spawning just within or near the mouths of the larger estuaries. After spawning, the fish return to the ocean, remaining near the coast until July or August, when they again seek the bays and sounds. No such distinct routes of migration have been recognized in Palmico Sound; however, there is some evidence to indicate a westward movement of the larger fish from Ocracoke Inlet, but our stations are not close enough together to determine the route of travel. It is well known that fish become very scarce early in November, and it is supposed that they return to the Atlantic Ocean.

Regarding the movements of the gray trout (weakfish) in northern waters, Bigelow and Welsh remark [13] that "it is now generally assumed that their autumnal migration takes place to avoid falling temperature and that they either move offshore to pass the cold season on the continental edge, or southward." While a considerable southward migration of fish in the region about Cape Cod and Long Island Sound is quite conceivable, it seems less probable that such movement occurs on the Carolina coast where Gulf Stream tempertures and shallow bottoms are within easy reach of the coast.

The records of fish taken at Gull Rock indicate that here is a concentration of the smaller sizes of trout. Not only are the larger age groups very scarce, but the average size of the younger fish is also less than in other localities. Some have argued that this is a distinct race of the species, which is localized in Hyde and Dare Counties on the northwestern side of Pamlico Sound, but we have no evidence to support this contention. Our measurements indicate the presence of the II-group and in all probability of the I-group throughout the season. The III-group is present early in the season but dwindles in importance as the season progresses. Whether or not this reduction in number is due to their migration to the sea or to their destruction by fishing gear is a question difficult to answer. It may be confidently stated, however, that the immature fish that are present in the sounds in the spring remain in inside waters throughout the entire fishing season.

EFFECT OF PRESENT FISHERY REGULATIONS

Regulations establishing minimum size limits are ordinarily enacted by the various States theoretically as conservation measures to protect the immature fish. Since the supply of fish in North Carolina waters is inadequate to meet the demand, it is but common sense to seek to prevent the useless waste of the present supply. But minimum size limits are actually designed to protect the dealer from the necessity of accepting from the fishermen fish too small to market profitably. Little attention is given to the protection of the species, for the limits are not placed high enough to protect the fish until they reach a spawning size. Whatever may be the merit of this principle, the present 9-inch minimum limit in North Carolina does not operate as a

[13] Fishes of the Gulf of Maine. By Henry B. Bigelow and William W. Welsh. Bulletin, U. S. Bureau of Fisheries, Vol. XL, 1924 (1925), Part I, p. 275. Washington.

conservation measure in this way, because, as shown in Figure 15, trout do not spawn until the third year, when they average more than 10 inches long in June. It is plainly evident, therefore, that where pound nets operate any minimum size limit is entirely ineffective, offering no protection whatever, for fish of all sizes above 5½ inches are taken freely, marketable sizes are selected and sold, and the remainder, which constitute, as we have seen, more than half by number of the total catch of trout, are destroyed.[14]

These small 2-year-old fish should be saved, for, although too small to be of value in the markets in June and July, their growth is so rapid that they are marketable by August, and they are really of desirable size by October. Table 16 shows the increase in length and weight of these 2-year-old trout during the fishing season. The lengths, in centimeters and inches, are the observed modal lengths of this year class caught in pound nets, as shown by Figure 5. The weights are calculated according to the formula by Crozier and Hecht.[15] While the length increases only 26 per cent from June to October, the weight increase during that period amounts to 101 per cent. In other words, while length increases only one-fourth, the weight of 2-year-old fish more than doubles during the growing season. It is highly desirable, therefore, that the small fish destroyed during June and July receive full protection until August and September, when they have reached a marketable and commercially valuable size. Since the imposition of a minimum size limit is both ineffective and wasteful, let us consider what other means are available for protecting the species.

TABLE 16.—*Growth in length and weight of 2-year-old gray trout*

Month	Length			Weight		
	Centimeters	Inches	Per cent increase	Grams	Ounces	Per cent increase
June	21.0	8.3		81.2	2.8	
July	22.0	8.7	5	93.4	3.3	15
August	24.0	9.5	14	121.3	4.3	49
September	25.5	10.1	21	145.4	5.1	79
October	26.5	10.5	26	163.2	5.8	101

REMEDIAL MEASURES

The only regulations that afford any promise of protection to the gray trout are (1) limits upon size of mesh in the nets fished, (2) the establishment of closed areas prohibiting fishing where immature fish congregate in greatest numbers or where spawning occurs most abundantly, and (3) designation of closed seasons prohibiting fishing

[14] It is claimed that culling of the catch in such manner that undersized fish are promptly returned to the water uninjured is generally practiced by trap and pound net fishermen on the Great Lakes, and similar care is exercised by certain conscientious fishermen in the Chesapeake Bay (Hildebrand and Schroeder). No attempt is made in North Carolina to save the undersized fish, for culling takes place at the base of operations, where the marketable fish are sold miles from the fishing grounds. Because of such local conditions as the prevailing weather and the unseaworthy construction of boats, it is unlikely that culling at the time of capture could be successfully practiced. But even if such culling were practicable, it would be impossible strictly to enforce the present minimum size limit so as to insure the return of undersized fish alive to the water.

[15] Correlations of Weight, Length, and Other Body Measurements in the Weakfish, *Cynoscion regalis*. By William J. Crozier and Selig Hecht. Bulletin, U. S. Bureau of Fisheries, Vol. XXXIII, 1913 (1915), pp. 139-148, 4 figs. Washington, 1914.

by pound nets during the part of the year when immature fish are most abundantly taken and during the height of the spawning season.

It has been suggested that increasing the mesh in the cribs of the pound nets from 1⅛ to 1½ inches or more would permit the escape of the smaller fish of all species and thus permit fishing at all times of the year with a minimum of wastage. This suggestion, however, is vigorously opposed by the fishermen on the grounds that any increase in size of mesh would permit the gilling of such quantities of the smaller fish in the meshes of the net that it would be impossible to operate. They contend that removing the gilled fish from the cribs of the nets would consume so much time that pound-net fishing would no longer be practical and that the nets would be destroyed by sharks feeding upon the gilled fish. Furthermore, it is unlikely that a slight increase in the mesh of the cribs would effect the release of the smaller sizes in appreciable quantities, for a gray trout from 5 to 6 inches in length can readily be passed by hand through meshes of a 1⅛-inch pound net, but these small fish follow the lead of the net, which is 12 inches or more stretched mesh, and are readily caught. If this method were at all feasible, the mesh should be increased so as to permit the escape of trout up to 12 inches in length in order to protect the fish until one year's spawning has occurred. Such a regulation would practically destroy the pound-net fishery, however, for our measurements show that relatively few fish exceeding that length are taken in the Pamlico Sound pound nets. It is not likely, therefore, that limits upon the size of mesh employed in pound nets would ever be an effective means of protecting the gray-trout fishery from depletion.

It is fairly well established that certain areas in Pamlico Sound are nurseries for the younger fish. Our records indicate that fishes taken on the northwest side of the sound are not only smaller representatives of the year groups but are composed of the younger classes, the older fish being notably lacking. Thus, Hyde and Dare Counties, including the pound-net areas of Stumpy Point, Englehard, Gull Rock, and Pamlico River, may be designated as nursery grounds and closed to commercial fishing. The presence of uniformly larger fish, most of which are in spawning condition, from May until July may be noted in the vicinity of Ocracoke Inlet, and the same conditions probably obtain at Hatteras as well. Protection may be afforded to the spawning stock by prohibiting pound-net fishing in these areas, but such regulations could hardly be considered desirable when the interests of the fishing populations are considered. Since pound netting is the chief industry of the people in these districts, the prohibiting of this form of fishing would work extreme hardship. Unless more satisfactory methods of protection can not be devised, such oppressive measures should be avoided.

The most promising method of protecting the species is that of imposing closed seasons. The most destructive period of fishing throughout the sound area is in the early months of the summer, when, as has been shown, a maximum wastage of gray trout of 78 per cent and 55 per cent, respectively, in June and July occurs in certain districts. This tremendous waste of potentially valuable fish could be overcome by imposing a closed season on all pound-net fishing in Pamlico Sound from the end of the shad season, in May, to the 1st of August. In this way the abundant supply of 2-year-old trout would be permitted to grow to marketable size. Our records also show that spawning is at its height during this same period, and the 3-year-old fish, as well as those still older, would be protected until after the year's crop of eggs had been laid. Such a regulation should apply to the whole sound area, for while relatively few of the smaller fish are destroyed near the inlets, the protection to the spawning fish is equally desirable, and while few spawning fish are taken on the northwest side of the sound, the reckless destruction of the immature should be prevented.[16]

Not only would this closed season tend to build up the fishery by increasing the stock of spawning fish and by insuring the depositing of spawn unmolested, but the increase in weight of the marketable fish thus protected would largely offset the economic loss resulting from inactivity of the fishermen during the closed season. We have no means of calculating accurately the gross amount of undersized trout caught and wasted in Pamlico Sound during the months of June and July. We do know, however, that it is a very great amount. Based on figures of the yield of fishermen at Gull Rock, given in Table 1, the weight of fish destroyed may be estimated at approximately 200,000 pounds. There is no evidence that these young fish leave the sounds during the season, so that if they were permitted to escape capture and to grow until August, September, and October, and if we assume that one-third of these young fish were caught in each of these months, they would weigh, when caught, approximately 331,000 pounds. Based upon this crude estimate, these fish, if permitted to remain in the water until the latter part of the season, would add to the income of the fishermen in this district more than $10,000.

This restriction would afford the same protection to the small fish of other species that are wasted during this period, such as butterfish, croaker, and spot, and would permit the spawning of starfish and butterfish, which spawn at the same time of year as the gray trout. The regulation would be easy to enforce, is favored by the fishermen themselves in preference to the alternate remedy of an increased mesh, and is opposed only by those who are opposed to any regulations whatever.

The arguments opposed to this plan of regulation are based upon selfish motives of personal gain. It may be argued that the imposition of the closed season during June and July would result in the loss of markets by the wholesale dealers of this region. The pound-net fisheries of Virginia produce virtually the same class of fish as those taken in Pamlico Sound. It is said that if pound-net fish are not available during June and July Virginia dealers will supply the trade and thus capture the regular customers. While such contentions must be given careful consideration, the argument loses force when we remember that great quantities of trout, spot, butterfish, and starfish are produced in the lower Chesapeake Bay during

[16] Following the presentation of this report on Dec. 8, 1925, the North Carolina Fishery Commission Board adopted a rule establishing the closed season from May to Aug. 1, in accordance with the plan herein recommended. Because of the dissatisfaction of certain interests, the board rescinded the rule at the April meeting, and provision was made for a public hearing on the question of pound-net regulation at the next regular meeting. On Aug. 16, 1926, before about 100 fishermen and dealers, the outstanding results of the investigation were again presented and the board passed a rule establishing a closed season ending June 1. Since the pound-net fishing for summer fish seldom starts before May 20, the gray trout thus receive only 10 days' protection!

April and May, when Pamlico Sound fish are not produced, and it is not apparent why this trade is not already captured by the Virginia dealers during these months. Moreover, it is said that conditions in the pound-net fishery of Chesapeake Bay closely parallel those in Pamlico Sound, and if this be true it can only be a matter of time until the facts will be ascertained and similar remedies applied.

RECOMMENDATIONS

We have seen that the supply of fish in North Carolina does not equal the demand, that wasteful practices exist in the pound-net fishery, and that the establishment of a closed season for all pound-net fishing in the sound during the months of June and July would correct these wasteful practices and tend to increase the fish supply.

With the facts discovered and impartially published, it now remains for the people of North Carolina to decide, through the agency of the Fisheries Commission Board, how long they shall permit such wasteful and destructive exploitation of the public resources to continue. The importance of sales in June and July for the benefit of the few must be balanced against the importance of maintaining the fisheries for all time for the benefit of all.

We therefore recommend that such closed season be established to meet the demand of the fishermen to "put more fish in the sounds."

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PREPARATION OF FISH FOR CANNING AS SARDINES[1]

By Harry R. Beard
Chief Technologist, United States Bureau of Fisheries

[1] Appendix III to the Report of the U. S. Commissioner of Fisheries for 1927. B. F. Doc. 1020. Technological Contribution No. 34.

INTRODUCTION

The sardine industry dates back to about 1845, when the first sardine canneries were established in France.[2] Since then sardine canning has developed on a large scale in Spain, Portugal, Norway, and the United States, and to a small extent in England, Canada, Chile, India, Sweden, and Algeria.[3] The following quotation gives an idea of the relative importance of production in the different countries:[4]

> For the decade 1904 to 1913 the average annual world pack is estimated at approximately 175,000,000 pounds. Of this amount the United States produced about 34 per cent, Spain 26 per cent, Norway 17 per cent, France and Portugal each 11.5 per cent. Production in other countries is negligible.

Sardine canning is an important part of the fishery industry of the United States. In 1926 over 3,800,000 cases were packed, having a value in excess of $14,500,000 (Table 1). These figures place this industry next to that of salmon canning in importance and, excluding Alaska salmon, first among the canned fishery products of the United States. This industry, too, can be expanded greatly, not only in the United States but throughout the world, there being large quantities of herring, pilchards, and like fishes suitable for canning as sardines from which to draw. In time this expansion undoubtedly will take place, largely as an economic necessity, to help meet the increasing world demand for cheap food of high protein content. Certain packs of sardines, as will be pointed out later, do meet this need.

American canned sardines, however, encounter very keen competition, and if we are to capture and hold our share of the world markets our products must be high in quality as well as low in price. The Bureau of Fisheries took cognizance of these facts and since 1920 has been conducting research upon the preparation of fish for canning as sardines, making available fundamental scientific information heretofore lacking upon this important subject and working toward the development of better and cheaper methods of preparing the fish. This document is a report of the investigations made in this field.

These investigations were for the most part carried out in the bureau's experimental laboratory at San Pedro, Calif., and in neigh-

[2] Much confusion exists concerning the term "sardine." Various clupeoid fishes throughout the world are called sardines, as well as the canned products prepared from these fish. In the United States the California pilchard and the Atlantic sea herring are used by sardine canners; in Norway the brisling, or sprat, and the sea herring; and in France, Spain, and Portugal the European pilchard and also the sprat. In certain foreign countries the term "sardine" has been restricted to canned European pilchards. However, the general concept of the term "sardine" refers to a kind of fish commonly known as a pilchard, and to all the individuals living in nature that are similar in structure, appearance, and habit and are generally recognized as a single kind. Specialists have noted differences in the members of this group from different areas, and these have been the basis for dividing the groups into species, subspecies, and races, without general agreement as to which of the true classes the individuals from different geographical areas belong. Geographically, they are found on the Atlantic coast of Europe, in the Mediterranean, and on the Pacific coasts of North and South America, Japan, Australia, New Zealand, and South Africa. They all belong to a homogeneous group similar in structure, growth, and habits but quite different from other members of the herring family. It is believed, therefore, that for the uses of commerce and for all practical purposes the term "sardine" can not with propriety be restricted to members of this group from a single geographical area. The United States Bureau of Chemistry holds that the term can be applied to any small clupeoid fish, providing the name "sardine" is accompanied by the name of the country or State in which the fish are taken or prepared and with a statement of the nature of the ingredients used in preserving or flavoring the fish. Differences in quality of the several species of herring canned as sardines in the several countries, if subjected to equally excellent treatment and uniformity of method in packing, are largely matters of individual taste and preference.

[3] A summarized history of sardine canning in different countries, including the United States, is given in the following document: Tariff Information Survey on Sardines. Published by the U. S. Tariff Commission, Washington, 1925.

[4] Page 17 of the paper referred to in footnote 3.

boring sardine canneries during the four canning seasons beginning in 1920. Methods in Maine were studied in 1922 and 1923, and in 1924 experiments were made in Eastport. Assistance from without the bureau aided very materially in carrying on this research. During a lapse in congressional support the California Fish and Game Commission met the total expense of the investigation upon changes in oil used for frying sardines and later contributed some toward the study of methods of preparing the fish. The cooperation furnished by the sardine canners was especially helpful. A large part of the experimental work was carried out in their plants. In this respect the Seacoast Canning Co. (now the Seacoast Packing Corporation) and the Van Camp Sea Food Co., both of East San Pedro, Calif., and the Blanchard Manufacturing & Canning Co., of Eastport, Me., were most helpful.

COMMERCIAL METHODS OF PREPARING THE FISH

Inasmuch as this paper deals with research directed toward improving methods of preparing fish for canning as sardines, an outline is given here of the important methods that have been and are now being used for this purpose. Since the methods of the California industry have never been described in detail, they will be described here. Some experimental data are included and discussed in this section in order to avoid having to repeat parts of the description in a later section.

CALIFORNIA METHODS

Sardines were first canned in California in 1890.[5] Extensive development, however, did not take place until the World War period. The first big year was 1917, when the pack increased to over 1,190,000 cases from the previous high mark of 166,000 cases in 1916. The pack remained at this high level for four years. In 1921, however, post-war deflation had a disastrous effect on the industry, as shown in Table 1. Since then lost ground has been regained steadily, and in 1926 the industry's largest pack was prepared.

TABLE 1.—*Sardine pack of the United States, 1921–1926*

Year	Maine		California	
	Cases [1]	Value	Cases [2]	Value
1921	1,399,507	$3,900,910	398,668	$2,346,446
1922	1,869,719	5,750,109	715,364	3,361,480
1923	1,272,277	5,288,865	1,100,162	4,607,931
1924	1,899,925	7,191,026	1,367,139	5,445,573
1925	1,870,786	6,716,701	1,714,913	6,380,617
1926	1,717,537	6,727,388	2,003,278	7,807,404

[1] Converted to standard basis of one hundred ¼-pound cans per case.
[2] Converted to standard basis of forty-eight 1-pound oval cans per case.

Sardine canning is confined to three localities, namely, Monterey, San Pedro and immediate vicinity, and San Diego. An idea of the relative importance of these districts and of the general composition

[5] For a good history of the industry see: "Historical Review of the California Sardine Industry." By Will F. Thompson. California Fish and Game, vol. 7, pp. 195–206. Sacramento, 1921.

of the packs can be obtained from Table 2. Statistics for the Maine pack are given for purposes of comparison.[6]

TABLE 2.—*Sardine pack of the United States, 1926*

Product	Maine (herring)[1]		Product	California (pilchards)				
				Monterey district	San Pedro district	San Diego district	Total	
	Cases	*Value*		*Cases*	*Cases*	*Cases*	*Cases*	*Value*
In olive oil, quarters (100 cans).	57,674	$394,474	½-pound oval (48 cans).[2]	29,841	-------	2,725	32,566	$101,693
In cottonseed oil, quarters (100 cans).	1,282,967	5,042,572	1-pound oval (48 cans):					
In mustard:			In tomato sauce	1,056,301	809,038	49,941	1,915,280	6,992,473
Quarters (100 cans).	117,517	537,382	In mustard	70,222	32,302	5,103	107,027	402,193
			Soused	1,929	3,285	244	5,458	19,417
Three-quarters (48 cans).	163,595	629,821	In other sauces	16,125	1,406	------	17,531	65,991
			¼-pound square (100 cans).[3]	2,835	-------	13,988	16,823	136,441
In other sauces, quarters (100 cans).[2]	23,802	123,139						
			½-pound square (100 cans).[4]	490	15,982	4,966	21,444	89,226
Total	1,645,555	6,727,388	Total	1,177,749	862,013	76,967	2,116,729	7,807,404
Total (standard cases).[5]	1,717,537	---------	Total (standard cases).[5]	---------	-------	------	2,093,278	---------

[1] Includes 1 small factory in Massachusetts.
[2] Largely in tomato sauce.
[3] Largely in olive oil.
[4] Includes the pack of 6-ounce round cans, 100 to the case; also a few cases of No. 10 cans, 6 to the case. Both packs have been converted to the basis of ½-pound cans, 100 to the case.
[5] Represents the various-sized cases changed to the uniform basis of one hundred ¼-pound cans to the case for Maine herring and forty-eight 1-pound oval cans to the case for California pilchards.

The canning season in Monterey usually begins in July or August and runs into February or March. In San Pedro canning usually begins in November and continues well into March. The canning season in San Diego for large fish roughly corresponds to that for San Pedro. The canning of small fish, however, is continued throughout the spring. In general, the canning of large fish starts as soon as the fish begin to get fat and ends when they get to be lean.

The fish used for sardine canning is a pilchard (*Sardina cærulea*). It is a true sardine, in the sense understood by scientists, and is very similar to the pilchards canned in Europe.[7]

PRODUCTS

Ordinarily 90 per cent or more of the sardines prepared in California are of the so-called "pound-oval" pack. A can of this product usually contains 4 to 10 large-sized pilchards, packed with spiced tomato sauce in a flat oval can containing normally 15 ounces, of which approximately 1½ ounces are sauce.

Small fish are canned in San Diego. They are usually put up with olive oil in regular key-opening "quarter-oil" and "half-oil" cans, holding 3½ and 7 ounces, respectively. At times as many as 25 and as few as 4 fish are packed in a quarter-oil can, about 8 to 12

[6] The survey referred to in footnote 3, p. 68, gives extensive statistical comparisons of the various branches of the world sardine industry.
[7] The fish used throughout the world for sardine canning are listed in the following article: "The sardine of California," by Will F. Thompson. California Fish and Game, vol. 7, pp. 193-194. Sacramento, 1921.

being the usual number. The half-oil product is prepared from larger fish.

Other products are put out in small quantities. Half-pound oval cans are used at times for smaller fish. Other sauces placed in the can include (in addition to tomato sauce) mustard, souse (vinegar and spices), and soy for the orientals. Fancy packs are prepared by making fillets of sardines and by smoking to add the delicate flavor obtained in that manner.

The California industry is quite different from any other important sardine industry in the following respects: The pack consists for the most part of large fish in tomato sauce rather than small fish in oil. The can used is oval in shape and holds about 1 pound of contents. Canning practically has been secondary in importance to the manufacture of fish meal and oil from whole fish and cannery offal. The State law never has required the canners to pack all the fish they have taken. The liberal excess that has been allowed has been taken advantage of for the manufacture of these products. Inasmuch as there is more profit in the manufacture of fish meal and oil than in sardine canning, every effort has been made to expand this branch of the industry. To do this it has been necessary, in order to comply with the State law, to can more fish. To get rid of this canned fish the price has had to be lowered—low enough, in fact, to stimulate a large foreign demand, especially in the Orient, for pound-oval sardines. In some places this product has supplanted the cheaper grades of canned salmon; in fact, in 1925, for the first time, exports of canned sardines exceeded canned-salmon exports.

Whatever advantages or disadvantages the policy discussed above may have in the long run, it has brought about large-scale production and wide distribution of California pound-oval sardines. Adjustments are bound to come in the future, which will have their effect on the industry. In time pound-oval sardines must sell at a price that is based on their own cost of production. Production of fish meal and oil can not continue to dominate canning. Table 3, taken from the twenty-ninth biennial report of the California Fish and Game Commission, summarizes the use to which pilchards are put in California.

TABLE 3.—*California cannery, fish-flour, and edible-oil plant production, season June 1, 1925, to May 31, 1926*

District	Cases 1-pound oval cans per ton	Tons fish received	Tons fish used for canning	Tons fish used for meal and flour	Tons offal	Cases 1-pound ovals packed
Monterey	15.6	69,011	48,587	19,832	16,193	937,014
San Pedro	16.3	61,992	49,192	12,800	16,643	968,495
San Diego	16	5,214	3,940	1,274	1,312	66,074
Northern California	16	248	104	54	65	3,892
Total, all districts	15.9	136,465	101,913	33,060	34,213	1,975,475
Deduct fish used for other purposes		8,247	Add other sizes, 1-pound ovals			65,382
Fish used by canning plants		128,218	Equal to total cases, 1-pound ovals			2,040,857

TABLE 3.—*California cannery, fish-flour, and edible-oil plant production, season June 1, 1925, to May 31, 1926*—Continued

District	Cases other sizes packed	Other sizes equivalent to cases of 1-pound ovals	Meal, tons	Ratio per ton, meal	Oil, gallons	Gallons oil per ton of offal and fish	Tons of fish used for other purposes
Monterey	37,220	35,956	[1] 6,393	5.7	1,110,983	30.8	[2] 6,248
San Pedro	16,492	16,361	5,962	6	658,817	22.4	[3] 1,729
San Diego	16,373	13,065	467	5.5	43,995	17	[4] 270
Northern California			20	5.5	2,629	24.1	
Total, all districts	70,085	65,382	12,842	5.3	1,816,424	26.6	8,247

[1] 262 tons fish flour produced, not included in meal production.
[2] 592 tons used for salting purposes, 4,468 tons used for manufacturing fish flour, 1,188 tons used for manufacturing edible oil.
[3] 1,729 tons used for manufacturing edible oil.
[4] 270 tons used for manufacturing edible oil.

For the past few years California pound-oval sardines have sold at the factory for about $3.50 to $4 per case of 48 cans. At this price, which little more than covers production costs, it is evident why this product is finding a good market. In the United States, for instance, individual cans sell for 10 to 20 (usually about 15) cents. It is difficult to get more food value for the money. For this price one gets about 1 pound of high quality protein and oil ready for immediate consumption and in a form that keeps in any climate until used. In many places throughout the world there is a big demand for such a product as California pound-oval sardines. If the price can be kept low the demand is sure to increase. Although the market for pound-oval sardines in tomato sauce has not been large in the United States, this product has, to a large degree, supplanted similar imported articles. It should be possible, however, to increase the demand considerably if the likes and dislikes of American consumers were studied and if the product were properly advertised.

FOOD VALUE

Canned sardines, like other fish, both fresh and preserved, are excellent food, being especially rich in good quality protein and fat. Although no oil is added to the can with the sauce, pound-oval sardines generally contain about as much fat as the average run of sardines that have been packed in oil. Since representative analyses of pound-oval sardines have not been published, several are given in Table 4.[8]

[8] For extensive data on the composition of quarter-oil sardines see: "The Maine Sardine Industry." By F. C. Weber, H. W. Houghton, and J. B. Wilson. U. S. Department of Agriculture Bulletin No. 908, 126 pp. Washington, 1921.
Similar data for European sardines are given in the following paper: "Methods of fish canning in England." By J. Johnstone. Fishery Investigations: Series I—Freshwater Fisheries and Miscellaneous, Vol. II, No. 1, 25 pp. London, 1921.

TABLE 4.—*Several analyses showing the composition of California pound-oval sardines*

Sample	Composition, by weight (in grams)				Chemical composition (in per cent of total)				
	Total contents of can	Meat	Sauce	Oil	Moisture	Protein	Fat	Ash	Undetermined
Raw fish (portion used for canning) [1]					59.97	17.63	20.66	1.87	
Canned in "souse" sauce [2]	468	390	60	18	59.00	20.38	15.33	3.22	2.07
Canned in tomato sauce [2]	472	379	75	18	61.25	20.75	13.08	3.74	1.18
Do.[2]	470	371	79	20	62.30	23.10	9.79	3.24	1.57
Canned in mustard sauce [2]	502	412	77	13	62.00	24.29	8.19	3.51	2.01
Canned in tomato sauce [2]	482	403	67	12	61.70	24.01	8.93	3.81	1.55

[1] From "A Comparative Study of the Chemical Composition of the Sardine (*Sardina cærulea*), from California and British Columbia." By D. B. Dill. Ecology, vol. 7 (1926), pp. 221–228. Brooklyn.

[2] Analyses made by the Nutrition Department, University of California, for one of the California canners.

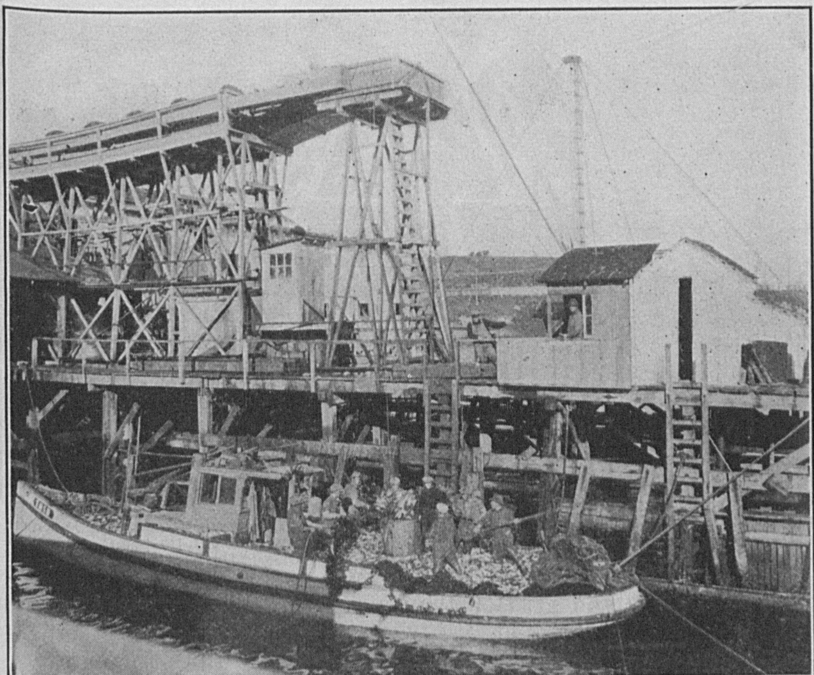

FIG. 1.—Unloading pilchards at California sardine cannery

PREPARATION OF FISH BY THE FRYING-IN-OIL METHOD

Sardines are canned in modern packing establishments situated on the water front close to the fishing grounds. The size of the plants varies greatly. Some are able to handle only a few tons of sardines a day, while others can easily care for 150 tons in the same period of time. Most plants make extensive use of mechanical equipment.

The methods described here are representative of those generally used in California in the preparation and canning of fried pound-oval sardines. These methods, therefore, will be given in detail, followed by a few general statements concerning the preparation of the fish by other processes. In this connection it is to be kept in mind that the methods given here are subject to considerable variation in the many canneries. These differences, however, are only different means of attaining the same end.

Description of a process is generally made clearer if it is treated according to the steps into which it naturally divides itself. This plan is used here.

Receiving.[9]—The fish are shoveled from the boats into a mechanical hoist,[10] which raises them to an elevated platform, where they are

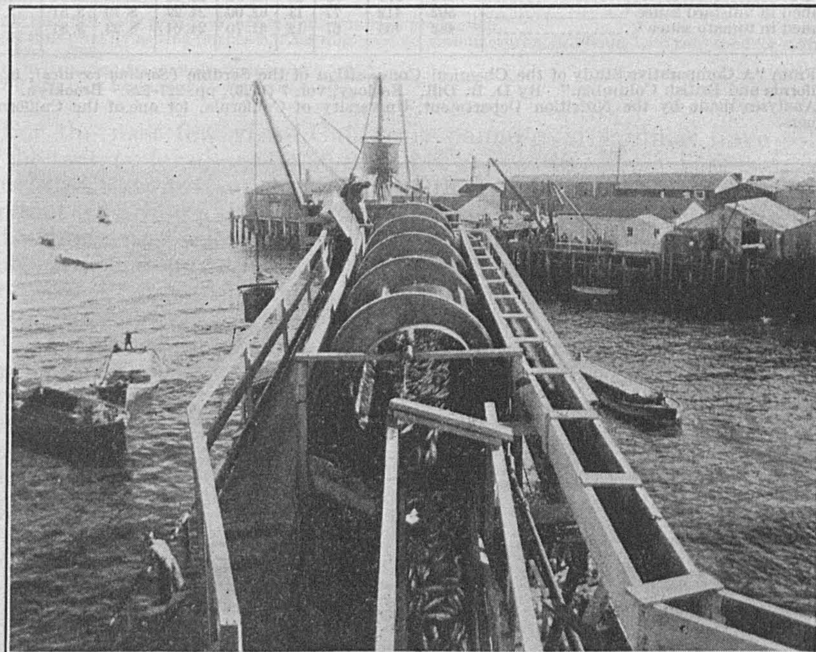

FIG. 2.—Scaling. The fish are passing through a revolving drum, covered with coarse wire screen. They are also being washed. The fish are next flumed to holding tanks in the plant. This view also shows the fish market wharf in Monterey and Monterey Bay in the background

weighed. Water and gravity then carry the fish from the weighing vat into the cannery proper.

Scaling.—The first operation in preparing sardines for canning is to scale them. This is accomplished by passing them through a large cylinder of heavy screening, which is rotated in a tilted position. Most of the scales are removed by the rubbing of the fish against each other and against the screen wall of the cylinder. Water is sprayed on the fish at the same time to help remove the scales and to wash the fish. The sardines next go to supply tanks,

[9] For a good description of fishing methods and gear see "Methods of Sardine Fishing in Southern California." By Elmer Higgins and Harlan B. Holmes. California Fish and Game, vol. 7, pp. 219–237. Sacramento, 1921. Also "Purse Seines for California Sardines." By W. L. Scofield. *Ibid*, vol. 12 (1926), pp. 16–19.

[10] For a description of an improved method of removing the fish see "Speeding the discharge of bulk fish." Anon. Fishing Gazette, review number, 1926, pp. 55–56. New York.

which discharge upon the cutting tables. In some plants the fish are scaled again after being cut.

Cutting.—Cutting is done largely by hand. In San Pedro all this work is done by Japanese women. Some plants have recently started to use machines that are fed by hand.[11]

The cutting operation by hand is carried out as follows: The fish is held, belly down, on the cutting board. One cut with a sharp knife is made almost through the body, well back from the head. A sidewise motion with the knife then tears the head portion from the fish, pulls out the entrails, and forces all refuse through a hole in the table. At the same time the other hand drops the "cut" fish into a bucket. The cutters do all this so rapidly that one can hardly

FIG. 3. Hand cutting. The fish from the holding tanks are flumed to tables as needed

see what they really are doing. The refuse from this operation goes to the by-products plant, where the oil is removed and the residue made into fish meal.

Brining.—In California large pilchards for the pound-oval pack are usually brined 60 to 90 minutes in 85 to 100 per cent saturated solutions of common salt (NaCl). Small fish for the quarter-oil pack are kept from 10 to 30 minutes in 40 to 80 per cent saturated brine. Each canner has his own preferences, and in the end each accomplishes more or less the same result. In general, the stronger the solution, and also the smaller the fish, the shorter the time needed for them to take up a given amount of salt. The real purpose of brining is to salt the fish. This step at times is omitted when the fish are canned in a watery sauce such as tomato, mustard, or vine-

[11] Machines are described in U. S. Patents No. 1544986, July 7, 1925, and No. 1599807, Sept. 14, 1926.

gar. The sauce, if made salty enough, will in time impart its flavor to the fish. Oil does not do this. Brining removes some water from the fish and tends to make the flesh firmer and skins tougher, due both to extraction of water and to the coagulating effect salt has on proteins. Soluble proteins, especially blood, are removed to some extent, causing a loss of valuable food material. Removal of blood, however, tends to whiten the flesh, and this is considered desirable. Brining probably has some preserving effect that helps toward keeping the fish in good condition until they are cooked.

Some data on the loss in weight brought about by brining are shown in Table 5. The loss in weight for large-oval size fish in 100

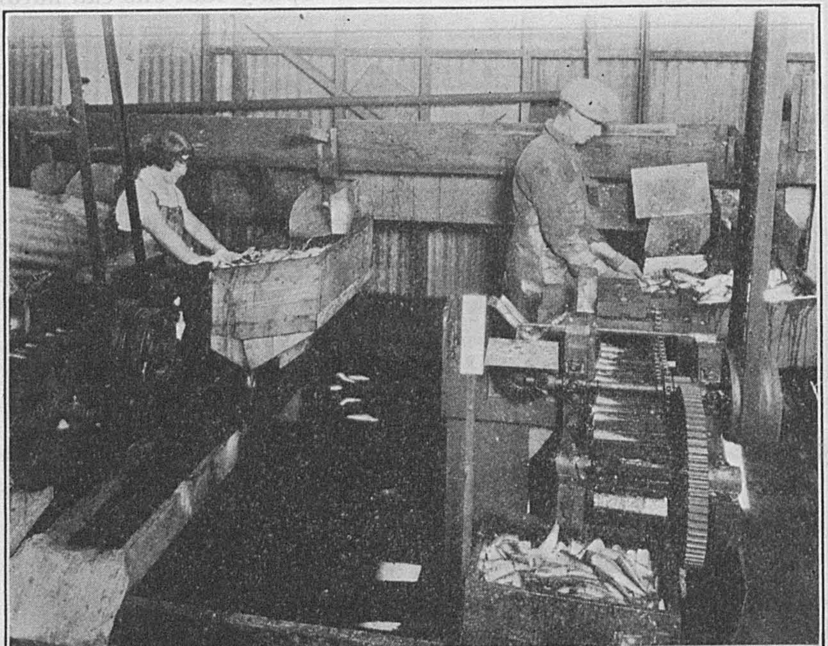

FIG. 4.—Machine cutting

per cent saturated brine ran from 1.46 per cent for 90 minutes to 2.94 per cent for 240 minutes immersion. Most of this loss unquestionably was water. Weber (see footnote, p. 72) made an extensive study of brining and salting Maine herring. California pilchards undoubtedly behave in a very similar manner.

TABLE 5.—*Loss in weight in California pilchards, due to brining (100 per cent saturated salt solution at 64.4° F.)*

Time (minutes)	Original weight of sample (grams) [1]	Per cent loss in weight	Time (minutes)	Original weight of sample (grams) [1]	Per cent loss in weight
90	989. 6	1. 46	135	938. 8	1. 95
105	928. 3	1. 47	150	964. 3	1. 97
120	989. 5	1. 95	240	964. 3	2. 94

[1] Eight large pound-oval pilchards used in each case (large excess brine used), fish blotted with dry towel each time before being weighed.

Drying.—Experience has shown that some form of drying is necessary before the fish are placed in hot oil. Originally drying was done in the sun and wind, but now artificial driers are used. Those used in the California industry, although they vary greatly in size and design, are all tunnel driers, so named because a long, narrow room or tunnel is used to confine the air that is forced or drawn through it. This air first passes over steam coils, then comes in contact with the fish spread loosely over wire flakes or belts. Some of these drying chambers are as large as 3 feet wide, 8 to 10 feet high, and 50 to 75 feet long, and handle as much as 6 tons of "cut" fish per hour.

The fish usually are handled on endless wire belts. One carries them to the top of the drier and drops them upon another, which

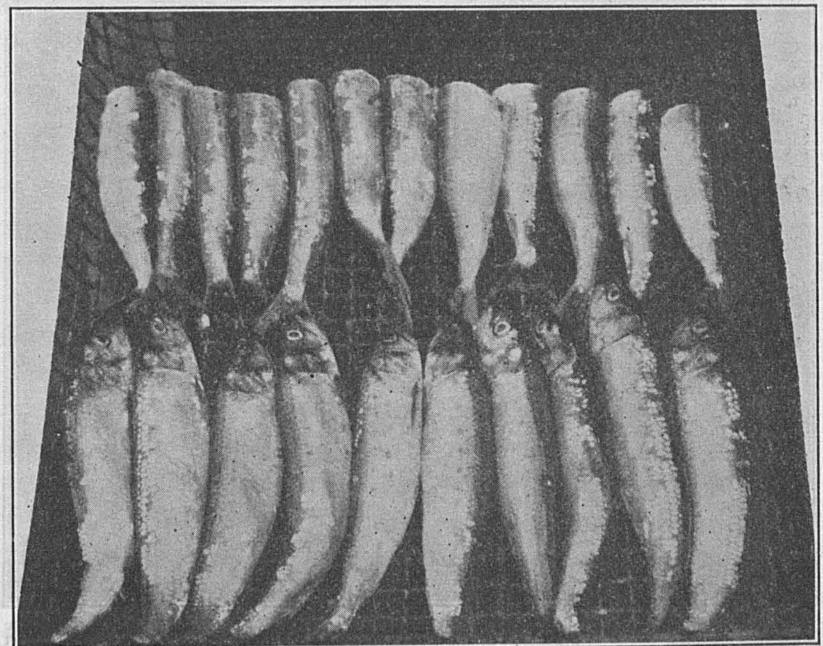

FIG. 5.—California pilchards before and after being "cut"

carriers them through it. They then fall on a belt traveling in the opposite direction. A set of such belts, placed one below the other, repeats this operation several times before the fish leave the drier (see fig. 8). In some driers but one long belt is used and in others tiers of flakes containing the fish are wheeled on trucks through the chamber. This latter type of drier is used for fish that have been steamed and that can not be tumbled about in the same way as raw fish.

The time of drying is controlled by changing the speed of the belts or the rate of putting in and taking out trucks. Temperature is the other factor under control. This is regulated by changing the amount or pressure of the steam in the heating coils. Ordinarily the fish are dried about 30 to 60 minutes in air having a temperature of

90 to 120° [12] and a velocity of 500 to 1,500 feet per minute, losing about 3 to 6 per cent in weight in the process.

The warm air moving about the fish removes the water and toughens the skins so that they will not break when placed in hot oil or when handled during packing. Although probably it is necessary for some water to be removed from the fish, the actual amount is of secondary importance. The drying conditions and the amount of water removed vary so greatly among canneries that it is evident that these factors are secondary to skin toughening.[13]

Frying in oil.—This step consists of submerging the dried fish (held in flat wire baskets) in a vat of cottonseed or other oil kept at a temperature of 220 to 260° (usually about 230°) for 7 to 15 minutes

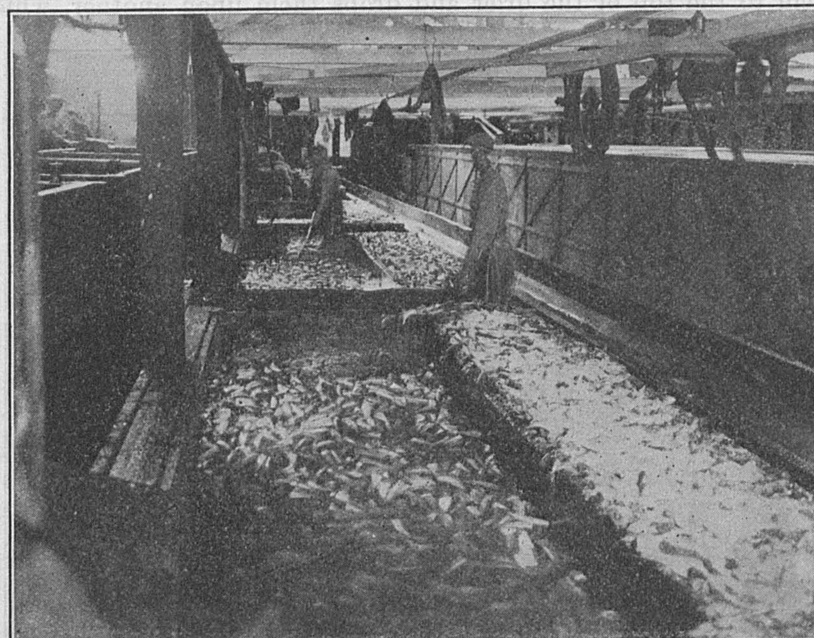

FIG. 6.—Brining the fish. On the left are shown the tanks in which the "cut" fish are placed. Part of the dryer is shown on the right

for large pound-oval and 3 to 10 minutes for quarter-oil fish. Frying usually is considered complete when the backbone can be pulled out easily and shows no redness. Considerable water is cooked from the fish. Much of this is vaporized, but some settles and mixes with the water under the steam coils, carrying with it soluble extractives from the fish. The heat also renders some oil from the fish, which mixes with the cooking oil.

The following figures show the losses in weight that took place in one cannery that prepared small oval-sized fish for canning. The calculations were made on the weight (371 ounces) of "cut," brined fish used for the experiment:

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[12] All temperatures are given in °F.

[13] This and other matters discussed in this paragraph are considered in detail, pp. 116 and 117. Table 9, p. 125, gives details on drying conditions in several plants.

Drying 55 minutes, average air temperature 100°, and velocity about 500 feet per minute, 6.5 per cent.

Frying 9 minutes, average oil temperature about 230°, plus 9 minutes draining, 7 per cent.

Draining, 18 hours, 7.1 per cent.

The total loss was 20.6 per cent. This is larger than usual. For large ovals the loss in various canneries probably will run around 12 to 18 per cent. In the two experimental runs on frying oil, described in the first part of this document, a total of 3,711 pounds of oval-sized sardines were cooked in oil 8 minutes at 230° and drained 8 minutes over the frying vat. The average loss in weight during frying was 7.7 per cent.

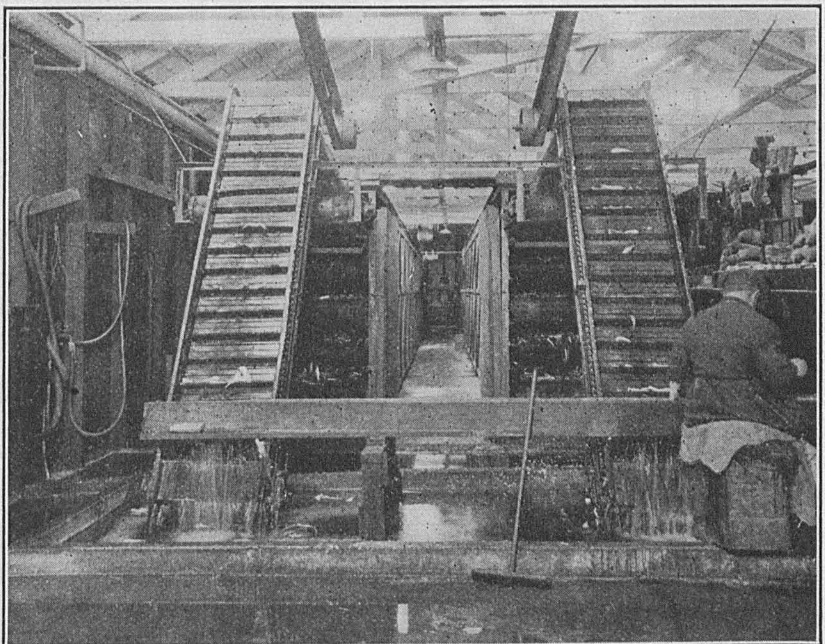


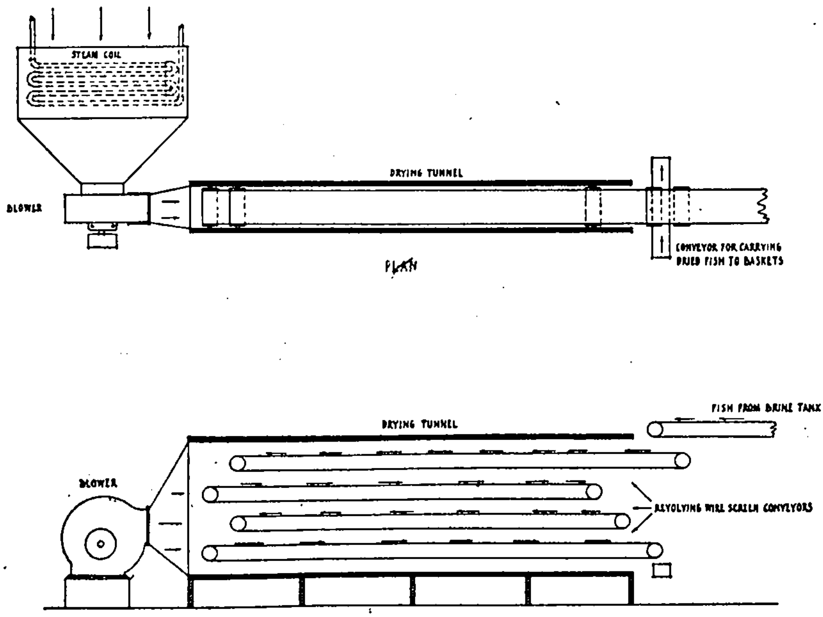
FIG. 7.—Drying. Fish from the brine tanks are flumed to the conveyors shown in the foreground. See Figure 8 for detailed plan of operation

Cooking the fish destroys autolytic enzymes and partially sterilizes the fish, so that under ordinary conditions they keep in excellent shape one or two days, and even longer, while waiting to be packed.

A cross-sectional sketch of a typical fry bath is shown in Figure 10. The baskets of fish are drawn through the oil by an endless-chain conveyer, or they are lifted in and out of the oil by hand. The oil is heated by means of steam coils placed in the lower part of the oil just below the place where the baskets travel. Underneath the coils (yet not touching them) is water, on which the oil floats. This water is placed there to take care of particles and body juices coming from the fish, as they, being heavier than oil, sink. The control of temperature is accomplished by regulating the steam supply. The speed at which the conveyer is run determines the time the fish remain in the oil.

At the start of a run the bath is filled with sufficient fresh cottonseed oil to cover the fish. Frying is continued in this same oil, sometimes for weeks, with such additions and subtractions as become necessary, until, in the judgment of the operator, the oil is no longer fit for use. It is then thrown away or sold as a low-grade oil. Judgment on the stopping point is quite varied; the operator is influenced at times by the saving effected by prolonging the use of the oil. Usually, after a day of frying is completed, the oil is separated from the water and placed in tanks and the fry bath is cleaned. Daily (or at less frequent intervals) the oil is given some sort of cleansing treatment in some canneries.

Draining.—The baskets of hot fish coming from the cooking vat are stacked, several deep, on a truck and set aside to cool and drain



LONGITUDINAL SECTION

FIG. 8.—Diagram of a typical California sardine dryer

until they are to be packed (usually next day). Stacked in this manner they cool but slowly, and this facilitates draining. Much liquid runs from the fish; some of this is oil but most of it is water containing dissolved proteins. The losses of valuable extractives here and in frying are considerable. Upon standing, the fish become firm and the skins are further toughened. The oil covering the fish tends to dry (in the sense that linseed oil dries), and this makes the skins tough and rubbery. This oxidation of the oil, however, detracts from its palatability.

Packing.—After sufficient cooling the baskets of sardines are placed on the packing table, where women discard the broken fish and pack the others into cans. These cans come through a chute from a different part of the plant to the packing tables. The filled cans are then placed on a belt conveyer, which carries them in a steady stream under a mechanical sauce distributer, which adds the correct amount of tomato sauce to each can. In some plants sauce is added to the cans before the fish are packed into them.

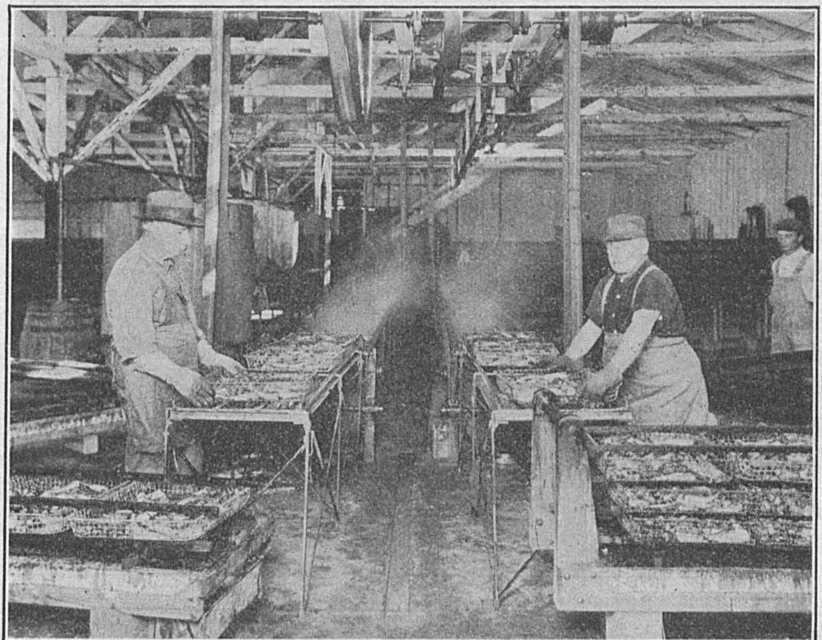


FIG. 9.—Frying in oil. Fish from the dryer fall into baskets placed in the oil, and are conveyed mechanically through the vat. See Figure 10 for plan of operation

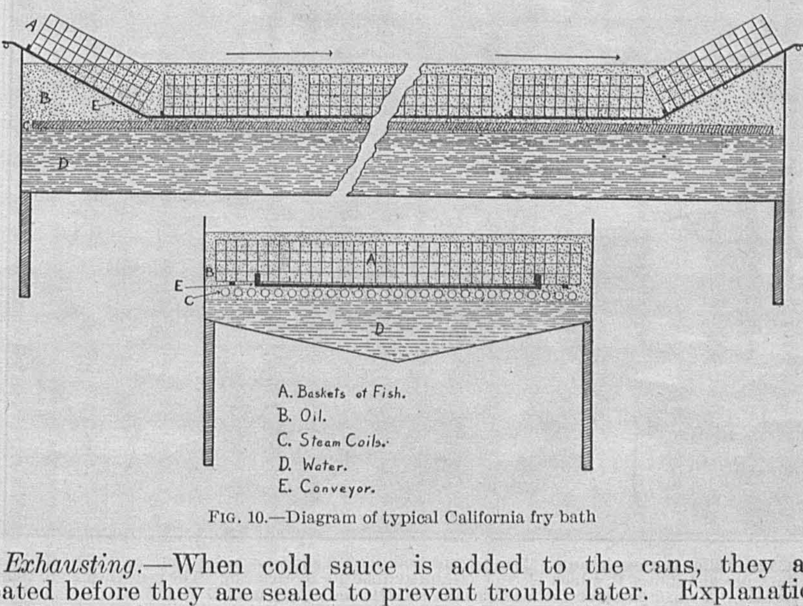


FIG. 10.—Diagram of typical California fry bath

Exhausting.—When cold sauce is added to the cans, they are heated before they are sealed to prevent trouble later. Explanation of this is easily given. Cans sealed cold on a cold day contain cold

FIG. 11.—Cooling and draining. Large fish usually stand overnight for this purpose. Note containers at ends of trucks for catching oil and water draining from the fish

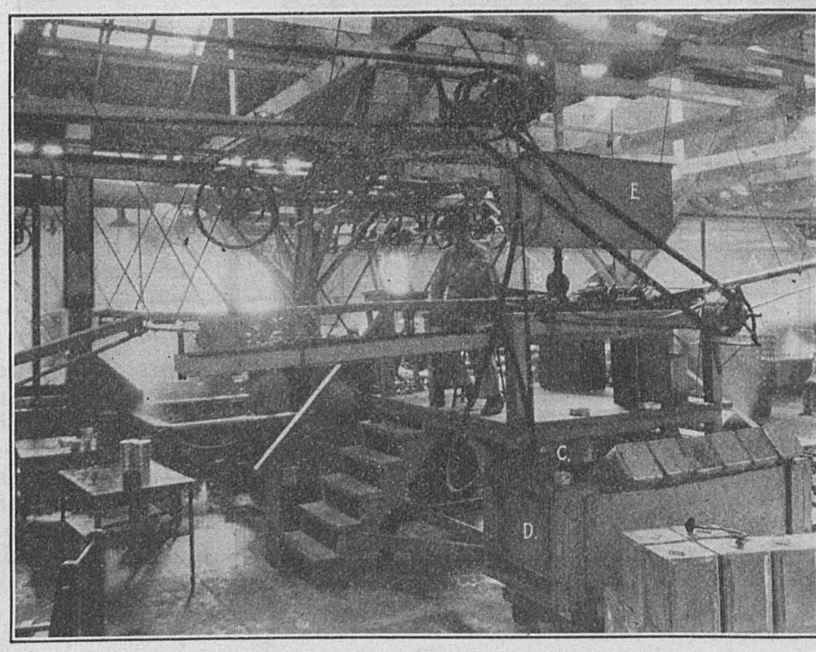


FIG. 12.—Filling cans with sauce. Empty cans from the loft slide down the chute A, passing under the sauce distributor B, which places a measured quantity in each can. The cans then go to the packers. A small pump on the tank elevates sauce to the supply tank E

Fig. 13.—Packing. Men empty baskets of fish on the tables as needed. Cans with sauce in them are obtained from the upper conveyor A, and when filled are weighed and then placed on the lower conveyor B, which carried them to the sealing machines. C is the exhaust box shown in Figure 14

Fig. 14.—Exhausting the cans. The filled cans from the packing tables pass through the machines B, which lightly crimp lids on them. The cans next enter the exhaust box C at D. E is a stock of filled cans ready for exhausting

air, and later, when a hot day comes, the air expands and the cans swell. Before sealing, the cans and contents should be heated to drive out some of the air, for, if sealed hot, a partial vacuum will exist in the cans when they cool. Addition of hot sauce, followed by immediate sealing, is one way of warming the cans and contents. Another method, more widely used, is to exhaust the filled cans by heating them with "live" steam for about five minutes. This heating usually is accomplished by conveying the cans through a narrow chamber, into which the steam is turned.

Sealing.—The cans are conveyed from the steamer (exhaust box) to an automatic sealing machine, which places a cover on the can and then seals it on. The can carries a flange, which fits into a groove in the lid, having an extended edge bent downward. In

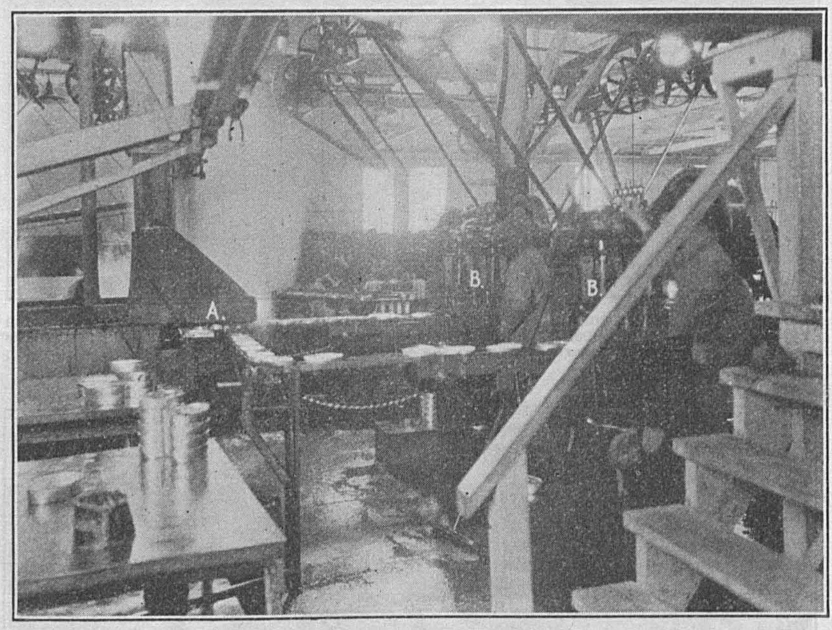


FIG. 15.—Sealing the cans. Exhausted cans are leaving the exhaust box at A and are passing through the sealing machines B

sealing, the flange of the can and edge of the lid are interlocked so as to form a double seam. The groove in the lid carries a very thin layer of rubber compound, which serves as a gasket between the seams. In some plants the can is sealed in two operations—one machine just crimps the cover to the can and another seals the can after it comes out of the exhaust box.

Processing.—Sterilization of the contents of the cans is necessary to insure their keeping qualities; in addition, more cooking is required to soften the bones. Proper heat treatment accomplishes both of these steps at one time.

Trucks containing cans from the sealing machines are wheeled into large steel retorts, where the cans are heated with steam under pressure. Various temperatures are used in this step. Usually, however, a temperature of 240° for one and one-half hours is deemed sufficient. When the steam is turned off, the pressure inside the retort is maintained by compressed air until the cans have been partially cooled by water. This procedure prevents the cans from bulging, due to greater pressure inside than outside the can.

The cans are then washed in a cleaning solution and allowed to dry. In some factories the cans are next sent through a machine that lacquers them to prevent rusting. They are then placed in temporary storage for a few days, after which they are labeled, either by hand or machine, and boxed.

Quarter-oil pack.—Small fish are prepared for the quarter-oil pack in the same general manner as large fish, except the frying time is

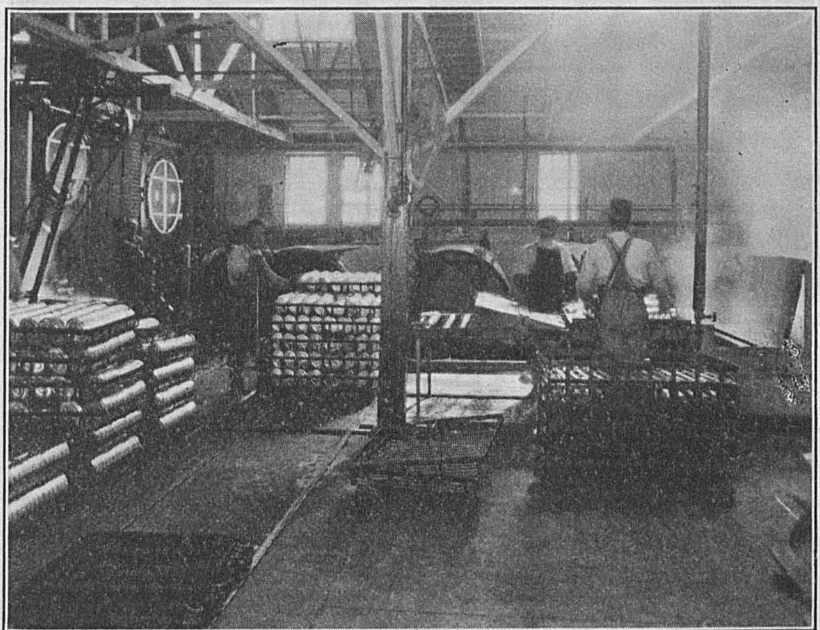


FIG. 16.—Processing. The sealed cans are placed in baskets and stacked on trucks, as shown. This facilitates handling them in and out of the retorts. This view also shows sterilized cans from the retorts being placed in a hot soap solution for washing

shortened slightly. Quarter-pound cans are usually processed about three hours at 212 to 214° and half-pound cans three and one-half hours at the same temperatures. Higher temperatures and shorter times also are used.

PREPARATION OF FISH BY WAYS OTHER THAN FRYING IN OIL

Instead of being cooked in hot oil, some fish are prepared by being cooked in steam or in hot brine. In the past some fish also have been packed raw.[14]

Steaming.—Large-oval sized fish are cleaned, brined, and dried as for frying in oil. They are then spread on wire flakes. Since the

[14] A section of this document (pp. 103 to 116) is given over to the consideration of these methods as substitutes for frying in oil.

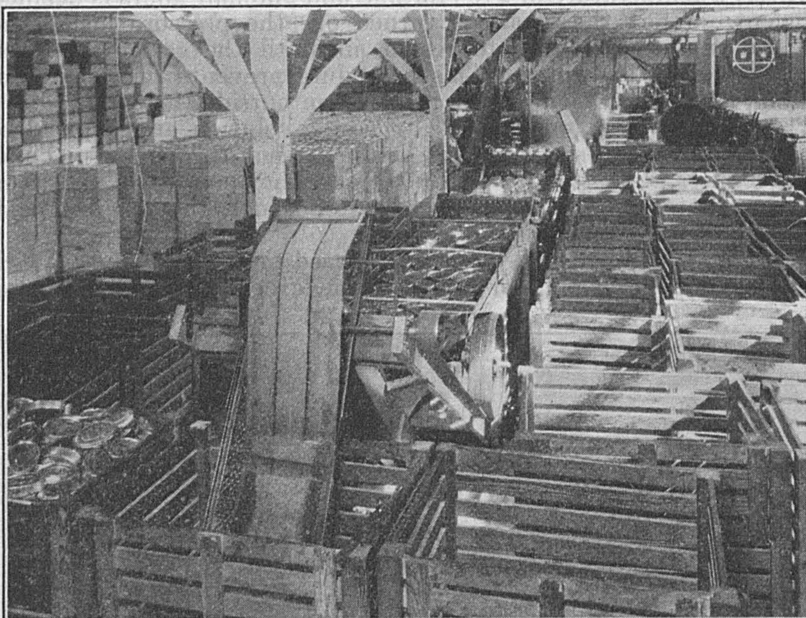


FIG. 17.—Lacquering the cans. As soon as the hot cans from the washer are dry, they are passed through a machine that covers them with a thin layer of lacquer to prevent rusting. The lacquered cans are placed in large crates for cooling

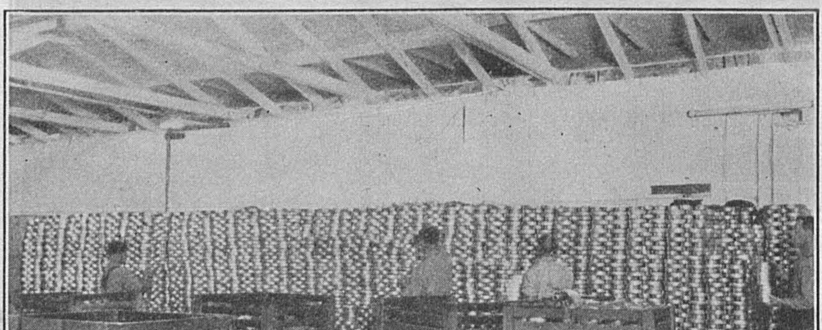


FIG. 18.—Testing and storing. When the cans are cool they are stored in stacks. After several days' storage defective cans are detected easily, when the cans are again handled

FIG. 19.—Labeling the cans

FIG. 20.—Boxing

cooked fish tend to stick together, they are placed so as not to touch each other. The flakes are next placed on a truck and wheeled into a retort or steam chest and cooked with steam under slight pressure for 15 to 30 minutes. They are then removed and allowed to stand and cool, after which they are packed.

At times the dried fish are packed raw into cans, which are inverted on wire flakes and steamed.

Brine cooking.—This process is the same as frying in oil, except that the fish are cooked in hot brine and not brined before being dried. A saturated solution of common salt boils at 227°. This gives a cooking temperature close to that ordinarily used for frying in oil.

Raw-packing.—In this process the fish are brined, or brined and dried, then packed raw into the cans with sauce, exhausted, sealed, and processed. Results have been so unsatisfactory, commercially, that few fish now canned are prepared in this way.

MAINE METHODS

Only an outline is given here of the methods that have been and are now being used in Maine. There are a number of papers[15] that give a history of the industry and describe the methods used in the past. Present methods are described in detail by Weber (see footnote, p. 72).

The fish used is the sea herring (*Clupea harengus*). The supply for canning for the most part comes from weirs on the coasts of Canada and Maine. The fish are transported to the canneries in water-tight tanks or wells aboard the fishing boats. When placed in tanks at the weirs the fish are mixed with salt or brine, the amount being varied according to the size of the fish and the time it will take for the boat to reach the cannery. Ordinarily about 200 to 500 pounds of salt to a hogshead (about 1,200 pounds) of fish is used. This salt brines the fish and also aids in keeping them in good condition. At the factory the fish are weighed or measured and flumed to storage tanks, where they may or may not be brined further.

From the tanks the fish are flumed to a conveyer, which carries them to a mechanical flaking machine. This machine spreads the fish quite evenly upon wire flakes. The flakes are placed in trucks and run into a steam chest, into which steam at a pressure of 80 to 100 pounds is turned for 8 to 15 minutes. The chests are not tight but are so constructed as to permit considerable escape of steam. The trucks of fish then go to a large drying room, where they are subjected to the action of warm air. Time, temperature, and air velocity vary greatly in different factories. Usually the time is about 60 minutes. The temperature ordinarily used is about 100° to 120°, and the velocity about 300 to 1,000 feet per minute. After drying, the trucks stand until cool. The flakes of fish are then given to the packers.

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[15] "The Sardine Industry." By R. Edward Earll. The Fisheries and Fishery Industries of the United States, Sec. V, Vol. I (1887), pp. 489–524. Washington. "The American Sardine Industry in 1886." By R. Edward Earll and Hugh M. Smith. Bulletin, U. S. Fish Commission, Vol. VII, 1887 (1889), pp. 161–192. Washington. "The Herring Industry of the Passamaquoddy Region, Maine." By Ansley Hall. Report, U. S. Commissioner of Fish and Fisheries, 1896 (1898), pp. 475–479. Washington. "The Preservation of Fishery Products for Food." By Charles H. Stevenson. Bulletin, U. S. Fish Commission, Vol. XVIII, 1898 (1899), pp. 335–563 [sardines, pp. 526–537]. Washington. "The Packing of American Sardines." By H. H. Hansen. Original communications, Eighth International Congress of Applied Chemistry, vol. 18, pp. 131–138. Washington, 1912.

The packers now remove the heads from the fish with shears or pinch them off as they pack. The packed cans are placed on flat trays and cottonseed oil is added to them, a tray at a time, by an oiling machine. At times mustard sauce is added to the cans instead of oil. They then pass through the sealing machine.

In most plants quarter-oil cans are processed in boiling water for one and one-half to two hours. Steam retorts are coming into use. After processing the cans are cleansed by shoveling them about in sawdust or by washing them with a cleaning solution.

Most of the pack consists of quarter-oils. Large quantities of the so-called "three-quarters" mustard pack are prepared. The preparation of this pack is virtually identical with that for quarter-oils. In fact, the larger fish seldom are separated from the smaller ones, all being prepared together. The larger fish are then packed in three-quarters cans (contents 10 ounces) with mustard sauce. These cans are processed about two hours in boiling water.

The process just described is the one used for "standard" goods. Fancy packs usually are fried in oil, as already described under "California methods." These packs often are put in olive oil. Some fish are smoked also before being canned.

Years ago the fish were cooked in Ferris-wheel type ovens over coke fires. Crackers still are cooked in this kind of oven. This and other equipment, employing similar cooking conditions, have not proved satisfactory. The natural draft of the furnace did not create enough velocity to get rapid heat transfer from the air to the fish or to put enough heat in the cooking chamber to prepare the fish quickly unless high air temperatures were used. Such temperatures, besides scorching the fish and oxidizing the oil, caused excessive loss of oil and sticking of the fish to the wire flakes.

FOREIGN METHODS

In France, Spain, and Portugal sardines[16] are prepared by the frying-in-oil process.[17] This process was first developed by the French and is now widely used in California and to some extent in Maine. Details of the process are described under "California methods," pages 73 to 85.

A translation of the description given by Gruvel[18] of the Norwegian process for preparing quarter-oil sardines follows:

> Immediately after arriving at the cannery the small sprat, or brisling, are placed in 20° brine for about a quarter of an hour. When this is completed, from 20 to 30 of the fish are placed at one time upon a metal rod. A machine is used for this purpose. The fish are placed head foremost into cavities in a wooden frame. A lid is then lowered, which holds the fish in place, while a heavy wire is threaded through a hole in the frame, catching all the fish a little below the eye. Thirty such rods are prepared and placed in a wooden frame where they are retained by lateral notches. These 30 rods contain around 600 fish. The frames are placed one above another in a smoke oven. In order to get an even smoking, the frames are moved from the lower part of the oven, near the burning sawdust, to higher places, and eventually removed from the top. New frames take their places and are so moved from the bottom to the top. An oak fire is used, burning sufficiently for three things to be accomplished:

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[16] Immature European pilchards (*Sardina pilchardus pilchardus* and *Sardina pilchardus sardina*) are used.

[17] The following paper gives an excellent description of French methods: "The French Sardine Industry." By Hugh M. Smith. Bulletin, U.S. Fish Commission, Vol. XXI, 1901 (1902), pp. 1-26, 8 pls. Washington.

[18] "En Norwège l'Industrie des Pêches." By A. Gruvel. Office Scientifique et Technique des Pêches Maritimes. Notes et Mémoires, No. 16, p. 60. Paris, 1922.

First, the drying of the fish; second, a slight cooking; and third, a slightly accentuated smoking. The duration of this operation is from 45 to 60 minutes.

When smoking is completed, each frame is placed horizontally in a special apparatus, where a hand-operated triangular knife advances and cuts the heads off the fish, which drop on a moving curtain running to the packing tables. The heads are removed from the wires and are used for making meal and oil.

The methods used in other countries are similar to those already described.

AMERICAN DIFFICULTIES

GENERAL CONSIDERATIONS

Information as to how to prepare high-quality sardines has not been lacking. There are but few canners who do not know how to prepare such products. What is needed is information that will permit high-quality sardines to be packed cheaply.

Maine and California sardines for the most part have been prepared to fill the big demand that exists in the United States and elsewhere for cheap sardines. Buyers generally have been more interested in price than in quality, provided quality was passably fair. This buying practice has led to ruinous competition, in which quality frequently has suffered in the race to meet prices. These conditions have been more acute in Maine than in California, where to some extent canners have been able to rely on by-products for profits that they have sacrificed on canned fish.

The serious effects of this ruinous competition upon the canners and the markets for their products are being realized and definite steps are now being taken to correct matters.

American canners undoubtedly will continue to prepare sardines largely for the low-price field. Quality, however, will have to be considered more important than it has been in the past. Research, therefore, should be carried out with the view of furnishing information that will be helpful in producing better sardines at low cost. This idea was constantly kept in mind in planning and carrying out the research reported upon in this document. A disheartening factor faces anyone who plans to carry out research for the sardine-canning industry. It may be possible to produce helpful information only to find that it is not used to improve quality but rather to lower prices still further. If quality is overlooked and competition for quantity production at the lowest cost continues as strong as it has in the past, this will happen.

TECHNOLOGICAL CONSIDERATIONS

The production of good-quality sardines depends upon a few well-defined factors: (1) the quality of the fish themselves, including their condition, handling, and cleaning; (2) the preparation of the fish for canning; (3) the materials placed in the can with the fish; (4) the canning procedure itself; and (5) the chemical and physical changes that take place within the can during processing and later storage.

It was decided at the start of the investigation that the field covered by (2)—the preparation of the fish for canning—offered the greatest opportunities for research. The publication by Weber (see footnote, p. 72) on the Maine sardine industry was the only report of scientific work along this line that had been published.[19] It appeared evident that once the principles underlying this step were known it would be possible to make improvements in existing processes and to develop new and better ones. Research, therefore, was confined to this field.

The most important difficulties of a technological nature that faced the California industry when the investigation started were connected with frying in oil. An excellent product can be prepared in this way. The process, however, has some rather serious disadvantages. It is time-consuming and costly to carry out properly—so costly, in fact, that American canners generally have been unable to carry it out as it should be done. It was because of these facts that the Maine canners turned to other ways of preparing the fish, finally ending with the steaming process, which serves their needs better than the frying, although it is also unsatisfactory in some ways. The greatest trouble with the frying process has been with the oil used for cooking the fish. This problem, because of its importance, was the first to be studied. It is discussed in detail in the next section. The difficulties encountered in the steaming process are discussed in another section.

It will be helpful to consider very briefly what is known about the other factors mentioned, upon which the production of good-quality sardines depends, and to point out where there is most need for research.

1. *The fish themselves, including their condition, handling, and cleaning.*—It is generally realized that the quality of the final pack can be no better than the raw materials from which it is prepared. The condition of many kinds of fish varies considerably throughout the year. A number of studies have been made that give information upon these variations in some of the fish used for sardine canning.[20]

Much that will help keep the fish in good condition from the time they are caught until cooked undoubtedly can be learned through research. Weber (see footnote, p. 72) did some work along this line.[21]

Although machines are now used for cutting the fish, there is need of much study in this field to bring about further improvements.

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[19] The following papers have been published by the writer on this subject since the investigation was begun. "Changes in oil used for frying sardines." Fish and Game Commission of California, Circular No. 1, 8 pp. Sacramento, 1922. Also, Fishing Gazette, vol. 39, No. 11, pp. 32–34, 63, and 65. New York, 1922. "Some considerations concerning the canning of sardines." Transactions, American Fisheries Society, 53d Annual Meeting, 1923, pp. 122–150. Hartford. "Drying of fish for canning as sardines." Pacific Fisherman, vol. 22, No. 10, pp. 9–10. Seattle, 1924. "New method of preparing sardines." Pacific Fisherman, vol. 23, No. 3, pp. 12–14. Seattle, 1925. "Methods of preparing sardines." Canning Age, vol. 7, pp. 979–987, New York, 1926. "A new process is perfected for canning sardines." Ibid., vol. 8, pp. 413–420 and 423. 1927.

[20] "The food value of the herring." By T. Milroy. Twenty-fourth annual report for 1905 (1906), Fishery Board for Scotland, pt. 3, pp. 83–107; twenty-fifth annual report for 1906, pt. 3, pp. 197–208. Glasgow, 1907. "Den Franske Industris kamp mot de Norske sardiner." By Johan Hjort. Aarsberetning vedkommende Norges Fiskerier for 1912; 4 de Hefte, pp. 445–560. Bergen, 1913. "Seasonal variations in the chemical composition of herrings, etc." By James Johnstone. Reports, Lancashire Sea-Fisheries Laboratory, for 1914 (1915), pp. 154–181; 1917 (1918), pp. 13–59; 1918 (1919), pp. 36–63; and 1919 (1920), pp. 16–23. "The fat content of Irish Sea herring." By James Johnstone. Transactions, Liverpool Biological Society, vol. 29, pp. 216–223. Liverpool, 1915. Paper by Johnstone. See footnote 8, p. 72. "A chemical study of the California sardine (*Sardinia cærulea*)." By D. B. Dill. Journal of Biological Chemistry, vol. 48, No. 1, pp. 93–103. Baltimore, 1921. Paper by Dill. See note, Table 4, p. 73.

[21] Although research was not carried out in this field during the course of the investigation reported upon in this document, attention should be called here to a procedure that probably will prevent much of the deterioration that takes place in the fish from the time they are caught until used.

Small Maine herring, especially when their intestines contain much food (usually the so-called "red feed"), deteriorate rapidly, causing much waste of valuable fish. Small pilchards behave quite similarly in California. In fact, large fish also deteriorate quite rapidly in both places, although not so quickly as the small ones.

Weber showed that Maine herring, salted and carried in a layer 2½ feet deep in the hold of the boat, heated considerably in being carried to the cannery. One lot of fish, half of which it was estimated contained red feed, rose in temperature from 51° to 74.3° in 3 hours. Another lot, 90 per cent of which contained feed, rose from 51° to 99.5° in 10½ hours. During the experiment the air temperature did not rise

2. This has already been discussed.

3. *The material is placed in the can with the fish.*—Oil, sauce, and other flavoring ingredients, including those added by smoking, have considerable influence on the quality of the final pack. The use of oil is well understood. It seems probable, however, that a study of sauces from the standpoint of their blending qualities and how well the public likes the various kinds will yield information that might aid materially in popularizing large fish canned in sauces in the United States.

4. *The canning procedure itself.*—The various steps (packing, exhausting, sealing, and processing), have been quite well worked out. Considerable information on these subjects has been published. Although little of it refers directly to fish canning, much of it can be applied to this field. There is need for bacteriological studies to show how to sterilize canned sardines more effectively. Some papers have been published on this subject [22] and others will follow when certain work now in progress by two or three agencies is completed.

5. *The chemical and physical changes that take place within the can during processing and later storage.*—Were more known concerning these changes in canned fishery products and the factors causing them it might be possible, in a measure, to control them so as to enhance the quality of the products.[23]

EXPERIMENTAL PART

The experimental work reported upon in this paper and its application are of greatest interest and value to those actively engaged in the sardine-canning industry and to those who contemplate entering upon such work. Since but few of these people are technically trained, an endeavor has been made to present the material in the main part of the document in such a way as to be understandable to all. Most of the experimental data and technical discussions thereof,

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above 68°. It is evident that the temperature of the outside air was not sufficient to account for the changes in temperature that occurred in the fish. The water temperature undoubtedly was about 51°, since it must have been approximately the same as the temperature of the fish when they were removed from it.

Weber says in regard to these experiments: "The rise in temperature of masses of fish in bulk is caused by decomposition changes due to bacterial growth, by far the greater part of which takes place in the viscera and contents. As the temperature of the mass of fish rises and approaches the optimum temperature favorable to bacterial growth, it is evident why the decomposition of feedy fish proceeds at times so rapidly."

His recommendations for improving matters follow: "Where practicable it would be desirable to install some method of refrigeration on all boats used to haul the fish long distances. Boats thus equipped not only greatly extend the fishing radius, but also bring the fish to the canneries in a condition far superior to that of fish carried in salt. The decomposition due to 'heating,' which was found to occur in large masses of fish during transportation, can be retarded by shipping them in small bulk at low temperature. Small compartments, permitting the circulation of cold air, are necessary in boats equipped with refrigeration devices."

In my opinion the way to get the necessary cooling effect is to use sea water. All the cooling that is necessary probably can be obtained at any time of the year from sea water off the coast of eastern Maine. At the time Weber carried out his experiments the sea water was about 51°. Had a small amount of fresh sea water been sprayed continuously over the fish and been pumped off at the bottom of the hold their temperature probably could have been kept close to that of the water and spoilage greatly retarded. Two small rotary pumps driven by the power plant in the boat and a small amount of piping and carpentry work is all the equipment needed.

The bureau expects to carry out experiments along this line in the near future. What evidence is now available indicates that they will be successful. Sardine canners in Monterey preserve "cut" fish by circulating cold sea water over them. (See p. 151.) Menhaden steamers now successfully preserve their catch by circulating refrigerated sea water over them. (See "Refrigeration as applied to the menhaden industry." By Robert S. Taylor. Annual review number of the Fishing Gazette, January, 1926. New York.) Use of naturally cold or refrigerated sea water should be helpful in preserving fresh fish wherever they have to be kept for prolonged periods, especially when massed in large bulk.

[22] "The bacteriology of swelled canned sardines." By W. Sadler. American Journal of Public Health, vol. 8, pp. 216–220. Chicago, 1918. "A bacteriological study of sardines." By Maud M. Obst. Journal of Infectious Diseases, vol. 24, pp. 158–169. Chicago, 1919.

[23] Maturation in canned fish is discussed by Weber and by Johnstone. (See footnote, p. 72.)

which must, of course, be included, have been placed in the Appendix for ready reference by the few who will also want to consider them.

GENERAL SUMMARY

Following is a summary of the experimental work reported upon in this document and of the results obtained:

1. The nature of the change in composition and properties of oil used for frying sardines was determined.
2. These changes are largely due to the presence of varying quantities of fish oil and to the action of air and heat upon the oil in the cooking vat.
3. Fry-bath oil gets into the final pack, lowering quality, especially when the oil has seen much use.
4. Ways are shown to diminish frying costs and the bad effects from frying in oil.
5. Attempts to reclaim used fry-bath oil by mechanical and chemical treatment were unsuccessful. It is improbable that a satisfactory cheap method will be developed.
6. Although further improvement in the frying procedure probably can be made, certain difficulties will continue to be troublesome. For this reason attention was turned to the study of substitute methods of preparing the fish instead of continuing work on frying in oil.
7. The following substitute methods were studied and procedures developed and compared with frying in oil: (*a*) Brine cooking, (*b*) steaming, and (*c*) raw packing.
8. Packs prepared by the various processes withstood extended storing and shipping tests about equally well.
9. All the processes produced excellent packs of pound-oval sardines. When the advantages and disadvantages of each were compared it did not seem as though any of them could supplant frying in oil, unless it be the raw-packing process, and this possibility depends upon shortening the time needed for drying the fish.
10. Study of the behavior of the fish under different drying conditions showed, however, that the drying time can not be shortened materially in this process.
11. In other respects excellent results were obtained from the drying study. It showed how fish may be dried for cooking in oil or by some other method in much less time and consequently with less equipment than had been done.
12. The drying data obtained now enables drying procedures and equipment to be planned on a scientific basis.
13. A new process for quickly preparing both large and small fish was devised, using rapidly moving hot air to simultaneously dry, cook, and, if desired, smoke the fish. The cooked fish can be cooled quickly in a blast of cold air and packed immediately afterwards.
14. The new process obviates the difficulties incident to frying in oil and produces as good (in most cases better) packs of California and Maine sardines as any other process and at less cost.
15. Details regarding equipment and operating conditions are given, with recommendations.

CHANGES IN OIL USED FOR FRYING SARDINES

INTRODUCTION

In the first section of this document a description is given (pp. 73 to 85) of the method employed in preparing sardines in California by the frying-in-oil process. Further information will be found on pages 103 and 104. At the time this investigation was started (1920) virtually all California sardines were being prepared in this way. This procedure also was followed to some extent in Maine. Conditions have changed little since then.

Continued use of the oil for frying sardines causes it to gradually become dark in color and viscous. Eventually the oil becomes almost black when viewed even through relatively thin layers, and when cold almost as viscous as molasses. It also acquires a disagreeable odor and flavor, both of which are characteristic. Although these changes take place gradually, they become quite pronounced within a few days.

When such oil is used for frying, it has a bad effect on the cooked fish. A quantity of this oil necessarily adheres to them and is carried out of the vat. Part of the oil drains away while the fish cool, waiting to be packed, yet some remains and gets into the cans; except when the cooking oil has seen little use, this is undesirable. It would be too expensive, however, to put a new batch of oil into the vat, so frying is continued. Where ordinary precautions are observed in handling the oil it is improbable that it ever gets insanitary, but conditions do become undesirable and at times very much so.

Undoubtedly frying-in-oil difficulties were the most important ones of a technological nature met by the California industry. They were of considerable industrial significance because of the large quantity of oil used for this purpose. In 1920 over 50,000,000 pounds of sardines were fried in California.

PREVIOUS WORK BEARING ON THE PROBLEM

As far as it has been possible to determine, no results of any investigation on the frying of sardines has yet been published, other than a summary (see footnote, p. 91) of this particular study. Weber (footnote, p. 72) mentions corn oil as having been used some years ago in Maine for frying sardines. The oil gave off a disagreeable odor and foamed badly when used. At that time, however, commercial corn oil was not as highly refined as it is to-day. Several articles were found giving some data on oils used for frying purposes. Morgan and Cozens[24] give a good summary of these articles.

The literature on vegetable, animal, and fish oils is voluminous. It is quite well summarized in many places, however. Lewkowitsch[25] gives the best summary. A series of articles by Hepburn[26] furnishes a good discussion of the changes that take place in oil. Since, in the present report, cognizance must be taken of the natural changes that take place in the oils, these are briefly described below:

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[24] "Changes in physical and chemical constants of fats used in frying a standard dough." By Agnes F. Morgan and Ella R. Cozens. Journal of Home Economics, vol. 11, pp. 394-402. Baltimore, 1919.

[25] "Chemical technology and analysis of oils, fats, and waxes." By J. I. Lewkowitsch and G. H. Warburton. 6th edition. Vol. I. London, 1921.

[26] "A critical study of the natural changes occurring in fats and oils." By J. S. Hepburn. Journal, Franklin Institute, vol. 168 (1909), pp. 365-384 and 431-456; vol. 169 (1910), pp. 22-54. Philadelphia.

Organisms (bacteria, molds, and yeasts) act upon oils and give rise to changes in their composition, the main change being an increase in acidity. The enzyme lipase occurs in the seeds of many plants and in some animals. It acts on oils (in the presence of moisture), splitting them into free fatty acids and glycerin.

On exposure to air oils are oxidized, giving rise to a number of changes. The most important one is the development of a rancid taste and odor. Some oils thicken and eventually become solid; this takes place in air and is called drying. Sardine oil exhibits this phenomenon.

Light and heat produce polymerization of the fats (visually indicated by thickening of the oil). They accelerate the action of moisture on oils, giving rise to increased acidity. Oxidation changes are similarly accelerated.

Rancidity in oils may be looked upon as being due to the formation of free fatty acids by enzymes in the presence of water and the subsequent action of oxygen and light on the free fatty acids. Fats and oils kept fully protected from light, air, and moisture will keep indefinitely in their original condition.

Sardine canners have used methods of one nature or another in an endeavor to improve their oil during use. These efforts usually have been of a mechanical nature—washing with water and filter pressing or centrifuging. At times fuller's earth and other similar substances have been used on the oil. It is safe to say that none of these methods (although all are helpful) have been very successful. Chemical methods of recovering used oil have been tried but they have been found to be expensive and unsatisfactory.

Discussion with canners elicited many conflicting suggestions as to the nature and causes of the changes that take place in frying oil. It was generally believed, however, that more or less fish oil gets into the cottonseed oil and causes trouble.

This lack of knowledge made it clear that in studying the problem it would first be necessary to determine the exact nature of the changes that take place in the oil and the factors that contribute thereto. With such information at hand, the problem would resolve itself into a study of means to eliminate the objectionable factors, if possible, or to devise a better method of accomplishing the same end. This was the path followed.

EXPERIMENTS

FRYING

Two runs of frying tests were carried out in order to obtain accurate information concerning the changes that take place in oil used for frying sardines. Each run consisted of tests on two lots of oil.

The equipment used in these tests consisted of two small vats, or fry baths, as they are usually called, 14¾ by 10½ by 9¾ inches, inside dimensions, with steam coils midway of their depth.

Procedure and data, first run.—Large, fat, California pilchards were prepared for frying by being scaled, headed, and eviscerated, then dried for 60 minutes in air having a velocity of about 500 feet per minute and a temperature around 100°. Most of the fish were brined 45 minutes in an 85 per cent saturated salt solution before being dried. Accurate account was kept of the weight of fish before and after frying. Individual lots of fish were cooked 8 minutes in oil having a temperature close to 230° and were allowed to drain over the bath 8 minutes before being removed and weighed.

Enough water was added to each bath, so that it came almost to the bottom of the steam coil. At the beginning of the experiment an excess of oil was used; later, however, just enough oil was floated on the water to a little more than cover the basket of fish immersed in it.

In order to identify the two lots of oil, the baths are referred to as bath I and bath II. The oil in bath I was not treated, except that it was separated from the water and "foots"[27] after a day of frying. Most of the oil in the "foots" was recovered by placing them in a

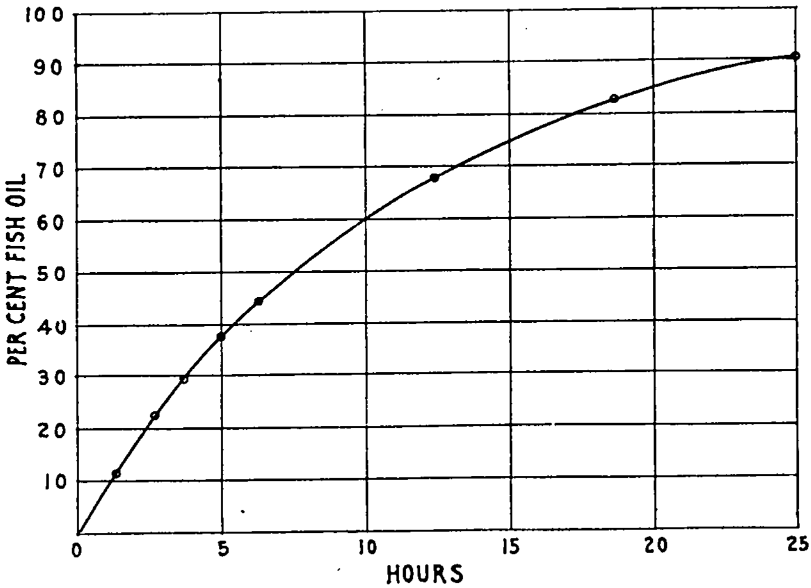

FIG. 21.—Increase in fish-oil content of oil used for frying fat fish. Data obtained from Table 20, p. 166

bottle and heating for an hour or so in boiling water. The clear oil hat formed was then floated off and added to the other oil.

In bath II the oil was separated similarly, then returned to the bath with enough clean water to cover the steam coil. In this manner the water was boiled by the steam, and this caused the oil and water to form an emulsion. In order to break the emulsion, water was run out until the steam coil was in the emulsion. Steam was then turned on and this caused the emulsion to "break." Further heating drove the remaining water out of the oil.

Fifty cubic-centimeter samples of oil were taken from each bath after a batch of fish had been fried. From bath II an extra sample frequently was taken after the oil had been cleansed. These samples were placed in corked bottles and later examined and analyzed. Equal quantities of the same batch of cottonseed oil were placed in

[27] The layer of oil and water emulsion that forms between the oil and water.

each bath. The two lots of oil were treated in a similar manner, except for the cleansing given the oil in bath II.

The run was stopped long before the oils had reached a condition where they could no longer be used, because sufficient data and samples for practical purposes had been collected. It was also apparent that any figure that might have been obtained concerning the maximum quantity of sardines that could be fried per gallon of oil used would depend on so many varying factors that it would have only very limited application. In this run 226 pounds of large, fat sardines in the "round" were fried per gallon of cottonseed oil used. Out of a period of 28 days frying was carried on 14 days. The actual time of frying, however, covered approximately 53 hours.[28]

Procedure and data, second run.—This experiment was carried out to gain information as to the practicability of using oils other than cottonseed for frying pound-oval sardines. Olive oil at times had been used for frying fancy quarter-oil sardines, apparently with good results, but its cost would be prohibitive for frying pound-oval sardines. Weber (footnote, p. 72) mentions that corn oil was used years ago in Maine with poor results. The quality of this oil has been much improved since then, so that better results undoubtedly would be obtained. Should it have advantages, a suitable grade for frying purposes could be obtained at a price nearly equal to that of cottonseed oil.

The use of a hydrogenated oil, such as Crisco or similar products, seemed practicable, provided it could be purchased cheaply enough. A fat of this nature does not oxidize as rapidly as cottonseed oil.

In this run corn oil (Mazola) and Crisco were used. The procedure followed was the same for both lots as that followed in the first run for bath I. Frying was continued until the daily oil losses became marked, due to the cooking of lean fish.

In this run 510 pounds of prepared sardines per gallon of oil were fried in each bath. Actual frying time was 46 hours, carried out during a period of 36 days.[29]

CHANGES IN QUANTITY AND COMPOSITION

Data kept on the change in the quantity of oil in the two runs of frying tests show that the oil content remained approximately constant for days at a time when large, fat fish were being fried. For a short period, when the fish were very fat, the oil content increased. Late in the season the sardines became very lean and the oil losses then became very marked.

Cooked fish when removed from the bath carry considerable oil with them, which is mechanically held on the surface, under the skin, in the body cavity, and soaked in the flesh. Experiments actually show that lean fish remove much oil in this way; fat fish must do likewise. It is evident, then, that when the oil content of the bath remains constant or increases oil must cook out of the fish. Under such conditions the sardine-oil content of the bath must increase.

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[28] Detailed data on the quantity of fish fried and oil used are given in Tables 13 and 14, pp. 161 and 162.
[29] Complete quantitive data concerning the amount of fish fried and oil used are given in the Tables 15 and 16, pp. 162 and 163.

It was not possible to determine with any degree of accuracy how rapidly the sardine-oil content of the frying oils increased during use by analyzing the samples of oil collected from time to time during the frying tests. The oils had been heated and exposed to the air for a long time, during which period much oxidation must have taken place. Such changes make the usual methods of analysis impracticable.

A good idea concerning the change that must take place in the composition of oil used for frying sardines and the way in which it takes place can be obtained by using certain experimental data in connection with a series of calculations. These calculations are based partly on assumptions. They are reasonable ones, however, and the conclusions reached must be quite close to conditions actually attained in practice. The results of such calculations are very helpful in indicating ways in which frying can be improved. This work is summarized below.[30]

When fat sardines are fried in cottonseed oil some oil cooks out of them and mixes with the oil in the bath. They leave more of this oil in the bath than they remove from it, and in this way the amount of sardine oil in the bath continues to increase. The rate of increase is rapid at first but lessens as frying continues. Nevertheless, it is not long before the frying oil is almost all fish oil. The nature of this change in composition is shown in Figure 21. Other calculations show that the fish-oil content of a given quantity of frying oil increases less rapidly the larger the size of the individual units cooked at one time. An example will illustrate: If a ton of fish sufficiently fat to keep the oil content of the bath constant is fried 4 pounds at a time in 12 pounds of oil the fish-oil content of the frying oil will be less than if the same quantity of fish is cooked in units smaller than 4 pounds each. Still other calculations show that when the fish are fat enough to cause the oil in the fry bath to increase the percentage of fish oil increases less rapidly if the oil in the bath is allowed to increase than if the excess oil is removed as it collects. The application of these findings to improving frying procedures is discussed later.

CHEMICAL AND PHYSICAL CHANGES

Examination of the oil samples from the frying experiments showed that the oils gradually darkened with use, becoming red in color. At the end of both experiments the oil appeared almost black when viewed through thick layers. However, thin layers about an inch in thickness showed a deep red color. The viscosity of the oils increased greatly with use. The longer the oil was used the more unpleasant it became, acquiring a tallowy, paintlike odor and taste, both of which are characteristic and hard to describe. The free fatty-acid content of the oils increased but slightly, going from about 0.1 to 0.6 per cent in each lot of oil.[31] The oils became only slightly rancid. Everything taken into consideration, it can not be said that they became insanitary—merely unpalatable.

As far as the examination went, the oils remaining from the two runs (four lots) seemed to be quite comparable in quality; that is,

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[30] Actual calculations are given on pp. 164 to 167. [31] More complete data are given in Table 25, p. 168.

the changes that take place in frying oil with use appeared to have taken place to about the same extent in each case.

The viscosity of the oils can be laid to oxidation and polymerization changes, and the odor and taste can reasonably be laid to the presence of fish oil and to oxidation products of this oil and cottonseed oil. The cause of the deep red color was assumed to be the action of oxygen and heat on sardine oil. To prove this, a number of heating tests, in air and away from air, were run on cottonseed, Mazola, Crisco, and sardine oils, alone and on mixtures of each of the first three with the last. The following results were obtained: When heated at 230° in air only the sardine oil darkened appreciably, becoming redder in color the longer it was heated. Other things being equal, the more surface exposed the darker the oil became. All samples became viscous and the acidity increased slightly. Sardine oil and mixtures of sardine oil with the other oils acquired a color, taste, and odor quite comparable to oils that had been used for frying sardines. Samples heated in the absence of air were not changed appreciably.[32]

MECHANICAL AND CHEMICAL TREATMENT

Mechanical treatment by washing the oil during the first run of frying experiments did not pay for the trouble; the improvements were scarcely noticeable. A few of the ordinary methods used in purifying oils were tried on fry-bath oil. The methods of treatment included fuller's earth, superheated steam, oxidizing agents, hydrogen according to Schuck's method,[33] and dilute caustic solution. (Experiments described on pp. 167 to 170 in the Appendix.) All methods gave more or less negative results. The caustic treatment improved the color of the oil but not the taste. This, however, like the other chemical methods, is wasteful of oil and expensive to carry out.

DISCUSSION

METHODS OF IMPROVEMENT

There is a big demand for canned sardines that sell at a low price. Competition for this business is very keen. In order to help keep production costs low, a batch of cooking oil is used much longer than it should be. This lowers frying costs, but, as has been shown, undesirable changes take place in the oil and some of the oil gets into the canned product, lowering its quality more or less, according to how much use the oil has had. Any improvement in the frying procedure that tends to keep the oil in better condition will improve the quality of the canned product.

Betterment can take place along several lines, namely, (1) preventing or minimizing undesirable changes that take place in the oil, (2) treating "old" oil so as to remove its objectionable properties, (3) using better suited and cheaper oils for frying, and (4) minimizing the amount of frying oil that gets into the can with the fish. There is also the possibility of getting around the difficulties

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[32] Data on the tests are given in Tables 26 to 28, pp. 168-169.
[33] "Process for deodorizing fatty oils." By W. P. Schuck. Metallurgical and Chemical Engineering, vol. 16, pp. 608-609. New York, 1918.

of frying in oil by developing a substitute method of preparing the fish for canning. These subjects are discussed below in the light of the experimental results.

Minimizing undesirable changes.—The changes that take place in frying oil have been shown to be due largely to the action of the oxygen of the air upon the heated oil. Fish oil is affected more by oxidation than cottonseed oil. It darkens quickly, becomes viscous more rapidly, and when oxidized is more unpleasant as to taste and odor. It would be advantageous, therefore, to keep the fish-oil content of the frying oil as low as possible and to do whatever is practicable to prevent oxidation of the frying oil. Fish oil can not be kept out of the frying oil, and oxidation changes probably can not be prevented in a practical manner, so the difficulties can not be completely eliminated. There are ways, however, in which improvements can be made.

In a typical fry bath, for example, a layer of oil 6 inches deep may be spread out in a vat 50 by 3 feet. With such a large surface of heated oil exposed to the air in proportion to the amount of oil in the vat, it is no wonder that oxidation takes place so rapidly. These changes can be lessened considerably by placing an inexpensive, removable cover on the vat, leaving the ends open where the baskets of fish enter and leave the oil. Steam coming from the fish will collect in the inclosed space, excluding air. One canner agreed to try this and found that the oil remained in better condition when the cover was used. The blanket of confined steam over the oil also minimized temperature variations in the oil and lowered the amount of steam used in running the vat. In order to further conserve steam, the whole exposed surface of the cooking vat should be well insulated.

It is important in constructing a fry bath to build it so that the smallest possible amount of oil can be used. The vat should be but slightly wider than the baskets that pass through it, and they should move as close together and as near to the steam coils as possible. The coils should be placed so as to aid in permitting the use of the minimum amount of oil. Only enough oil should be used to cover the fish as they pass through the vat. Had these precautions been taken in constructing many of the fry baths now in use it would be possible to use as much as 1 to 3 barrels of oil less in filling them, with a saving at the time of filling of possibly $50 to $150. By taking these precautions, too, the oil in the vat that gets into the canned product will, in the long run, be in better condition than otherwise. The main reason for this follows: A given lot of fish will mechanically carry away a certain amount of oil, which has to be replaced either by oil from the fish or by adding oil, no matter how much there is in the vat. The amount removed, however, will be a greater part of the total oil the less oil there is in the vat. It is an advantage for the oil replacements to be as large a part of the total oil as possible, because the more rapidly it is replaced the better the quality of the oil in the vat and the longer the time before it will have to be discarded entirely.

Using the minimum amount of oil also keeps the fish-oil content of the frying oil from increasing as rapidly as it would otherwise. Calculations show this to be true for all cases except where the oil content of the bath is increasing, as it does when very fat fish are fried. Then, if the only consideration is to keep the fish-oil content at its lowest, the oil should be allowed to increase as much as conditions permit and as long as such a condition exists. Although it has been shown that usually it is best to keep the fish-oil content of frying oil as low as possible, in this special case undoubtedly it would be better to remove the excess oil as it collects and fry in the minimum amount of oil because of the distinct advantages that come from rapid oil replacements.

The second run of frying experiments furnishes an example of the beneficial results to be obtained from an application of the principles discussed here. In the second run almost twice the quantity of fish was fried per gallon of oil used as in the first, yet final oil conditions were comparable. In the second run there were approximately twice the oil replacements there were in the first run and less time for the simultaneous action of high temperature and air. It can hardly be argued that different oils were used in the second run, because fish oil is soon the main oil in any case where fat sardines are fried.

Improving the quality of "old" oil.—It would be a distinct advantage were it possible to prevent objectionable properties from developing in frying oil by frequently treating the oil or by removing objectionable substances as they are formed. Experiments along these lines were unsuccessful. Apparently little is to be expected from such attempts when one realizes that there is only one sure method of removing the taste and odor from fish oil—namely, hydrogenation—and this is impracticable with a contaminated, oxidized oil.

It is advisable, however, to handle this oil properly during use. When frying is completed, the oil should be separated from the "foots" and water and stored in a clean tank, preferably away from the air. The "foots" should be heated gently to "break" the emulsion and the clear oil obtained added to the other oil. More oil can be obtained from the remaining "foots" by boiling the water out of them. This oil should not be used for frying, as it is likely to be of poor quality. The frying vat should be cleaned, of course, and fresh water added when it is used again. Some canners claim that it pays to centrifuge the frying oil. Undoubtedly this is helpful, as it removes water and finely divided particles from the oil.

Using better-suited and cheaper oils.—There are oils and fats more suitable in many ways for frying purposes than cottonseed oil. Since oxidation changes are the main ones that take place in oil used for frying sardines, it would appear better to use an oil that is especially resistant to oxidation. In the experiments such an oil was used—namely, Crisco, a hydrogenated oil. No better results were obtained from its use, however. It is easy to explain this behavior. When fat fish are fried, it is not long before the oil first placed in the fry bath has been replaced by fish oil. The Crisco did not remain in the vat long enough for its desirable properties to show up. Under such conditions it makes little difference what kind of oil is used for frying, providing it stands up reasonably well under use and has no objectionable flavor or odor. When lean fish are cooked, however, it would be well to use an oil that is resistant to oxidation, since this is the main oil always in the cooking vat, losses being made up by adding new oil.

There is one rather serious disadvantage in using a fat that is solid at ordinary temperatures. It is difficult to handle unless hot, and that which is carried out of the vat solidifies on the fish and gives an undesirable appearance to them. Some canners tried cocoanut oil, which is solid at ordinary temperatures, and found this to be the main objection to it.

It is possible to lower frying costs by using a cheaper oil than cottonseed oil. Since it is but a short time until almost pure fish oil is being used when fat fish are fried, there is little reason why high-grade fish oil should not be used in the first place. Whenever available, it is considered cheaper than cottonseed oil. Except for the solid nature of hydrogenated fish oil, it would make an especially valuable frying oil.

In an endeavor to get around the expense for frying oil, one canner at least packing pound-oval sardines at times took fish oil from his by-products plant for cooking purposes, using a new lot each day. It was claimed that the fish were in good shape for canning, having been cooked in fresh oil, and that so little damage was done to the oil that it sold for the same price as other oil from the by-products plant. Another canner, packing quarter-oil sardines, cooked fish in new olive oil for a few hours, then removed it from the cooking vat, and used it in packing the fish. These developments are very interesting. I have been unable actually to observe the results obtained and therefore can give no more than an opinion as to what results are to be expected. High-grade fish oil should make a good cooking oil. I believe, however, that an oil good enough for this purpose will, even in one day, undergo changes that probably will lower its quality more than enough to offset any advantage gained by using it. If the oil is not high-grade to start with, it will lower the quality of the prepared fish. As for cooking in olive oil and then using the oil for packing purposes, it is probable that the changes that take place in the oil will detract enough from its value as a packing oil to minimize any advantage gained.

Lessening the amount of frying oil that gets into the canned product.—An improvement in the results obtained from frying can be brought about by lessening the amount of frying oil that gets into the can with the fish. Improving draining conditions will help to do this. It is customary to stack the baskets of cooked fish several deep, one on top of another. The oil and water that drain out of one basket run down over the fish below. It would be better, in order to facilitate draining, to have under each layer of baskets some sort of drip pan to protect the other fish and to convey the drippings away.

Attempts have been made to remove at least a good part of the frying oil from fried fish by steaming them. I am not familiar with the actual results obtained. I do not think, however, that such a procedure would do enough good to pay for the extra trouble and expense involved.

ELIMINATING FRYING IN OIL

The research has shown ways in which frying in oil can be improved and cheapened but not how the difficulties met can be overcome. It is improbable that further research will do this, although other improvements probably would follow from such work. Even after such improvements as can be made are effected, frying oil will continue to take on undesirable properties, and very likely it will continue to be used longer than it should be, because in this way frying can be cheapened still further. "Old" oil will continue to get into the canned product as before and be equally objectionable. Because of these facts, it did not seem best to continue the investigation in this field. Instead, it seemed more practical to endeavor to avoid frying in oil by the use of some other process of preparing the fish, which would, if possible, produce better and cheaper sardines. The rest of this document deals with the endeavors along this line.

METHODS OF PREPARING THE FISH

INTRODUCTION

The study upon changes in oil used for frying sardines showed that, although very helpful improvements in the frying procedure can be made, certain difficulties probably will continue to be troublesome. For this reason elimination of the necessity of cooking in oil as a step in the preparation of sardines for canning presented a most desirable field for investigation. This was especially true in California, where, at the time of planning this particular work (1921), considerable interest was evident (yet little was known) as to methods of accomplishing this end. Little, too, was known about how well fish prepared in other ways than cooking in oil would withstand shipment and storage. No commercial attempt with a substitute method had yet been satisfactory. Cooking in oil had already been eliminated by most canneries in Maine because a steamed pack was cheaper to prepare. Steaming, however, as done there, was generally believed to be unsuitable for California.

In this investigation three substitute methods of preparing the fish for making California pound-oval and quarter-oil packs were studied. Procedures were developed for each of them and packs were prepared, stored, and shipped. These substitute methods ordinarily are referred to as cooking in brine, steaming, and raw packing. In order that these methods may readily be compared with frying in oil, the advantages and disadvantages of the latter process are discussed first.

FRYING IN OIL

The steps involved and the changes that occur in frying in oil are described in detail in the introduction (pp. 73 to 85). The advantages and disadvantages of this process are summarized here for comparison with those of other processes.

Advantages.—The cooking-in-oil process, especially as a means of preparing fish for the pound-oval pack, is as nearly "foolproof" as one can reasonably expect any process to be. A wide variety of conditions in the various steps of preparation can be depended upon to prepare the fish so that they will give a pack of at least fair quality. Because of this, the canneries are able to operate almost wholly with unskilled labor.

The lubricating effect of the cooking oil prevents serious sticking of the fish to each other and to the wire baskets. They can be stacked quite thickly in baskets, and this enables a large quantity of cooked fish to be handled easily and stored in a small space until the most convenient time for packing arrives.

The tough skins and firm fish produced by the process permit relatively rough handling, thus facilitating their being packed in cans.

A most important consideration is the rapid and efficient way in which water is removed from the fish by the hot oil. Equipment for frying is relatively inexpensive and does not take up excessive floor space. Frying tends to make the fat content of the canned product uniform. It adds oil to lean fish and removes some oil from fat fish.

Disadvantages.—The most serious objection to cooking in oil is the bad effect it has upon quality. If new oil could always be used this objection would not be serious. Where cottonseed oil or some similar oil has been used it has been economically impossible to change the oil frequently. Consequently, when "old" frying oil finds its way into the can it imparts its characteristic disagreeable taste and odor to the fish, darkening them and the oil and sauce in the can. Evidence indicates that such a pack is not digested as easily as one in which the "old" oil is absent.

Cooking large quantities of fish in oil and subsequently handling them and caring for the oil and equipment are at best very disagreeable undertakings. The fumes that come from cooking vats, especially as the oil gets "old," are unpleasant to most people.

Considerable labor must be expended in handling the fried fish. The baskets of cooked fish are stacked and moved to the cooling room. Next day they are moved to the packing tables, unstacked, emptied, stacked again, moved once or twice, unstacked, and filled with fish for frying.

Oil for cooking purposes amounts, in the long run, to a considerable item of expense. Upon inquiry several canners stated what their cost for cottonseed oil was per case of pound-oval fish cooked. Some claimed a cost as low as 5 cents and others as much as 15 cents. One packer of fancy quarter-oil sardines said it cost him 30 cents a case, and yet he was not changing his oil as often as is desirable. The expense of caring for the oil and equipment is considerable. The oil and extractives removed from the fish are excellent food and should go into the can.

COOKING IN BRINE

In October, 1920, E. B. Gross, then of Field & Gross (Inc.), Monterey, told me that at some time in the past he accidently had cooked fish in a hot salt solution instead of the customary hot oil. The fish appeared to him to be better and more palatable than fried fish. When packed with tomato sauce they produced an excellent product. Although some of his customers also considered the fish better, he did not continue preparing his product in this way because of the general demand for fried-in-oil sardines. Later, however, during the 1922–23 season Mr. Gross began to prepare fish by this process and has continued to do so since then.

In December, 1920, Arthur W. Wells and I packed some sardines that were prepared by cooking them in brine. Later in the season Mr. Wells prepared other packs in a similar manner with very good results. The next season (1921–22) I made a study of this method of preparing the fish.[34] The general results of this work are discussed here.

In this section and elsewhere in this document procedures are outlined for carrying out certain steps in the preparation of the fish for canning. It will be noted that these directions seldom are explicit. It is not practicable to make them so, as too many widely varying factors enter into the matter. The fish may be small or large, lean or fat, good or in poor condition, and fish falling into two or more of these classes may be mixed together, so that it does not pay to separate them. Many other factors also must be considered. The sauce for packing may be thick or watery; an important consideration is the sort of final product desired. One canner may desire the fish to be especially dry and firm and another may wish them otherwise. Knowledge gained from actual experience alone will teach how best to modify the method of preparation so as to obtain the desired result.

EXPERIMENTAL RESULTS

The first experimental packs were prepared for canning in the same way as fried fish, except that they were cooked in a boiling, 100 per cent saturated salt solution instead of in oil. Excellent results were obtained in this way. Experiments, however, to determine the best conditions for preparing the fish were not carried out at that time.

Cooking in a strong salt solution brings about changes in the fish similar to those brought about by cooking in hot oil. The temperature of boiling brine is about 227° (if saturated). This is almost as high as the average temperature of the oil used in many cases for frying. Fish, therefore, cook approximately as quickly as they do in the oil. Some fat is rendered and water and soluble extractives removed as in oil. In addition, the strong salt solution abstracts water by osmosis.

The experiments showed that it is advisable to toughen the skins by drying the fish before cooking them in brine, as is done before frying fish in oil.

The fish should not be brined, because salt diffuses into the tissues during cooking and some brine clings to the fish when they are removed from the cooking vat. The more concentracted the solution and the smaller the fish the more pronounced is the salting effect. Cooking in saturated brine salts pound-oval size fish about the right amount. Quarter-oil fish, however, have such a large surface, compared to their size, that they easily become too salty when cooked in strong brine. Lowering the concentration of the cooking solution prevents excessive saltness. Rinsing with fresh water does likewise. Both of these practices, however, are to be avoided. Lowering the concentration also lowers the boiling point of the solution, and the fish do not cook as quickly or lose water as readily as when high concentrations are used. Rinsed fish tend to stick to each other and to the wire baskets more than unrinsed ones.

Tressler[35] showed that impurities, such as calcium and magnesium compounds in salt (sodium chloride), used for curing fish produced

[34] Data on the experiments and packs produced are summarized in Table 29, p. 171.

[35] "Some Considerations Concerning the Salting of Fish." By Donald K. Tressler. Appendix V, Report U. S. Commissioner of Fisheries, 1919 (1921). Bureau of Fisheries Document No. 884, 55 pp., 8 figs. Washington, 1920.

marked differences in the quality of the salted product. Cooking solutions were used which had been made from salts containing as high as 10 per cent by weight of calcium and of magnesium chlorides. Except for having a slightly sharper taste, no material difference was noted between fish cooked in these solutions and those cooked in pure sodium chloride.

Several packs of brine-cooked fish were prepared. In some cases, for purposes of comparison, similar packs were prepared from the same lot of fish by the regular cooking-in-oil process. These packs showed that cooking in brine, when carried out properly, produces an excellent pound-oval pack at least equal in quality to the fried-in-oil product. The brine-cooked packs would have been better, as far as flavor and appearance go, had the fried pack been cooked in "old" oil. Very good quarter-oil packs were produced, except that all were too salty. The process is not suitable for small fish.

PROCEDURE RECOMMENDED

Brine cooking is best suited for preparing fish for the California pound-oval and the Maine three-quarters mustard packs. It is best to use "cut" fish that have not been brined or otherwise salted. The skins should be toughened by drying in the same way as fish are prepared for cooking in oil.[36] The dried fish should be scattered in wire baskets not more than two or three deep and cooked in a saturated salt solution kept at or near the boiling point (about 227°). Vigorous boiling should be avoided, as it tends to move the fish about and causes brusing. Cooking for 6 to 12 minutes (depending on the result desired) should be enough; however, cooking should be at least sufficient to enable the backbone to be removed easily and show no uncooked blood. The baskets of fish then should be stacked and set aside to drain and cool, preferably over night. The amount of salt in the final pack can be controlled by varying the amount of salt in the sauce.

RECOMMENDATIONS REGARDING EQUIPMENT

Ordinary galvanized-iron cooking vats and wire baskets used for cooking fish in oil also can be used for brine cooking. The hot brine, however, soon removes the zinc from the iron, which then rusts badly. It is preferable to use either Monel metal or heavily tinned copper for all metal parts. These combinations of metals (Monel metal being an alloy) are very resistant to hot brine.

Heavily tinned copper equipment was used in the experiments with excellent results. In addition, concentrated brine was kept in the cooking vat for over two years. The metal appeared to be in excellent condition at the end of this time.

ADVANTAGES

Cooking in brine, like frying in oil, furnishes a rapid and efficient way of removing water from the fish.

Cooking equipment, although more expensive than for frying in oil, is still relatively inexpensive and does not take up excessive space.

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[36] Details described on pp. 125 to 129.

The cooking solution costs little and therefore can be changed frequently. Even when this is done the expense will be considerably less than for oil.

Brining is eliminated, thus saving one step usually carried out in preparing fish by frying in oil.

The oil that cooks out of the fish is of good quality and can be recovered and sold.

Most important, cooking in brine obviates the bad effects brought about when fish are cooked in "old" oil.

DISADVANTAGES

The process is not suitable for preparing small fish for the quarter-oil pack.

It is frequently advantageous to brine fish quite heavily in order to keep them until it is convenient to cook them. This can not be done with fish that are to be brine cooked.

Since fish float in strong brine, baskets with tops must be used to keep the fish submerged. Compared with cooking in oil, this means more trouble.

The skins of brine-cooked fish tend to break and stick to each other and to the basket much more than is the case with fried fish. For this reason less fish per basket must be cooked.

As with fried fish, considerable labor must be expended in handling the brine-cooked product.

There is a material loss of valuable extractives and oil from the fish in brine cooking, as there is in cooking in oil.

STEAMING

Steam cooking has been practiced on a commercial scale in California on numerous occasions. Results usually have been unsatisfactory, however, and especially so during the World War period, when large quantities of steamed fish were put up in round cans. In general, in preparing fish by this method the skins have broken badly during steaming, especially where they touched the wire flakes, and after being cooled the fish have tended to stick to the flake and to each other. The packs produced have been of poor quality and have not stood up well under ordinary storage and shipment. The cans usually turned out to be slack-filled and to contain considerable water, and the fish themselves were soft, with tender, easily broken skins.

Soon after the war a canner in Santa Cruz had considerable success in selling a product prepared by packing the fish in oval cans, inverting them on wire flakes, and cooking the fish with steam. For some reason, apparently other than the quality of the pack prepared, this company soon discontinued operations. Later, a canner in Monterey began to steam cook fish and still continues to do so with much success. The process used is essentially the same as the one recommended here as having proved best by experiment. The development of the process by this canner and my experiments were independent of each other. At present no other canner makes a practice of canning steamed fish in California.

Experiments were carried out to learn not only how to prepare a good pack of steamed fish having satisfactory shipping and keeping qualities, but how to minimize the difficulties that had been met in preparing the fish for canning. The general results of these experiments are discussed here.[37]

EXPERIMENTAL RESULTS

Brining.—During cooking much steam condenses on the fish and some juices run from them. These liquids remove salt, necessitating heavy brining if the cooked fish are to retain enough salt to flavor them. The heavy brining also helped a little in toughening the skins of the fish. Other than this, it had no pronounced effect upon the manner in which the fish withstood steaming.

Drying.—It is advisable to toughen the skins by drying before steaming the fish. In the experiments this helped considerably in preventing breakage, both during steaming and later when the fish were packed. Drying also removes some water, and this aids in getting the fish in good condition for canning.

Cooked fish lose considerable water when they stand on flakes exposed to the air for several hours. Ten lots of various-sized steamed fish, some partially dried after steaming, lost, when allowed to stand overnight on different nights, from 7.1 to 14.2 (average 10.9) per cent of their original weight before being steamed. Under similar conditions 16 lots of fish that had been cooked in a current of hot air averaged 6 per cent loss in weight.

Most people connected with sardine canning believe that partially dried fish absorb water when exposed to air containing much moisture, as on a rainy day. Weber makes this mistake. On page 58 of his paper (see footnote, p. 72) he writes of dried fish, particularly on rainy days, absorbing enough water to make their handling difficult. The only way partially dried, steamed fish can become moist from water in the air is for vapor to condense upon them. This can not take place unless the temperature of the fish is below the air temperature, and this seldom happens in sardine-canning practice. What really takes place is this: The surface of fish coming from the drier is dry to the touch and remains so as long as water is removed from the surface faster than it diffuses from within. When the relative humidity of the air is high, as on a rainy day, a condition is soon reached in which water diffuses to the surface more rapidly than it is removed. The fish then appears as if it had taken up water from the air. Even under such adverse conditions the fish continues to lose some water upon standing.

Some experiments were carried out on the drying of steamed fish of sizes suitable for the half-oil and quarter-oil packs. Complete data are given in Table 31, page 180. The drying of steamed fish is discussed in detail elsewhere (pp. 121 to 129).

Steaming.—Cooking with steam removes some water from the fish. Even when "wet" steam at 212° and atmospheric pressure were used there was some loss in weight. With "wet" steam under pressure the loss was greater and in a current of superheated steam still greater. In "wet" steam the loss in weight comes from the cooking effect, which renders some oil, destroys the cellular structure, and thus causes juices to drain from the fish. Superheated steam

[37] Details are given in Table 30, p. 175.

also has a pronounced drying effect, removing water from the fish in the same way that hot air does.

In one series of experiments the oil and extractives that drained from the fish during steaming were caught, dried, and weighed. If the assumption is made that the fish were 40 per cent fat and dry solids (a high figure), then from 3 to 8.3 per cent of the fat and dry solids were removed during steaming in these tests.

PROCEDURE RECOMMENDED

Large pilchards for the pound-oval pack should be brined heavily (one and one-half to three hours) in a saturated salt solution. Brining can be eliminated if extra salt is added to the tomato sauce. Fish to be packed in oil, however, must be brined. The skins of the fish should be toughened by drying in the same way as for frying in oil (pp. 125 to 129).

The dried fish should be spread on wire flakes for steaming. To prevent sticking, they should not touch each other. If the flakes are not oily from being used, a little oil spread upon them will help to prevent excessive sticking. The fish should be steamed for 15 to 30 minutes under conditions that will assure moisture being removed from them. Cooking in a retort under about 5-pound pressure, with good escape of steam from the petcock, is satisfactory. In a steam chest, where steam can escape and the cooking therefore is done at atmospheric pressure, the steam should be turned into the chest at boiler pressure, and it should be allowed to escape quite freely from the cooker. Reduction of the steam pressure from that of the boiler to that of the atmosphere superheats the steam, and this helps to remove water from the fish. A little experimenting will show what steaming conditions give best results.

The fish also may be steamed in the can. Dried fish should be used for this purpose, and the can should be slightly overfilled, as the fish shrink during steaming. The cans should be inverted on wire flakes during steaming, so that liquids will drain from the cans. After cooking, hot sauce should be added to the cans, and they should be sealed while hot. This sealing while hot eliminates regular exhausting.

Fish steamed on flakes should stand until cold, or they should be cooled by blowing cool air over them. They are then ready for packing.

Fish steamed before packing also should be packed quite tightly into the cans, as they may shrink somewhat when sterilized. Thick sauce should be used, and this will take up any water that cooks out of the fish in the retort.

It is important that the procedure used remove sufficient water from the fish. The experiments on steaming do not tell how much water should be removed, but later experiments do.[38] For the pound-oval pack in tomato sauce there should be a loss in weight of 10 to 15 per cent. Most of this loss, of course, is water. If drying, steaming, and cooking in air do not dry the fish enough they should stand in air until dry enough or be dried artificially. Steaming, however, can be carried out so as to remove enough water.

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[38] Experiments with the new process reported upon in the last section of this document.

For the quarter-oil and half-oil packs the loss in weight should be 20 to 30 per cent. Artificial drying after steaming is necessary to bring about this loss. Drying before steaming can be dispensed with if the damage caused by steaming undried fish is not excessive.

ADVANTAGES

The steaming process has one big advantage over cooking in oil—the quality of the pack is not likely to be lowered by the presence within the can of any objectionable product, such as "old" frying oil.

Steamed fish spread out on flakes cool more quickly than baskets of fried fish and therefore can be packed sooner.

DISADVANTAGES

Compared with frying in oil, steaming requires a little more labor, especially from having to place the fish carefully upon the flakes. The cooked fish are more troublesome to handle, and a given quantity of steamed fish requires more storage space than an equal quantity of fried fish.

Skin breakage is greater than when the fish are fried, and more extractives and salt are removed from the fish.

Although definite figures are not at hand, steaming undoubtedly is wasteful of fuel.

RAW PACKING

Packs of sardines in California and Maine at times have been prepared by packing from raw fish. Usually the fish have been given some sort of preliminary treatment in order to get them into condition for canning. Results, however, have been so unsatisfactory generally that no canner in California or Maine makes a practice of canning raw fish. The packs produced have stored and shipped poorly as a rule. The cans have turned out to be slack filled, with far too much water in them, and the fish themselves have been too soft.

Although raw packs are not produced by the regular sardine canners, in British Columbia some large, fat pilchards are put up raw, without sauce or oil, in pound-tall cans. On the east coast of the United States alewives are canned in a like manner in No. 1 and No. 2 cans. These products are good foods. They find only a limited market, however, partly because they are judged by standards for canned sardines. When packed raw, they have the same disadvantages and therefore are subject to the same criticism as are the ordinary raw-packed sardines.

It seemed obvious that good results could be obtained in packing sardines raw if enough water were removed from the fish before they were canned. Experiments were carried out with this idea in mind. followed by research aimed at bettering the method of preparing the fish for canning.[30] Most of the research reported upon in the next section of this document, under the heading "Partial drying of the fish," was performed as a part of the research on this problem. A general summary of the results of all these experiments follows:

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[30] The results of this work, other than the special drying experiments, are summarized in Table 32, p. 182.

EXPERIMENTAL RESULTS

The experiments clearly show that good packs of pound-oval sardines in tomato sauce can be prepared by packing the fish raw if sufficient water be first removed by brining and drying. Satisfactory results were not obtained by packing untreated fish or fish that have been brined only.

Brining, aside from salting the fish, helps prepare them for canning by removing some water. It is advisable to brine the fish as long and in as strong a solution as possible in order to take full advantage of this dehydrating effect. Two to three hours in saturated brine is about as long as large "ovals" can be brined without taking up too much salt.

Satisfactory results were obtained in preparing large fish for the pound-oval pack by drying two hours in air having a temperature of 95° to 105° and a velocity of about 500 feet per minute. These fish, of course, had been brined heavily. After drying they were packed firmly into cans and lightly salted thick sauce added. Two hours' drying under these conditions did no more than remove the minimum of water, and at times it failed to do this.

During the 1921–22 sardine season good packs of pound-oval sardines were prepared consistently by the raw-packing process. These packs when properly prepared were better than packs produced by the other processes. The flavor of the fish was excellent, little besides water having been removed from them. The appearance was very good, the fish being always bright in color and the skins intact. The physical condition of the fish generally was not quite as good as were similar packs of fried fish, for the reason that more water had been removed by the frying process. Preliminary tests, however, showed that the product obtained was virtually as good in storing and shipping qualities as were fried-in-oil packs.

It is a real disadvantage, however, to have to dry fish two hours or longer. Large and relatively expensive equipment is needed in order to do this. Raw packing would be much more feasible if the drying could be done in less time. It was not possible to tell how well the drying was being done or to know what could be expected, since no information upon the behavior of the raw fish under various drying conditions was available. Experiments, therefore, were carried out to furnish this information and to learn, if possible, how to shorten the drying period. Much valuable information was obtained from these experiments. Complete data are given and the results discussed in another section. Here it is sufficient to summarize only those results that apply to this problem.

The experiments indicate clearly that little can be done to hasten drying in preparing the fish to be packed raw. Increasing the temperature of the drying air will do this, but the fish soften badly and oil is rendered from them. This change is undesirable; it gives a soft fish, and during drying the fish break when they drop from one run to the next in the continuous driers.

On several occasions raw packs were prepared from fish that had stood in the air about 21 hours. Some of these fish had been brined and dried; others had been brined only and had to be dried before being packed. The fish kept well and packed satisfactorily. Undoubtedly it would be better not to dry the fish until just before they are to be canned. Warming the fish in the drier hastens bacterial and autolytic activities, which probably continue at a greater rate than it does in fish that have not been warmed, although the warmed fish may soon return to the temperature they had before being dried.

It was necessary to find out how well the fish keep over night, because the packing of prepared fish into cans is usually done by women who work only in the daytime. In southern California, for instance, the fish usually arrive at the canneries between midnight and 9 or 10 o'clock in the morning. The fish are unloaded, cut, and brined as soon as possible. Under ordinary conditions fish to be packed raw could be prepared and be ready for packing early in the morning, and a steady supply furnished throughout the day. There are times, however, when fish arrive late in the day or early in the evening. These fish must be preserved until the next day before they can be packed. If they are fresh and if they are cut and brined sufficiently, both the experiments and general experience by the canners show that they keep well over night, or even longer, in the brine tanks. The air temperature at night on the coast of southern California in winter, when sardines are canned, seldom goes above 60° and may drop as low as 32°. Should higher temperatures prevail or the fish be in poor condition a layer of cracked ice on a tank of brined fish would aid greatly in keeping them. Conditions for keeping fish in Monterey are excellent. A supply of clean, cold, sea water is always available, and if run over the fish in tanks keeps them in excellent condition for from 24 to 48 hours.

Experiments upon the preparation of fish for the quarter-oil pack were limited in extent. It is evident, however, that a good pack can be obtained by preparing small fish in the same general way as large fish for the pound-oval pack, except considerably more water (20 to 30 per cent) must be removed from the small fish. This can be done by drying, but, except in the case of very small fish, it is a slow process, just as it is a slow process to remove less water from large fish.

One difficulty was met with raw-packed fish in oil that is not encountered with fish that have been cooked. Some of the packs (not all) when opened contained small masses of what apparently was coagulated protein. This detracted somewhat from the appearance of the product. It seemed that this substance was present only when the fish were not real fresh or had softened considerably during their preparation for canning. This coagulable substance undoubtedly drains during cooking from fish that are cooked before being canned. It was not noticed, however, in the tomato-sauce packs, probably because its presence was hidden by the red sauce.

PROCEDURE RECOMMENDED

Pound-oval sized fish, to be canned raw with tomato sauce, should be "cut" and then brined in a saturated salt solution as long as possible (about two to three hours) without making the final product too salty when packed in a very lightly salted or unsalted tomato sauce.

The brined fish next should be dried with air having an average temperature of 95° to 115° and a velocity of 1,000 feet, or more, per minute (preferably 1,500 to 2,000) for two to three hours. The temperature should be kept low enough to prevent the fish from becoming very soft and to keep much oil from being rendered. Experience with the kind of equipment used and with different drying conditions and sizes of fish is necessary to determine these in any individual case. At least 6 to 8 per cent of water (preferably more) should be removed from the fish by drying. Generally speaking, less water has to be removed from fat fish than from lean ones to obtain satisfactory results. This is because fat fish contain less water than lean ones. A fish analyzing 16 per cent fat may analyze about 64 per cent water, while a lean fish containing 1 per cent of fat may contain 78 per cent water.

Drying can be accomplished with least expenditure of labor in a continuous multiapron, tumbling drier. Recommendations with regard to this kind of drier are given on pages 127 to 129. These and the general notes given in that part of this document apply equally well here.

The fish should be packed tightly into the can as they will shrink somewhat when sterilized. A very lightly salted, thick, tomato sauce should be used, and this will take up the water that cooks out of the fish in the retort.

The regular process used in sterilizing fried fish is sufficient for raw-packed products.

Fish for the quarter-oil pack should be prepared in the same general way as for the pound-oval pack, except that much more water should be removed from them. The process, however, is not as satisfactory for preparing fish for the quarter-oil as for the pound-oval pack.

ADVANTAGES

Fish properly prepared for raw packing are in almost perfect physical condition. Little other than water having been removed from them, appearance, flavor, and food value are conserved to the fullest extent.

The yield in cases per ton of fish handled is greater with this process than with any of the others.

DISADVANTAGES

The time required to prepare fish for canning when packed raw is much greater than for any other process. This is a distinct disadvantage, as large units of relatively expensive drying machinery are needed to handle the fish.

Fish to be packed raw must be canned within a reasonable length of time after being caught. They can not be prepared and then kept two or three days until it is convenient to can them.

During drying the fish are heated to and kept for a considerable period at a temperature favorable for bacterial and autolytic activity. The changes brought about in fresh fish by the acceleration of such activity are not objectionable; in fact, they are not noticeable. They might be, however, if fish that are a little stale are used. At times fish that have been out of the water for some time and are not in the best of condition are received at the cannery. Nevertheless, they are still in fair condition for canning and will give a good product if prepared quickly. In any of the processes where the fish are

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cooked they are barely warmed during the short drying period, and decomposition ceases when the fish are cooked.

STORING AND SHIPPING TESTS

In considering the merits of any process account must be taken of the storing and shipping qualities of the packs produced. The product must stand up well. Pound-oval sardines prepared by frying in oil proved excellent in this respect. In the average canner's mind, however, it seems very doubtful whether packs produced by methods other than frying in oil would be satisfactory. The raw-packed and steamed sardines produced during the World War period were poor in this respect. Many of these packs became a mushy mass when handled in the same way as fried sardines. Although these bad results undoubtedly were due to improper preparation of the fish, nevertheless it was necessary to prove that properly prepared products would stand up well before the canners would even consider using any process other than frying in oil. The various packs were therefore subjected to rather severe storage and shipping tests in comparison with similar fried-in-oil packs, many of which were prepared from the same lots of fish, both by regular canners and in the laboratory. The general results of this work are discussed here.[40]

EXPERIMENTAL RESULTS

In general, all packs withstood the storing and shipping tests about equally well, whether prepared by frying in oil or otherwise, provided they were properly prepared for canning. On the other hand, when the necessary precautions were not taken to get the fish into good physical condition for canning, they disintegrated more or less.

Only a very few cans from the different packs definitely spoiled—that is, "swelled" from the formation of putrefactive gases. During the third year of storage a large number of cans of pound-oval, tomato-sauce sardines did "swell," due to the formation of hydrogen, probably from the action of the acids in the sauce upon the metal of the cans. In other ways the contents appeared to be normal.

The fish, however, had acquired a slightly bitter taste, probably due to metal salts. Most cans in every pack that was 3 years old were affected. It was noticed, too, that as time went on the cans became quite badly "detinned." Fish packed in oil, however, did not acquire the bitter taste, nor did the cans "detin" to a pronounced degree.

Occasionally among normal cans of the different packs that were 2 to 3 years old there was found a can in which the fish had softened badly, otherwise the contents appeared normal. In extreme cases the outline of the individual fish could hardly be distinguished. I can give no explanation for this action. Probably it was due to some sort of bacterial activity.

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[40] Details of the tests made with the various packs are given on p. 190.

DISCUSSION

The experimental work has shown how excellent packs of pound-oval sardines, having good storing and shipping qualities, can be prepared in ways other than by cooking in oil. These processes—namely, steaming, brine-cooking, and raw-packing—have been compared with the frying-in-oil process and the advantages and disadvantages of each pointed out. The general results of the study, however, taken as a whole, need to be discussed.

In the first place, a few statements can be made that are in the nature of conclusions. In some ways they seem so obviously true as to require no proof. They are substantiated, however, by experimental data given in this section, and are proven further in the last section of this document.

1. The preparation of fish for canning as sardines is essentially a process of removing excess water and of getting the fish into good physical condition.

2. As far as the storing and shipping qualities of a pack are concerned, it makes little difference by what process the fish are prepared for canning, provided they are in good condition and packed firmly into the can, and provided sufficient water has been removed so that the fish will not shrink badly and give up an undue amount of water when sterilized.

3. The best product will be given by that process that adds no objectionable foreign substance to the fish (such as "old" fry-bath oil), that removes the least amount of oil [41] and soluble extractives, and that best preserves the original appearance of the fish and leaves them in the best physical condition for canning.

Of course, quality of pack must be considered in relation to the cost of production, and proper cognizance must be taken of these factors when methods of preparing the fish are considered. Under certain circumstances a small addition in cost is secondary in importance to a gain in quality, while under other circumstances cost of production must be kept down even if quality has to be sacrificed somewhat. It is highly desirable that a process be developed that will produce fish of the best quality at the lowest cost. This, as stated before, was set as the ultimate goal of the line of research considered in this document.

The processes experimented with do get around frying-in-oil difficulties, and although they will, in the long run, produce better packs of sardines than does frying in oil as now carried out commercially, it does not seem to me that any one of them has sufficient additional advantages to enable it generally to supplant that process.

When the fish are properly prepared, raw packing produces the best pack. The difficulty in getting enough water out of the fish and the amount of equipment and time required to prepare them probably will prevent this process from becoming widely used, if at all. Brine cooking does not appear to be adapted to southern California conditions, under which it is advisable to brine the fish as an aid in preserving them until they are to be cooked. Besides,

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[41] Some believe that as much as possible of the natural oil in the fish should be removed, contending that a better pack is produced in this way. General practice among canners does not seem to confirm this. Maine and Norwegian canners prefer fat fish for their quarter-oil packs, and California canners cease operations when oval-size fish become lean. My own experience has convinced me that the natural oil in the fish, unaffected by outside influences, adds considerably to the flavor, texture, and food value of the fish.

the process is not well suited to small fish. In Monterey, where conditions are different, there are possibilities for this process to be developed into a good substitute process for frying in oil. The steaming process offers possibilities of being developed into a good substitute process if a procedure is developed that will permit the preparation of pound-oval sardines as cheaply as they can be prepared by frying in oil.

Research on ways of carrying out the brine-cooking and steaming processes and on the development of the right kind of equipment probably would yield good results. This, however, did not seem to be the best path for further research. Instead, the investigation was continued upon the development of a new process having the desired advantages. This research is covered in the section entitled "New process for preparing the fish."

APPLICATION OF EXPERIMENTAL RESULTS TO THE MAINE INDUSTRY

In Maine it has been customary to prepare the better grades of sardines by the frying-in-oil process and the "standard" grades by steaming. Frying in oil has been found to be unsatisfactory for the same reasons that obtain in California, and steaming is objected to because it removes so much salt, oil, and soluble extractives and because the fish frequently break badly when cooked.

Although the research on methods of preparing the fish for canning as sardines applies directly to California pilchards, the results should apply almost equally well to the preparation of Maine herring. Maine's three-quarter mustard pack is very similar in character to the California pound-oval pack in tomato sauce. The bulk of the total pack, however, consists of quarter-oil sardines.

The results of the study on methods of preparing the fish indicates no process that would better conditions in Maine. Frying and steaming, as well as baking in Ferris-type ovens, have already proved unsatisfactory. It seems doubtful, therefore, if further research on the methods already studied would lead to information of much value to the Maine industry. This is another reason why work was continued upon the development of a new process.

PARTIALLY DRYING THE FISH

INTRODUCTION

In the section "Methods of preparing the fish," under the heading "Raw packing" (p. 110), it was pointed out that for the raw-packing method to supplant frying in oil it would be necessary for the long drying period to be shortened. The primary reason for undertaking the investigation described in this section was to learn, if possible, how to do this. A secondary reason was to gain information of value in improving existing drying methods used by sardine canners. The results of this research, as applied to the raw-packing process, have been discussed previously. This section of the document is devoted to a general discussion of drying and of the experimental results of the investigation and their application to commercial practices.

Partial dehydration is an important step in the preparation of fish for canning as sardines. So far the removal of some water from raw or steamed fish by subjecting them to the action of moving warm air has been found to be an essential step in all commercial methods of preparing the fish. The principles underlying this step and their practical application are, in general, unknown to sardine canners. Then, too, the behavior of raw and steamed fish under various drying conditions has not yet been worked out. Accurate knowledge of this latter point is necessary to permit application of the fundamental principles of air drying to the designing of apparatus and to the improving and cheapening of this necessary step in the preparation of the fish.[42]

THE RÔLE OF DRYING IN THE PREPARATION OF THE FISH

In Maine, in order to obtain a satisfactory product, it is necessary partially to dry the fish after they have been steamed. Partial drying prior to some form of cooking presents a somewhat different problem from the drying of steamed fish or fish to be canned raw. In the latter cases the problem is essentially one of moisture removal. In the former case the most important thing is to get the fish into good physical condition for withstanding the rest of the preparation for canning. It is a process of toughening the skins and of removing surface water and some internal combined moisture, so that the fish will withstand frying, steaming, or cooking in brine with minimum damage. The actual amount of water removed is of secondary importance and may vary somewhat without detriment to the final pack, especially if plans are laid to remove more or less water in the subsequent preparation. In the frying process, for example, a study of different cannery procedure shows considerable variation in the amount of water removed by drying, yet the final product of each plant is satisfactory. The large amount of water removed by frying and draining overnight tends to equalize small differences in loss of moisture due to drying. In this study of partial dehydration it is important to keep these ideas in mind.

GENERAL PRINCIPLES OF DEHYDRATION

A good understanding of the fundamental principles of air drying, on the part of the sardine canners, will be of much assistance in improving drying conditions in the industry. For this reason part of what is known about air drying and its application to drying fish is explained here.

Air is a combination of gases that, when dry, can take up or associate with itself a definite quantity of water vapor for each temperature at which it may be. The quantity of water vapor that can be taken up by a given weight of dry air increases very rapidly with rising temperature. For instance, 1 pound of dry air at a temperature of 122° can take up 7.4 times as much water as an equal amount of air at 62°, and at 182° the amount is 62 times that at 62°. This example indicates why it is possible on a rainy day, when the temperature is, say, 62° and the air is already saturated with moisture, to heat the air by passing it through a steam coil and then to have it take up moisture from wet fish. Contrary to popular opinion, heat does not dry air; it only makes it possible for it to associate more mois-

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[42] The various kinds of drying apparatus used by the California sardine canners are described on pp. 77–78.

ture with itself, due to its change in temperature. If the air after heating were cooled to its original temperature (62°), it would again become saturated; and if cooled further, water would immediately begin to condense from it. The temperature at which water vapor begins to condense from air that is being cooled is known as the dew point—in this case 62°. If in this example, however, after heating the air it had been allowed to take up some water from wet fish before being cooled, the dew point would have become higher; and, with certain limitations, the more water it had taken up the higher the dew point would have been. In fact, it is actually possible for so much water to be taken up in the first part of a tunnel full of fish that when the air later strikes cold fish just entering the far end of the tunnel it will condense on them. This must be avoided, of course.

Fractions of the total amount of water vapor that can be present in air at a given temperature are expressed as "per cents relative humidity." For example, saturated air has a "relative humidity" of 100 per cent and half-saturated air 50 per cent.

Air is heated to increase its moisture-absorbing capacity. Another reason for warming the air is to furnish the heat needed to vaporize the water that is to be removed. It takes much heat to change water to vapor (steam) at the boiling point; yet it takes virtually the same quantity to change water to vapor at lower temperatures. In drying, the warm air that strikes an object furnishes this heat. Were it not furnished, a body from which water can evaporate freely would soon become so cool that the rate of evaporation would become negligible.

Air in contact with a wet object soon becomes saturated, and if evaporation is to proceed this air must be replaced. This is done by continuously blowing air through the drier. This air conveys heat to the object and carries away the water that has vaporized. Increasing the temperature of the drying air causes a marked increase in the drying rate, and this is also true for increased air velocity. An idea of the effect of changing the intensity of these factors can be gained from the following comparisons, which are based on relations given in Tables 6 and 7. If, from a definite water surface and in a given time, air blowing at the rate of 250 feet per minute will evaporate 1 pound of water with the temperature of the air and water at 72°, then at a temperature of 132° 6.75 pounds will be removed; and if at this higher temperature the air velocity is increased to 1,000 feet per minute the amount of water evaporated will be 9.25 pounds.

Due to limitations set by the substance being dried, such increases in drying seldom are realized by bettering drying conditions. The temperature of the drying air may have to be kept low, so that the temperature of the substance itself will not rise to a point where undesirable changes take place or the substance may give up its moisture so slowly that the cost of maintaining a high air velocity will not be justified.

The amount of moisture in the drying air also has its effect on the drying rate. Except where modified by other influences, the higher the humidity the lower the drying rate.

TABLE 6.—*Relative evaporation rate from water surfaces, due to air motion* [1]

Air	Area of water surface	Rate of evaporation	Air	Area of water surface	Rate of evaporation
Still	25 square feet	1.5	1,000 feet per minute velocity.	Any area	4.8
250 feet per minute velocity.	do	3.5	2,500 feet per minute velocity.	do	8.1
800 feet per minute velocity.	Any area	4.5	4,000 feet per minute velocity.	do	12.6

[1] From "High-Temperature Drying." By Burt S. Harrison. American Society of Heating and Ventilating Engineers' Guide for 1922, p. 50. New York.

TABLE 7.—*Relative evaporation rate from water surface, due to heat* [1]

Temperature of water and air, °F.	Relative rate of evaporation	Temperature of water and air, °F.	Relative rate of evaporation
32	1	132	27
52	2	152	44
72	4	175	71
92	8	195	135
112	16	212	165

[1] From p. 51 of paper referred to in Table 6.

An effect known as "casehardening" frequently is encountered in drying substances that give up their moisture slowly. This is brought about by such rapid drying of the surface of the material that further drying is hindered. This usually is prevented by using high-humidity air.

Since the nature of the material to be dried has its influence on the method and rate of drying, it is important to consider partial dehydration of fish with this idea in mind. The fish are usually taken out of the brine or steam chest and placed in the drier. These fish are covered with more or less free water, which is removed easily. The rest of the water, however, is within the cells that make up the flesh of the fish. This water must reach the surface and vaporize before it can be removed. In fact, water not only has to reach the surface of the fish, but, after vaporizing, it must pass through a stationary film of air surrounding the fish. The water passes through the fish and water vapor through this film of air by a process known as "diffusion." The rate of diffusion is slow, but it increases as the temperature of the fish is raised. Decreasing the thickness of the air film also increases diffusion. It likewise increases the rate of heat transfer from the air to the fish, because heat also must pass through the film. The thickness of this film of air is decreased as the air velocity over the fish is increased. However, if the rate of diffusion is slow, increased air velocity will have little effect in increasing moisture loss other than that brought about by greater heat transfer to the fish at the higher velocity.

The more technical aspects of drying will not be discussed here, nor will a review of the literature on drying (which is large) be taken up.[43] Much research has been carried out on air drying in connection with the chemical and allied industries and in the fruit and vegetable dehydrating field. Many of the papers deal with the reaction of various substances to varying drying conditions and may include a discussion of the principles of air drying. Others discuss drier design, a subject treated but briefly in this article. Some experimenting on rather complete moisture removal has been done, but apparently no study has ever been made of partial dehydration of fish as applied to the sardine-canning industry. This problem will be shown to be somewhat different from more complete dehydration.

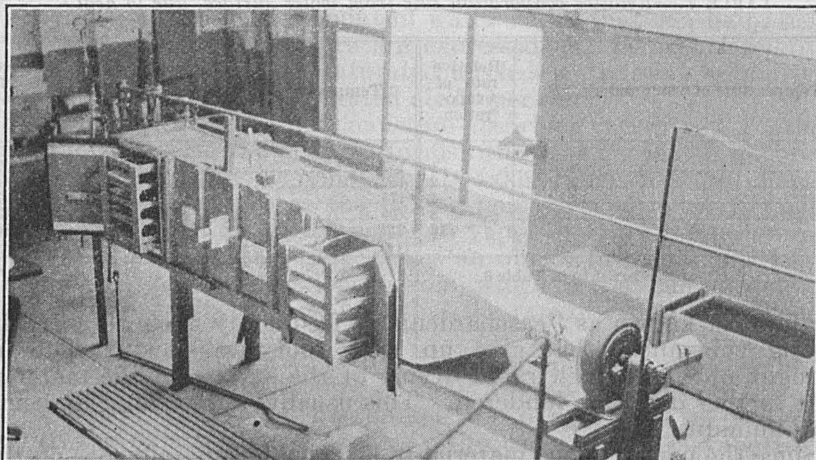

FIG. 22.—Experimental drying equipment

THE PROBLEM

The problem with respect to partial dehydration of raw and steamed fish for canning as sardines is, first, to determine, by experiment, the behavior of the fish under different drying conditions. With these data in hand, and having determined just what the function of drying is in the different methods of preparing the fish and the extent to which it should be carried out, one will be able to apply that which is already known on air drying to improving and cheapening this important step.

[43] The technical side of air drying is thoroughly covered in the following papers and books: "The rate of drying solid materials." By W. K. Lewis. Journal of Industrial and Engineering Chemistry, vol. 13, pp. 427–432. Easton, Pa., 1921. "The theory of atmospheric evaporation with special reference to compartment driers." By W. H. Carrier. *Ibid.*, pp. 432–438. "The compartment drier." By W. H. Carrier and A. E. Stacey, jr. *Ibid.*, pp. 438–447. "Tunnel driers." By Graham B. Ridley. *Ibid.*, pp. 453–460. "High-temperature drying." By Burt S. Harrison. American Heating and Ventilating Engineers' Guide for 1922, pp. 49–60. New York. "The temperature of evaporation." By W. H. Carrier. *Ibid.*, pp. 61–82. "Principles of chemical engineering." By William H. Walker, Warren K. Lewis, and William H. McAdams. Chap. XVI. New York, 1923. "Industrial drying, the apparatus and how it works." By Lucien Buck. Chemical and Metallurgical Engineering, vol. 29, pp. 626–631. New York, 1923. "Fan Engineering." By W. H. Carrier. 2d ed. Buffalo, N. Y., 1925.

EXPERIMENTS

The drying apparatus used in the experiments is shown in Figure 22. Its operation is described and the procedures followed in the experiments are given in the Appendix (pp. 191 and 192).

MOISTURE REMOVED FROM RAW AND STEAMED FISH BY DIFFERENT DRYING CONDITIONS

The factors influencing the drying rate of an object are the humidity and temperature of the air, its effective velocity, and the physical and chemical properties of the substance being dried. These factors, then, are the ones that must be studied with respect to the partial dehydration of raw and steamed fish. By varying one factor and making the others (including the fish, as nearly as possible) constant it is possible to get an idea of the effect of each. Many valuable data were obtained from experiments of this nature.[44]

These data show that increasing the temperature of the drying air brings about a marked increase in the amount of water removed from both raw and steamed fish, and this is also true to a lesser extent for increased air velocity. These results were expected. Increasing the amount of moisture in the drying air, however, gave somewhat unexpected results, in that this caused but little decrease in the rate of moisture removal, provided the humidity was not raised enough to cause some condensation to take place on the fish. It is evident from these experiments that moisture diffusion is so slow that even with high-humidity air the drying effect at the surface of the fish is sufficient to remove the water as rapidly as it comes to the surface.

Considered from the standpoint of time, moisture removal, in partially drying the fish, is relatively rapid at first, after which it declines to a more nearly uniform rate.

Under similar conditions steamed fish lose water more rapidly than raw ones. The flesh of steamed fish has been cooked, and this destroys its cellular structure, freeing water and making the fish much more porous. Therefore, moisture diffusion, being easier, takes place more rapidly. With steamed fish, too, greater advantage can be taken of the more rapid diffusion at higher temperatures. The danger of harming cooked fish by overheating is not so great as with raw ones.

RELATION OF SIZE TO THE DRYING RATE

Drying conditions being equal, small fish lose water more rapidly than large ones. Small fish offer, per unit of weight, a greater surface from which evaporation can take place than do larger ones. Further, diffusion in small fish takes place more readily because, being small, they heat quickly and the bulk of the moisture is nearer the surface in small fish than it is in larger ones.

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[44] Table 35, p. 193, contains all the data.

TEMPERATURE OF THE FISH AS A FACTOR IN DRYING

The temperature of the raw fish is an important factor in drying. It is of importance from the very beginning of the operation. The fact that higher fish temperatures increase the drying rate by hastening moisture diffusion has already been noted. Acting against this favorable result are the undesirable changes that take place in the fish if they are heated too much. In such a case the flesh softens, and if the fish are fat oil is rendered. Even partial cooking may take place. It is necessary, then, to know something concerning the conditions under which these changes take place if they are to be avoided.

Effect of air temperature upon the condition of the fish.—Raw fish usually have about the temperature of outdoor air when placed in the drier. In the drier warm air strikes them and gradually raises their temperature almost to that of the drying air. Evaporation of water retards this heating by using much of the heat taken up by the fish. In Table 8 are given data that illustrate changes in temperature when large pilchards are dried at different temperatures and the effect of heat upon the fish.[45]

In actual practice the fish behave quite similarly to the way they did in the experiments covered by Table 8. Most canners do not want the fish to soften much or become oily during drying, consequently they seldom employ a drying temperature greater than 110°. A few, however, shorten the drying time to about 30 minutes and use air at slightly higher temperatures.

Experiments indicate that the undesirable changes take place rapidly only after the fish attain a temperature of 95° to 100°. Good-quality, large, fat pilchards can be dried with air having a temperature up to 95° for at least 3 hours without bad effects. An hour at 105° to 110° and 30 minutes at 115° to 120° are about as long as the fish can be heated at these temperatures without much change. These statements should be approximately true for air velocities of about 500 to 1,500 feet per minute.

TABLE 8.—*Temperature rise in large, fat, California pilchards, and the effect of heat on the condition of the fish*

Experiment No.	Air temperature, ° F.	Air velocity, feet per minute	Temperature of fish, ° F.[1] (time in minutes)					Condition of fish	
			Start	30	60	90	120	End of 1 hour	End of 2 hours
102b	95	634	-----	-----	-----	-----	-----	Firm	Firm; very little oil rendered.
103a	95	602	60	80	90	92	93	do	Do.
103b	105	616	61	-----	100	102	103	Good condition	Softened somewhat; some oil rendered.
104c	105	602	63	94	-----	102	103	do	Do.
102a	115	602	-----	-----	-----	-----	-----	Softened somewhat; some oil rendered.	Soft; oil rendered.
103d	115	580	62	100	109	112	112	do	Do.

[1] Taken about ⅛ inch under the skin at thickest part of body—"cut" fish used.

The softening that takes place probably is brought about mainly by autolytic changes in the flesh of the fish.

[45] More complete data on changes in temperature are given in the Appendix (p. 203).

Cause of slow drying on rainy days.—Driers handling raw fish at times show a marked diminution in their ability to dry the fish satisfactorily. This usually takes place on a rainy day, and the claim is always made that there is too much water in the air for good drying. This is not a logical explanation, because the experiments have shown that the amount of moisture in the drying air has little effect upon the drying rate of fish that are being partially dehydrated when there is no condensation on the fish. Further investigation showed that the slackening in drying referred to here is brought about by fish entering the drier at a lower temperature than the dew point of the drying air. The dew point of the air in the drier can be no higher (and it may be lower) than that of the air outdoors when it may be raining and the temperature is at, say, 60°. This outside air is saturated with moisture at this temperature; its dew point is 60°. This air may be heated, but its dew point will still remain at 60°. Now, if this air strikes fish that have a temperature of 50° it will not remove water from them; in fact, some small part of the air will be cooled to a temperature below its dew point, and water will condense upon the fish. In a few minutes, however, the warm air striking the fish will raise their temperature above 60°, and then evaporation will commence.

Where the drying time is short (say, 30 to 45 minutes) and the temperature of the drying air is low (95° to 100°), and where perhaps the velocity also is low (500 feet per minute), the slackening in drying is considerable. Under such conditions (they prevail in many commercial installations) it takes a good many minutes to heat the fish to a temperature where drying can take place.

When confronted by such circumstances as these, the operator usually raises the temperature of the drying air until he gets the results ordinarily attained in the usual length of time. This works quite well, because the higher temperature heats the fish quickly and tends to cause more rapid drying. Another way to get around this difficulty is to see that the fish that enter the drier have a temperature high enough to prevent moisture from condensing upon them. The temperature of the fish can be raised easily, when they are brined, by warming the brine before it is placed on the fish. This worked nicely in small-scale experiments and should do likewise with large quantities of fish. The temperature of the brine must not be too high, however, because this tends to soften the fish; nor should the fish enter the drier at too high a temperature. In this case additional heating by the air causes the fish to soften too much. This difficulty was encountered when an attempt was made to hasten drying by first heating the fish with warm brine, so that moisture diffusion would be rapid from the very beginning of the drying period. The more rapid diffusion brought about in this way, however, caused greater moisture loss from the heated fish.

Recirculation of the drying air.—The amount of air leaving the drier, which may be used again, depends largely upon the temperature of the entering fish themselves. It has just been shown that when the temperature of the fish entering the drier is below the condensation point (dew point) of the water vapor in the drying air drying is delayed. When this condition exists, it is inadvisable to recirculate any of the exhaust air, as it would increase the moisture content of the drying air and slacken drying still further. Most of the time such conditions do not prevail and it is possible to use part of the air again.

It is safe to return to the fan and through the drier a little less air than an amount that, when added to fresh air, will cause condensation on the fish. In practice it is easy to regulate recirculation by observing the fish and cutting down the amount of air returned to the fan if there is any slackening in the drying. Although recirculation increases the humidity of the air, it will have little effect on the drying. Partial drying of the fish can be carried out about as well in air having a high humidity as in drier air, providing no condensation of moisture takes place on the fish.

Rapid drying has been shown to depend on vigorous circulation of as warm air as possible through the drier. In order to keep the temperature from falling much through the drier, a large excess of heated air is used. In the case of most driers now in use for partially drying fish for canning as sardines (and undoubtedly the same will be true for future installations), the air leaving the drier is still quite warm and has absorbed only a part of the moisture that it is able to take up. Operating costs can be lowered by recirculating as much of this air as possible.

COMMERCIAL SARDINE DRIERS

In the California industry accurate operating data were collected on most of the commercial sardine driers in use during the 1922–23 season. Many of these data are given in Table 9. It will be observed that drying conditions varied greatly and that temperatures from 75° to 120° and air velocities from 339 to 1,676 feet per minute were used. The drying time varied from 28 minutes to about 2 hours, with moisture losses on large fish running from 3.8 to 10.7 per cent. In all cases raw fish were being dried for cooking in oil, brine, or steam, and in each instance the skins were so conditioned that the fish cooked satisfactorily without undue breakage. These observations again call attention to the fact already discussed—that to prepare fish for cooking it is necessary only to toughen the skins of the fish and to remove a little water from them.

TABLE 9.—*Examples of operating conditions employed in several California sardine driers, season 1922–23*

Plant	Entering air temperature, °F.	Drop in temperature through drier, °F.	Velocity *in*, feet per minute	Velocity *out*, feet per minute	Time in minutes	Per cent loss in weight	Size of fish	B. t. u. of heat used per pound of fish handled
A[1]	119	10	1,360	904	28	3.8	Large "ovals"	399
B[2]	107	27	257	914	55	6.5	do	190
C[3]	96	4	1,676	781	35	4.7	do	820
D	120	23		519	70	6.0	do	556
E	75	10	1,503	532	105	10.7	Medium "ovals"	
F	97	15		488	120	9.4	do	
G[4]	109	24	339	321	90	3.4	do	
H	115	11		738	31	6.8	Small "ovals"	
I[5]	109	8		401	41	6.6	do	
J[6]	101	12	357		124	10.6	Large "quarter oils"	
K	102	6	1,445	833	75	6.1	Large "ovals"	

[1] Air for this drier was drawn from the fish-packing room. When these data were obtained, the dew point of the air entering the drier was 70° and the temperature of the fish entering the drier about 55°. The fish, therefore, had to be warmed in the drier to 70° before any drying took place. Had air from outside (the dew point of which was 55°) been used, drying would have commenced almost immediately.

[2] Fan drew air through steam coils, then over fish. More air was drawn in through cracks in the housing of the drier than entered through the steam coils.

[3] Cross section of this drier gradually diminished in size from where air entered to where it left. Leakage was so great through the drier housing that only 10 per cent of the air reached the far end of the drier.

[4] Too little air for the quantity of fish handled.

[5] Fully 20 to 30 per cent of the air being sent through this drier escaped through an open space where it could do no good at all.

[6] The method of handling the fish in this drier permitted but little of the large amount of air being handled to strike the fish.

These data on California sardine driers do not adequately describe conditions. They really are much worse than outlined, because account is not given here of wide variations in many other contributing factors. There are big opportunities for improvement in this field. These are covered in part in the next section, and the whole subject is thoroughly discussed later.

A great many data were not collected on the operation of sardine driers in Maine. Enough installations were examined and sufficient information obtained, however, to show that the knowledge gained from the California experiments can be applied to improving procedures and equipment in Maine. It is evident, too, that the opportunities for betterment are large. This subject is taken up later.

RAPID DRYING OF FISH BEFORE COOKING

Some one of the widely varying sets of conditions made use of by the California canners in preparing fish for cooking must be better than the rest, when judged from the standpoint of cost and results obtained. It is possible, too, that some new set of conditions might even be better for the purpose. This proposition was studied and a way found in which to prepare fish for cooking in much less time, and consequently with less equipment than previously. This result can be obtained by using vigorous air circulation, combined with higher air temperatures, than have been used for this purpose.

These conditions cause very rapid drying to take place. When they are used, however, it is necessary to shorten the drying period in order to prevent undesirable changes in the fish, such as softening and rendering of oil, due to the high air temperature used.

In the experiments a number of frying tests were run at different times during two seasons upon fish that had been prepared for frying by various drying conditions. Some information on these experiments is given in Table 10. These results furnish further evidence of the wide variety of conditions that can be used successfully to prepare fish for cooking in hot oil. They show, too, that higher temperatures and shorter times than those used by California sardine canners are practical.

When the air temperature is raised too high, the wires of the flake or moving apron become so hot that they cook the skin of the fish wherever they touch it. The marks made are quite prominent, and when the fish are placed in hot oil the sudden tension brought about in the skin tears it apart at these marks. No trouble was encountered from this source when the air temperature was around 140°. It is not advisable to use air having a temperature much above this, especially if the velocity is high. High air velocities intensify the effect of temperature, due to the greater heat transfer brought about. It is necessary, however, to use a relatively high velocity because this hastens drying.

TABLE 10.—*Frying tests with California pilchards dried under different conditions*

[Temperature of oil, 230° to 240° F.; time, 7 to 10 minutes]

Drying experiment No.	Size of fish	Air temperature, ° F.	Velocity in feet per second	Time in minutes	Per cent loss in weight	Notes on frying test
109c	Large "ovals"	115	646	30	3.5	Fried satisfactorily.
110a	do	150	623	15	3.5	Do.
110b	do	150	623	15	3.1	Do.
111c	Medium "ovals"	149	646	10	3.3	Do.[1]
111d	do	150	646	10	3.5	Do.
130a	Medium large "ovals"	140	900	15	3.9	Skins broke.[2]
130b	do	160	900	10	3.6	Fried satisfactorily.
130c	do	180	900	5	2.7	Do.
130d	do	200	900	5	2.9	Do.
131a	Medium "ovals"	170	900	10	3.2	Skins broke in hot oil, starting at flake marks.
131b	do	152	900	10	3.4	Do.
131c	do	142	900	15	4.3	Fried satisfactorily.
Feb. 14, 1924	Large "ovals"	160	1,400	12		Skins broke in hot oil, starting at flake marks.
Do	do	140	1,400	12		Fried satisfactorily.
Do	do	140	1,400	12		Do.
Do	do	140	1,400	12		Do.[1]

[1] Made good canned product. [2] Why some of the skins broke can not be explained.

In later experiments in connection with a new method of preparing the fish for canning considerable experience was obtained in toughening the skins of large and small California pilchards and Maine herring. In these experiments air having a temperature close to 140° and a velocity from 1,400 to 2,000 feet per minute was used, the time being 10 to 15 minutes. Excellent results were obtained with these conditions. Although none of the fish were fried, it was evident that they would have stood up well under such treatment.

DISCUSSION

In one respect the work upon drying was not successful—a way to dry fish rapidly for the raw-packing process was not found. In other ways, however, excellent results were obtained. The effects of various drying conditions upon raw and steamed fish undergoing partial dehydration were determined. This is important information, because without it the fundamental principles of air drying can not be applied adequately to bettering and cheapening processes and equipment.

This investigation, considered in connection with earlier studies, has furnished the basis for a new method of preparing the fish for canning. Undoubtedly this is the most important result of the drying research.

APPLICATION OF EXPERIMENTAL RESULTS

The principal reasons for the unsatisfactory conditions existing in the drying of fish prior to cooking are: (1) Uncertainty as to just what should be accomplished by the drying process, (2) the lack of information upon the behavior of the fish under various drying conditions, and (3) the designing of drying equipment by men unqualified for such work. Even competent drying engineers can not properly design equipment and devise processes without adequate information. This is now available.

Although the experimental results have not been published except in summarized form, they and the general subject of drying have been discussed with all California canners and many of the packers in Maine. Defects in equipment and procedures have been pointed out, and help has been lent in designing new driers. In many instances material improvements have come about in this way.

The experimental drying results obtained upon California pilchards apply equally well to Maine herring. For this reason correct application of these results should assist materially in preparing better quarter-oil sardines from steamed fish. It is especially important that the steamed fish be well dried before they are packed into the cans. In Maine the fact that vigorous effective air circulation is needed if drying is to take place rapidly is being realized, and changes are constantly being made toward this end.

The experiments have shown how both large and small fish can be prepared for cooking in from 10 to 15 minutes. Adoption of this procedure, along with the use of properly designed and operated drying equipment, should accomplish much toward bettering and cheapening the preparation of fish for cooking in hot oil or by some other method.

RECOMMENDATIONS

It is firmly believed that a canner's best interest will be served by having a qualified drying engineer's cooperation in planning and erecting drying equipment. This seems expensive, but in the end it is cheapest. Such work as this requires technical knowledge and experience that no canner or anyone in his employ is likely to have. Each installation usually is a problem in itself and more frequently than not requires special handling if satisfactory and efficient operation is to be attained. For this reason no attempt is made here to furnish detailed plans and specifications for a typical sardine drier. There are presented, however, in this paper sufficient data to enable engineers to design drying equipment for preparing fish for cooking in hot oil, hot brine, or steam. Information also is given that should enable a canner to operate such equipment with the best results.

The following recommendations of a technical nature are made regarding the equipment:

1. *Air velocity.*—About 2,000 feet per minute throughout the free spaces of the equipment.

2. *Air temperature.*—Desirable possible variation in entering air, 90° to 160°. Permissible drop in temperature under operating conditions when entering air at 150°, about 20°. Average operating temperature should be about 140°.

3. *Air quantity.*—Sufficient to meet conditions imposed in 1 and 2.

4. *Drying time.*—Fifteen minutes; means to be provided for varying speed of conveyer so that time can be varied from 10 to 30 minutes as desired.

5. *Heat supply.*—Any approved method of heating the air is satisfactory, the cheapest to install and operate being preferred. Direct products of combustion from gas and oil fired furnaces operating without smoke are satisfactory.

6. *Type of equipment.*—Similar to the regular California "multi-apron" drier described elsewhere in this publication. In passing from one "apron" to another a fall of 8 to 10 inches or less is satisfactory for pound-oval size fish. Means should be provided for recirculating some or almost all of the air that leaves the drier, as desired, same to be easily controlled.

7. *Weight of fish per unit of drying surface.*—Assume that each square foot of wire screen surface in use at any one time for holding fish will handle 1.8 to 2 pounds of "cut" fish. (See p. 155.)

It will be necessary for the canner to furnish data upon the size (if different than given above) and quantity of fish to be handled per hour, the space available for the drier, and the manner in which the fish are to be handled to and from the drier.

It is not advisable to attempt to outline detailed instructions for preparing the fish. Their size and condition and other factors are constantly varying. To meet this variation changes must be made in drying conditions. Just what to do under the various circumstances must be learned by experience. In general, however, the air velocity and temperature used should be as high as possible, so that the drying time can be reduced to a minimum. The air velocity can not be increased much above 2,000 feet per minute without encountering difficulty from the fish being blown about. Caution must be used in raising the temperature of the air. If the wires touching the fish get too hot, they tend to cook the skins, and when these fish are placed in hot oil the skins will break badly. Little trouble will be met if the air temperature does not rise much above 140°. As much of the air leaving the drier as possible should be recirculated, otherwise there will be excessive heat losses.

The efficiency and capacity of driers now in use can be increased greatly by making such changes as will permit the drying conditions recommended above to be realized. I have never examined a commercial sardine drier that prepares fish for frying in oil that could not have been changed so as to prepare at least twice as many fish per unit of time as it was preparing. In some cases it would have been necessary only to have increased the air temperature and the speed of the conveyers; in others extensive improvements would have been necessary. The cost of these, however, would be much less than to have to purchase additional equipment when production has to be increased.

Often the packer himself can do much by studying his drier in the light of the information given in this paper and by making such changes as he can. In general, however, where present operation is very unsatisfactory or where production is to be increased materially it will pay to get the assistance of a drying engineer to make or at least point out the changes that should be made.

The above recommendations apply equally to small and large California pilchards or Maine herring, where these are to be dried prior to being cooked.

Fish that are first steamed and then dried can not be tumbled after being cooked. It is necessary for them to be dried on the flakes on which they were cooked. In Maine, where this procedure is practiced, the trucks containing the flakes are run into the drier, and there the fish are subjected to the action of moving warm air. This procedure, as now practiced, undoubtedly can be improved greatly. The drying time can be shortened and the labor required for handling trucks can be lessened. The best drying conditions should be determined and used in a continuous type of truck drier. It is not possible to make definite recommendations upon these points without first carrying out some research along these lines. It was not advisable, however, to spend time on this work. Although better procedures undoubtedly could be worked out, it would only be found that the fish could not be prepared as well or as quickly as by the new process described in detail in the next section of this document.

Much can be done to improve the drying qualities of units now operating in Maine by increasing the air velocity and in many cases the temperature. The air velocity, however, must be effective; that is, the air should go between the flakes, where it can strike the fish. These changes will bring about better drying and probably permit the drying time to be shortened considerably.

If a new drier for handling steamed fish should be built, a drying engineer should be engaged to design the equipment. His work will include a small amount of research to determine the best set of drying conditions. It would be much better, however, to install a combined cooker and dryer for carrying out the new process mentioned above and to cook and dry at the same time.

NEW PROCESS FOR PREPARING THE FISH

GENERAL CONSIDERATIONS

Research up to this point clearly showed that the preparation of the fish for canning consists mainly in removing excess water and in getting the fish into good physical condition for canning. The process should add to the fish no objectionable foreign element nor should it remove valuable substances from them. In general, aside from removing blood by brining and distribution of salt throughout the fish by this method, that process of preparation that comes nearest to removing only water from the fish is best.

In addition to considerations as to quality of the product, there arises, of course, the important question of production costs. These, if possible, should be lowered.

Frying in oil, as now practiced, adds objectionable oil from the fry bath to the final product, unless the oil in the fry bath is changed frequently, and the cost of doing this as often as is advisable is prohibitive. Frying also removes considerable oil, salt, and soluble extractives from the fish. The loss of these valuable substances is especially high when fish are steamed. Fish are also likely to break up more or less during the steaming operation. In Maine it is generally conceded that steaming detracts from the quality of the fish.

Research has shown how improvements can be made in these two processes. It has not shown, however, how the difficulties mentioned can be eliminated. Other processes do not have these difficulties, but they do not offer sufficient other advantages over present practices to enable them to supplant those now used in Maine and California.

In the first paragraph of this section an outline was given of what should constitute an ideal process for preparing the fish. As far as quality goes, the raw-packing process comes nearest to meeting these demands, both from a theoretical standpoint and from the results of experiments when applied to the preparation of fish for the pound oval pack. The process falls down otherwise; it takes too long to remove the necessary water from the fish. Drying research indicated that this time can not be shortened materially. Other information gained from this study, with that from the other investigations, did point the way to a new process[46] for preparing the fish, which not only lacks the disadvantages of frying in oil and steaming but possesses a number of commercially important advantages over the old methods. This new process is discussed first from a theoretical standpoint.

HIGH-TEMPERATURE, HIGH-VELOCITY AIR AS A MEANS OF PREPARING THE FISH

Air-drying is accomplished in the following manner: Moving warm air striking the fish furnishes the heat needed to vaporize the water and then carries this water vapor away. After surface water is vaporized more can be removed only after it has diffused from within to the surface. It will thus be seen that the rate of moisture loss depends upon how rapidly this diffusion takes place. The higher the temperature of the fish the more rapid is the diffusion. The obvious thing to do, then, to bring about rapid drying, is to heat the fish as quickly as possible to as high a temperature as is practicable and to keep this temperature until the desired amount of water has diffused from the fish and been removed by the current of air. The rapidity of heating depends on the rate of heat transfer

[46] This process is covered by the following patents: United States No. 1553290, Sept. 8, 1925; Spain, No. 15335, May 27, 1925; France, No. 597059, Nov. 12, 1925; Portugal, No. 14135, Nov. 26, 1925; Canada, No 260084, Apr. 27, 1926; and Great Britain, No. 241169, Nov. 30, 1926. Norwegian patent allowed (application No. 32745, Apr. 7, 1925) but no patent number yet available.

from the air to the fish. Rapid heat transfer can be induced by making the temperature difference between the fish and the air large and by using high-velocity air to decrease the thickness of the stationary film of air surrounding the fish. Thinning this film not only increases heat transfer but facilitates moisture removal. Therefore, air having as high a temperature and velocity as practicable should be used. Temperatures sufficient to cook the fish can be used, and this also aids drying, because cooking liberates water from the cells of the fish and makes its removal easy. Due to the excellent drying conditions that prevail at the surface of the fish, the tendency is for the water to evaporate immediately and leave soluble products behind. This should keep the skin tough and dry, so that relatively small losses of juice and oil take place. While the fish are being cooked it should be possible to smoke them lightly simply by adding smoke to the drying air. The smoking effect should be accelerated by high air velocities in the same way that heat transfer is accelerated.

Hot fish must be cooled before they can be packed in the cans. It should be possible to do this quickly and effectively by blowing cool, outdoor air over them. Such air will take away heat from the fish in proportion to its velocity and coolness; therefore, the temperature should be as low and the velocity as high as practicable. It will now be shown how well this theory works out in practice.

EXPERIMENTAL PREPARATION OF CALIFORNIA PILCHARDS

Experiments with the new process, as applied to the preparation of California pilchards for canning, were conducted throughout the 1923–24 sardine season, first in a small way in the laboratory and later on what may be termed a fairly large scale. Near the end of the season's work, during the period March 10 to 15, 1924, the process was demonstrated to those canners who accepted a general invitation given for this purpose. A small amount of additional experimental work was done in Monterey in December, 1924.[47]

EQUIPMENT AND PROCEDURE

The first experiments were carried out in the drier that had been used in the drying experiments. (Fig. 22, p. 120.) In order to get a temperature high enough to cook the fish all the air in the drier was recirculated continuously. Heat was furnished by steam coils, over which the air passed, and by gas flames placed under the pipes leading to the tunnel and from it to the recirculating duct. In this way air temperatures up to 222° were obtained.

Cooling the air was accomplished by turning off all heat and sending air at room temperature through the drier, none of which was recirculated. Cooling was slow, due to so much heat being retained by the drier itself. Later experiments were carried out with the cooker, drier, and cooler shown in Figure 23. The products of combustion from a gas-fired furnace were drawn by suction from the fan through a pipe (*A*) leading to the air-mixing chamber (*B*). A slide on top of the mixing chamber (*C*) allowed as much cold air as desired to be drawn into the fan and mixed with the hot air. The fan for handling

[47] Detailed data covering the experiments are given in Table 42, p. 204.

cold air is also shown. In this apparatus 8 flakes of fish could be cooked and 12 cooled at one time.

In the experiments with the small equipment only enough fish to fill a pound-oval can could be prepared at one time. In the experiments with the larger equipment one flake (30 by 30 inches), holding about 10 pounds of "cut" fish, usually was used, although frequently 3 to 6 such flakes were cooked. The fish were weighed before and after drying, precautions being taken to see that similar samples were used wherever comparisons were being made.[48] The fish used were cut and brined at one of the canneries, and the packs were exhausted and processed in the same place. Usually cans of the fried-in-oil pack prepared in the canneries from the same lot of fish were

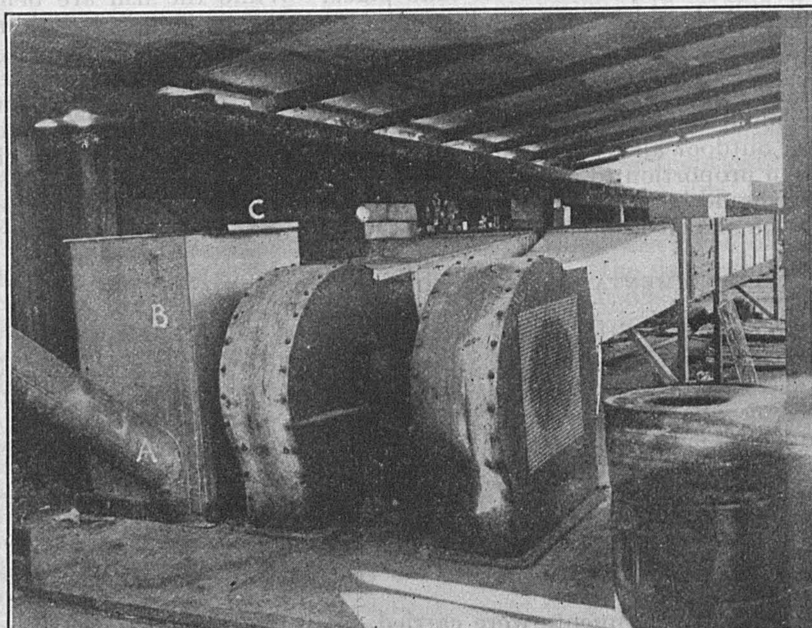

Fig. 23.—Air-mixing chamber, fans, and housing, California experimental cooker and cooler

obtained for comparison purposes. Unless a statement to the contrary is made, the discussion here refers to the preparation of large fish for the pound-oval pack.

DETERMINATION OF THE BEST CONDITIONS FOR PREPARING THE FISH

The first experiments were made with the idea of learning the practicability of preparing the fish in the manner proposed and of determining how much water should be removed from them. In preparing the raw packs a moisture loss of 8 to 10 per cent gave good results when fat fish and thick sauce were used. In those experiments it would have been better, however, to have removed more water from the fish. In the experiments with the new process it was soon learned that a loss in weight of 13 to 16 per cent (exclusive

[48] In general, the same precautions were taken as in the drying experiments. See pp. 191-192.

of brining) was sufficient. Large-oval fish that lost 15 per cent in weight during preparation gave up no more water when sterilized than did the regular run of fried-in-oil fish.

The preliminary experiments showed that the process offered much promise and that it produced an excellent product. Research was then directed to the determination of the best and most practical conditions for removing the necessary amount of water from the fish.

The factors influencing moisture loss are the same as those discussed in the drying experiments, namely, air temperature, velocity, and humidity, as well as the size of the fish and the time of exposure to the drying air. The results of experiments involving these factors are discussed below.

Air temperature.—The effect of increasing the air temperature upon loss of moisture is well illustrated by the results given in Table 11.[49] According to these results, and assuming that 13 to 15 per cent loss in weight is sufficient for a good oval pack, it takes about four times as long to prepare such fish for canning at 175° and twice as long at 220° as at 307°. Still higher temperatures dry the fish more rapidly, as shown by the loss at 392°. Such temperatures as this, however, proved unsatisfactory because the fish browned and stuck to the flake excessively and much oil was rendered, which then oxidized badly. With an air velocity of about 1,300 feet per minute, satisfactory results were not obtained at temperatures much above 300° to 325° for oval-sized fish. This range of temperatures proved best in the experiments. Undesirable changes in the fish were not excessive, yet the advantage of rapid moisture removal was obtained.

TABLE 11.—*Loss in weight of medium "pound-oval" pilchards in air at different temperatures. Velocity 1,300 feet per minute*

Experiment No.	Air temperature, °F.	Time in minutes			Experiment No.	Air temperature, °F.	Time in minutes		
		15	30	60			15	30	60
150a	175		8.2	13.4	150c	220		13.5	22.0
150b	200		11.2	17.4	168a	307	14.5		
160b	210	6.3			157c	[1] 392	20.0		

[1] Air velocity 1,000.

The results attained at various temperatures depend to a considerable extent upon the air velocity.

Other factors.—The effect upon the moisture loss of increasing the air velocity, the temperature remaining constant at 325°, is illustrated by the following losses in weight brought about in 15 minutes in large oval-size fish by the stated air velocities: 600 feet per minute, 9.7 per cent; 1,400 feet, 13.7 per cent; and 2,000 feet, 14.4 per cent. The fish subjected to the lowest velocity were not as well cooked as the others, showing that heat transfer had not been as great in that case as in the others. Further work was not done along this line with California pilchards. The experiment was repeated, however,

[49] Selected from Table 42, p. 204.

with Maine herring and yielded similar results. The results to be obtained from high air velocities are too well known to require more than confirmation here.[50]

Inasmuch as drying is being accomplished at temperatures above the boiling point of water, the amount of water vapor (steam) in the drying air will have little effect upon the rate of moisture loss from the fish. It has already been shown that increasing the humidity of the air has little effect upon the drying rate of fish that are being partially dehydrated, provided no condensation takes place on them.[51]

The following data from experiments 156b to 156e, Table 42, p. 208, illustrate the effect of time upon moisture removal from large, fat, oval-size pilchards by air having high temperature (300°) and velocity (1,400 feet per minute): 10 minutes, 12.3 per cent loss in weight; 15 minutes, 18.8 per cent; 20 minutes, 20.5 per cent; and 30 minutes, 25.3 per cent. In these experiments the fish cooked 30 minutes, browned, and stuck to the flake excessively. Other experiments showed that 15 minutes is about as long a time as is advisable to subject large "ovals" to an air temperature of 300° to 352°. However, more time can be used if the temperature be lowered. Air velocity has its effect, too, as high velocity tends to intensify temperature effects.

Small fish naturally dry more rapidly than larger ones. They heat through more rapidly and consequently are affected by the application of heat to a greater extent than are larger fish. It was necessary, therefore, to use lower air temperatures for quarter-oil fish in order to keep them from browning and sticking excessively. The subject of correct procedures for quarter-oil fish is discussed under the Maine experiments.

Sticking of fish to flakes and to each other.—In preparing the fish they had a tendency to be marred by the flake upon which they were cooked and to stick both to the flake and to each other. During cooking the fish softened and the weight of the fish pressed the skin firmly against the hot wires of the flake. Large fish, of course, were pressed more firmly than small ones, and they actually did mar to a greater extent. The gluey substances in the skins dried and caused them to stick to the flakes and to each other. Fat fish did not stick as much as lean fish, and when the flake was oily this helped materially to prevent sticking, as did the use of clean flakes. The higher the air temperature used the greater was the tendency of the fish to stick.

When the flakes of fish were removed from the cooker, and also from the cooler, it was noticed that the fish usually had a tendency to stick to the flakes more than after they had stood for a short time. This behavior can be explained as follows: When the fish are removed from the current of air in the cooker their surface is dry. However, water continues to diffuse to the surface of the fish, where it is not removed as readily as it is when they are in the current of air, and this water softens the gluey substance that holds the skins to the flake. This

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[50] See the discussion on moisture diffusion, p. 119, also Table 35, p. 103. If the results shown here are compared with moisture losses for similar velocities at lower temperatures, it will be noted that at the higher temperatures, where diffusion is relatively rapid, the effect of increased air velocity on moisture loss is more pronounced than at the lower temperatures.

[51] See the discussion on p. 121. Experiments 137a and 138a, Table 42, p. 204, furnished additional evidence at a higher temperature.

softening effect is particularly noticeable when the relative humidity of the air is high.[52]

The question naturally arises as to how serious this sticking proved to be. Experiments were carried out with the new process throughout the 1923–24 season in San Pedro without special precautions being taken to prevent sticking other than to use relatively clean flakes. It was necessary, however, to place the fish on the flakes so that they did not touch each other. Under these conditions neither breakage nor marring from the flakes was particularly serious, except at the very end of the season, when very lean fish were cooked. There was some breakage (at times more than others), but on the whole it was little greater, if any, than that which occurred with fried fish. Even should breakage be more pronounced than with fried fish, this should detract but little from the selling quality of the final product. An occasional flake mark is less objectionable to most people than the presence of "old" frying oil.

It was found that the sticking of lean fish to the flakes could be prevented by toughening the skins of the fish by drying in the same way as the skins are toughened for frying in oil. This was done by treating the fish with air that had a velocity of about 1,400 feet per minute and a temperature of about 140° for nearly 10 minutes. At the end of about six minutes the fish were shifted about on the flake so that the part in contact with the wires would have a chance to dry; otherwise, toughening the skins would have done little or no good. This treatment virtually eliminated sticking, both with medium "ovals" and quarter-oil fish. In fact, it was unnecessary to place these fish on the flake so as not to touch, as they tended to stick to each other but slightly. These experiments were carried out at the end of the sardine season in San Pedro, when fat fish or even those with a small amount of fat are seldom to be found. It was not possible, therefore, to try the effect of drying upon fat fish at that time. In experiments the following season at Monterey dried fat fish behaved about the same as untreated fish. It seems as though drying is really helpful only with very lean fish. Further experiments were not carried out. The experimental results reported upon here and their application are discussed in a later section.

Drippings from the fish.—During cooking a small amount of juice and oil (if the fish are fat) drips from the underside of the fish, where they are in contact with the flake. Drying is not so efficient there, and gravity also tends to concentrate any free liquor at that place. Dripping was more pronounced with large fish than with small ones. This is natural, as large fish contain, in proportion to their size, as much water as small ones but less surface, per unit of weight, from which water can evaporate.

It was more pronounced, too, when the fish were very fat and had been "cut." In any case, however, the amount of protein and oil lost in this way was small. The excellent drying conditions that prevail virtually all over the fish cause water to evaporate as soon as it reaches the surface and leave the dissolved substances behind. One naturally would expect the loss of oil from fat fish, cooked by the new process, to be large. It is not, however, because the action of

[52] Although the following procedure is not recommended, being unnecessary, it would be possible to humidify the air used for cooling the fish in order to minimize sticking. There is one drawback, however—fish cooled in this way would be slightly sticky to handle.

the hot air draws the skin tightly about the flesh and holds the oil under it.

Although the drippings were small in amount, they caused trouble. They fell on the fish below and dried, leaving unsightly marks. The protein, including blood, left dark stains. The oil dried (oxidized) in the sense that paint does, turning dark in color. In fact, it actually baked on the skin as enamel is baked on an automobile fender in an oven. Some fat fish, upon which the marks were quite pronounced, did not lose the marks very soon after canning. At the end of a year, when examined, most of the marks had disappeared, but the oil in the can showed that the dark oil had mixed to some extent with the light yellow oil from the fish.

It was a simple matter to prevent these difficulties. A drip pan was placed under the fish and this protected those below.

Cooling.—In the experiments large "oval" fish, direct from the cooker, always were cooled sufficiently to be handled for packing in 15 minutes, when placed in the large cooler and treated with outdoor air having a velocity of about 1,400 feet per minute and a temperature ranging from 65° to 80°. In experiments 159a and 163a fish were cooked, cooled in this way, and given to a girl to pack as they were removed from the cooler. No difficulty was encountered.

QUALITY OF PRODUCTS

Fish prepared by the new process were excellent, both before and after canning. Their physical condition was equal to and their appearance and taste better than the general run of fried fish. The bad effects that frying in "old" oil has upon quality were absent, of course (p. 104). These conclusions were drawn from the results obtained from at least 95 different cooking experiments spread out over the entire 1923–24 sardine season in San Pedro, Calif. A few lots were also prepared in Monterey during the next season. The fish from 40 of these experiments were canned, and of this number 27 were compared with commercial packs of fried fish put up in a regular sardine cannery from the same lots of fish as were used in the experiments. In one experiment enough fish were prepared to make 304 cans and in another 289 cans.

Most of the work was done upon the preparation of fish for the pound-oval pack. Of the experiments, however, 10 were upon fish for the quarter-oil pack, 5 lots of which were canned. These experiments were very successful and show the possibilities the new process holds out to producers of quarter-oils in California.

In one experiment fillets from large, oval-size, fat fish were used. They cooked rapidly, lost much water, and were excellent, except for two drawbacks. The exposed flesh darkened and the oil, not being held in the fish and protected by the skin, oxidized considerably. This oxidized oil gave a sort of "biting taste," which persisted when these fish were canned. It was more pronounced when the fish were canned in oil than in tomato sauce. The latter seemed to mask the taste considerably. Lowering the air temperature, although it did not prevent oxidation, bettered matters.[53]

[53] Part of the information given in this paragraph was obtained from some experiments not reported upon here. It would be possible to blow over the fish air from which most of the oxygen had been removed by combustion. Oxidation could be kept at a minimum in this way, and this should give a better product.

The darkening of exposed flesh mentioned above also took place with "cut" fish where the head had been removed from the body. The darkening was more pronounced than with fried fish. It was not, however, objectionable. One would hardly notice the difference in the canned product.

STORING AND SHIPPING QUALITIES OF THE PACKS

Prior to the time work was begun upon the new process enough had already been learned from experiments on the storing and shipping qualities of pound-oval sardines not to require similar tests with packs prepared by the new process. The physical condition of the fish when packed was excellent. It has already been shown that, so far as the shipping and storing qualities of a pack are concerned, it makes little difference by what process it is prepared, providing it is properly prepared.[54] However, a good test of the new process has been made. Many of the packs so prepared have now (October, 1926) been in storage over two and one-half years and have been shipped by boat from San Pedro, Calif., to Washington, D. C. Results have been entirely satisfactory; all the packs have stood up as well as those prepared by the frying process.

EXPERIMENTAL PREPARATION OF MAINE HERRING

Experiments were carried out in Maine during September, 1924. From September 22 to 26 the process was demonstrated to those canners who took advantage of a general invitation given for this purpose.

It was not necessary for the work to be extensive in Maine, as the process had been given a thorough trial and the groundwork laid in California. What was needed was to prove that the process was suitable and practicable for preparing Maine herring for the quarter-oil and three-quarters mustard packs and to determine the best conditions for doing this. A discussion of the general results obtained from the experiments follows.[55]

EQUIPMENT AND PROCEDURE

The equipment used is pictured in Figure 24. Heat was furnished by a bed of glowing coke. The suction of the fan drew the products of combustion from the furnace into a small mixing chamber, where they mixed with cool air and were then blown through the tunnel over two flakes (30 by 30 inches) placed one following the other. A damper in the pipe leading from the furnace to the mixing chamber controlled the amount of furnace gases that were drawn into the mixing chamber. Another damper on top of the chamber allowed mixture of as much cold air as was desired, and another between the chamber and the fan controlled the quantity of gases entering the tunnel. These controls permitted the use of air at any desired temperature and velocity up to the capacity of the fan.

Smoke for smoking the fish was made from hardwood sawdust in a box back of the fan. The flue from this box was placed over the

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[54] See pp. 114-115.

[55] Detailed data are given in Table 42, p. 204.

cold-air entrance to the mixing chamber, where suction from the fan drew in the smoke. It then mixed with the hot air and was blown over the fish.

The other fan forced cool outdoor air through the other tunnel, which was used as a cooler. A damper on the inlet side of the fan controlled the quantity of air entering the fan and tunnel.

The two flakes together handled about 10 to 20 pounds of fish, according to their size and how thickly they were spread out. The fish were obtained from the canneries and had already been brined. They were weighed before and after drying, precautions being taken to see that similar samples were used wherever comparisons were being made. After cooking, the fish were compared with some of the same lot prepared in the cannery by the regular steaming process. After canning and processing, which was done in the cannery, the products were again compared.

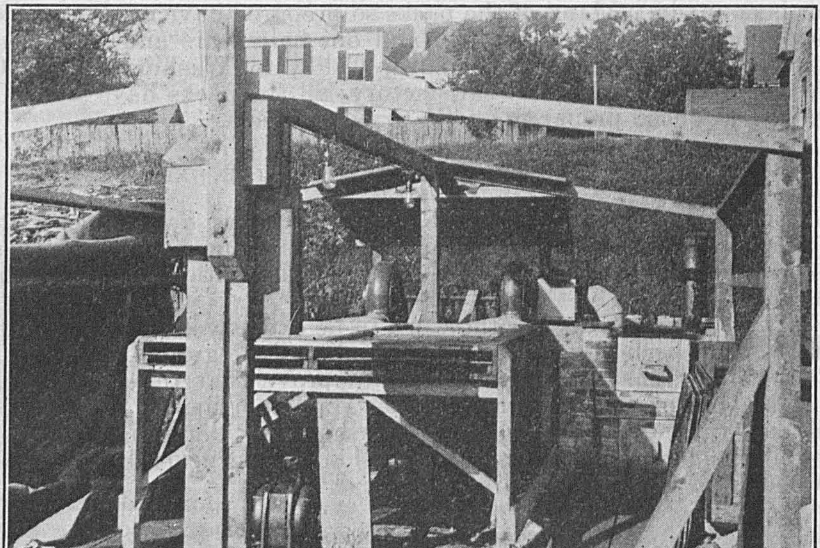

FIG. 24.—Maine experimental cooker and cooler

The discussion that follows refers to the preparation of small fish for the quarter-oil pack unless a statement to the contrary is given.

DETERMINATION OF THE BEST CONDITIONS FOR PREPARING THE FISH

Weber (see footnote, p. 72) and his associates, in their bulletin (pp. 51 to 58) on the Maine sardine industry, give experimental evidence on the amount of water removed from the fish prior to the time they are canned. They conclude that satisfactory results will be obtained if the raw fish lose about 15 per cent in weight in being prepared for canning. This seems to be a little low for a good quarter-oil pack, although for some "standard" packs it probably is sufficient. It is certainly too little for fancy California quarter-oil sardines. For this pack a loss of about 25 per cent is desirable.[56] In Maine

[56] See Table 42, p. 204, experiments 147, 148, and 179, for data on California quarter-oils. California packers want very little water in the can with the fish.

it seems as if the loss should be around 18 to 25 per cent. This was the standard followed in the experiments, and with excellent results.[57]

The preparation of the fish for the three-quarters mustard pack is comparable to the preparation of fish for the pound-oval pack in tomato sauce, and fish that are satisfactorily prepared for one should be suitable for the other. A 13 to 16 per cent loss in weight is sufficient for these packs if a thick sauce is used. It will be noted that it is recommended that less water be removed from the fish for this pack than for the quarter-oil pack. This view is based on adequate experimental evidence, and it differs from that of Weber and his coworkers on this subject. They contend that fish to be packed in mustard sauce need to be dried to a greater extent than those to be packed in oil.

This question of how much water shall be removed from the fish is, in the end, one for the individual packer, who must decide the kind of pack he desires and then dry his fish accordingly. No attempt is made here to do other than outline the safe limits and to show how such losses, as well as larger and smaller ones, can best be brought about.

The first trials plainly showed that the new process was entirely suitable and practicable for the preparation of Maine herring. The best conditions for doing this, therefore, were determined, followed by the preparation of a number of packs with different kinds of fish to prove that the same results could be obtained consistently. Other experiments were made in order to learn if fancy grades of sardines could be prepared by this process from Maine herring. The results of these experiments are described below.

Air temperature.—Several results are given in Table 12, which show the effect of air temperature upon moisture removal. With a velocity of about 1,900 feet per minute, a temperature of 275° to 300° gave best results. This temperature and velocity caused about the right loss of weight in various quarter-oil size fish and sufficient loss in three-quarters mustard fish in about 15 minutes. A higher air temperature caused excessive browning, oxidation of oil, and sticking to the flakes. Such results as these were quite pronounced with air at 356°, although the velocity was lowered to 800 feet per minute.

Other factors.—In one experiment (No. 185) medium large quarter-oil fish were cooked 15 minutes at 275° with air having different velocities. The per cent loss in weight at the different velocities was: 18.2 per cent at 2,000 feet per minute, 16.2 at 1,400, and 12.1 at 700. The fish prepared at the lowest velocity were, in fact, not fully cooked, as red blood showed along the backbone.[58]

No experiments were made upon the effect of moisture content of the drying air, fish size, and drying time upon moisture removal from the fish. These subjects are considered on pages 133 and 134, and the discussion also applies to the handling of Maine herring.

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[57] Experiments 45 and 47, Table 31, p. 180, give some data on commercial losses.
[58] See p. 134 for similar data on large fish.

TABLE 12.—*Loss in weight of "quarter-oil" herring in air at different temperatures. Velocity 1,900 feet per minute*

Experiment No.	Air temperature, °F.	Time in minutes		Experiment No.	Air temperature, °F.	Time in minutes	
		15	20			15	20
182a	225		12.0	187b	300	24.8	
182b	250		20.4	187c	325	30.0	
182c	275		19.7	206b	275	22.0	
182d	300		24.6	206a	[1] 356	25.0	
187a	275	19.4					

[1] Air velocity 800.

Smoking.—Extensive smoking experiments were not carried out. Enough, however, were made to show that the method employed was entirely practical. A good flavor and light brown color were given to small and medium-size quarter-oil fish simply by adding hardwood smoke to the hot air used in cooking the fish. The high-velocity air brought about rapid smoking. Other conditions being equal, large fish will smoke more slowly than the smaller ones.

In the experiments the concentration of the smoke was not as high as it should have been. The smoke generated was discarded after it had passed over the fish once. In a correctly designed plant most of the air that passes over the fish will be recirculated. This will quickly build up and maintain a heavy concentration of smoke, which will cure the fish rapidly. Nevertheless, the experiments made were quite successful.

Sticking to the wire flakes and to each other.—Maine herring did not tend to stick to the flakes and to each other to as great an extent as California pilchards did. Throughout the experiments the fish were spread upon the flakes, even for fancy packs, in the same general manner as they are spread by the flaking machine. Many of the fish, therefore, touched other fish. There was some marring and some breaking. It was no greater, however, than that obtained with steamed fish. For "standard" goods and ordinary fancy packs no problem is presented. For very fancy goods it probably would pay to place the fish on the flakes, as now and then a tail will become glued to the skin of another fish and be broken off if they are scattered about.

Toughening the skins of the fish prior to their being cooked had little, if any, beneficial effect as far as preventing sticking is concerned.

Drippings from the fish.—As with California pilchards, dripping occurred (although only to a small extent) with quarter-oil fish. It probably would have been advisable, however, had one flake been cooked over another to protect the lower flake with a drip pan.

Cooling.—Most of the fish cooked were placed in the cooler and treated with outdoor air having a velocity of about 2,000 feet per minute and ranging in temperature from 65° to 70°. In all cases they cooled sufficiently to be handled for packing in 10 to 15 minutes.

QUALITY OF PRODUCTS

Fish prepared by the new process were better in appearance and taste both before and after canning than fish from the same lots prepared by the steaming process. Steaming removes much salt, oil, and soluble extractives—the very substances that give flavor to the fish. The new process retains virtually all of these substances. Steamed fish flattened on the flakes and had a washed-out appearance. Those prepared by rapidly moving hot air retained much of their original appearance. The skins were toughened and slightly wrinkled, like fried fish. There were not as many cracked and belly-blown fish obtained as when the fish were steamed. This was especially noticeable when heavily salted or "feedy" fish were cooked. No direct comparisons with fried fish were made, but it is certain that the product would, in the long run, as in California, be better because of the absence of the usual bad effects of frying in oil.

Some excellent fancy packs were prepared—packs that would compete, on a quality basis, with the best of imported goods from France and Norway.

Forty-one cooking experiments were conducted. The fish from 20 of these were canned, and of this number 7 were compared with packs of steamed fish prepared from the same lots of fish. Both small and large fish were experimented with, also lean and fat ones, all with equally good results.

STORING AND SHIPPING QUALITIES OF THE PACKS

Some of all the packs prepared have now (October, 1926) been in storage more than 2 years. Many of the cans have been shipped to the Pacific coast and back, as well as elsewhere. The new packs have stood up just as well as those prepared by the steaming process.[59] This should furnish adequate experimental proof of the shipping and keeping qualities of the pack for those who might have doubts in this matter.

APPLICATION OF THE EXPERIMENTAL RESULTS TO COMMERCIAL OPERATIONS IN CALIFORNIA AND MAINE

Small-scale tests with the process were very successful, as evidenced by the experiments. The best conditions for preparing the fish were worked out, and it was shown that such conditions produced excellent products. There remains to be explained, however, how large-scale commercial operations can be carried out successfully and how practical this proposition will be.

RECOMMENDATIONS FOR COOKING, DRYING, AND COOLING

In the experiments certain conditions uniformly produced excellent results in preparing one or several flakes of fish. The same results are certain to be obtained with any number of flakes, one or a thousand, if each individual flake is subjected to these same conditions. These conditions are taken up here. In a following section ways for handling the flakes and treating them in the desired manner are shown and discussed.

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[59] All of the packs were put up in cans having no gasket on the covers where the lid is double-seamed to the body of the can. If no gasket is used, an absolutely tight seam is not assured, and it is a well-known fact that fish put in such cans do not keep well over a long period of time. In the experiments the cans were stored in a room where the temperature probably never went below 60° nor above 90°. Few cans actually spoiled, but a large number of them "wept"—that is, oil escaped from the double seam, making quite a mess. When the packs were about 1½ years old it was noticed that the fish in most of the cans had acquired a rather strong, fishy taste. The use of gaskets and correct processing temperatures and times will virtually obviate these difficulties. The 1926 season saw the general adoption of gaskets.

Air velocity.—Throughout the free spaces over and under the flakes of fish the velocity should be as high as can be used without the force of the air moving the fish. A velocity of at least 2,000 feet per minute can be used without difficulty, and it is recommended that the velocity be this or slightly higher. Even higher velocities would be desirable, and it may be possible to use them up to about 2,500 feet per minute for cooking large oval-size fish. Small quarter-oils, however, tend to be blown about when the velocity is much greater than 2,000 feet per minute.

In addition to increasing moisture loss there are two important advantages in using high-velocity air that have not yet been discussed:

1. Large quantities of heat are needed to raise the temperature of the flakes and fish and to vaporize the water. Now, the higher the air velocity, the greater is the amount of air, and consequently heat, that can be put into a given space per unit of time. A tunnel does not have to be nearly as large, then, to handle a given quantiy of fish at a velocity of, say, 2,000 feet per minute as at 1,000. Size and cost of equipment can be kept down in this way. Of course, the same quantity of heat can be put into the tunnel with low-velocity air by raising its temperature. This, however, proved unsatisfactory.

2. Air, especially when mixed with considerable water vapor, makes a light gas when heated to about 300°. Being light, it is hard to force it through a long tunnel evenly because of its tendency to rise and collect at the top. The higher the velocity, however, the less trouble there is in this respect.

Air temperatures.—In addition to high velocity, the air should have as high a temperature as possible. In this way the fish can be prepared most quickly. For large, pound-oval sardines a temperature around 300° should be used for preparing the fish, with an air velocity of 2,000 feet per minute. These conditions remove about the right amount of water from the average run of fish in about 15 minutes. For quarter-oil fish the same velocity and time are about right, but a temperature around 275° is better. Three-quarters mustard fish are prepared satisfactorily at either temperature. Exact recommendations can not be given in either case, as it is necessary to vary the temperature and time to meet different conditions. The fish may be extra large, rather small, or mixed, and they may be lean or fat. Different canners have different ideas as to how dry they wish their fish to be. All of these conditions can be cared for easily. A little experience, which can be gained quickly, is all that is necessary to enable an operator satisfactorily to meet the various conditions as well as the time factor.

In large-scale operations it will not be practicable to maintain the same temperature throughout the tunnel or chambers in which the fish are cooked. The air will enter at one end, say, of a tunnel full of fish, and go out the other. The temperature will drop as it passes through, due to the heat that has been taken from the air by the fish, the flakes, and the rest of the equipment. Under operating conditions this drop in temperature will be quite uniform. A drop of 50° to 75° is not too much for good results if an average temperature of 275° to 300° is maintained. For example, in the case of a 50° drop the air will enter the tunnel, say, at 325° and leave at 275°, giving an average temperature of 300°. The flakes of fish will pass in at one end and out the other, so that they will be subjected to the average temperature. These conditions will give the desired results.

Time.—As high air velocity and temperature as practicable have been recommended in order that the fish can be cooked and dried in the shortest possible time. Economy of time is important. It leads to many savings, among which the saving in quantity of equipment required is very important. About 15 minutes is sufficient even for very large pound-oval fish and for quarter-oil fish when prepared with air at the velocity and temperature recommended above. Here, again, exact recommendations can not be made for reasons already stated. It will be found, however, that the time can not be extended much over 15 minutes without undesirable changes taking place in the fish, unless the temperature is lowered.

Some canners may not wish to remove as much water from their fish as will be taken out in 15 minutes under the above conditions. In this case the time can be shortened sufficiently to give the desired result. It is to be remembered, too, that cooked fish lose considerable water when they stand on flakes exposed to the air for several hours (p. 108). Under some circumstances advantage can be taken of this fact to shorten the cooking period a little or to increase total moisture loss. If the trucks of cooked fish are allowed to stand a few hours they will cool and also dry to an appreciable amount. In fact, these effects can be accelerated by forcing a good draft of air through the cooling room.

Humidity.—In commercial operations, in order to conserve heat, a large part of the air that passes over the fish should be recirculated; that is, it should be returned to the fan, mixed with more hot air, and again sent over the fish. This will increase the moisture content of the air in the cooker. Part of the air (probably not more than 10 per cent) must be discarded, however, to carry out of the cooker the water that evaporates from the fish. The exact amount that can be recirculated will vary with different conditions and must be determined by experience. It will be very easy to control recirculation, and no difficulty will be met.

Moisture loss.—Average size pound-oval fish and three-quarters mustard fish, prepared according to the recommendations given above, will lose about 13 to 16 per cent in weight. This is about right for fish that are to be packed in fairly thick sauce. Average size quarter-oil fish will lose about 20 to 25 per cent in weight.

In practice a packer should vary his drying conditions some in order to get the exact results desired. In doing this it will pay to determine what loss in weight occurs, as this gives a good index to actual results: The loss is easy to determine, using ordinary kitchen scales. Weigh a flake of fish before and after cooking and from these weights subtract that of the flake. This gives the weight of the fish before and after cooking. The difference between these is the loss. The loss divided by the weight of fish taken, multiplied by 100, gives the per cent loss in weight.

Drippings from the fish.—Drip pans are needed whenever large, fat fish are being cooked; although it may turn out that they are not needed for quarter-oil fish, it is much safer to include them in equipment for preparing the fish.

Minimizing breakage.—Raw fish can be handled quite roughly without injury; for instance, they can be dropped 8 to 12 inches from run to run in a multiapron drier. Cooked fish, especially when hot, can not be treated in this way. The fall would cause serious breakage, and shifting of the fish about on the wire screening would cause excessive breaking and marring of the skins. Cooked fish should remain on the flake until removed, one by one, for packing.

In order to prevent breakage, California pilchards should be placed on the flake so as not to touch each other. Breakage due to the fish sticking to the flake will not be serious, except with very lean fish. Toughening the skins by drying before cooking prevents lean fish from sticking but does little good with fat fish. This procedure, therefore, is not recommended unless large quantities of lean fish are to be prepared. In this case the skins should be toughened by drying in the same way as for frying in oil.[60] A small drier for doing this could be placed so as to empty dried fish into the machine for spreading, as described in a later section. In any case the flakes should be kept clean, as this helps prevent sticking. Oiling the flake lightly with a cheap heat-and-oxygen-resisting oil, such as coconut oil or a hydrogenated oil, will be particularly helpful, too, when sticking does become troublesome.

Only with fish for very fancy packs need extra precautions be taken in handling Maine herring. The flaking machine spreads the fish evenly enough if operated correctly.

Cooling.—The coolest outdoor air obtainable should be used for cooling the fish, and it should be blown over them at as high a velocity as possible (2,000 to 2,200 feet per minute, at least), just as in cooking, so as to get the maximum heat transfer from the fish to the air.[61] If the fish are cooled to about 80°, they can be handled without difficulty. During the sardine season in Monterey and San Pedro the temperature of outdoor air seldom rises this high. With high-velocity air at 80°, large "ovals" can be cooled to about 80° in 15 minutes. Along the coast of Maine out-of-door air is almost always cool.

EQUIPMENT RECOMMENDED FOR PREPARING AND HANDLING POUND-OVAL FISH

The frying-in-oil process is not a continuous one. As carried out in California, the fried fish are kept overnight to cool and drain. Much labor is expended in handling the fish as frequently as they must be handled, and excessive floor space is required for storing them overnight. A real saving in cost of production can be effected through the use of such equipment as will handle the fish continuously, from brine tanks to the cans, and thus complete the process in a short time and with little expenditure of labor. The equipment for carrying out the new process, illustrated in Figure 29 and described below, will accomplish these ends if operated as recommended.

The equipment and plan of operation are described here as applied to the handling of California pound-oval fish. The handling of quarter-oil fish and the use of other equipment and plans of operation, both for quarter-oil and pound-oval fish, are taken up later.

These discussions on equipment endeavor only to outline practical ways of carrying out the process. Any canner who puts in equipment should cooperate with well-qualified drying engineers in doing so, for

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[60] This procedure is described on pp. 125 to 129.

[61] It will not pay to cool air for this purpose by refrigeration, but in commercial practice conditions might arise which would make it practicable to cool the air by humidifying it with a spray of sea water or by passing it over coils through which sea water is circulated.

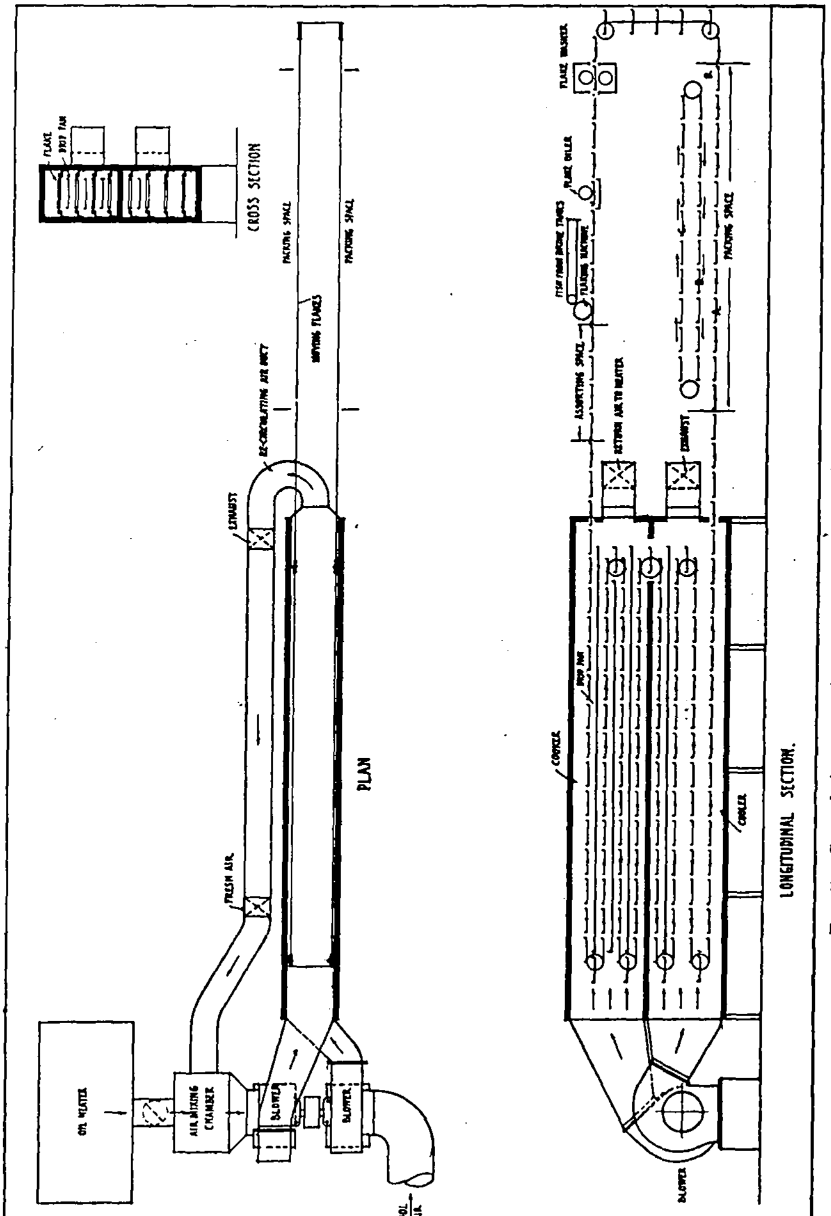

FIG. 25.—General plan for continuous cooking, cooling, and packing of sardines

the reasons stated in the discussion on drying (p. 127). The wide experience that such men have had in handling similar problems undoubtedly will lead to improvements in the equipment described here.

General scheme of operation.—The raw fish are conveyed from brine tanks to a series of moving flakes, one following another, so as to form an almost continuous surface upon which the fish are spread mechanically; then they are more carefully arranged by hand. The flakes next pass into the cooker and are conveyed back and forth, as illustrated, the flakes, of course, always remaining in virtually a horizontal position to prevent the fish from being thrown from them. From the cooker the flakes go to the cooler, where they are conveyed in a like

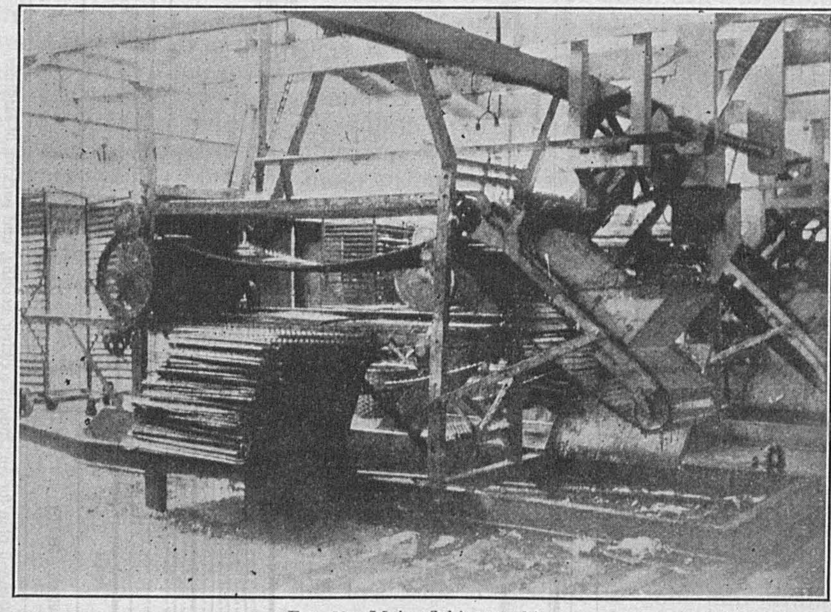

FIG. 26.—Maine flaking machine

manner. The fish are now ready to be packed and next pass between two rows of packers, who obtain their fish from the moving flakes. The empty flakes then pass through a mechanical scrubber and an automatic oiler, after which they are ready to receive another supply of fish. The various steps involved in preparing the fish are discussed below.

Spreading the fish.—The fish can be scattered over the flakes quite evenly, either by the means now used in California[62] or by a Maine flaking machine (fig. 26). The flaking machine will serve the purpose better, as it places no fish on the open spaces between the flakes. Since the fish are already quite evenly spread, one or two girls can quickly arrange them to prevent touching as the flakes pass in front of them.

Cooking and cooling.—Air for cooking can be heated in a number of ways. Electrical heating, except for its prohibitive high cost, would

[62] Figure 7, p. 79, illustrates this procedure.

be most satisfactory. The air can also be heated by passing it over pipes, through which high-pressure steam, hot oil, or combustion gases are circulated. Of these the last probably is most satisfactory. Another type of heater heats the air by mixing with it the products of combustion from a furnace burning oil or gas. Hard coal or coke can also be used, but not very satisfactorily. If correctly designed and operated with good grade fuel, even ordinary fuel oil, this type of furnace gives very high fuel efficiencies, operates with negligible odor and smoke, and will not damage the fish. It is recommended that this type of furnace be used if gas at a low enough price to make its use feasible can not be obtained. Several companies manufacture and guarantee such furnaces. They are not dangerous to operate and should not materially increase fire insurance rates on the plant in which they are located.

In the California plants, either oil or natural gas is used for fuel, being cheaper than coal. In Maine, however, heat units can be purchased in the form of coal at about half their cost in the form of oil. This should be considered in planning equipment, as it may turn out to be advisable for this reason to heat the air by passing it over high-pressure steam coils or through a heat interchanger, coal being used as the fuel.

Heat from the furnace is mixed with the recirculated air and blown through the cooker by the fan, as shown in the diagram. The temperature of the air in the cooker can be controlled by hand or automatically, whichever is more desirable. Such controls as this have proved very satisfactory.

One method of handling the flakes so that they will remain in a virtually horizontal position throughout their passage through the cooker and cooler is illustrated in Figure 27.

Details in regard to chains, sprockets, guides for the chains and flakes, and the best method of driving the unit should, of course, be handled by an engineer versed in these matters. Chain manufacturers are in a position to handle such details. Two points in particular should be kept in mind in handling the flakes. At the ends of the conveyer, where the flakes change from one level to another, through shafting can not be used because the flakes pass between the sprockets. At other places, however, it can be used. It is particularly necessary for the two chains to run evenly, otherwise the flake carriers or flakes will get out of line and cause difficulty. Chain manufacturers can show how to make the two chains run evenly. "Take-ups" for the two chains should be geared together so that each chain will be taken up in the same amount.

Rollers can be placed on the flakes so that they can be conveyed directly on the chains. It will be much better, however, to use a light metal framework as a carrier upon which the flakes are placed. This permits light-weight, inexpensive flakes to be used. Either system allows the flakes to be removed as they come from the cooler. At times it may be desirable to remove some flakes and keep them on trucks for a time instead of sending them directly to the packers.

In designing the cooker the upper runs of flakes should be spaced a little farther apart than the lower ones, if the fish enter at the top. Should they enter at the bottom the arrangement should be reversed. This spacing can be made by using different sized sprockets, or preferably by having the line of flakes move down a slight incline, from one sprocket to the next, at the other end of the tunnel. The following arrangement is suggested for 12 lines of flakes in a tunnel 12 feet high; 18 inches for the first line and 16, 14, three 12, and six 10 for the others. The purpose of such an arrangement is to give more air to the cooler flakes in order to raise the temperature of the fish quickly, so that rapid moisture loss will be brought about. A few well-placed baffles over each line of flakes (and this applies to the cooler, too) should be provided to assure good air distribution.

In the cooler, however, the lines of flakes should be spaced equally. Although drip pans are not needed under all the lines for catching

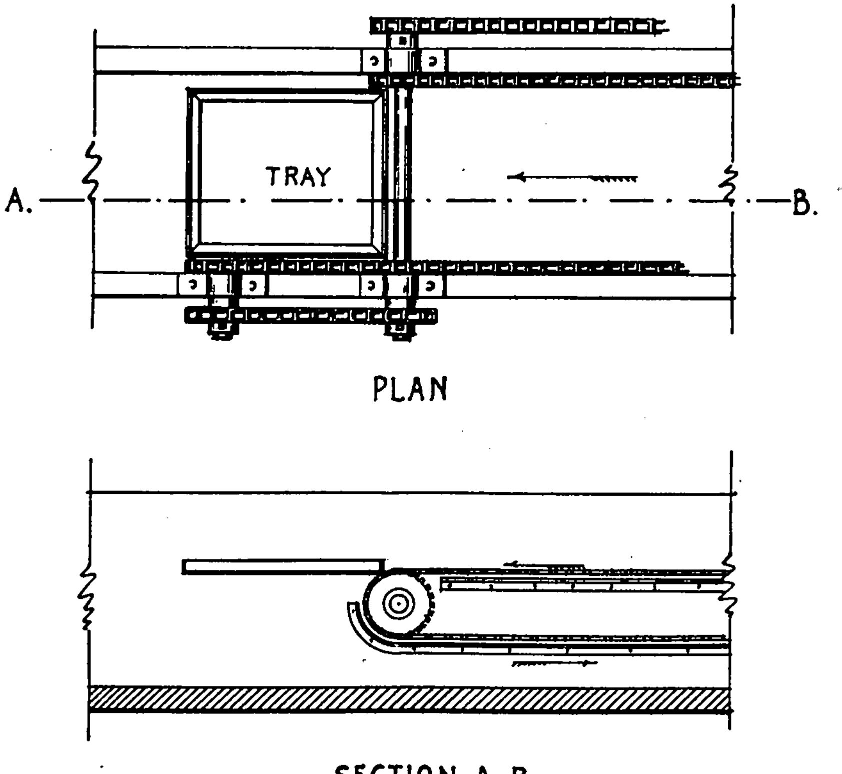

FIG. 27.—Plan for handling flakes

drippings, some means of dividing the main tunnel into smaller ones, through which each line of flakes passes, should be used. For instance, should there be 12 lines of flakes in the cooler, the fish would be treated with 12 different lots of cool air. This arrangement should be very effective.

In the cooker any mixing of the air that passes over one line of flakes with that of another (for instance, around the sides of the drip pans) will be helpful, in that it will tend to equalize the temperature throughout the cooker. In the cooler, however, the partitions that separate the various lines should be tight enough to prevent much mixing of air, as better cooling will be effected if air that has been warmed in one line does not mix with the cooler air in the next.

The air that has been warmed by passing over the first line or two of flakes in the cooler can be used for intake air for the furnace. Some heat can be recovered in this way.

Packing.—So far as I am able to discover, sardines have not yet been packed from moving flakes. I see no important reason why this could not be done, especially with fish for the pound-oval pack. Packers could be placed alongside the moving flakes, each having a small platform a little above the flakes for holding the can to be packed, or the boards that cover moving parts on each side of the flakes could be used for this purpose. Fish could be selected from those in front of the packer in the same way that they are selected from a stationary flake. Conveyers for empty and full cans could be placed over the moving flakes on a higher level than the packing platform. These details will have to be worked out for each installation, to fit the plant and the general ideas of those in charge.

It will be argued that the first packers will pick out all the big fish when they are paid for piecework. This is true, but this tendency can be controlled to a great extent by proper supervision. When the fish are badly mixed, however, they usually are packed according to size in order to enable the canner to furnish packs containing a definite number of fish per can. The system of packing recommended here will aid in doing this, as certain packers can pack fish of a given size.

At the end of the packing line one or two packers will be needed to care for any inequalities in the amount of fish that comes through from time to time. Since they will be idle part of the time, they must work on a time basis.

In planning the packing line about 6 to 10 feet of free space should be left between the end of the cooler and the first packer for removing and replacing flakes. Each packer will require about 2 feet of space and will, on the average, pack about 4½ cases of "oval" fish per hour. The surface of the flakes should be about 32 inches off the floor. Flakes 30 by 30 inches should be used. It will not inconvenience a packer to reach to the middle of a flake of this size, even if 4 to 6 inches between the packer and the edge of the flake is taken up by the conveying system. A flake of this size is handled easily, too, when off the conveyer. A larger flake offers an important advantage—if it could be used it would lower equipment costs.

Should packing from moving flakes prove unsatisfactory to any canner, or should he prefer in the first place to have the fish packed from stationary flakes, this can be done as follows: Over the line of moving flakes, for the distance used by the packers, there can be placed a conveyer system similar to that used in California and Maine for keeping the packers supplied with baskets or flakes of fish and for carrying away the empty containers. (See fig. 25.) The packers can be placed at tables on both sides of the conveyer, just as at present. When a packer needs a flake of fish, she will take it from the conveyer *C* (or at *A*, if possible), which carries it to the end of the conveyer at *D*. At *D* an operator places the flakes that were not removed from *A* on the conveyer *B*. At the point *D*, too, the empty flakes are returned to the flake carriers. The conveyer *B* is so designed as to move the flakes forward only as rapidly as they are removed. This kind of a conveyer is in regular use in California and in Maine. Conveyer *A* is designed to supply fish as rapidly as needed. Conveyer *B*, then, serves only to care for inequalities in the removal by the packers of flakes from conveyer *A*.

Cleaning and oiling the flakes.—The flakes should be kept clean. At times it probably will be advisable to scrub them after each time or two they are used. This can be done easily and inexpensively by passing them through a mechanical scrubber. This scrubber can consist of two revolving brushes, upon which a strong cleaning solution is sprayed. The flakes should then be rinsed in a spray of water.

Just before the flakes receive fish they should be oiled, whenever this is necessary. A number of simple automatic contrivances can be devised to do this. One that would serve well can be made in the form of a perforated drum covered with fairly heavy felt or wicking material, through which the oil or fat contained in the lower half of the drum passes, in the same way that oil passes through a lamp wick. The drum can rest on the flakes and be left free to revolve so that it moves with the flakes, spreading a thin film of oil over their surface as they pass under the drum. A small steam coil should be placed so as to dip into the oil in the bottom of the drum. This will liquify a fat that is solid at ordinary temperatures.

General considerations.—It is necessary to consider how well the method just described for handling the fish fits into the general plan of operations that must be followed in a sardine cannery. Conditions in southern California (San Pedro) are considered first.

Except in emergencies, the fish must be packed during the daytime, when women packers are obtained most easily and cheaply. Assuming that the packers work 10 hours, equipment must be provided for handling the desired amount of fish in that number of hours. Of course, such equipment would also be available for overtime work.

As a rule, the fishing boats go out in the evening and return between midnight and dawn.[63] Usually some fish are available as early as 5 or 6 a. m. Generally, most of the boats are in by 9 to 10 a. m. There are exceptions, however, and when these occur the fish have to be cared for just the same. At certain periods moonlight interferes with night fishing, in which case the boats either do not fish or go out early in the morning and return by noon or early afternoon.

When the fish are prepared by the frying-in-oil process, it makes no particular difference when they arrive. Generally, unloading and cutting start soon after the first boat arrives and are continued until all the fish have been cut and sent to the brine tanks. As soon as the tanks of fish have been brined the excess brine is drained off and the fish remain in the tanks until used. Drying begins as soon as the first brined fish are ready. Drying, frying, stacking, and storing of fried fish is continued until all the catch has been disposed of. The following morning the packers begin packing the fish that were prepared on the previous day.

This method of handling the fish tends to minimize deterioration in the factory, inasmuch as cooking is begun soon after the first fish arrive. In the proposed method the fish are not cooked until just before they are packed. Because of this it will be necessary at times to keep uncooked fish in the tanks for several hours until cooking

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[63] Fishing methods are described in detail by Higgins and Holmes; see paper referred to in footnote 9, p. 74.

can be started. This will happen infrequently, because, as stated above, the fish usually arrive at the cannery in the early morning and cooking can begin at 6 or 7. a. m. Fish that arrive in the afternoon, however, will have to be kept until the next morning before cooking can begin. Except in rare cases, no difficulty should be encountered in keeping the fish. California pilchards that are in good condition keep well if they are "cut," brined fairly heavily, and allowed to remain in the tanks until after the brine has drained from them. Winter nights in San Pedro are generally cool, the temperature very seldom going over 60°. In exceptional cases, when the weather might be very warm or the fish in poor condition when received, crushed ice could be spread over the fish in the tanks. This would hardly be necessary more than three or four times a season.

In Monterey no trouble at all is experienced in keeping good-quality cut fish 24 hours or even longer at any time of the year. It is only necessary to keep them in the tank and circulate water from the bay over them. This water is always quite cool. Such fish need not be brined at first. If the sea water does not brine them sufficiently, they can be covered with a stronger salt solution for a time just prior to being used. This procedure probably would work equally well in San Pedro in the winter if fresh sea water were available.

It is warmer in San Diego, and consequently it is a little more difficult to keep fish in good condition there than in San Pedro. In San Diego, however, where the pack is small, equipment probably will be preferred which does not include a cooler or special arrangement for expediting packing operations. Plans for operating under these conditions are given later.

EQUIPMENT RECOMMENDED FOR PREPARING AND HANDLING QUARTER-OIL FISH

The equipment and plan of operation discussed above apply equally well and with the same advantages to the handling of quarter-oil fish. There is some doubt in my mind, however, as to how well packing from moving flakes would work out for quarter-oil fish. Packing from stationary flakes, which the packers remove from the conveyer, of course, offers no difficulty as far as actual packing is concerned.

At present trucks are used almost exclusively in Maine for handling flakes of fish. Most of the fish are steamed, and this way of handling the flakes has worked best for the purpose. Most of the Maine canners probably would want to follow present practices as far as possible. This can be done by using a cooker without special cooling and packing equipment. The fish can be flaked as they are now, and go directly into the cooker, as shown in Figure 25 (p. 145). The flakes coming out of the cooker can be placed in trucks and then handled as at present.

Trucks for handling flakes in the cooker.—The fish can also be cooked on flakes in trucks. A simple type of cooker for doing this is shown diagrammatically in Figure 28. This particular unit holds eight trucks in the main part of the tunnel. At each end there is a vestibule with double doors, holding two trucks each. Assuming that the unit is operated so that it takes 15 minutes to prepare the fish, then eight trucks will pass through the main part of the tunnel every 15 minutes. When operating at capacity two trucks will be placed in one vestibule and two removed from the other about every 4 minutes. While doing this the door between the vestibule and the main tunnel must be kept closed, after which it should be opened and the outer door closed. The conveyer that carries the trucks is moved forward by compressed air or by some other means about one truck length at a time, instead of moving continuously. This method of handling gives plenty of opportunity for loading and unloading between the times when the trucks move.

Several canners have raised this question: "Why not use two tunnels, emptying and filling one while fish are being prepared in the other? The air supply can then be shifted and the process repeated for the other tunnel." This is impracticable; it is not possible to get uniform results in this way. If the air temperature is right for the fish in the first truck, each succeeding lot will be treated with cooler and cooler air. Much heat is removed from the air by each truck of fish. If the air temperature is raised sufficiently so that the last truck is treated with air at the right temperature, the fish on the

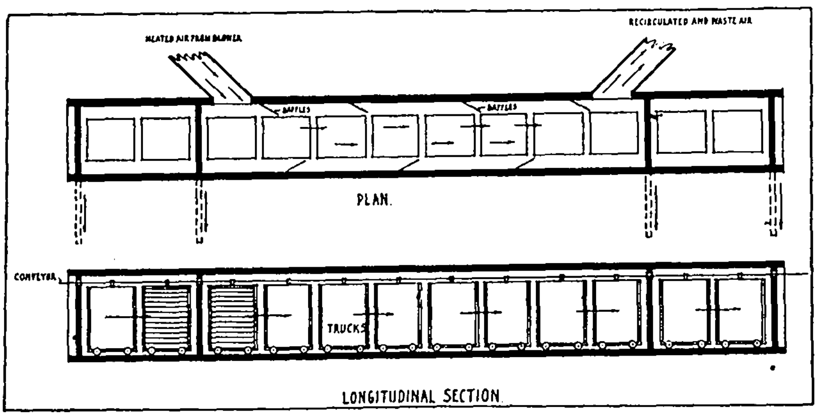

FIG. 28.—Plan for cooker, using trucks

first trucks will be greatly overcooked. For uniform results the trucks should pass progressively through the tunnel, so that all fish are subjected to the same range of temperature.

The purpose of two doors on each vestibule is to prevent excessive loss of heat due to escaping air and to make it possible for a man to push the trucks into the vestibule.

It will be noted that the tunnel is considerably wider than the trucks. This is necessary when more than three or four well-loaded trucks are used, to permit enough air to pass through the tunnel. Correctly designed and spaced air baffles are necessary at intervals in the free space on each side of the trucks to deflect the air, first from one side through the trucks and then back again; otherwise it would take the path of least resistance, and most of it would go along the sides of the trucks. Baffles also are needed where the air enters, to deflect it in a straight path through the tunnel (not shown in the figure).

Trucks should enter at the end where the hot air enters. In this way the fish will be heated to a high temperature where rapid moisture diffusion takes place, more quickly than if they enter at the other end. The drop in air temperature in a tunnel of given size will not have to be as great if air is handled in this way.

Another plan of handling the trucks so as to prevent loss of heated air where the trucks enter and leave the cooking tunnel is shown in Figure 29. *A* and *B* are two vestibules so arranged on a platform with rollers that the whole can be shifted from the position shown (*CD*) to the position *DE*, and back again, as desired. Trucks of fish as loaded are run into *A*. When full, and as soon as all the trucks in *B* have moved into the cooker *F*, the door *G* is closed and *AB* is moved to the position *DE*, after which *G* is again opened. While the trucks are passing from *A* to *F*, more trucks are loaded in *B* at *E*. The vestibules *A* and *B* slope towards *F*, so that the trucks move into *F* as fast as there is room for them.

In *F* the trucks continue to roll forward, down a slight incline, to *H*, where they are picked up by a conveyer and carried up an incline at the desired speed and out of the cooker at *I*. The hot air is blown through the tunnel in the same direction that the trucks move. This

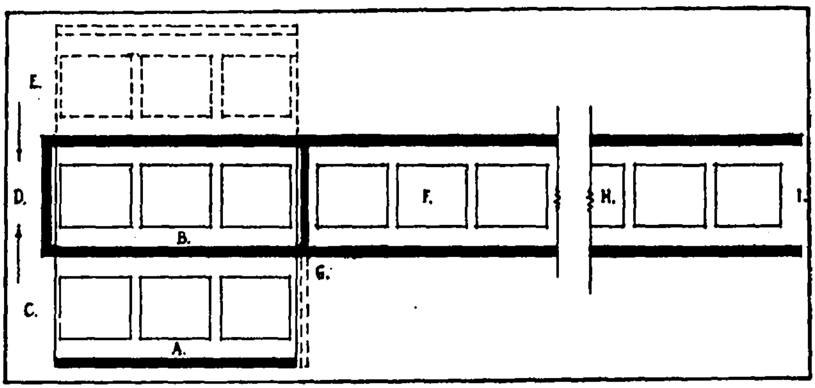

FIG. 29

air can be handled in such a way as to prevent much loss of air at *I*, although the tunnel is open at this point. A window in the end of the tunnel at *D* and a light somewhere in the tunnel near *G* will enable the operator to know when more trucks should be placed in the cooker.

One firm of drying engineers suggested the use of a cooker in which the air is blown at right angles to the direction in which the trucks are conveyed. Equipment of this sort is used extensively in drying substances where the drying time usually is long and the air velocity low. It can be changed, however, to make an excellent cooker. In Figure 30 is shown a plan of operation that will give good results. The trucks *A* are made with two solid sides, *BB*. As they enter and leave the cooker they pass through a vestibule, *GG*, just the size of the trucks and a little over one truck width in length. The two solid sides prevent loss of air. In the center of the cooker a similar arrangement divides it into two parts, through which the air is made to travel in different directions in order to give all trucks more or less similar heat treatment. If high-pressure steam is used for heating the air, coils can be placed in front of the fan at *C*, between the trucks at *D* and at *E*. Fresh air can be made to enter at *H* and leave at *I* or elsewhere in the housing, as desired. If a furnace is used, heat can enter at *H*. The air will have to be correctly baffled along the sides at *C* and *E* to get uniform air movement through the trucks.

This system can be used with one or two lines of trucks. More than two lines of trucks, even with high-velocity air, will not give uniform cooking on all trucks. As it is, with only two trucks, the fish on the edges facing *D* will not be cooked quite as well as those on the outer edges, unless coils are placed at *D*. This difference, however, will give no trouble.

Trucks for holding the flakes should be of metal and as lightly constructed as practicable. Under each flake there should be a

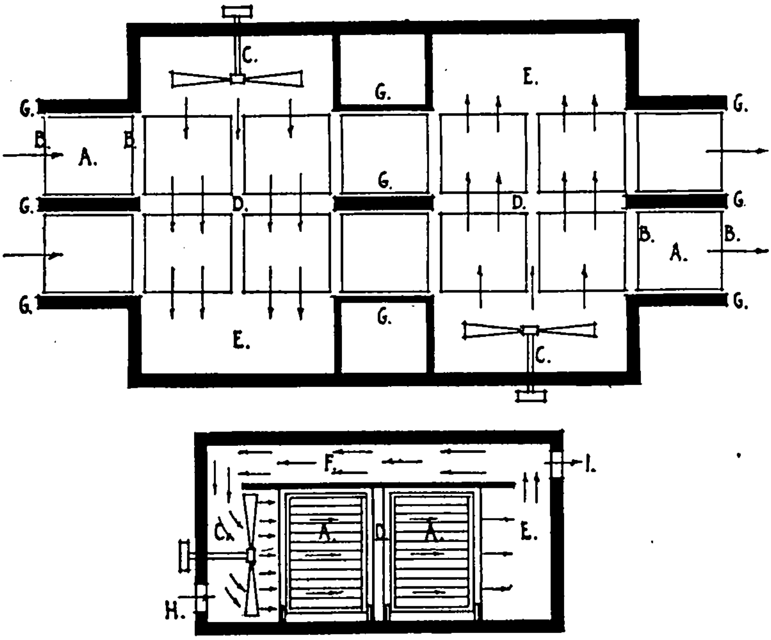

FIG. 30

light-weight, rigid, removable drip pan, which will not sag. The pan should be but $\frac{3}{16}$ or ¼ inch deep, so as to interfere as little as possible with the flow of air between the flakes.

The flakes must be spaced on the truck so as to allow sufficient air at the right velocity to pass between them. For quarter-oil sardines a spacing of about 3½ inches should be enough for each flake and its drip pan. The pan takes up about ¼ inch and the flake about 1 inch, leaving 2¼ inches, which should be proportioned so as to have 1 inch of space under the flake and 1¼ inches above the fish. For pound-oval fish a 4-inch space should be sufficient. It probably will be possible to get along with less free space, especially with the type of cooker shown in Figure 30. Possibly, too, drip pans may be unnecessary with quarter-oil fish. The above recommendations are safe ones, however.

FURTHER RECOMMENDATIONS REGARDING EQUIPMENT

The design and construction of such equipment as has been discussed here, so that it will function in the desired manner, should offer no particular difficulty to drying and conveying engineers qualified for such work. It is very important, however, that they be competent, otherwise serious difficulties are certain to arise. The data needed by such engineers has already been given. To these must be added the amount of fish to be handled per hour, the weight of fish to be handled per flake or per square foot of flake surface, and the space available for the outfit.

The amount of fish that can be handled on a flake varies greatly with the size of the fish. The larger they are the greater the weight that can be placed on the flake. The amount of fish, "cut" or "round," that can be handled per square foot of flake surface varies from about 0.8 to 2.4 pounds. The first weight applies to quarter-oil fish (8 to 10 per can) and the second to the largest oval-size fish (4 per can). For small to medium sized "ovals" (6 to 10 per can) the weight is about 1.8 to 2 pounds. For the general run of "quarter-oils," as they are flaked in Maine, the weight is about 1 pound.

In the appendix (p. 219) specifications in regard to operating conditions for handling either small or large fish are summarized in convenient form, ready for submission to drying engineers. Reliable engineers will be ready to guarantee to fulfill these requirements. From these data approximate operating costs are determined. These calculations indicate how the experimental data are applied and give an idea of the approximate size of the unit.

Equipment should be designed so as to permit considerable variation in the operating conditions. This is especially important in the first units of a new line of equipment. The specifications referred to were made with this idea in mind.

PRODUCTION AND EQUIPMENT COSTS FOR PREPARING CALIFORNIA POUND-OVAL FISH

Approximate estimates of production and equipment costs for handling 5 tons of pound-oval fish per hour are given below and compared with estimates for preparing the fish by the frying-in-oil process. The experimental equipment was not large enough, nor was it constructed in such a way as to enable production costs to be obtained from actual operations, nor has a large enough unit yet been built from which data upon these costs, as well as those for the equipment, can be obtained. The equipment and production costs considered are only those having to do with handling the fish after they are brined and until they are given to the packers to put into cans; other costs should be the same as they are now.

Fuel.—For a properly constructed plant the fuel oil required per case should not be greater than 0.5 gallon. The cost, then, when oil is $1.50 per barrel of 42 gallons, is 1.8 cents per case.[64] The actual amount of fuel used in preparing fish by the frying process is not available. Canners do not keep separate fuel costs for the various uses to which steam is put in their plants. The calculations indicate, however, that at least 77 per cent as much fuel is required for preparing the fish by the frying-in-oil process as by the new one. The

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[64] Calculations given on pp. 219–221.

cost on this basis, then, is 0.77 x 1.8, or 1.4 cents. In California fuel oil or natural gas is used for generating steam.

Power.—In connection with the estimate upon equipment costs made by a firm of drying engineers and discussed later, it was estimated that the total power required for a 5-ton unit would be about 50 horsepower. This will take about 38 kilowatts of electricity per hour. At 3 cents per kilowatt hour, the cost is $1.14, or for 110 cases (22 cases per ton of fish prepared), about 1 cent per case. It is assumed that the cost for the frying process is 0.5 cent per case.

Frying oil.—Whatever the cost for frying oil may be, it will be saved. It is assumed that this amounts to 5 cents per case. If a canner uses a good grade of cottonseed oil and changes his oil at least twice a season and takes into account the oil added to make up for losses when the fish are not very fat, the cost will be this much at least and probably more. If the oil is changed frequently enough for the fish to be cooked at all times in good oil, the cost will be far greater.

Labor.—For preparing the fish and delivering them to the packers there will be required one operator, two girls at 30 cents per hour each to arrange the fish after they have been flaked by the machine, and one extra packer at 50 cents per hour, most of whose time will be wasted. Excluding the operator, the cost comes to $1.10 per hour, or 1 cent per case. For the frying-in-oil process there are required one operator for the drier and fry bath, two men for the fry bath (one at each end to handle baskets of fish), two men to move trucks of fish to the cooling room and to supply trucks of empty baskets for the fry bath, two men to move trucks of cooled fish from the cooling room to the packing tables and to remove trucks of empty baskets, one man to feed baskets of fish to the conveyer supplying the packing tables, and one man to care for empty baskets from the conveyer. Excluding the operator, there are required eight men at 40 cents per hour, totaling $3.20, or 2.9 cents per case.

The cost of an operator will be about the same for either process and can be left out of consideration. Incidental labor for cleaning, handling oil, and for other such purposes will be considerably less for the new process; however, in these calculations it is assumed to be equal for both processes and therefore is not included in the calculations.

Equipment.—A 5-ton per hour unit for continuous cooking, cooling, and packing is estimated to cost about $25,000 to $30,000, and for a unit half as large about $15,000 to $18,000. This estimate was made by a firm of drying engineers for one of the canners and is for a complete unit, erected, ready for operation. The same equipment can be obtained at less cost if the engineers only furnish plans and supervise construction and the canner himself purchases materials in the open market and furnishes his own labor.

It is estimated that a drier, fry bath with oil storage and cleaning equipment, frying baskets, trucks, conveyer for furnishing the packers with baskets of fish, and boiler capacity in excess of other requirements will cost about $15,000 to $18,000 if furnished by equipment manufacturers.

Less floor space will be required by the new process [65] than for frying in oil. The equipment itself requires no more floor space than present equipment. A space, however, at least 40 feet square, now

[65] For details in regard to approximate space required see p. 221.

used for cooling, need not be provided for the new process. However, extra space equal to about one-third of the above will be required in the brining room for extra brine tanks not needed in the frying process. It will be recalled that all the fish may have to be held for a time in the brine tanks when the new process is used.[66]

Discussion.—It is realized that the estimates given are only approximations. They are liberal ones, however, being high, it is believed, for the new process and low for the frying-in-oil process. In the absence of accurate data, they are useful in gaining some idea as to what actual costs probably will be. Production-cost items taken up above total 3.8 cents for the new process and 9.8 cents for frying in oil, a difference of 6 cents per case in favor of the new process.

Production costs, however, should not be considered alone; there is also quality, which is very important. Fish prepared by the new process are better than the general run of fried fish, and if sold in a market where quality commands a premium they will sell not only more readily but for a better price. It is believed the improved quality of the product would in the long run justify the adoption of the process in plants now equipped for frying in oil.

PRODUCTION AND EQUIPMENT COSTS FOR PREPARING MAINE QUARTER-OIL FISH

Approximate estimates of production and equipment costs for handling 3 hogsheads (3,600 pounds) of "round" quarter-oil fish on the flakes, or 4 hogsheads (4,800 pounds) if the "cut" portion only is cooked, are given below and compared with estimates for preparing the fish by the steaming process. Costs considered are only those having to do with handling the fish after they are brined and until they are given to the packers to put into cans; other costs should be the same. Cooking only is considered, and it is assumed that the fish are handled on trucks.

Fuel.—Fuel required should not be greater than 0.75 gallons per case when "round" fish are handled, or 0.6 gallons of fuel oil per case for "cut" fish.[67] The cost, then, when oil is 8 cents per gallon, is 6 and 4.8 cents per case, respectively. For the steaming process, when coal is $7.25 per long ton (0.324 cents per pound), the estimated cost[68] is 7.9×0.324, or 2.5 cents per case for preparing "round" fish and 5.9×0.324, or 1.9 cents per case for "cut" fish. The figures 7.9 and 5.9 represent the amount of coal, in pounds, required to prepare a case of fish. If high-pressure steam coils or a heat interchanger are used for heating the air, coal being the fuel, the costs for the new process should be no greater than for the old.

Power.—It was estimated by a firm of drying engineers that the total power required for cooking the fish would be about 20 horsepower. This is about 15 kilowatts of electricity per hour. At 3.5 cents per kilowatt-hour the cost is 52.5 cents. For "round" fish it is 0.7 cent per case and for "cut" fish 0.53 cent. It is assumed that the cost for the steaming process is 0.4 and 0.3 cent per case, respectively, for handling "round" and "cut" fish.

Labor.—For preparing the fish and placing them on the conveyer that leads to the packers there will be required 1 operator, 1 man to feed flakes to the flaker, 1 man to place full flakes in the trucks, 1 to

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[66] See p. 150. [67] Calculations are given on pp. 222–223. [68] See p. 223.

load and unload the cooker, 1 to supply with flakes the conveyer leading to the packing tables, 1 to remove empty flakes from the conveyer, and 1 to move trucks and flakes about. The 2 men on the flaking machine will spend about half their time for this purpose, too. This totals (exclusive of the operator) 6 men. At 35 cents per man per hour, this amounts to $2.10, or 2.8 cents per case for preparing "round" fish and 2.1 cents for "cut" fish.

To prepare the same quantity of fish by the steaming process requires 1 operator, 1 man to feed flakes to the flaker, another to remove them and place them in trucks, 1 man to move the trucks in and out of the steam chest, 2 to handle the trucks through the dryer, 1 to supply the conveyer leading to the packing tables with flakes, 1 to remove empty flakes from the conveyer, and 1 to move trucks and flakes about. The 2 men on the flaking machine will spend about half their time for this purpose also. This totals (exclusive of the operator) 8 men. At 35 cents per hour per man, this amounts to $2.80, or 3.7 cents per case for "round" fish and 2.8 cents for preparing "cut" fish.

If continuous cooking and cooling equipment to handle single flakes were used, 6 men less than are necessary in the steaming process would be required. This would be a saving in labor of 2.8 cents per case in preparing "round" fish and 2.1 cents in preparing "cut" fish.

Equipment.—A unit that employs trucks to cook 3 hogsheads of "round" fish per hour is estimated to cost about $9,000 to $12,000, including trucks, drip pans, and flakes.

The discussion on page 156, in regard to the estimate given there, also applies here.

It is estimated that steam chests, a drier, trucks, and flakes for steaming the fish, including boiler capacity in excess of other requirements, will cost about $6,000 to $8,000 if furnished by equipment manufacturers.

Less floor space will be required for the new process.[69] The space now required for steaming the fish can be saved.

Discussion.—Although the estimates given are only approximations, it is believed that they are liberal ones, being high for the new process and low for the steaming process.

Production-cost items discussed above total 9.5 cents for preparing "round" fish by the new process and 6.6 cents for steaming, if oil is used for fuel, giving a difference of 2.8 cents per case in favor of the old process. For preparing "cut" fish the totals are 7.4 cents for the new and 5 cents for the old, a difference of 2.4 cents in favor of the old process. Continuous cooking and cooling would make costs about equal.

The savings effected by the new process over frying in oil will be considerable. It costs at least 20 to 30 cents per case for frying in oil in preparing quarter-oil fish, and then results are not satisfactory. One canner stated that his oil cost was about 35 cents per case, and yet he did not consider that he changed his oil as often as necessary.

For smoked fish there should be a marked saving over present practices. It will cost much less than 1 cent per case extra to smoke fish by the new process. The old method requires special equipment for doing this and the process is a slow one.

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[69] For details in regard to approximate space required, see p. 223.

The new process should give a slightly better yield in cases per hogshead of fish, and this will lower costs somewhat.

The new process appears to be a little more expensive than steaming. Any additional expense, however, is more than offset by the gain in quality over steamed fish, and this gain is a marked one. It is firmly believed to be sufficient to warrant general adoption of the process, although the change involves scrapping old equipment and purchasing relatively expensive new equipment.

COMMERCIAL DEVELOPMENT

At the conclusion of the experimental work in Maine the equipment used was purchased by an indivudal who started to prepare quarter-oil sardines by the process. In 1925 this equipment was enlarged and used throughout the year. Two other concerns, one in Maine and one in Canada, put up similar equipment and prepared sardines during that year, and all canned again during the 1926 season. These operations proved conclusively that excellent sardines can be prepared consistently by the new process. Unfortunately, however, in each case the equipment used was small and modeled after the experimental unit used in Maine, so that little that had not already been proved was demonstrated, as far as equipment goes.

One big drawback to the process that has already been referred to is that it requires relatively expensive equipment, different from any now being used. Naturally, there is reluctance upon the part of the canners to scrap old equipment and purchase new until there is positive proof that the venture will be successful, both from a technical and a business viewpoint. Even where there is no old equipment to be cast aside, there is the same hesitancy and for similar reasons. Although plans for conducting the process are based on sound engineering principles, and the cost data show that operating expenses are reasonable, such information seems to have little weight with the canners. They want to see a commercial plant in successful operation before they will be convinced as to the commercial possibilities of the process. The individual canner feels, too, that if he puts in equipment his competitors will profit, without expense, by any mistakes he makes and by improvements that naturally will follow the building of the first unit.

Means have not been available for giving a large commercial demonstration. Fortunately, however, one of the largest canners in Maine erected a semicommercial unit for trying out the process during the 1926 season. Their trials proved satisfactory, and they are going to install in their largest plant equipment for preparing their fish by the new process. The unit is to be large enough to prepare fish for about 1,500 cases of quarter-oil sardines in 10 hours' operation. This installation should demonstrate fully the commercial possibilities of the process. Once this has been accomplished, it is believed that its general adoption will be but a matter of time.

APPLICATION OF EXPERIMENTAL RESULTS TO COMMERCIAL OPERATIONS IN OTHER LOCALITIES

Sardine canners the world over undoubtedly are faced with essentially the same problems in preparing their fish. The experimental results obtained with pilchards and herring in the United

States must be very similar to those that would be obtained elsewhere, both with the same kinds of fish and with others that are suitable for canning as sardines. For this reason the principles worked out from the experiments and the recommendations given apply in general elsewhere. The new process offers fully as many advantages to foreign producers of sardines as to those in this country.

ADVANTAGES AND DISADVANTAGES

The more important advantages and disadvantages of the new process are summarized below:

ADVANTAGES

The quality of the fish prepared is excellent, giving in the long run a better product than frying in oil or steaming. The process adds no foreign product such as old fry-bath oil, which detracts from the quality of the final product; nor does it remove large amounts of oil and soluble extractives (including salt previously added in brining) as steaming does. The loss of these substances detracts considerably from the flavor and food value of the product.

The process is rapid, cooking and drying the fish in 15 minutes or less, which is a fourth to a fifth the time now ordinarily used in Maine and California. By combining cooling in a blast of cool air with cooking, the fish can be cooled, ready for packing, in about 15 minutes, making the whole preparation, including packing, continuous. In California this eliminates the usual overnight cooling and draining for pound-oval fish.

While the fish are being cooked and dried they can also be lightly smoked at slight additional cost, giving a much more rapid and labor-saving process for preparing smoked sardines than any now used.

Less labor is required for preparing the fish than for the processes now practiced. Use of the continuous cooking, cooling, and packing process developed should effect savings in labor.

The new process will prevent the disagreeable odor that prevails in a factory where fish are fried in oil, and will also eliminate most of the oil that is unavoidably spread about the factory.

Space required for preparing the fish is less than that for any other process.

The cost of preparing the fish on a large scale by the new process will be less than for frying in oil and possibly no greater than for steaming, as carried out in Maine.

DISADVANTAGES

Adoption of the new process in existing factories requires the scrapping of most of the equipment actually used in preparing the fish and the installation of relatively new equipment. It is believed, however, that the advantages to be gained from the new process are sufficient to warrant such action. In new factories installation of the new equipment will be but little more expensive.

The cost of preparing Maine herring may be a little greater than by the steaming process.

Flake marks upon the fish will tend to be more pronounced with the new process than with frying in oil.

APPENDIX

In this section are placed tables and technical discussions that, for reasons given on page 92, were not included in the main body of the document.

CHANGES IN OIL USED FOR FRYING SARDINES

FRYING EXPERIMENTS

Frying tests.—Data covering the first and second tests are given in Tables 13 to 16.

Changes in quantity and composition.—It is important to know how rapidly the fish-oil content of fry-bath oil increases during use. Chemical analyses of the oil can not be depended upon to give an accurate index of the increase. Oxidation changes in frying oil make inaccurate the usual analytical procedures that can be used for determining fish oil in cottonseed oil. The increase, when large, fat fish are fried, must be rapid, because the oil content of the bath remains constant or increases for long periods of time, even with large quantities of mixed oil being carried from the bath by the cooked fish. This oil is mechanically held on the surface, under the skin, in the body cavity, and soaked into the fish. Oil that replaces that carried out of the bath can only come from the fish.

TABLE 13.—*Frying data—First run of frying experiments*

Date, 1921	Time of frying		Bath I				Bath II			
			Weight of fish before frying		Weight of fish after frying		Weight of fish before frying		Weight of fish after frying	
	Hours	*Minutes*	*Pounds*	*Ounces*	*Pounds*	*Ounces*	*Pounds*	*Ounces*	*Pounds*	*Ounces*
Jan. 13 [1]	3	0	13	8	10	12	13	12	11	4
Jan. 14	2	40	16	7	14	0	15	14	13	8
Jan. 15	2	30	18	7	15	13	19	7	16	4
Jan. 17	1	30	14	6	12	6	16	4	12	14
Jan. 18	3	0	26	13	23	1	27	6	23	9
Jan. 19	4	50	36	7	30	5	40	11	34	3
Jan. 20	3	15	27	3	23	11	22	5	19	10
Jan. 24 [2]	4	55	29	12	24	12	29	14	25	0
Jan. 28	6	0	46	11	39	11	46	8	40	2
Feb. 1 [3]	5	0	72	15	67	1	72	0	67	13
Feb. 2	3	0	49	10	44	12	47	10	43	0
Feb. 3	4	20	72	0	67	2	74	6	68	14
Feb. 4 [4]	3	30	75	13	70	15	75	11	70	7
Feb. 9	5	30	93	8	85	10	93	5	87	3
Total	53	0	593	8	529	15	594	1	533	11

[1] The dried sardines were weighed by the bucketful. After frying they were placed in buckets and weighed again.
[2] Part of the fried fish had been brined.
[3] All fish now being brined.
[4] Fish were now weighed in the fry basket before and after frying.

TABLE 14.—*Oil data—First run of frying experiments*

Date, 1921	Bath I			Bath II			Oil cleaned
	Weight of oil after frying (includes samples)		Samples taken	Weight of oil after frying (includes samples)		Samples taken	
	Pounds	*Ounces*	*Ounces*	*Pounds*	*Ounces*	*Ounces*	
Jan. 13	21	11		21	11		No.
Jan. 14							No.
Jan. 15							No.
Jan. 17 [1]			3.2			3.2	Yes.
Jan. 18							No.
Jan. 19							No.
Jan. 20 [2]	24	3	3.2	23	3	3.2	Yes.
Jan. 24							No.
Jan. 28 [3]			1.6			1.6	Yes.
Feb. 1							No.
Feb. 2			1.6			1.6	Yes.
Feb. 3 [4]	13	7	1.6	14	15	1.6	Yes.
Feb. 4	13	10	3.2	15	7	1.6	Yes.
Feb. 9 [5]	12	13	1.6	13	7	1.6	Yes.

[1] Oil separated from "foots," which were thrown away.
[2] After the oil had been weighed the amount of oil in each bath was reduced to 16 pounds.
[3] "Foots" were separated by placing them in a bottle. Salt was added at times. The bottle was then kept in boiling water until the "break" occurred. The oil was floated off the water and remaining "foots."
[4] Oil was much darker and more viscous than at the start. The emulsions formed were more permanent.
[5] "Foots" were boiled to get the water out. They were then allowed to stand. The recovered oil was added to the original batches of oil. This treatment gave a very dark oil from the "foots."

TABLE 15.—*Frying data—Second run of frying experiments*

Date, 1921	Time of frying		Bath I (Crisco)				Bath II (Mazola)			
			Weight of fish before frying		Weight of fish after frying		Weight of fish before frying		Weight of fish after frying	
	Hours	*Minutes*	*Pounds*	*Ounces*	*Pounds*	*Ounces*	*Pounds*	*Ounces*	*Pounds*	*Ounces*
Feb. 11	4	45	89	12	83	14	87	12	82	1
Feb. 15	4	30	85	8	80	7	86	7	80	14
Feb. 16	5	0	96	2	91	0	92	11	87	5
Feb. 17	3	30	104	4	100	3	104	3	99	7
Feb. 18	3	30	111	12	105	4	112	4	106	15
Mar. 4	4	40	131	1	120	7	128	5	118	9
Mar. 6	2	45	104	13	96	6	103	0	96	9
Mar. 7	4	15	120	12	113	2	118	14	110	9
Mar. 8	4	0	120	13	114	8	121	1	113	9
Mar. 9	1	30	28	9	27	1	28	2	26	4
Mar. 10	2	30	72	8	68	0	72	2	66	14
Mar. 16	1	0	21	15	20	7	23	3	21	13
Mar. 17	3	0	117	8	106	14	116	10	107	5
Mar. 18	2	0	61	2	57	13	62	6	59	9
Total	46	55	1,266	7	1,185	6	1,257	0	1,177	11

TABLE 16.—*Oil data—Second run of frying experiments*

Date, 1921	Bath I (Crisco)			Bath II (Mazola)		
	Weight of oil after frying (includes samples)		Samples taken	Weight of oil after frying (includes samples)		Samples taken
	Pounds	*Ounces*	*Ounces*	*Pounds*	*Ounces*	*Ounces*
Feb. 11 [1]	16	0	1.6	16	0	1.6
Feb. 15			1.6			1.6
Feb. 16			1.6			1.6
Feb. 17	15	13	1.6	15	11	1.6
Feb. 18			1.6			1.6
Mar. 4	13	15	1.6	14	8	1.6
Mar. 6 [2]			1.6			1.6
Mar. 7 [3]	12	11	1.6	13	0	1.6
Mar. 8 [4]	11	15	1.6	12	3	1.6
Mar. 9 [5]						
Mar. 10 [6]	10	11	1.6	11	6	1.6
Mar. 16 [7]						
Mar. 17	12	12	1.6	13	0	1.6
Mar. 18 [8]	11	12	1.6	12	13	1.6

[1] Oil separated from "foots" by heating them, with or without adding salt, until the "break" occurred. The oil was then floated off. Remaining "foots" discarded.
[2] Oil in Bath I darker than oil in Bath II. Bath I had been harder to keep down to 230°.
[3] The oil in Bath I continued to heat more rapidly. The oils were changed to see if the heating was due to the baths or to the oil. Data given correspond to the oils just as if no change had been made. Mazola tends to foam more than Crisco.
[4] Oil changed again. Two days of testing showed that Bath I heated the oil contained in it more rapidly than did Bath II.
[5] Oils still changed. This was done so that the oil normally contained in Bath II could have the effect of greater heat for a few days.
[6] "Foots" in Bath I about twice as large as those in Bath II. This was a daily occurrence.
[7] Three pounds of each oil were added to the baths before starting to fry on this date. There were then 12 pounds 11 ounces of oil in Bath I (not counting samples).
[8] Not counting samples there remained 10 pounds 9 ounces of oil in Bath I.

That much oil does cook out of fat fish has been proved by experiment. When such fish are cooked in a saturated salt solution at a temperature and for a time comparable to frying in oil, considerable bright yellow oil is rendered from them and rises to the surface. Most of the fat in the California pilchard is just below the skin and next to the lining of the body cavity, positions from which it is easily rendered by heat.

An index of the amount of oil removed from the bath by large, very lean fish was found in the following manner: Part of a sample of such fish was boiled in brine for a long time to ascertain what quantity of oil would cook out of them. Only a trace appeared. Another part of the sample was prepared for frying in the usual manner, cooked 8 minutes in cottonseed oil kept at 230°, and allowed to drain 8 minutes. Data for this experiment are given in Table 17.

An idea of the amount of sardine oil that gets into frying oil during the cooking of a batch of large, fat sardines was determined as follows: A sample of 20 large, fat sardines was prepared for frying and was divided into two parts, one part of which was fried for 8 minutes at 230° and not allowed to drain over the frying oil. This cooked part and the other (uncooked) part were analyzed for fat content. Moisture was determined by drying the finely divided samples in an air oven at 230°. Slight errors entered here, due to oxidation changes; however, as both samples received the same treatment results are comparable. Fat in the dry samples was extracted by anhydrous ether in Knorr extractors; the extracted fat was then dried and weighed. Data are given in Table 18. Included in the table are data on losses in weight in preparing the fish.

TABLE 17.—*Oil carried from the fry bath by lean California pilchards*

	Grams		Grams
Oil before frying	3,942.000	Sardines after frying	3,108.500
Oil after frying	3,773.500	Oil loss (including drainings) in units per unit [1] of fish fried	0.050
Oil draining from fish	51.500	Oil loss (not including drainings) in units per unit of fish fried	0.035
Oil loss (including drainings)	168.500		
Oil loss (not including drainings)	117.000		
Sardines before frying	3,329.500		

[1] In this case grams per gram of fish fried.

TABLE 18.—*Changes in oil content of fat California pilchards in frying* [1]

Sample	Weight, grams	Per cent moisture	Per cent fat	Weight of fat in fish, grams
Before frying	1,263	60.9	11.2	141.5
After frying	1,167	58.2	13.6	158.7
Oil loss from bath to fish				17.2
Oil loss from bath to fish, per units of fish fried				0.0136

[1] In preparing the fish for frying, 20 fish, weighing 4,210 grams, lost 37.9 per cent in weight in being butchered, 0.1 in brining, and 3.3 in drying, calculated on the original weight. On the same basis the loss in frying in 10 fish which were fried was 4.4 per cent.

In this experiment the oil removed from the bath per unit of fish fried was 0.0136 (0.0136 gram per gram of fish fried). These fish were not allowed to drain 8 minutes over the bath, as was done in the experiment with lean fish (Table 17). Had they been allowed to drain, undoubtedly as much oil (and probably more, since the fish were very fat) would have drained from them as did from the lean fish (0.015 unit of oil per unit of fish fried). Such fish as these would give up a little more oil than they remove, thus causing the oil in the bath to increase with use. Pure cottonseed oil (1,475 grams) was used for frying the 1,263 grams of fish. After frying there remained approximately 1,458 grams of oil (1,475 grams minus 17 grams carried out by the fish). The sardine-oil content of this oil was determined by calculation from the iodine numbers of pure sardine and cottonseed oils and the mixed oil after frying. The sample of sardine oil analyzed was obtained from fat fish by boiling them in brine. Determinations were made by the Hanus method. Scott[70] describes this method and the method of calculation used in determining the sardine-oil content. The results of this determination, given in Table 19, show that the cottonseed oil after frying, contained 4 per cent, or 58.3 grams, of sardine oil. This gives a loss of at least 0.046 unit of sardine oil from the fish to the bath for each unit fried. The loss was more, however, because some sardine oil was removed as a part of the mixed oil carried out of the bath by the cooked fish. Oxidation of the oil during the heating period tended to lower the iodine number of the mixed oil, and this in turn tended to lower the calculated amount of sardine oil. This tendency, however, was small, the oils being heated, in all, less than 1 hour.

TABLE 19.—*Fish-oil content of cottonseed oil used in frying one lot of large, fat California pilchards* [1]

Oil	Iodine number		
	1	2	Average
Sardine	160.0	160.0	160.0
Cottonseed, before frying	107.5	107.0	107.2
Cottonseed and sardine, after frying	109.5	109.2	109.3

[1] 1,263 grams fish fried in 1,475 grams of oil—1,458 grams left after frying.

$$\text{Calculation: } \frac{100\ (109.3-107.2)}{160.0-107.2}=4 \text{ per cent sardine oil.}$$

It has been shown experimentally that a sample of large, lean fish, which would give up no oil in the fry bath, removed about 0.035 unit of oil from the bath for each unit of fish fried 8 minutes in oil at 230° and allowed to drain over the oil in the bath for 8 minutes. It is very probable that large, fat fish fried in the same manner would mechanically carry out of the bath an equal quantity of oil. If this is true, and if it is assumed that the oil content of the bath remains constant, then 0.035 unit of oil must cook out of the fish per unit fried. Oil does cook out of the fish and mix with the oil in the bath, for it has just been shown that

[70] Standard Methods of Chemical Analysis. By Wilfred W. Scott. 3d ed., vol. 2, pp. 1128–1130. New York, 1922.

0.046 unit of sardine oil remained in the frying oil for each unit of large, fat fish cooked under conditions similar to those used in cooking the lean fish. It is possible, by using the figure (0.035) for the amount of oil that cooks out of the fish in the bath and the amount of oil removed from the bath, to make calculations that show at least how rapidly the sardine-oil content of frying oil must increase when large, fat sardines are fried, the oil content of the bath remaining constant. Use of a value larger than 0.035 would give figures showing a more rapid increase.

The average amount of sardines fried at one time in the second run of frying experiments was about 4 pounds. Calculations were made, therefore, on 4-pound units. It was also assumed that the quantity of oil in the bath remained at 12 pounds. The amount of oil that cooked out of each 4 pounds of sardines was taken as 0.035 pound$\times$4=0.140 pound. The same amount of mixed oil was assumed to be mechanically carried out of the bath by each 4 pounds of sardines fried. After cooking the first unit there would be 12.14 pounds of oil in the bath. Mixing of the oils would be quite complete, due to the action of steam coming from the fish and bubbling constantly through the oils. On lifting the fish out of the oil a quantity of the mixed oils would be carried out of the bath. Part of this would return during the draining period and the rest (0.140 pound) would be permanently removed. The fish oil left in the bath would be 12.0$\times$0.140/12.140. The fraction (12.0/12.140) of the amount of fish oil in the bath would remain after each unit was removed. In general—

Let a = pounds of fish oil that cook out of the fish for each unit cooked.
b = fraction of fish oil remaining in the fry-bath oil left behind after each unit is cooked and removed.
Xn = pounds of fish oil in the bath after n units of fish have been cooked and removed.

$$X_1 = ba.$$
$$X_2 = b\ (ba + a) = a\ (b^2 + b).$$
$$X_3 = b\ [b\ (ba + a) + a] = a\ (b^3 + b^2 + b).$$
$$X_4 = a\ (b^4 + b^3 + b^2 + b).$$
$$X_n = a\ [b^n + b^{n-1} + b^{n-2} + \cdots + b^{n-(n-2)} + b^{n-(n-1)}] \text{ or } X_n = X_{n-1} + ab^n.$$

The last equation shows that each succeeding calculation can be made by adding ab^n to X_{n-1}. In this case ab^n is only $b \times ab^{n-1}$. Each succeeding unit can therefore be found by adding log. b to log. ab^{n-1}, then finding the number that corresponds to this sum and adding this number to the preceding value of X_{n-1} to get the new value of X_n. If a number of these calculations are made, it will be seen that log. ab^n—log. ab^{n-1} is constant for the different values of n. This difference, when successively added to the logarithm of ab, gives the succeeding logarithm of ab^n. The value of this logarithm is then added to the value of X_{n-1} to get X_n. In finding the value of X_n the calculations are simplified by multiplying the difference in the logarithms mentioned above by $n-1$ and adding it to the first logarithm. The difference is then successively subtracted (algebraically) from this new logarithm. This gives a list of logarithms. The numbers that correspond to these logarithms are then written down and added to get the value of X_n. This mode of attack, used with the aid of a tabulating adding machine, greatly simplifies calculations. The equation and method of calculation developed is applicable to other problems where the amount of oil in the bath remains constant.

The values used in this set of calculations are given below. The results of the calculations are listed in Table 20.

$$n = 200$$
$$a = 0.140 \text{ (log. } a = 9.1461 - 10)$$
$$b = \frac{12.0}{12.140} \text{ (log. } b = 9.9950 - 10)$$
$$\text{log. } ab^n - \text{log. } ab^{n-1} = 0.0050$$

Another set of calculations was made, assuming the same conditions to exist, except that 1-pound units were taken. Results are shown in Table 21.

Other calculations along similar lines were made, which show the effect on the sardine-oil content of fry-bath oil when the oil content of the bath increases. Two such calculations were made—one to show how the increase takes place if the oil content of the bath is allowed to increase and the other to show the effect of removing the increase after each unit is fried, so as to keep the oil content constant. It was assumed that 0.180 pound of oil cooked out of each 4 pounds fried, and that 0.140 pound was removed by each 4 pounds fried. Enough of these calculations are given in Tables 22 and 23 to show the trend of affairs.

It is realized that these calculations are partially based upon assumptions and approximations, yet it is felt that they are not far from the truth; if anything, they are too low. In any case, they accurately show the nature of the changes that take place and clearly indicate how the sardine-oil content of the frying oil can be kept at a minimum. Experimental evidence tending to substantiate these calculations follows:

TABLE 20.—*Calculated fish-oil content of fry-bath oil*

[Four-pound units fried; oil content constant at 12 pounds]

Frying time in hours	Pounds of fish fried	Pounds of fish oil in fry-bath oil	Per cent fish oil in fry-bath oil	Frying time in hours	Pounds of fish fried	Pounds of fish oil in fry-bath oil	Per cent fish oil in fry-bath oil
0.125	4	0.138	1.2	3.750	120	3.526	29.4
0.250	8	.275	2.3	5.000	160	4.454	37.1
0.375	12	.410	3.4	6.250	200	5.280	44.0
0.500	16	.544	4.5	12.500	400	8.235	68.6
0.625	20	.676	5.6	18.750	600	9.890	82.4
1.250	40	1.314	10.9	25.000	800	10.816	90.2
2.500	80	2.484	20.7				

TABLE 21.—*Calculated fish-oil content of fry-bath oil*

[One-pound units fried; oil content kept constant at 12 pounds]

Frying time in hours	Pounds of fish fried	Pounds of fish oil in fry-bath oil	Per cent fish oil in fry-bath oil	Frying time in hours	Pounds of fish fried	Pounds of fish oil in fry-bath oil	Per cent fish oil in fry-bath oil
0.5	4	0.139	1.2	2.0	16	0.546	4.6
1.0	8	.276	2.3	2.5	20	.679	5.7
1.5	12	.412	3.4	5.0	40	1.319	11.0

TABLE 22.—*Calculated fish oil content of fry-bath oil*

[Four-pound units fried; oil content increasing from 12 pounds at start]

Pounds fried	Calculations	Pounds sardine oil in 12 pounds of fry-bath oil
4	$12.040\times\frac{(0.180)}{12.180}\times\frac{12.0}{12.040}=$	0.177
8	$12.040\times\frac{(0.177+0.18)}{12.180}\times\frac{12.0}{12.040}=$	.352
12	$12.040\times\frac{(0.352+0.18)}{12.180}\times\frac{12.0}{12.040}=$	.524
16	$12.040\times\frac{(0.524+0.18)}{12.180}\times\frac{12.0}{12.040}=$	.694

TABLE 23.—*Calculated fish-oil content of fry-bath oil*

[Four-pound units fried; oil content kept at 12 pounds by removing accumulated excess after each unit is fried]

Pounds fried	Calculations	Pounds sardine oil in 12 pounds of fry-bath oil
4	$12.040 \times \frac{(0.180)}{12.180} \times \frac{12.0}{12.040} =$	0.177
8	$12.040 \times \frac{(0.177+0.18)}{12.180} \times \frac{12.0}{12.040} =$	.352
12	$12.040 \times \frac{(0.352+0.18)}{12.180} \times \frac{12.0}{12.040} =$	.524
16	$12.040 \times \frac{(0.524+0.18)}{12.040} \times \frac{12.0}{12.040} =$	.694

The sardine-oil content of the frying oil remaining after 800 pounds of sardines had been fried per 12 pounds of oil used (Bath I, second run of frying experiments, Tables 15 and 16), was 45 per cent, being calculated from the iodine numbers of the remaining oil and the pure constituents. This value is low because oxidation changes took place to a considerable extent, which lowered the iodine number, and this in turn lowered the calculated result. This value is half the corresponding calculated value given in Table 24, but the oil diminished 21 per cent during the frying period. Results are not comparable, therefore, but it is shown that the increase of sardine-oil content of frying oil is rapid even when the sardines give up less oil to the bath than they remove.

Chemical and physical changes.—Tables 25 to 28 give data on the changes that took place in the oils used in the frying and heating tests.

Chemical treatment.—Chemical treatment of fry-bath oil was tried in an endeavor to develop methods for improving the oil during use and for recovering the "old" oil. In undertaking these experiments it was realized that a suitable method would have to be rapid and inexpensive. A study was made of the various methods used in purifying oils, and the most promising of these was then tried on "old" fry-bath oil. This phase of the subject could have been studied to much greater extent, but the hopelessness of this line of endeavor was quite apparent.

TABLE 24.—*Fish-oil content of oil remaining in Bath I, second run of frying tests, after frying, March 10*

Oil	Iodine number
Sardine	160.0
Pure Crisco	74.2
Frying oil	113.0

Calculation: $\frac{100\ (113.0-74.2)}{(160.0-74.2)} = 45$ per cent sardine oil.

TABLE 25.—*Free fatty-acid content of fry-bath oil samples from the first and second runs of frying experiments* [1]

Run	Date, 1921	Per cent, Bath I	Per cent, Bath II	Run	Date, 1921	Per cent, Bath I	Per cent, Bath II
First	Start.	0.1	0.1	Second—Contd.			
Do	Jan. 17	.2	.1+	Do	Feb. 16	.3+	.2
Do	Jan. 18	.2	.1+	Do	Feb. 17	.5	.2+
Do	Jan. 20	.2+	.2+	Do	Feb. 18	.5+	.2+
Do	Jan. 21	.2+	.2+	Do	Mar. 4	.5	.3
Do	Jan. 29	.3+	.3+	Do	Mar. 6	.5	.3
Do	Feb. 2	.4+	.4+	Do	Mar. 7	.5	.3+
Do	Feb. 3	.4+	.4	Do	Mar. 8	.5	.5
Do	Feb. 4	.4	.5	Do	Mar. 10	.6	.5
Do	Feb. 9	.6	.6	Do	Mar. 17	.6+	.5+
Second	Start.	.2+	.1	Do	Mar. 18	.6+	.5+
Do	Feb. 11	.2+	.1				
Do	Feb. 15	.3+	.2				

[1] Analyses conducted as follows: Sample taken with pipette, which delivered 8.6 grams of oil. Hot neutral alcohol (50 c. c.) was added and the acidity neutralized with N/10 sodium hydroxide, using phenolphthalein as an indicator. Percentage of free fatty acids calculated as oleic acid.

TABLE 26.—*First set of heating tests on oils used in frying sardines. Color and viscosity comparisons* [1]

COLOR

Sample No.	Cottonseed, c. c.	Mazola, c. c.	Crisco, c. c.	Sardine, c. c.	Color comparison of sample with original sample [2]					
					Apr. 15		Apr. 22		Apr. 27 (1921)	
					Open to air	Closed to air	Open to air	Closed to air	Open to air	Closed to air
1	200				No change.	No change.	Slightly lighter.	Slightly lighter	Same	Same.
2		200			do	do	do	Same	Very slightly lighter.	Do.
3			200		do	do	do	Very slightly darker.	do	Slightly darker.
4				200	do	do	Reddish	Same	Red	Same.
5	100			100	do	do	Dark yellow.	do	Reddish tinge	Do.
6		100		100	do	do	do	do	do	Do.
7			100	100	do	do	do	Slightly lighter	do	Slightly lighter.
8	150			50	do		do.[3]		do.[3]	

[1] Samples to be exposed to air were placed in 250-cubic centimeter beakers with glass stirring rod. Other samples were placed in the same sized bottles, having ground glass stoppers. Beakers and bottles were then partly buried in the sand or a sand bath placed on an electric hot plate and the oils kept at a temperature of 212 to 240° F. Ten cubic-centimeter samples were taken at the beginning of the run and at three other times.

[2] Heating began on Apr. 14, 1921. All original samples were yellow in color. Colors were observed in 12 cubic-centimeter test tubes, each of which held slightly over 10 cubic centimeters of oil.

[3] Lighter than sample 5.

VISCOSITY

Rough visual comparison of the viscosities of the oils heated to April 27 showed the following: Pure oils, in order of decreasing viscosity, 4, 2, 3, and 1 the same; mixed oils, 8, 5, 6, and 7.

TABLE 27.—*Samples from first set of heating tests on oils used in frying sardines. Per cent free fatty acids in samples at end of test* [1]

Sample No.	Original sample	Heated in air	Heated away from air	Sample No.	Original sample	Heated in air	Heated away from air
1	0.1	0.7	0.3	5	0.4	0.7	0.5
2	0.1	0.4	0.1+	6	0.4	0.8	0.5
3	0.3	1.6	0.9	7	0.5	1.2	0.6
4	0.7	1.2	1.0	8	0.4	0.7	----------

[1] See Table 25 for method of analysis.

TABLE 28.—*Second set of heating tests on oil used in frying sardines* [1]

[Color comparison of heated oils with oils not heated] [2]

Sample No.	Composition of oil sample		Sample heated 2 days in vacuum	Sample heated 2 days in air	Sample heated 7 days in air
	Cottonseed	Sardine			
1	20	----------	Same	Same	Slightly darker.[3]
2	----------	20	Very slightly darker	Reddish	Red.[4]
3	10	10	do	do.[5]	Do.[6]

[1] Samples were placed in 250 cubic-centimeter beakers. This made a shallow layer of oil in each. One set of samples was heated 2 days under 25 inches of vacuum at 212° to 240° F. Another set was heated 2 days, and still another 7 days in air at the same temperature.
[2] All samples were light yellow at the beginning.
[3] Very viscous, having dried to a sticky film.
[4] Not quite as viscous as sample 1.
[5] Not as dark as sample 2.
[6] Not as dark red as sample 4; not quite as sticky a film as in sample 1.

The action of fuller's earth and of finely divided carbon from kelp (Kelpchar) was tried. Ten per cent of the decoloring material was added, with stirring, to the oil, which was kept at 176°. This process was carried out for 15 minutes, and then the oil was filtered. It was expected that the decolorizing material would remove (by adsorption) the coloring matter dissolved in the oil. This, however, was not the case, as the oil was not lightened in color. It was decided, therefore, that the color was possibly a molecular characteristic of part of the fish oil and not a dissolved pigment. In such a case it would be useless to try to remove the color in this manner.

A sample of partially "spent" fry-bath oil was kept at 300° to 350° for 2 hours while steam was bubbled through it. The oil became darker in color, while the taste and odor remained the same.

About 2 per cent of sodium dichromate, dissolved in a minimum amount of water, was added to partially "spent" fry-bath oil and the whole emulsified. A quantity of hydrochloric acid, chemically equivalent to the amount of sodium dichromate used, was added to the sodium dichromate solution-oil emulsion and the whole thoroughly mixed. The mixture was then heated for a short time at 130° to 140°. The oxygen liberated in the reaction acted on the oil and its impurities, turning the whole very dark in color. Water was then added and the whole emulsified. Even standing for several days did not help in breaking the muddy emulsion, so further attempts were not made.

The method used commercially in purifying cottonseed oil was tried. "Old" fry-bath oil was emulsified with a slight excess of sodium hydroxide (one-fifth normal) over that needed to neutralize the free, fatty acids present. The mixture was then heated a little, water added, emulsified, and boiled. Salt (to help in breaking the emulsion) was added to the boiling emulsion, after which the mixture was placed in a bottle and heated in boiling water until the emulsion was broken. Part of the oil was poured off, washed with water, dried, and the improvement in color, taste, and odor observed. The taste and odor remained about the same; the color, however, was considerably improved. A second treatment of the refined oil improved the color still more.

In settling the emulsion separated into three layers. On top was the cloudy oil and on the bottom an alkaline solution, very dark in color, appearing as if a large part of the color had concentrated there. Between the two layers was a small amount of apparently unbroken emulsion. The lower aqueous layer was alkaline in reaction, and on addition of acid fatty acids separated out, which were chocolate in color. The soap in this alkaline solution was salted out by calcium chloride. This cleared the solution and gave a very dark brown-colored soap.

The removal of color in this case appeared to be adsorption of the colored material by the soap solution as it appeared from the emulsion. It might have been a case of selective reaction between the hydroxide and the red-colored oil. This is in line with the statement given on page 169. The question is an interesting one but hard to settle definitely from the information at hand.

Schuck (see footnote, p. 99) claims that oils that have been burnt in use and have absorbed the odor of fish can be sweetened, brightened, and deodorized by his process. His method consists of blowing hydrogen for about 20 minutes through the oil, which is heated to about 520°. A small amount of hydrogenation is claimed to take place. "Old" fry-bath oil was treated in this manner with negative results. The oil used was freed from moisture by heating; then it was treated. The resulting oil had a burnt taste and odor and was much darker in color. It is possible that the procedure was not carried out under as favorable conditions as were Schuck's experiments. It is more probable, however, that his claims can not be verified on "old" fry-bath oil.

METHODS OF PREPARING THE FISH

A large number of experiments were made, and almost an equal number of packs were prepared during the course of the investigation on methods of preparing the fish. Storing and shipping tests also were made with the prepared packs. Detailed data covering these experiments, packs, and tests are given here in tabular form (Tables 29 to 32). The general discussion upon this work is in the main body of this report.

NOTES APPLYING TO THE TABLES

Unless otherwise stated in the tables, the fish used were pilchards (*Sardina cærulea*) caught off the coast of southern California, in good canning condition, and of the size ordinarily used for the pound-oval pack. The fish had been scaled and the heads and entrails removed before they were prepared for canning.

Unless otherwise stated, "brine" means a 100 per cent saturated solution of salt (sodium chloride) at ordinary air temperature. "Brined" means that the fish were immersed in such a solution.

"Dried" means (unless data to the contrary are given) that the fish were scattered on a wire flake and subjected to the action of a current of air having a temperature of about 100° to 110° and a velocity of about 500 feet per minute.

"Raw pack" indicates that the fish were sealed into the cans without first having been cooked.

Except where statements to the contrary are given, canning consisted of the following steps: The prepared fish were packed into pound-oval cans with tomato sauce. In the case of fried fish they were allowed to stand overnight before being packed into the cans. The product was then exhausted by means of "live" steam or by adding hot tomato sauce. The cans were then sealed while hot and processed 1½ hours at 240° with steam in a retort.

In most of the experiments results were checked by comparing the product obtained with a similar product prepared by the standard fried-in-oil process.

TABLE 29.—*Experimental data on the preparation of California pilchards for canning as sardines by the brine-cooking process* [1]

Experiment No.	Date	Fish	Preparation for canning	Notes on preparation and condition of prepared fish	Canning data	Pack No.	Examination of canned product	General results
1a	1920 Dec. 16	Large	Cooked in brine 15 minutes at 227°; cooled.	Physical condition good except skins in poor condition; taste good.				Brine cooking prepared a product comparable in quality with the fried-in-oil fish; poor condition of skins was probably due to their not being toughened by drying.
1b	do	do	Cooked in oil 15 minutes at 230°.	do				
2a	do	do	Dried; cooked 12 minutes in brine at 227°.	Well cooked, firm, skins in good condition, taste excellent.	Fish cooled, packed in 1-pound tall cans with tomato sauce, exhausted, sealed, processed 1¼ hours at 240°.	1	Firm, skins intact, taste excellent.	Brine cooking produced an excellent pack of tomato-sauce sardines.
3a	1921 Oct. 26	Small	Dried; cooked 8 minutes in saturated brine solution made by using salt having the following composition: 100 per cent sodium chloride (cooking temperature 227°); cooked fish rinsed with water and cooled overnight.	Brine-cooked fish slightly more moist and skins slightly more tender than fried-in-oil product; taste slightly too salty yet not too salty for canning with unsalted sauce.				In dry-salting fish the presence of impurities, such as calcium and magnesium chloride, produces differences in the final product; this experiment shows that the presence of these impurities makes little difference in brine cooking except to increase the salty taste; pure or nearly pure sodium chloride probably would be best for cooking purposes.
3b	do	do	Same, only composition of salt used to make brine was 99 per cent sodium chloride and 1 per cent calcium chloride, by weight.	Same, physical condition of fish no different from 3a.				
3c	do	do	Same, only composition of salt was 98 per cent sodium chloride and 2 per cent calcium chloride, by weight.	Same as 3b				
3d	do	do	Same, only composition was 97 per cent sodium chloride and 3 per cent calcium chloride, by weight.	do				
3e	do	do	Same, only composition was 96 per cent sodium chloride and 4 per cent calcium chloride, by weight.	Same as 3b; more salty tasting than fish cooked in brine made from pure sodium chloride.				
3f	do	do	Same, only composition was 96 per cent sodium chloride and 4 per cent magnesium chloride, by weight.	Same notes as 3b.				
3g	do	do	Preparation same as 3a, except fish cooked in oil 8 minutes at 227°.	Same notes as 3a.				

[1] See notes, p. 170.

TABLE 29.—*Experimental data on the preparation of California pilchards for canning as sardines by the brine-cooking process*—Continued

Experiment No.	Date	Fish	Preparation for canning	Notes on preparation and condition of prepared fish	Canning data	Pack No.	Examination of canned product	General results
4a	1921 Oct. 26	Small quarter-oil size.	Preparation same as 3a	Too salty to be used for quarter-oil pack.				
5a	Oct. 28	Large	Dried; cooked 7 minutes in 100 per cent saturated sodium chloride solution at 227°.	Very good condition, skins intact, taste good.				Impure salt gave a more salty taste to brine-cooked fish than did pure salt; difference, however, not strongly pronounced.
5b	do	do	Same, only solution made from salt having following composition: 90 per cent sodium chloride and 10 per cent calcium chloride, by weight.	Same, only slightly more salty.				
5c	do	do	Same, only cooked in oil 7 minutes at 227°.	Same as 1a, only lacked salt.				
6a	Nov. 9	Large; poor condition.	Brined 1 hour, dried, and cooked 8 minutes in brine at 227°.	Examined after standing overnight, appearance good, salty tasting but probably would can well.				
6b	do	do	Same, only cooked in oil 8 minutes at 227°.	Same, only less salty and slightly less firm.				
7a	Nov. 12	Small; lean	Brined 30 minutes and cooked 6 minutes in brine at 227°.	Physical condition good, taste too salty, skins intact.	Canned	2	Physical condition good; taste too salty; pack, taken as a whole, poor, due to use of very lean fish.	Brine cooking produced a pack comparable in quality to regular fried-in-oil product; being too salty probably was due to small fish and especially to the combination of brining and cooking in brine.
7b	do	do	Same, except cooked in oil 6 minutes at 230°.	Same, only not too salty	do		Same, only not too salty.	
8a	Nov. 17	Large quarter-oil size, poor condition.	Dried; cooked in brine 6 minutes at 227°.	Skins almost in as good condition as fried product.	do	4	Skins in very good shape; taste too salty.	Brine-cooking, where the skins have been toughened, gave a pack of the same quality as the fried article; small fish took up too much salt when cooked in strong brine, and especially so if they had been brined and then cooked in brine.
8b	do	do	Same except also brined 30 minutes.	do	do	5	Same, only more salty.	
8c	do	do	Brined 30 minutes; cooked 6 minutes in oil at 227°.	Skins in best condition	do	6	Same, only not too salty.	

9a	Nov. 22	Large quarter-oil size.	Dried; cooked in boiling 85 per cent saturated brine 8 minutes.	Skins in good condition	Fish stood overnight, then packed with olive oil in quarter-oil cans; sealed, processed 1 hour at 240°.	7	Skins in good shape; taste slightly too salty.	Cooking in 85 per cent instead of 100 per cent saturated brine did not prevent large quarter-oil fish from becoming too salty; saltiness of fried fish was due to overbrining.
9b	do	do	Brined 30 minutes; dried; cooked 8 minutes in oil at 227°.	do	do	8	do	
10a	Nov. 30	do	Dried; cooked in brine for 6 minutes at 227°; stood overnight.	Physical condition of fish good, including skins; taste salty.	Packed with olive oil in quarter-oil cans; sealed, processed 1 hour at 240°.	9	Physical condition good; taste too salty.	It was necessary to lower the concentration of the salt solution below 60 per cent saturated to prevent large quarter-oils from becoming too salty; lowering the concentration gave a less satisfactory product from the standpoint of physical condition; the fish got softer and the skins more tender as the concentration was lowered; lowering the cooking temperature, using 100 per cent brine, did not prevent the fish from becoming salty.
10b	do	do	Same, only cooked in 80 per cent saturated brine for 6 minutes at 223°.	Physical condition of fish, including skins, not as good nor taste quite as salty as 9a.	do	10	do	
10c	do	do	Same, only cooked in 60 per cent brine for 6 minutes at 219°.	Skins tender	do	11	Slightly softer than 9a; taste a little too salty.	
10d	do	do	Same, only cooked in 40 per cent brine for 6 minutes at 217°.	Satisfactory, except skins too tender.	do	12	About like 9c, except not too salty.	
10e	do	do	Same, only cooked in 100 per cent brine 6 minutes at 219°.	Skins tough; taste salty	do	13	Physical condition good; taste too salty.	
11a	Dec. 12	Medium	Dried; cooked in brine for 7 minutes at 227°.	Skins in good condition	Canned	14	Physcial condition good; taste slightly too salty.	In preparing medium pound-oval fish, lowering the concentration to 80 per cent prevented excessive saltiness; as the concentration of the cooking solution was lowered the physical condition of the cooked fish became poorer.
11b	do	do	Same, only cooked at 219°	do	do	15	Physcial condition good; not too salty.	
11c	do	do	Same, only 80 per cent brine at 223°.	Skins in fair condition	do	16	Not as firm as 11a or 11b.	
11d	do	do	Same, only 60 per cent brine at 219°.	Skins broken	do	17	Not as good as 11a or 11b.	

TABLE 29.—*Experimental data on the preparation of California pilchards for canning as sardines by the brine-cooking process*—Continued

Experiment No.	Date	Fish	Preparation for canning	Notes on preparation and condition of prepared fish	Canning data	Pack No.	Examination of canned product	General results
12a	1922 Jan. 10	Medium, fairly fat.	Brined 1 hour; cooked 10 minutes in brine at 100°.	No material difference in the appearance of skins or other physical conditions of fish observable between a, b, and c.				Lowering the concentration of the brine-cooking solution produced no observable difference in cooked product; some difference probably would have shown up had the cooked fish been canned.
12b	...do	...do	Same, only cooked in boiling 66 per cent brine.	...do				
12c	...do	...do	Same, only cooked in boiling 33 per cent brine.	...do				
13a	Jan. 21	Large, fat	Dried; cooked in brine 8 minutes at 227°.		Canned	18	Very good	Brine-cooking produced pack comparable to fried-in-oil product.
13b	...do	...do	Brined 1 hour; cooked 8 minutes in oil at 227°; cooled and drained overnight.		...do		...do	
14a	Jan. 28	Medium, fat	Dried; cooked 8 minutes in brine at 212°.	The stronger the brine the better the physical condition of the fish.				The stronger the brine-cooking solution the better was the physical condition of the cooked product.
14b	...do	...do	Same, only cooked in 66 per cent brine at 212°.	...do				
14c	...do	...do	Same, only cooked in 33 per cent brine at 212°.	...do				
14d	...do	...do	Same, only cooked in water at 212°.	...do				
15a	Feb. 23	Large, fat	Dried; cooked in brine 8 minutes at 227°; cooled and drained overnight.		Processed 3 hours at 230°.	19	Excellent	
16a	Mar. 2	...do	Same as 15a		Same as 15a	20	Physical condition very good; taste poor, due to fish being cooked in old brine that had stood several days after previous use.	

TABLE 30.—*Experimental data on the preparation of California pilchards for canning as sardines by the steaming process* [1]

Experiment No.	Date	Fish	Preparation for canning	Notes on preparation and condition of prepared fish	Canning data	Pack No.	Examination of canned product	General results
17a	1921 Oct. 26	Small	Dried; cooked 30 minutes in steam at 212°; stood overnight.	Drier than 17b; skins in excellent shape.				Steaming produced an excellent cooked product.
17b	do	do	Same, only cooked in oil 8 minutes at 227°.					
18a	Oct. 28	Large	Brined 30 minutes; cooked 10 minutes at 240° by steam under 25 pounds pressure.	Skins broke badly, being worse than fish steamed at atmospheric pressure and 212°.				Steaming under pressure caused more breaking of skins than when steam at atmospheric pressure was used; no material difference observed between fish steamed 15 or 30 minutes, brined or not brined.
18b	do	do	Same, only cooked 15 minutes at 212° with steam.	Skins broke, excepting 18a; no difference noticed in 18a to 18e.				
18c	do	do	Same as 18b, except cooked 30 minutes.	do				
18d	do	do	Brined 1 hour; cooked 15 minutes with steam at 212°.	do				
18e	do	do	Same as 18d, only cooked 30 minutes.	do				
19a	Nov. 4	Large, poor condition.	Brined 18 hours; cooked 15 minutes in steam at 212°.	Skins tough; flesh dry, firm; taste much too salty.				Brining 18 hours seemed to keep skins from breaking but it made the cooked product too salty.
19b	do	do	Same, only steamed 30 minutes.	About the same as 19a.				
20a	Nov. 8	do	Brined 4 hours; cooked 15 minutes in steam at 212°; stood overnight.	Skins tough; flesh firm.				Brining 4 hours seemed to toughen the skins; large fish did not get too salty.

[1] See notes, p. 170.

TABLE 30.—*Experimental data on the preparation of California pilchards for canning as sardines by the steaming process*—Continued

Experiment No.	Date	Fish	Preparation for canning	Notes on preparation and condition of prepared fish	Canning data	Pack No.	Examination of canned product	General results
21a	1921 Nov. 9	Large, poor condition.	Brined 1 hour; cooked 15 minutes in steam at 212°; stood overnight.	Skins in good condition				The longer the brining the better was the physical condition of the steamed fish; up to 4 hours brining combined with steaming did not give a too salty cooked product; drying and 1 hour's brining with steaming gave about as good a product as 4 hours' brining with steaming; fried-in-oil product had toughest and best skins.
21b	do	do	Same, only brined 2 hours	Skins better than 21a; not so good as 21c.				
21c	do	do	Same, only brined 4 hours	Physical condition excellent; skins tough.				
21d	do	do	Same, only not brined	Skins broken; taste flat				
21e	do	do	Brined 1 hour; dried; cooked 15 minutes in steam at 212°; stood overnight.	Skins good, although not as tough as 21c.				
21f	do	do	Same as 21e, except cooked 8 minutes in oil at 230°.	Skins in best condition				
22a	Nov. 12	Small, lean	Brined 2 hours; dried; cooked 11 minutes in steam at 212°.		Canned	21	Physical condition good; pack, taken as a whole, poor, due to use of very lean fish.	Brining and drying, followed by steaming, produced a pack with skins in better condition than the fried-in-oil product. Difference here probably due to poor drying of fish to be fried.
22b	do	do	Brined 30 minutes; dried cooked in oil 6 minutes at 230°.		do	22	Same; skins not quite as tough.	
23a	Nov. 17	Large quarter-oil size; poor condition.	Brined 30 minutes; dried; cooked 12 minutes in steam at 212°.	Skins in good condition	do	23	Skins in good condition.	Large, lean, quarter-oils brined up to 3½ hours showed little difference in physical condition after steaming; brining 3½ hours gave a too salty product; frying in oil produced fish having toughest and best skins.
23b	do	do	Same, only brined 2 hours	do	do	24	do	
23c	do	do	Brined 3½ hours; cooked in steam 12 minutes at 212°.	do	do	25	Skins in good condition; taste too salty.	
23d	do	do	Same as 23a, except cooked in oil 6 minutes at 227°.	Skins toughest	do	26	Skins in excellent condition.	

24a	...do....	Large, fat......	Brined 3½ hours; cooked in steam 15 minutes at 212°.	Skins broke in cooking....	.....do...............	27	Good pack; firm, but skins broken and tender.	Skins of large, fat fish broke badly during steaming, even with the long brining.
25a	Nov. 22	Large quarter-oil size, lean.	Brined 30 minutes; dried; cooked 12 minutes in steam at 212°.	Skins good...............	Stood overnight; then packed with olive oil in quarter-pound cans, sealed, processed 1 hour at 240°.	28	Skins fine; taste good..	Brining and drying were better than long brining alone in preparing fish for steaming.
25b	...do....	.....do........	Same, only brined 70 minutes and not dried.	.....do................	.....do...............	29	Skins not as good as 25a; taste good.	
26a	Nov. 30	Large quarter-oil size.	Brined 30 minutes; dried; cooked 15 minutes in steam at 212°.	Skins tender..............	Stood overnight; canned.	30	Taste and appearance good.	Steaming 30 and 45 minutes seemed to make the skins more tender than 15 minutes steaming.
26b	...do....	.....do........	Same, only steamed 30 minutes.	Skins very tender........	.....do...............	31	.....do..............	
26c	...do....	.....do........	Same, only steamed 45 minutes.	.....do................	.....do...............	32	.....do..............	
27a	Dec. 12	Small quarter-oil size.	Brined 15 minutes in 60 per cent saturated brine; dried; cooked 10 minutes in steam at 212°.	Skins broke some during steaming.	Cooled; packed with olive oil in quarter-pound cans; processed 1 hour at 240°.	33	Good, except for skins.	Skins of fish not dried before being steamed broke more during steaming than those that had been dried first.
27b	...do....	.....do........	Same, only steamed, then dried.	Skins broke badly during steaming.	.....do...............	34	.....do..............	
28a	Dec 13	Medium pound-ovalsize, lean.	Brined 1 hour; dried; cooked 15 minutes in steam at 212°; stood overnight.	Skins tender..............	Canned..............	35	Fish in fair condition; taste good.	Increasing the steaming time increased skin breakage.
28b	...do....	.....do........	Same, only cooked 30 minutes.	Skins fair condition, yet tender.	.....do...............	36	.....do..............	
28c	...do....	.....do........	Same, only cooked 45 minutes.	Skins broken..............	.....do...............	37	.....do..............	
28d	...do....	.....do........	Same, only cooked 60 minutes.	.....do................	.....do...............	38	.....do..............	
29a	...do....	Medium, fat...	Brined 1 hour; dried; cooked 15 minutes in steam at 212°; stood overnight.	Skins very tender........	.....do...............	39	Good..............	Skins of fish brined 3½ hours and steamed broke more than when brined 1 hour, dried, and then steamed.
29b	...do....	.....do........	Same, only brined 3½ hours and not dried.	Skins broken badly.......	.....do...............	40	Good except for skins being broken.	

TABLE 30.—*Experimental data on the preparation of California pilchards for canning as sardines by the steaming process*—Continued

Experiment No.	Date	Fish	Preparation for canning	Notes on preparation and condition of prepared fish	Canning data	Pack No.	Examination of canned product	General results
30a	1921 Dec. 14	Medium, lean	Brined 1 hour; dried; cooked 15 minutes in steam at 212°.		Packed raw in pound-oval cans; cans inverted on flakes and steamed, hot tomato sauce added; sealed; processed 1½ hours at 240°.	41	Physical condition good; skins good but very tender.	Packing in can then steaming tended to prevent skin breakage.
31a	Dec. 17	Medium pound-oval size; lean.	Brined 1 hour; dried; cooked 15 minutes in steam at 212°; stood overnight.	Skins broke some during steaming.				Skins broke during steaming.
32a	1922 Jan. 9	Medium pound-oval size; fat.	Brined 1 hour; dried; packed in pound-oval cans; steamed in inverted position 15 minutes at 212°.	Appearance good				Packing in can before steaming helped prevent skin breakage.
33a	Jan. 21	Large, fat	Brined 1 hour; dried; cooked in steam ½ hour at 212°.		Packed into pound-oval cans raw, then steamed in inverted position on flake; hot tomato sauce added; sealed and processed 1½ hours at 227° and ½ hour at 240°.	42	Very good pack; skins in good condition; firm.	Steaming brined, dried, large, fat fish in inverted cans produced a pack comparable to fried-in-oil product; increasing the brining time did little, if any, good in improving the physical condition of the fish.
33b	do	do	Same, only brined 2 hours		do	43	do	
33c	do	do	Same, only brined 3 hours		do	44	do	
33d	do	do	Brined 1 hour; dried; cooked 8 minutes in oil at 227°.		do	45	do	
34a	do	Small quarter-oil size.	Brined 25 minutes; cooked in steam 15 minutes at 212°, then dried 15 minutes in air at 100°, velocity about 500 feet per minute.		Packed with olive oil in pound-oval cans; sealed; processed 1½ hours at 227° and ½ hour at 240°.	46	Very good; slightly too salty; skins in fairly good condition.	Steaming and then drying brined, small, quarter-oil fish produced a very good pack.

35a	Mar. 3	Large; fair condition.	Brined 1 hour; dried; cooked 20 minutes in steam at 212°.	------------------------------	Packed into pound-oval cans raw, then steamed in inverted position on flake; hot tomato sauce added; sealed and processed 1½ hours at 240°.	47	Skins broken some; taste fair.	Little difference noticed between fish brined and dried and brined only when steamed in inverted cans.
35b	---do-----	-----do----------	Same, only brined 2 hours and not dried.	------------------------------	-----do----------------	48	-----do---------------	
36a	Nov. 18	Small----------	Brined 1 hour; cooked 15 minutes in steam at 212°.	------------------------------	Packed in quarter-pound cans; no sauce; processed 50 minutes at 227°.	49	Very good, except salty tasting.	Cooking in superheated steam 10 minutes at 260° gave a drier product than 15 minutes at 212°.
36b	---do-----	-----do----------	Same, only steamed 10 minutes in super-heated steam at 260°, pressure 1 atmosphere.	------------------------------	-----do----------------	50	Same, less water in can	
37a	1923 May 16	Small quarter-oil size; fair condition.	Whole fish used; brined 15 minutes in 75 per cent saturated brine; steamed 10 minutes at 212°; dried 90 minutes at 108°; air velocity 600 feet per minute.	------------------------------	Heads removed and packed in quarter-oil cans with olive oil; processed 1½ hours in boiling water at 212°.	51	Physical condition good; very little water in can; taste good; bones not soft; not sufficiently sterilized, as several cans spoiled in standing 2 years, other took on sour taste and turned quite red.	Steaming and then drying brined, small, quarter-oil fish produced a good pack.

TABLE 31.—*Additional experimental data on the preparation of California pilchards for canning as sardines by the steaming process* [1]

Experiment No.	Date	Fish	Steaming data				Drying data								Total per cent loss in weight steaming and drying	Notes
			Steam-gauge pressure in pounds per square inch	Temperature	Time in minutes	Per cent loss in weight	Air temperature	Air velocity in feet per minute	Per cent relative humidity	Per cent loss in weight in—						
										15 minutes	30 minutes	45 minutes	60 minutes			
38a	1922 Nov. 15	Medium pound-oval.	0	240	10	12.0									Cooked in current of superheated steam
39a	Nov. 18	do	0	260	10	20.1									Do.
40a	1923 Mar. 31	Half-pound oil; average weight of cut fish, 7 to 9 pounds.	0	212	15	2.1	90	501	31	6.8	9.5	11.1	13.0	14.8	
40b	do	do	0	212	15	2.9	100	524	30	7.0	9.3	11.5	12.7	15.2	
40c	do	do	0	212	15	2.6	120	501	31	8.5	11.0	13.4			
40d	do	do	0	212	15	3.7	166	598	18	10.1	13.9	17.4	19.8	22.8	
40e	do	do	0	212	15	3.5	166	598	6		14.5	18.5	20.4	23.1	
41a	Apr. 2	Same sized fish as experiment 40.	0	212	15	2.6	93	565	28	7.5	9.8	12.1	13.0	15.3	
41b	do	do	0	212	15	4.0	120	565	31	18.5	11.7	13.9	16.3	19.6	
41c	do	do	0	212	15	3.5	166	565	23	9.0	12.8	15.8	17.2	20.0	
42a	Apr. 3	do	0	212	15	3.5	142	565	8	9.4	12.9	15.7	17.8	20.3	Total loss in weight after standing 20 hours, 30.8 per cent.
42b	do	do	0	212	15	4.3	142	565	20	9.4		15.0	16.8	20.3	Total loss in weight after standing 18 hours, 30.7 per cent.
42c	do	do	0	212	15	6.7	142	565	30	9.2	13.2	15.7	18.6	24.0	Total loss of weight after standing 17 hours, 33.2 per cent.
43a	Apr. 4	do	0	212	15	2.1	92	498	28	9.1	12.3	14.9	17.8	19.5	Total loss in weight after standing 22 hours, 32.2 per cent.
43b	do	do	0	212	15	2.5	110	498	28	10.1	13.7	16.3	18.4	20.5	Total loss in weight after standing 20 hours, 28.6 per cent.
43c	do	do	0	212	15	3.8	130	498	28	9.2	12.2	15.7	17.4	20.6	Total loss in weight after standing 18 hours, 27.7 per cent.

44a	Apr. 5	do	0	212	30	11.2									Total loss in weight after standing in air 20 hours, 24 per cent; 1.2 per cent soluble extractives removed from fish.
44b	do	do	0	260	30	20.1									Total loss in weight after standing in air 19 hours, 34.3 per cent; 1.2 per cent soluble extractives removed from fish, steam superheated.
44c	do	do	0	230	30	17.0									Total loss in weight after standing in air 18 hours, 28.4 per cent; 1.8 per cent soluble extractives removed from fish; steam superheated.
44d	do	do	20	259	30	27.0									Total loss in weight after standing in air 17 hours, 39.6 per cent; 3.3 per cent soluble extractives removed from fish; fish broke badly when pressure was released.
45a	Aug. 29	Small, quarter-oil Maine herring.	0	212	12	9.2	110	330				9.0		17.3	Whole fish used.
46a	Aug. 30	Very small quarter-oil Maine herring.	0	212	10	16.6	100	700					[2] 28.6	40.5	Do.
47a	1924 Sept. 10	Medium, quarter-oil Maine herring.	0	212	14	8.8	110	330					9.3	19.2	Do.

[1] See notes, p. 170.

[2] 132 minutes.

TABLE 32.—*Experimental data on the preparation of California pilchards for canning as sardines by the raw-packing process* [1]

Experiment No.	Date	Fish	Preparation for canning: Minutes brined	Minutes dried	Cooked in oil, minutes and temperature	Other data	Canning procedure: Minutes in retort	Steam temperature	Other data	Pack No.	Examination of canned product	General results
48a	1921 Dec. 12	Large, fat	150				90	240		52	Watery; slack filled; skins in poor condition.	Brining alone produced a very poor pack.
48b	...do	...do	210				90	240		53	...do	
49a	1922 Jan. 10	...do	120	60			90	240		54	Physical condition good; taste good.	Brining and drying produced a good pack.
50a	Jan. 17	Very large, fat, poor condition.	120	120			90	240		55	About same as fried pack except taste better; both soft.	Brining and drying produced a pack comparable in quality with the fried-in-oil product.
50b	...do	...do	60	60	8 at 227°		90	240		56		
51a	Jan. 20	Large, very fat.	120	120			90	240		57	Excellent; better tasting than 58; also sauce slightly thinner.	Tendency shown for raw pack to taste better and physical condition not to be as good as fried-in-oil product.
51b	...do	...do	60	60	8 at 227°		90	240		58	Excellent; skins slightly tougher than 57.	
52a	Jan. 21	...do	180				90	240		59	Good; sauce more liquid than packs 57 and 58.	Increasing the brining time did not permit drying time to be shortened.
52b	...do	...do	180	60			90	240		60	Same; slightly salty	
53a	...do	Small quarter-oil.	25	30			90	240	With olive oil in pound-oval cans.	61	Good; slightly too salty; about same as 62.	Brining and drying produced an oil pack equal in quality to the steamed product; 25 minutes in strong brine was too long for small fish when packed raw.
53b	...do	...do	25	15		Steamed 15 minutes before drying.	90	240	...do	62	Good.	

[1] See notes, p. 170.

54a	Jan. 25	Medium	90	90		Packed in 1-pound tall cans.	180	240		63	Fish in good condition; taste poor; sauce had sort of charred taste.	3 hours processing at 240° was too much; caused sauce to have sort of charred taste.
54b	do	do	60	45	7 at 230°	do	180	240		64	do	
55a	Jan. 26	Large, fat	120	90		do	180	240		65	do	Same as for 63 and 64.
55b	do	do	60	60	8 at 230°	do	180	240		66	do	
56a	Feb. 1	Large, very fat.	120	120			165	230		67	Good pack; taste fair	Raw pack good; fried fish slightly firmer.
56b	do	do	60	60	8 at 230°		165	230		68	Good pack; taste fair; fish slightly firmer than 67.	
57a	Feb. 2	do	120	120			165	230		69	Very good; not quite as firm as 70.	Same as for 67 and 68.
57b	do	do	60	60	8 at 230°		165	230		70	Very good	
58a	Feb. 3	do	120	120			150	230		71	do	
59a	Feb. 6	do	120	120			150	230		72	Good; no different than 73.	
59b	do	do	60	60	8 at 230°		150	230		73	do	
60a	Feb. 7	do	120	30		Air 149°; velocity about 1,000.	150	230		74	Good; too much liquid in can.	Increased air temperature and velocity did not give as good results as longer time and lower temperature and velocity.
61a	Feb. 13	Medium	90	120			180	230		75	Physical condition of fish good.	
62a	Feb. 14	do		90		Weather moderate; brined 21 hours in 75 per cent saturated brine.	90	227		76	Good; taste too salty	21 hours brining brought about no undesirable changes other than to make the fish too salty, unless the concentration was low.
62b	do	do		90		Same, only 50 per cent brine.	90	227		77	Good; taste salty	
62c	do	do		90		Same, only 25 per cent brine.	90	227		78	Good	
63a	Feb. 15	Medium, fair condition.	120	120			180	230		79	Fair; fish slightly soft.	

TABLE 32.—*Experimental data on the preparation of California pilchards for canning as sardines by the raw-packing process*—Continued

Experiment No.	Date	Fish	Preparation for canning: Minutes brined	Minutes dried	Cooked in oil, minutes and temperature	Other data	Canning procedure: Minutes in retort	Steam temperature	Other data	Pack No.	Examination of canned product	General results
64a	1922 Feb. 20	Large, very fat	120	120			180	230		80	Excellent; taste and condition of skins better than fried pack; oil in can bright yellow; not quite as firm as fried pack but entirely satisfactory.	Raw pack better than regular commercial fried pack; prominence of fry-bath oil and its effects shown.
64b	...do	...do	90	60	10 at 230°	Brine 85 per cent saturated.	90	240	Pack prepared and canned by regular canner.	81	Good, except oil dark due to admixture of oil from frying vat; taste of frying oil prominent; fish plainly showed darkening due to dark oil; not as desirable pack as 80.	
65a	Feb. 21	...do	120	120			180	230		82	Same notes as 80	Same as 80 and 81.
65b	...do	...do	90	60	10 at 230°	Brine 85 per cent saturated.	90	240	Same note as 64b	83	Same notes as 81	
66a	Feb. 23	...do	120	120			180	230		84	Good; fish slightly soft.	
67a	...do	...do	120	120			180	230		85	...do	
68a	Feb. 25	Very large, very fat.	120	60		Air 104°; velocity about 1,000.	180	230		86	Very good; little if any difference between packs.	Varying air temperature caused no marked difference in quality of packs.
68b	...do	...do	120	60		Air 122°; velocity about 1,000.	180	230		87	...do	
68c	...do	...do	120	60		Air 140°; velocity about 1,000.	180	230		88	...do	
69a	...do	...do	120	60			180	230		89	Good; sauce slightly too watery.	60 minutes' drying did not give as good a pack as 120 minutes did.
69b	...do	...do	120	120			180	230		90	Good	

70a	do	do	120	120			180	230		91	Good; about same as 92.	3 hours' brining against 2 hours' brining gave no observable difference.
70b	do	do	180	120			180	230		92	Good	
71a	do	do	60	120		Excess brine used and stirred constantly.	180	230		93	Good, except slightly too salty.	Agitation increased rate at which fish took up salt. Compare with 70a and 70b.
71b	do	do	120	120		do	180	230		94	Good, except too salty.	
72a	do	do	180	120			180	230		95	do	3 hours' brining, even with rinsing in fresh water, proved too much in this case.
72b	do	do	180	120		After brining, fish were rinsed in fresh water.	180	230		96	do	
73a	do	do	120	120			180	230		97	Good; fish slightly soft.	Long brining brought about no particularly desirable change in the fish; the longer the brining time and the stronger the brine the more salty the canned product.
73b	do	do	180	120		Brine 80 per cent saturated.	180	230	Fish rinsed with fresh water after being brined.	98	Good, fish slightly soft; salty.	
73c	do	do	240	120		do	180	230	do	99	Good; fish slightly soft; too salty.	
73d	do	do	300	120		do	180	230	do	100	do	
73e	do	d	720	120		do	180	230	do	101	Good; fish slightly soft; much too salty.	
73f	do	do	960	120		do	180	230	do	102	Good; fish slightly soft; very salty.	
73g	do	do	1,200	120		do	180	230	do	103	do	
73h	do	do	240	120		Brine 60 per cent saturated.	180	230	do	104	Good; fish slightly soft; salty.	
73i	do	do	300	120		do	180	230	do	105	Good; fish slightly soft; too salty.	
73j	do	do	360	120		do	180	230	do	106	do	
73k	do	do	480	120		do	180	230	do	107	do	
73l	do	do	720	120		do	180	230	do	108	Good; fish slightly soft; much too salty.	
73m	do	do	960	120		do	180	230	do	109	Good; fish slightly soft; very salty.	
73n	do	do	1,200	120		do	180	230	do	110	do	
73o	do	do	240	120		Brine 40 per cent saturated.	180	230	do	111	Good; fish slightly soft.	
73p	do	do	300	120		do	180	230	do	112	Good; fish slightly soft; salty.	
73q	do	do	360	120		do	180	230	do	113	do	
73r	do	do	480	120		do	180	230	do	114	Good; fish slightly soft; too salty.	
73s	do	do	720	120		do	180	230	do	115	do	
73t	do	do	960	120		do	180	230	do	116	Good; fish slightly soft; much too salty.	
73u	do	do	1,200	120		do	180	230	do	117	Good; fish slightly soft; very salty.	

TABLE 32.—*Experimental data on the preparation of California pilchards for canning as sardines by the raw-packing process*—Continued

Experiment No.	Date	Fish	Preparation for canning: Minutes brined	Minutes dried	Cooked in oil, minutes and temperature	Other data	Canning procedure: Minutes in retort	Steam temperature	Other data	Pack No.	Examination of canned product	General results
74a	1922 Feb. 28	Large, fat	120	135		Air 90°; velocity about 500, but not particularly effective.	120	240	Fish did not dry sufficiently.	118	Poor pack; fish soft; sauce watery.	
75a	Mar. 6	Medium, half-pound oval.	90	60		Air 90°; velocity 500; fish rinsed after brining.	150	220	Fish stood 21 hours (air temperature 60 to 70°) before being canned in half-pound oval cans.	119	Physical condition of fish good; taste better than 121.	Bad effects of fry-bath oil in the canned product shown; allowing the fish to stand 21 hours after brining and drying before canning did no particular harm.
75b	do	do	90	60		do	150	220	do	120	do	
75c	do	do	60	60	8 at 230°	Same, only 85 per cent saturated brine used.	150	220	Regular commercial pack put up by regular canner in half-pound oval cans.	121	Same, except presence of fry-bath oil prominent both as to taste and appearance.	
76a	do	Very large, fat	120	60		Air 90°; velocity about 500.	120	240	Fish stood 21 hours (in air at 60 to 70°) before being canned.	122	Physical condition fairly good; taste poor.	Bad effect of frying shown; fried fish slightly firmer; allowing fish to stand 21 hours after brining, and after brining and drying before canning, did no particular harm.
76b	do	do	120	120		do	120	240	do	123	About same as 122, only a little firmer.	
76c	do	do	90	60		Same, brine 85 per cent saturated.	120	240	do	124	Not as good condition as 122; taste poor.	
76d	do	do	90	120		do	120	240	do	125	About same as 123	
76e	do	do	120	120		Air 90°; velocity about 500.	120	240	Fish stood 21 hours after being brined, then dried.	126	Physical condition fair; taste poor.	
76f	do	do	90	60	10 at 230°	Same, brine 85 per cent saturated.	120	240	Regular commercial pack put up by regular canner.	127	About same as other packs except a little firmer; taste poor; presence of fry-bath oil very evident.	

77a	Mar. 7	Large, fat	120	60		Air 90°; velocity about 500.	120	240		128	Physical condition fairly good; taste fair.	Physical condition fried fish somewhat better than raw-packed fish; raw packs good however.
77b	do	do	120	120		do	120	240		129	Same, not noticeably different from 128.	
77c	do	do	90	60		Same, brine 85 per cent saturated.	120	240		130	Physical condition not as good as 128 and 129.	
77d	do	do	90	60	10 at 230°	do	120	240	Regular commercial pack put up by regular canner.	131	Physical condition better than other packs; taste fair; fry-bath oil evident both as to taste and appearance.	
78a	Mar. 15	Large	120	120			180	230		132	Physical condition of fish good; taste poor; sauce evidently had caramelized during processing.	Allowing fish to stand 18 hours after brining or drying before packing caused no harm.
78b	do	do	120	120			180	230	After drying stood 18 hours, air temperature 60 to 70°, then packed.	133	Same, not noticeably different from other packs.	
78c	do	do	120	120			180	230	After brining stood 18 hours, then dried and packed.	134	do	
79a	Apr. 26	Medium quarter-oil, poor condition.	20	60		Air 95°; velocity about 350.	165	214	With olive oil in quarter-pound cans.	135	Poor pack; much water present; appearance marred by masses of coagulated protein and blood.	Brining and drying did not produce a good quarter-oil pack; too much water was present in raw packs and appearance was marred by coagulated blood and protein.
79b	do	do	20	120		do	165	214	do	136	Same, not noticeably less water in can.	
79c	do	do	20	60	8 at 230°	do	165	214	Same, regular commercial pack put up by regular canner.	137	Good; appearance good.	
79d	do	do	20	60		do			With olive oil in quarter-pound cans; processed 165 minutes at 214° plus 20 minutes at 240°.	138	About same as 135 except more water present.	
79e	do	do	20	120		do			do	139	Same as 138	

TABLE 32.—*Experimental data on the preparation of California pilchards for canning as sardines by the raw-packing process*—Continued

Experiment No.	Date	Fish	Preparation for canning: Minutes brined	Minutes dried	Cooked in oil, minutes and temperature	Other data	Canning procedure: Minutes in retort	Steam temperature	Other data	Pack No.	Examination of canned product	General results
80a	1922	Small				Regular commercial fried-in-oil pack.			Packed in San Pedro, season 1921-22.	140	Good firm pack used for shipping and storing tests.	
80b		Medium				do.			do.	141	do.	
80c		Large, fat				do.			do.	142	do.	
80d		Medium				do.			do.	143	do.	
80e		Large, fat				do.			do.	144	do.	
80f		Medium				do.			do.	145	do.	
81a	Nov. 18	Medium half-pound-oval size.	60	60			50	227	Packed without sauce in quarter-pound cans.	146	Taste good; appearance poor due to coagulated blood and protein which had run out of fish in can.	Brining and drying gave a better tasting pack than steaming did; steaming, however, prevented appearance of pack being marred by coagulation of juices.
81b	do.	do.	60			Cooked in steam 15 minutes at 212°.	50	227	do.	147	Taste good but not as good as 146; steaming removed salt and some of taste; appearance good; no coagulated juices present.	
82a	Dec. 12	Medium, lean	60	120			150	227	Packed in quarter-pound cans with tomato sauce.	148	Good	
83a	1923 Feb. 7	Large	90	132		Air 95°; velocity about 200; moisture removed, 6.3 per cent.	90	240	Fish soft when packed; had softened during drying.	149	Good; softer than fried fish; not too much liquid in can.	Raw-packed product good, yet slightly softer than fried product; effect of old fry-bath oil shown.
83b	do.	do.	90	30	10 at 230°	Commercial fried pack put up by regular canner.	90	240		150	Good; taste not so good due to presence of fry-bath oil.	
84a	Feb. 17	do.	90	120		Air 95°; velocity 620; moisture removed 6.8 per cent.	90	240	Fish stood overnight before being dried; soft after drying; had slightly putrid smell.	151	Appearance good; fish quite soft; taste poor.	Fried pack a little firmer.
84b	do.	do.	90	120		Commercial fried pack.	90	240		152	About like 151 yet not so soft nor taste as poor.	

85a	Feb. 19	Large, poor condition.	75	120	....	Air 95°; velocity 608; moisture removed 5.8 per cent.	90	240	Fish firm when canned.	153	Soft; too much water in can; taste poor.	Fried pack a little better; the more moisture removed from the fish the better the pack was; fish that had softened during drying canned as well as those which had not softened.
85b	...do.....	.....do........	75	120	....	Air 115°; velocity 618; moisture removed 7 per cent.	90	240	Fish soft when canned.	154	A little better than 153 in every way.	
85c	...do.....	.....do........	75	30	10 at 230°...	Commercial fried pack.	90	240	....	155	A little better than 154.	
86a	Feb. 20	Large, fair condition.	75	120	....	Air 115°; velocity 600; moisture loss 8.5 per cent.	90	240	Fish very soft when canned.	156	Good; slightly soft; little too much water in can.	
87a	Feb. 21	Large........	75	120	....	Air 105°; velocity 616; moisture loss 6.2 per cent.	90	240	....	157	Good; slightly too soft.	Longer brining and better drying gave a better pack.
87b	...do.....	.....do........	120	120	....	Same, loss 6.6 per cent.	90	240	....	158	Good; firmer than 157.	
87c	...do.....	.....do........	120	120	....	Same as 87b..........	90	240	In olive oil..........	159	Good; slightly salty; some water in can.	
88a	Feb. 25	Small........	60	120	....	Air 95°; velocity 617; moisture loss 8 per cent.	90	240	....	160	Soft; poor tasting......	
88b	...do.....	.....do........	60	120	....	.....do..............	90	240	In olive oil..........	161	.....do..............	
89a	Mar. 1	Large........	60	120	....	Air 105°; velocity 600; moisture loss 7.4 per cent.	90	240	....	162	Fair, fish slightly softer than 164.	Fried pack a little firmer.
89b	...do.....	.....do........	60	120	....	.....do..............	90	240	In olive oil..........	163	.....do..............	
89c	...do.....	.....do........	60	30	10 at 230°...	Commercial fried pack.	90	240	....	164	Fair................	
90a	May 16	Very small quarter-oil size.	10	90	....	Brine 75 per cent saturated, air 108°; velocity 650; moisture loss 20.4 per cent.	90	212	Packed in quarter-oil cans with olive oil.	165	Physical condition good; taste good; little more water in can than 166.	Brining and drying alone produced a good quarter-oil pack comparable to the steamed product; taste of raw pack better as juices and salt did not cook out of the fish as they did in the steamed pack; coagulated blood and protein not present in raw pack.
90b	...do.....	.....do........	15	90	....	Same, except fish dried *after* being steamed 10 minutes at 212°; moisture loss not computed.	90	212	....	166	About same as 165; taste not quite as good.	

STORAGE AND SHIPPING TESTS

The canned fish were stored on a platform near the roof of a shed in San Pedro, Calif. In summer the heat would become almost unbearable. At night it would be quite cool. In winter the air temperature probably went at times as low as 40° and as high as 90°. Beginning in July, 1924, storage was in the Fishery Products Laboratory, Washington, D. C. The air temperature of the laboratory probably never went below 60° nor above 90°.

The following shipping tests were made:

1. Cans wrapped only in paper, three to the package, and shipped via parcel post from San Pedro, Calif., to Washington, D. C., and return. These cans received very rough treatment, as they always returned with large dents in them.
2. Cans packed in regular cases and shipped as freight in January, 1923, from San Pedro to New Orleans, La., and return, one way being by boat through the Panama Canal and the other by railroad.
3. Shipment in regular cases from San Pedro to Washington by boat.
4. Cans placed under rear seat of a Ford automobile and carried from San Pedro to San Diego, Calif., and return, a total distance of about 270 miles.

Table 33 indicates the tests made upon the various packs. The general results obtained are discussed on pages 114 and 115.

TABLE 33.—*Storing and shipping tests made with the experimental packs of California pilchards*

Pack No.	Storage tests			Shipping tests			
	12 months in San Pedro	12 months in San Pedro and 12 in Washington	24 months in San Pedro and 12 in Washington	1	2	3	4
18	x				x		
19			x	x	x	x	x
20			x			x	
42 to 43	x			x	x		
44			x	x	x	x	
47 to 48			x			x	
57 to 58	x			x			
60			x	x	x	x	
63 and 65	x						
67 to 69			x		x	x	
71	x				x		
72 to 73			x		x	x	
74	x						
79			x			x	
79 to 83			x	x	x	x	x
85, 87 to 89	x						
91, 93 to 95	x						
98 to 115, 119	x						
120 to 121			x			x	
122 to 126	x						
128 to 132	x						
133			x		x	x	
134, 136 to 138	x						
140 to 143	x				x		
144			x		x		
145					x		
146			x			x	
149 to 155		x				x	
157, 160 to 166		x				x	

PARTIALLY DRYING THE FISH

APPARATUS

The apparatus used in drying is pictured in Figure 22, page 120. The plan of this drier is the same in principle as that shown in Figure 25, page 145, except that heat was furnished by steam coils; there was no cooler and no mechanical method for handling flakes. Air velocity was controlled by the operation of a damper leading to the blower. Other dampers made it possible to recirculate all or any part of the air that had gone through the drier. The temperature of the air was controlled by regulation of the quantity and pressure of the steam that entered the coils, and the humidity was raised, when desired, by recirculating part of the air, either with or without the addition of steam, on the intake side of the blower. The drier was first designed to handle a tier of four flakes and was so operated at first. Later, to get higher velocities, it was necessary to send all the air over and under just one flake.

A standardized Short and Mason anemometer was used for obtaining the air velocities, and wet and dry bulb thermometers were used for indicating the temperature of the air and its relative humidity. These were placed always in the same place—where they encountered the full velocity of the air—and in the case of the thermometers, at some distance back from the steam coils and just in front of the fish. The air temperatures, as obtained, are quite accurate, but the readings of the wet-bulb thermometer are undoubtedly high—probably 3 to 6 per cent. Carrier, in the American Heating and Ventilating Engineers' Guide (see footnote, p. 120), shows that such errors exist and that they are more pronounced at lower air velocities. The air velocities, too, being taken at the most favorable place, are a little higher than the average for the cross section used. The variations in velocity during any one series of runs, while studying one variable, are due to experimental errors. In taking these air velocities the anemometer was placed in position right after the fish were put in and was removed immediately after they were taken out. Due to this procedure, the time intervals were never exactly the same. On the whole, during any one run the temperature and humidity remained quite constant although there were frequent small variations, which were quickly corrected.

These errors, however, are not important here, since the experiments are, for the most part, comparative ones, in which case most of the errors tend to cancel each other. Then, too, the experimental results are only used for the purpose of showing general tendencies and not for the detection of fine differences in behavior.

PROCEDURES

In studying the effect of varying any one drying factor care was taken to use, wherever possible, like-sized fish, all of which had the same preliminary treatment. The supply to be used in a given experiment, consisting possibly of several runs of the drier, was placed in a large bucket with holes in the bottom, from which the fish were removed as needed, weighed, and arranged on the flake, always in the same general manner. The fish were weighed again immediately after being removed from the drier. They were then returned or discarded, as conditions demanded. Although precautions might be taken which would assure quite comparable drying conditions in any one experiment, the changes that take place in fish that have stood for several hours might seriously interfere with the experiment. These changes can be ignored if they make little difference in the amount of water removed from the fish by similar drying conditions during the time the experiment is in progress. Several series of runs of the drier were made in order to get information on this point. The results, given in Table 34, indicate no great difference in the amount of water removed from fish that have stood varying lengths of time. The variation shown is not pronounced nor is it constant; in fact, the experimental error itself might well be greater. In view of these facts, this variation will not be considered in the experiments unless the differences in the amount of water removed in the experiments under consideration are quite small.

TABLE 34.—*Effect upon the drying rate of holding raw California pilchards for different periods of time (all other variables constant)*

Experiment No.	Elapsed time in hours since start of experiment	Per cent loss in weight	Experiment No.	Elapsed time in hours since start of experiment	Per cent loss in weight
96a	0	3.7	118a	0	10.3
96b	4	4.1	118d	4	10.3
96c	26	3.8	118b	0	9.7
103b	0	4.5	118c	1	9.2
103c	2	4.7			

Steamed fish were cooked for the stated time in steam at 212°. No record was kept of the pressure of the steam turned into the cooker. It varied at times from 5 to 40 pounds. After steaming the fish were weighed immediately and placed in the drier. They were then handled in the same manner as raw fish.

EXPERIMENTAL DATA

With the exception of some additional material in Table 31, the complete experimental data are given in Table 35. In the subsequent handling of these data only those under discussion are given in the tables, reference being made to the original data by number and letter.

TABLE 35.—*The effect of different drying conditions in partially drying raw and steamed California pilchards* [1]

[Per cent relative humidities, dew-point temperatures, and vapor pressures obtained from relations given in tables and charts in American Society of Heating and Ventilating Engineers Guide for 1922. New York, 1922]

RAW FISH

Experiment No.	Date	Size of fish	Weight of sample	Air conditions						Per cent total loss in weight (time in minutes)								Notes
				Dry-bulb temperature	Wet-bulb temperature	Per cent relative humidity	Dew-point temperature	Vapor pressure, inches of mercury	Velocity, in feet per minute	10	15	20	30	60	90	120	180	
	1923		*Ounces*															
91a	Jan. 25	Large "ovals"	261	90	65	24	48	0.34	[2] 174					3.8				
91b	do	do	244	102	72	22	57	.47	[2] 174					4.6				
91c	do	do	258	110	76	20	60	.52	[2] 174					4.6				
91d	do	do	261	120	78	14	60	.52	[2] 174					4.6				
92a	Jan. 29	do	311	111	75	17	58	.49	[2] 174				3.5	5.8	7.4	8.7		
93a	Feb. 2	do	302	90	64	22	46.5	.32	[2] 174					5.3				
93b	do	do	290	100	71	22	56	.45	[2] 174					4.5				
93c	do	do	296	110	77.5	22	64	.60	[2] 174					4.7				
94a	Feb. 3	do	255	92	65	21	47.5	.33	[2] 174					3.9				
94b	do	do	275	120	74.5	10	50	.36	[2] 174					4.4				
95a	Feb. 5	do	321	100	69	19	51	.38	[2] 174					4.7				Fish at beginning were 57°.
95b	do	do	311	100	77	35	68	.69	[2] 174					4.5				Fish at beginning were 70°.
96a	Feb. 6	do	325	100	75	30	64	.60	[2] 174					3.7				
96b	do	do	320	100	75	30	64	.60	[2] 174					4.1				Fish stood 4 hours longer than 96a before being dried.
96c	Feb. 7	do	318	100	75	30	64	.60	[2] 174					3.8				Same as 96b, only 26 hours.
97a	Feb. 12	do	144	110	75	18	59	.50	667					4.9				
97b	do	do	147	110	75	18	59	.50	429					4.1				
97c	do	do	159	110	75	18	59	.50	110					2.5				

[1] See notes, p. 170.

[2] About.

TABLE 35.—*The effect of different drying conditions in partially drying raw and steamed California pilchards*—Continued

RAW FISH—Continued

Experiment No.	Date	Size of fish	Weight of sample	Air conditions: Dry-bulb temperature	Wet-bulb temperature	Per cent relative humidity	Dew-point temperature	Vapor pressure, inches of mercury	Velocity, in feet per minute	Per cent total loss in weight (time in minutes): 10	15	20	30	60	90	120	180	Notes
	1923		*Grams*															
98a	Feb. 13	Medium large "ovals"	1,351	90	65	24	49	0.35	670	-----	-----	-----	-----	4.4	-----	-----	-----	
98b	do	do	1,356	100	72	24	58	.49	649	-----	-----	-----	-----	4.6	-----	-----	-----	
98c	do	do	1,336	112	78.5	22	69	.71	654	-----	-----	-----	-----	4.7	-----	-----	-----	
99a	Feb. 15	do	856	116	82	23	70	.74	630	-----	-----	-----	-----	4.6	-----	-----	-----	Some condensation.
99b	do	do	868	105	75	23	61.5	.55	627	-----	-----	-----	-----	4.3	-----	-----	-----	Do.
99c	do	do	831	95	68	23	52	.39	619	-----	-----	-----	-----	4.3	-----	-----	-----	
100a	Feb. 16	do	841	90	65	24	49	.35	619	-----	-----	-----	-----	4.2	-----	-----	-----	
100b	do	do	790	95	68	23	52	.39	649	-----	-----	-----	-----	4.2	-----	-----	-----	
101a	Feb. 19	do	1,105	95	66	19	47.5	.33	608	-----	-----	-----	-----	4.6	-----	5.8	-----	
101b	do	do	1,127	115	72	10	47	.32	618	-----	-----	-----	-----	5.0	-----	7.0	-----	
101c	do	dc	1,118	115	79	19	64	.60	618	-----	-----	-----	-----	5.1	-----	7.0	-----	
101d	do	do	1,074	71	57	41	46	.31	615	-----	-----	-----	-----	3.6	-----	-----	-----	
102a	Feb. 20	do	1,121	115	75	14	56	.45	602	-----	-----	-----	3.9	5.4	6.8	8.5	-----	
102b	do	do	1,096	95	69	25	55	.44	634	-----	-----	-----	3.6	4.9	5.9	6.8	-----	
103a	Feb. 21	Large "ovals"	1,467	95	68	23	52	.39	602	-----	-----	-----	3.1	4.2	4.8	5.9	-----	Some condensation. (103a–103d)
103b	do	do	1,378	105	75	23	62	.56	616	-----	-----	-----	3.2	4.5	5.3	6.2	-----	
103c	do	do	1.411	105	75	23	62	.56	591	-----	-----	-----	3.5	4.7	5.6	6.6	-----	
103d	do	do	1,370	115	81.5	23	69.5	.73	580	-----	-----	-----	3.4	4.7	5.9	7.8	-----	
104a	Feb. 22	do	1,381	105	72	18	55	.44	588	-----	-----	-----	3.2	4.4	5.2	6.0	-----	Runs 104b and 104c began at the same relative humidity as 104a, but relative humidity was gradually increased within 30 minutes to given value (104a–104c)
104b	do	do	1,372	105	80.5	34	72	.79	610	-----	-----	-----	-----	4.2	5.1	6.0	-----	
104c	do	do	1,286	105	87.5	49	83	1.13	602	-----	-----	-----	3.3	4.3	5.0	5.8	-----	

105a	Feb. 28	....do....	1,342	95	64	15	42	.27	599				3.8	4.8	5.8	6.5		Run 105c began at 19 per cent relative humidity but was gradually increased within 30 minutes to the value indicated.
105b	...do....	....do....	1,252	95	71	30	59	.50	612				3.4	4.5	5.3	6.3		
105c	...do....	....do....	1,272	95	79	49	73.5	.83	603				3.5	4.5	5.2	5.7		
106a	Mar. 1	....do....	1,862	105	71	17	52.5	.40	[1] 613				3.0	4.0	4.9	5.5	7.4	
107a	Mar. 6	....do....	1,043	95	67	21	49	.35	[1] 613					4.5		6.1		
108a	Mar. 7	....do....	1,038	115	75	16	55	.44	[1] 613					5.3				Relative humidity for 108b: Start 16 per cent; 12 minutes, 29 per cent; 27 minutes, 34 per cent; 37 minutes, 50 per cent; increase gradual.
108b	...do....	....do....	954	115	75-96	16-50	55-92	.44-1.50	[1] 613					4.4				
109a	Mar. 8	....do....	1,288	115	77	17	60	.52	587				3.9					In runs 109b and 109d relative humidity began at 17 per cent and increased to 45 per cent; condensation upon the fish was prevented by keeping the dew-point temperature of the air always a little lower than the temperature of the fish.
109b	...do....	....do....	1,251	115	77-94.5	17-46	60-90	.52-1.42	597				3.5					
109c	...do....	....do....	1,305	115	77	17	60	.52	646				3.5					
109d	...do....	....do....	1,312	115	77-94	17-44	60-88	.52-1.33	617				3.1					
110a	Mar. 9	....do....	1,301	150	86	7	60	.52	623			3.5						
110b	...do....	....do....	1,615	150	86	7	60	.52	623			3.1						
110c	...do....	....do....	1,334	115	77	17	60	.52	612			2.6						
110d	...do....	....do....	1,365	115	77	17	60	.52	543			2.6						
111a	Mar. 12	Medium "ovals"......	868	166	93	7	71	.76	[1] 646	2.9								Dew points and vapor pressures should be alike for each experiment, as the same air supply was used, no steam being added.
111b	...do....	....do....	1,155	175	96	6	71	.76	[1] 646	3.9								
111c	...do....	....do....	1,135	149	88	8	71	.76	[1] 646	3.3								
111d	...do....	....do....	1,025	150	88	8	71	.76	[1] 646	3.5								

STEAMED FISH

112a	1923 Mar. 31	"Half-oils"........	337.5	90	68	31	56	0.45	501		6.8		9.5	13.0				Per cent loss, end of 45 minutes, 11.1.
112b	...do....	....do....	333.1	100	75	30	64	.60	524		7.0		9.3	12.7				Per cent loss, end of 45 minutes, 11.5.
112c	...do....	....do....	315.5	120	90	31	82	1.10	501		8.5		11.0					Per cent loss, end of 45 minutes, 13.4.
112d	...do....	....do....	326.5	166	110	18	101	1.98	598		10.1		13.9	19.8				Per cent loss, end of 45 minutes, 17.4.
112e	...do....	....do....	319.5	166	90	6	65	.62	598				14.5	20.4				Per cent loss, end of 45 minutes, 18.5.

[1] About.

TABLE 35.—*The effect of different drying conditions in partially drying raw and steamed California pilchards*—Continued

STEAMED FISH—Continued

Experiment No.	Date	Size of fish	Weight of sample	Air conditions: Dry-bulb temperature	Wet-bulb temperature	Per cent relative humidity	Dew-point temperature	Vapor pressure, inches of mercury	Velocity, in feet per minute	Per cent total loss in weight (time in minutes): 10	15	20	30	60	90	120	180	Notes
	1923		*Grams*															
113a	Apr. 2	"Half oils"	328.8	93	69	28	56	0.45	[2] 565	-----	7.5	-----	9.8	13.0	-----	-----	-----	Per cent loss, end of 45 minutes, 12.1.
113b	do	do	312.0	120	90	31	82	1.10	[2] 565	-----	8.5	-----	11.7	16.3	-----	-----	-----	Per cent loss, end of 45 minutes, 13.9.
113c	do	do	335.0	166	115	23	108	2.44	[2] 565	-----	9.0	-----	12.8	17.2	-----	-----	-----	Per cent loss, end of 45 minutes, 15.8.
114a	Apr. 3	do	305.5	142	84	8	50	.36	[2] 565	-----	9.4	-----	12.9	17.8	-----	-----	-----	Per cent loss, end of 45 minutes, 15.7.
114b	do	do	323.7	142	96	20	87	1.29	[2] 565	-----	9.4	-----	-----	16.8	-----	-----	-----	Per cent loss, end of 45 minutes, 15.0.
114c	do	do	307.9	142	107	32	102	2.04	[2] 565	-----	9.2	-----	13.2	18.6	-----	-----	-----	Per cent loss, end of 45 minutes, 15.7.
115a	Apr. 4	do	154.7	92	68	28	55	.44	[2] 498	-----	9.1	-----	12.3	17.8	-----	-----	-----	Per cent loss, end of 45 minutes, 14.9.
115b	do	do	141.3	110	81	28	70	.74	[2] 498	-----	10.1	-----	13.7	18.4	-----	-----	-----	Per cent loss, end of 45 minutes, 16.3.
115c	do	do	161.0	130	95	28	87	1.29	[2] 498	-----	9.2	-----	12.2	17.4	-----	-----	-----	Per cent loss, end of 45 minutes, 15.7.

RAW FISH

Experiment No.	Date	Size of fish	Weight of sample	Dry-bulb temperature	Wet-bulb temperature	Per cent relative humidity	Dew-point temperature	Vapor pressure, inches of mercury	Velocity, in feet per minute	10	15	20	30	60	90	120	180	Notes
	1923																	
116a	Apr. 9	Medium-large "ovals"	335.6	110	79	25	67	0.67	1,075	-----	-----	-----	6.5	10.2	12.7	-----	-----	
116b	do	do	351.3	110	79	25	67	.67	308	-----	-----	-----	4.2	7.4	-----	-----	-----	
116c	do	do	287.7	110	79	25	67	.67	656	-----	-----	-----	5.5	9.0	-----	-----	-----	
117a	Apr. 10	do	271.5	110	78	23	65	.62	638	-----	-----	-----	5.9	9.1	11.6	-----	-----	Three fish used.
117b	do	do	291.9	110	78	23	65	.62	255	-----	-----	-----	4.1	6.7	9.0	-----	-----	Do.
117c	do	do	334.7	110	78	23	65	.62	952	-----	-----	-----	5.3	8.3	10.7	-----	-----	Do.

[2] About.

118a	Apr. 11	-----do-----	275.6	110	79	25	67	.67	968	-----	-----	-----	6.7	10.3	-----	-----	-----	
118b	---do---	-----do-----	288.8	110	79	25	67	.67	575	-----	-----	-----	6.1	9.7	-----	-----	-----	
118c	---do---	-----do-----	303.8	110	80	26	68.5	.70	575	-----	-----	-----	6.1	9.2	-----	-----	-----	
118d	---do---	-----do-----	297.4	110	80	26	68.5	.70	968	-----	-----	-----	6.7	10.3	-----	-----	-----	
119a	Apr. 13	Average weight per fish, in grams, 39.7.	278.0	110	75	18	59	.50	1,015	-----	7.3	-----	10.1	14.8	-----	-----	-----	Per cent loss, end of 45 minutes, 12.7.
119b	---do---	Average weight per fish, in grams, 59.1.	354.4	110	76	20	61	.54	950	-----	5.0	-----	8.1	12.0	-----	-----	-----	Per cent loss, end of 45 minutes, 10.0.
119c	---do---	Average weight per fish, in grams, 95.5.	286.5	110	76	20	60	.52	978	-----	-----	-----	6.8	-----	-----	-----	-----	Per cent loss, end of 45 minutes, 8.9.
119d	---do---	Average weight per fish, in grams, 101.2.	303.5	110	76	20	61	.54	1,001	-----	4.5	-----	7.0	10.7	-----	-----	-----	Per cent loss, end of 45 minutes, 8.8.
119e	---do---	Average weight per fish, in grams, 91.8.	275.4	110	76	20	61	.54	979	-----	5.0	-----	7.7	11.6	-----	-----	-----	Per cent loss, end of 45 minutes, 10.0.
120a	Apr. 14	Average weight per fish, in grams, 54.5.	160.4	110	76	20	61	.54	1,000	-----	5.5	-----	8.8	12.9	-----	-----	-----	Per cent loss, end of 45 minutes, 11.0.
120b	---do---	Average weight per fish, in grams, 89.6.	268.7	110	76	20	61	.54	1,018	-----	4.2	-----	7.1	10.7	-----	-----	-----	Per cent loss, end of 45 minutes, 8.5.
120c	---do---	Average weight per fish, in grams, 43.8.	131.3	110	77	21	63	.58	974	-----	6.0	-----	8.6	13.0	-----	-----	-----	Per cent loss, end of 45 minutes, 10.9.
120d	---do---	Average weight per fish, in grams, 71.5.	214.5	110	78	23	65	.62	969	-----	4.0	-----	6.3	10.4	-----	-----	-----	Per cent loss, end of 45 minutes, 8.2.
121a	Apr. 16	Average weight per fish, in grams, 38.1.	152.3	110	75	18	59	.50	976	-----	-----	-----	8.1	-----	-----	-----	-----	
121b	---do---	Average weight per fish, in grams, 19.1.	76.3	110	75	18	59	.50	976	-----	-----	-----	10.6	-----	-----	-----	-----	
122a	Apr. 17	Small "quarter-oils"	91.5	96	73	32	62	.56	1,000	5.4	-----	8.0	10.2	-----	-----	-----	-----	
122b	---do---	-----do-----	93.8	110	76	20	60	.52	1,000	6.6	-----	11.2	14.0	-----	-----	-----	-----	
122c	---do---	-----do-----	93.6	162	90	8	67	.67	1,111	10.9	-----	-----	-----	-----	-----	-----	-----	Per cent loss, end of 5 minutes, 6.7.
123a	Apr. 21	Large "quarter-oils"	156.3	110	75	18	59	.50	1,094	-----	5.1	-----	7.4	-----	-----	-----	-----	
123b	---do---	-----do-----	154.1	90	68	31	56	.45	1,013	-----	4.0	-----	5.7	-----	-----	-----	-----	
124a	---do---	Small "quarter-oils"	72.0	90	68	31	56	.45	1,013	-----	6.9	-----	10.5	-----	-----	-----	-----	
124b	---do---	-----do-----	73.5	110	75	18	59	.50	1,012	-----	9.4	-----	13.0	-----	-----	-----	-----	
124c	---do---	-----do-----	67.0	100	75	30	64	.60	1,022	-----	8.1	-----	11.3	-----	-----	-----	-----	
125a	---do---	Medium "quarter-oils"	123.4	110	75	18	59	.50	1,012	-----	5.1	-----	7.9	-----	-----	-----	-----	
125b	---do---	-----do-----	133.2	100	75	30	64	.60	1,022	-----	3.8	-----	6.5	-----	-----	-----	-----	
125c	---do---	-----do-----	128.2	164	90	5	65	.62	911	-----	7.6	-----	-----	-----	-----	-----	-----	Per cent loss, end of 5 minutes, 4.4.
125d	---do---	-----do-----	126.4	140	82	7	57	.47	945	-----	7.0	-----	-----	-----	-----	-----	-----	Per cent loss, end of 5 minutes, 3.6.
126a	May 16	Small "quarter-oils"	668	108	73	18	55	.44	650	-----	-----	-----	-----	-----	20.4	-----	-----	
127a	Nov. 27	Medium "ovals"	301	120	79	17	61.5	.55	1,060	-----	2.3	-----	3.7	-----	-----	-----	-----	Temperature of fish entering drier, 61° F.

TABLE 35.—*The effect of different drying conditions in partially drying raw and steamed California pilchards*—Continued

RAW FISH—Continued

Experiment No.	Date	Size of fish	Weight of sample	Air conditions: Dry-bulb temperature	Air conditions: Wet-bulb temperature	Air conditions: Per cent relative humidity	Air conditions: Dew-point temperature	Air conditions: Vapor pressure, inches of mercury	Air conditions: Velocity, in feet per minute	Per cent total loss in weight (time in minutes): 10	15	20	30	60	90	120	180	Notes
	1923		*Grams*															
127b	Nov. 27	Medium "ovals"	269	120	79	17	61.5	0.55	1,060		3.3		5.2					Temperature of fish entering drier, 105° F.
128a	do	do	348	187	98	±6	75	.87	1,060	3.4								
128b	do	do	702	190	99	±6	75.5	.87	1,060	3.4								
129a	Dec. 7	Large "ovals"	495	196					900		7.7							
130a	do	do	307	140					900		3.9							
130b	do	do	304	160					900	3.6								
130c	do	do	298	180					900	[3] 2.7								
130d	do	do	308	200					900	[3] 2.9								
	1924																	
131a	Jan. 7	Medium "ovals"	502	170					900	3.2								
131b	do	do	418	152					900	3.4								
131c	do	do	490	142					900		4.3							
			Ounces															
132a	Apr. 17	Small "ovals"	91	140					1,400	5.5								
133a	do	Medium-small "quarter-oils."	96	140					1,400	8.5								Spread very thickly on flake.
134a	Aug. 10	Medium-large "quarter-oils."	72	140					1,900		8.3							Maine herring used in experiments 134 to 136.
134b	do	do	178	140					1,900		5.6							Spread very thickly on flake.
135a	Aug. 11	do	96	140					1,900		6.6							Do.
136a	do	Medium "quarter-oils"	124	140					1,900		7.3							

[3] 5 minutes.

Effect of change in water-vapor pressure of the air on the drying rate of raw and steamed fish.—Except where modified by the nature of the material being dehydrated, the rate of drying depends upon the difference in vapor pressure of the water vapor at the surface of the substance undergoing drying and that of the water in the air.[71] The larger this difference the greater the rate of drying should be. If all other conditions of the experiment are kept constant and the humidity is increased, this difference in vapor pressure will be decreased, and by comparing the amounts of water removed from the fish an idea will be obtained as to the effect of this variation.

The results obtained from experiments of this nature are given in Table 36. They show that there is a tendency for the amount of water removed from raw fish to decrease as the vapor pressure of the moisture in the drying air is increased. The difference in the total amount of moisture removed, however, is quite small, even under the rigorous conditions maintained in some of the tests. Only a small part of the moisture removed from the fish was free moisture. Evidently the diffusion of the combined moisture to the surface is so slow that the increased vapor pressure of the drying air has little effect upon the escape of this moisture to it. The experimental evidence is not as complete for steamed fish, but a similar tendency is shown.

Effect of change in air temperature upon the drying rate of raw and steamed fish.—Other conditions being equal, an increase in the temperature of the drying air brings about an increase in the rate of moisture removal from the fish. This conclusion can be drawn from the data given in Table 37. The warmer the air the greater will be the heat transfer from it to the fish in a given time. The higher temperature of the fish then causes a more rapid diffusion of water to the surface, where it can be removed by the drying air.[72] Increases in the temperature of the fish are taken up in the following section.

TABLE 36.—*Effect of change in water-vapor pressure of the air upon the drying rate of raw and steamed California pilchards* [a]

RAW FISH

Experiment No.	Vapor pressure in inches of mercury	Per cent loss in weight (time in minutes)				
		15	30	60	90	120
95a	0.38			4.7		
95b	.69			4.5		
101b	.32			5.0		7.0
101c	.60			5.1		7.0
104a	.44		3.2	4.4	5.2	6.0
104b [b]	.79			4.2	5.1	6.0
104c [b]	1.13		3.3	4.3	5.0	5.8
105a	.27		3.8	4.8	5.8	6.5
105b	.50		3.4	4.5	5.3	6.3
105c [c]	.83		3.5	4.6	5.2	5.7
108a	.44			5.3		
108b [d]	0.44–1.5			4.4		
109a	.52		3.9			
109c	.52		3.5			
109d [e]	.52–1.33		3.1			
109b [e]	.53–1.42		3.5			

STEAMED FISH

Experiment No.	Vapor pressure in inches of mercury	15	30	60	90	120
112c	0.62		14.5	20.4		
112d	1.98		13.9	19.8		
114a	.36	9.4	12.9	17.8		
114b	1.29	9.4		16.8		
114c	2.04	9.2	13.2	18.6		

[a] All other variables were constant in each experiment. There may be great variation, however, between various experiments.

[b] Experiments 104b and 104c were begun at the same vapor pressure, which was increased gradually within 30 minutes to given value.

[c] Experiment 105c was begun at 0.33 vapor pressure, which was increased gradually within 30 minutes to the value indicated.

[d] Vapor pressure for 108b was as follows: Beginning, 0.44; 12 minutes, 0.89; 27 minutes, 1.1; 37 minutes, 1.50. The increase was gradual.

[e] Experiments 109d and 109b were begun with a vapor pressure of 0.52 and were then increased to the values indicated. Condensation upon the fish was prevented by keeping the dew-point temperature of the air always a little lower than the temperature of the fish.

[71] This is shown to be true in the papers referred to in the footnote on p. 120.

[72] Increased diffusion, due to temperature changes in the object being dried, is discussed by Lewis and Carrier in the papers referred to in the footnote on p. 120.

TABLE 37.—*Effect of change in air temperature upon the drying rate of raw and steamed California pilchards* [1]

RAW FISH

Experiment No.	Vapor pressure in inches of mercury	Temperature, °F.	Per cent loss in weight (time in minutes)					
			10	15	20	30	60	120
91a	0.34	90					3.8	
91b	.47	102					4.6	
91c	.52	110					4.6	
91d	.52	120					4.6	
93a	.32	90					5.3	
93b	.45	100					4.5	
93c	.60	110					4.7	
94a	.33	92					3.9	
94b	.36	120					4.4	
98a	.35	90					4.4	
98b	.49	100					4.6	
98c	.71	112					4.7	
99c	.39	95					4.3	
99b [2]	.55	105					4.3	
99a [2]	.74	116					4.6	
100a	.35	90					4.2	
100b	.39	95					4.2	
101d	.31	71					3.6	
101a	.33	95					4.6	
101b	.32	115					5.0	
101c	.60	115					5.1	
102b	.44	95				3.6	4.9	6.8
102a	.45	115				3.9	5.4	8.5
103a	.40	95				3.1	4.2	5.9
103b	.55	105				3.2	4.5	6.2
103c	.55	105				3.5	4.7	6.6
103d [3]	.73	115				3.4	4.7	7.8
110c	.52	115				2.6		
110d	.52	115				2.6		
110a	.52	150				3.5		
110b	.52	150				3.1		
111c	.76	149	3.3					
111d	.76	150	3.5					
111a	.76	166	2.9					
111b	.76	175	3.9					
122a	.56	96	5.4		8.0	10.2		
122b	.52	110	6.6		11.2	14.0		
122c	.67	162	10.9					
123b	.45	90		4.0		5.7		
123a	.60	110		5.1		7.4		
124a	.45	90		6.9		10.5		
124c	.60	100		8.1		11.3		
124b	.50	110		9.4		13.0		
125b	.60	100		3.8		6.5		
125a	.50	110		5.1		7.9		
125d	.47	140		7.0				
125c	.62	164		7.6				

[1] All other variables except the vapor pressure were constant in each experiment. In Table 36 it was shown that an increase in the vapor pressure tends to lower the drying rate slightly. The vapor pressures in these experiments increase with the temperature; they therefore tend to prevent an increase in the amount of water removed by air at higher temperatures.

[2] In experiments 99a and 99b the fish entered the drier at a temperature below the dew-point temperature of the air. Drying in these runs, therefore, was slackened somewhat, due to condensation on the fish.

[3] In experiment 103d the fish entered the drier at a temperature below the dew-point temperature of the air. Drying, therefore, was slackened somewhat, due to condensation on the fish.

TABLE 37.—*Effect of change in air temperature upon the drying rate of raw and steamed California pilchards*—Continued

STEAMED FISH

Experiment No.	Vapor pressure in inches of mercury	Temperature, °F.	Per cent loss in weight (time in minutes)					
			10	15	20	30	60	120
112a	0.45	90		6.8		9.5	13.0	
112b	.60	100		7.0		9.3	12.7	
112c	1.10	120		8.5		11.0		
112e	.62	166				14.5	20.4	
113a	.45	93		7.5		9.8	13.0	
113b	1.10	120		8.5		11.7	16.3	
113c	2.44	166		9.0		12.8	17.2	
115a	.44	92		9.1		12.3	17.8	
115b	.74	110		10.1		13.7	18.4	
115c	1.29	130		9.2		12.2	17.4	

Effect of change in air velocity upon the drying rate of raw and steamed fish.—Data indicating the nature of the change in the drying rate of the fish, due to increased air velocity, are given in Table 38. It will be seen that increasing the air velocity brings about only a small increase in the moisture loss. Lewis, and also Carrier, in the Journal of Industrial and Engineering Chemistry (see footnote, p. 120), show that where the rate of diffusion of moisture within an object, to the surface, is slow increased air velocity has little effect in increasing moisture removal other than that increase that is brought about by greater heat transfer from the air to the object at the higher velocity. This undoubtedly explains the experimental results.

Change in drying rate of raw and steamed fish with respect to time.—In Table 39 an analysis is made of the data from various experiments, indicating the nature of the change in the drying rate with respect to time. It will be seen that the rate of moisture removal at first is relatively rapid, after which it slows down to a more or less uniform rate. This, of course, covers only the range of time investigated. During the first interval of time the free moisture on the surface of the fish and the most accessible combined moisture is removed. Following this the only water removed is that which reaches the surface by the relatively slow process of diffusion.

TABLE 38.—*Effect of change in air velocity upon the drying rate of raw California pilchards*

Experiment number	Velocity in feet per minute	Per cent loss in weight (time in minutes)			Experiment number	Velocity in feet per minute	Per cent loss in weight (time in minutes)		
		30	60	90			30	60	90
97c	110		2.5		117a	638	5.9	9.1	11.6
97b	420		4.1		117c	952	5.3	8.3	10.7
97a	667		4.9		118b	575	6.1	9.7	
116b	308	4.2	7.4		118c	575	6.1	9.2	
116c	656	5.5	9.0		118a	968	6.7	10.3	
116a	1,075	6.5	10.2		118d	968	6.7	10.3	
117b	255	4.1	6.7	9.0					

TABLE 39.—*Change in drying rate of raw California pilchards with respect to time*

[Average difference for experiments included]

Experiments included	Intervals of time				Length of intervals, minutes
	First	Second	Third	Fourth	
102-106	3.4	1.2	0.9	1.0	30
112-115	8.8	3.2	2.7	2.0	15
119-120	5.2	2.8	2.1	2.0	15

Effect of fish size upon the drying rate.—The data given in Table 40 plainly show (when considered as a whole) that large fish lose their moisture more slowly than small ones when dried under identical conditions.

Temperature rise in fish being dried.—Numerous data upon the temperature rise in fish undergoing drying were obtained during the course of the experiments. These are given in Table 41. The temperatures were obtained by placing the bulb of a thermometer about one-eighth of an inch under the skin of a fish at its thickest part. The fish was then kept in the path of the drying air. Readings were taken from the stem of the thermometer, which extended through the drier housing.

TABLE 40.—*Effect of fish size upon the drying rate.*[1]

Experiment No.	Average weight of individual fish in grams	Per cent loss in weight (time in minutes)					
		10	15	20	30	45	60
122b	11	6.6		11.2	14.0		
124b	18		9.4		13.0		
121b	19				10.6		
125a	31		5.1		7.9		
121a	38				8.1		
123a	39		5.1		7.4		
119a	40		7.3		10.1	12.7	14.8
120c	44		6.0		8.6	10.9	13.0
120a	55		5.5		8.8	11.0	12.9
119b	59		5.0		8.1	10.0	12.0
120d	72		4.0		6.3	8.2	10.4
120b	90		4.2		7.1	8.5	10.7
119c	92		5.0		7.7	10.0	11.6
118a	92				6.7		10.3
119e	96				6.8	8.9	
118d	99				6.7		10.3
119d	101		4.5		7.0		10.7
117c	111				5.3		8.3
116a	112				6.5		10.2

[1] All other variables were constant, except for small, negligible variations in vapor pressure. The fish, however, in addition to differences in weights, were, in a number of cases, from different lots.

TABLE 41.—*Temperature rise in fish being dried*

Experiment No.	Size of fish	Air temperature ° F.	Air velocity in feet per minute	Temperature in ° F. (time in minutes)[1]									
				Start	5	10	15	20	30	45	60	90	120
93a	Large "ovals"	90	174	56			65		70.5	76.5	80		
93b	do	100	174	58			69		76	80	86		
93c	do	110	174	64			75				99		
Feb. 2, 1923	do	120	174	66			82		92.5	101	106		
94a	do	92	174	56				63	67		77		
94b	do	120	174	60							107		
95a	do	100	174	57					76		85		
95b	do	100	174	70			78				91.5		
Feb. 14, 1923	do	95	673	75.2							89.6		
Do	do	105	653	75.2							98.6		
Do	do	116	641	75.2							100.4		
Do	do	116	641	60.8							93.2		
99b	Medium large "ovals"	105	627	59							95		
99c	do	95	619	59							87.8		
100a	do	90	619	61							78		
100b	do	95	649	61							88		
Feb. 16, 1923	do	90	619	75							80		
Do	do	95	649	75							88		
Do	do	95	632	62							86		
Do	do	95	617	62							85		
101b	do	115	618	64				94					112
101c	do	115	618	64									110
101d	do	71	615	65							68		
103a	Large "ovals"	95	602	60					80		90	92	93
103b	do	105	616	61							100	102	103
103d	do	115	580	62					100		109	112	112
104a	do	105	588	62					88		97	101	
104b	do	105	610	62					90		99	101	
104c	do	105	602	63					94			102	103
108b	do	115	613	55.4							109.4		
109a	do	115	587	62					88				
110a	do	150	623	63	70	84	96						
110b	do	150	623	63		80	92						
122a	Small "quarter oils"	96	1,000	66	75	79	83	85	88				
122b	do	110	1,000	68	85	93	98	100	100				
122c	do	162	1,111	73	110	125							
Nov. 27, 1923	Medium "ovals"	190	900	62		110			158		176		
Dec. 3, 1923	Small "ovals"	200	900	63	104	132	154	167	180				
Sept. 26, 1924	Medium "quarter oils"	275	2,000	70		210	220						

[1] Taken about ⅛ inch under skin at the thickest part of body ("cut" fish used).

NEW PROCESS FOR PREPARING THE FISH

Detailed data on the various experiments carried out on California pilchards and Maine herring are given in Table 42.

TABLE 42.—*Experimental data on the preparation of California pilchards and Maine herring for canning as sardines by the use of high-temperature, high-velocity air* [1]

Experiment No.[1]	Date	Fish	Drying, cooking, and canning data							Pack number	Examination of canned product	General results
			Air temperature, °F.	Air velocity in feet per minute	Time in minutes	Per cent loss in weight	Cooling data	Total per cent loss in weight	Notes			
137a	1923 Nov. 27	Medium, lean	190	900	60	10.9	Air blast 30 minutes; stood overnight on flake.	12.9	Fish in excellent shape; cooked as well as fried fish; skins showed flake marks.	167	Very good; no different from 168 except sauce less liquid.	New process produced as good a pack as frying in oil; tendency shown for flake marks to mar appearance of fish; blast of cool air cooled fish so that they could be packed soon after being cooked.
137b	do	do							Commercial fried pack put up by regular canner.	168	Very good	
138a	do	do	196	900	60	11.6	Air blast 30 minutes.	12.4	During cooking humidity was run up almost to the saturation point by turning steam into the air; fish about the same as in 137a.			Cooking in humid air gave about same results as when dry air was used.
139a	Dec. 3	Medium to small, lean.	200	900	30	8.9	do	10.4	Fish in excellent shape but tended to stick to flake, which was quite dirty.	169	Good; physical condition comparable to 173, except for flake marks; better than 174 because of absence of fry-bath oil.	New process produced better pack, due to absence of bad effects from frying in oil; skins marred some by process; cooking 30 minutes at 200°, plus standing in air overnight, removed about as much water from the fish as 60 minutes' cooking and drying did.
139b	do	do	200	900	30	8.3	Air blast 30 minutes, stood overnight on tray.	16.0	Good; flake marks well defined on skins; some skins broken.	170	Same, firmer than 169	
139c	do	do	188	900	30	7.1	do	13.7	do	171	About same as 170	
139d	do	do	204	900	60	13.9	do	18.1	Same, canned without sauce.	172	About 8 cubic centimeters liquid in can.	
139e	do	do							Commercial fried pack	173	Good	
140a	Dec. 4	Medium, lean	193	900	60	12.7	Air blast 30 minutes.	13.6	Good; skins broken some by sticking to flake.			

141a	Dec. 6	do	200	900	35		Air blast 15 minutes.	10.0	Fish did not stick badly to tray; woven-wire belting used instead of ¾-inch mesh wire screen.	174	Good, but too much water in can.	Good pack produced by new process; skin marring less where flexible woven wire belting was used instead of ¾-inch wire screening; the wire belting was like that used in continuous sardine driers.
141b	do	do	204	900	50		Air blast 20 minutes.	13.1	Same, except skins marred some.	175	Good; slightly too much water in can.	
141c	do	do	194	900	60		do	11.9	do	176	Good; slightly more water in can and little softer than 175.	
141d	do	do							Commercial fried pack	177	Good	
142a	Dec. 7	Large, medium	196	900	90	17.4	Air blast 30 minutes.	18.1	Fish in excellent shape; did not stick badly to wire belting.	178	Better than fried pack; no oil taste; fish firmer.	New process produced better pack than frying in oil; standing in air removed considerable water from cooked fish.
142b	do	do	196	900	15	7.7			Total loss in weight after standing in air 3 hours, 10.7 per cent; after 20 hours, 15 per cent.	179	Comparable to fried pack.	
142c	do	do							Commercial fried pack	180	Good	
143a	Dec. 11	Medium	196	900	30	7.7	Stood 21 hours on flake.	14.3		181	Except for presence of fry-bath oil in fried pack, there was no observable difference in the packs.	New process produced better pack because no "old" fry-bath oil present.
143b	do	do							Commercial fried pack	182		
144a	Dec. 12	do	198	900	60		Air blast 30 minutes.	14.7		183	Both packs same, except for fry-bath oil in fried pack; air-cooled fish were brighter and retained more of raw appearance.	New process retained more of original appearance of fish.
144b	do	do							Commercial fried pack	184		
145a	Dec. 29	do	200	900	30	7.8	Stood 28 hours on flake.	15.4	Did not stick to flake			
146a	1924 Jan. 7	do	206	900	30	8.4	Total loss in weight after standing 5 hours; 13.5 per cent, after 22 hours.	18.6		185	Physical condition same as fried pack.	Standing in air removed much water.
146b	do	do	204	900	53	14.1	Air blast 30 minutes.	15.5	In olive oil	186	Same, 8 to 10 cubic centimeters water in can.	
146c	do	do							Commercial pack	187	Good	

[1] See notes, p. 170.

[2] Experiments 137a to 153a were carried out with California pilchards of pound-oval size (unless a statement to the contrary is given), using a small experimental drier.

TABLE 42.—*Experimental data on the preparation of California pilchards and Maine herring for canning as sardines by the use of high-temperature, high-velocity air*—Continued

Experiment No.	Date	Fish	Drying, cooking, and canning data: Air temperature, °F.	Air velocity in feet per minute	Time in minutes	Per cent loss in weight	Cooling data	Total per cent loss in weight	Notes	Pack number	Examination of canned product	General results
147a	1924 Jan. 8	Large, quarter-oil size.	200	900	60	23.2	Air blast 20 minutes.	25.2	Packed with olive oil in quarter-pound can; processed 1½ hours at 240°.	188	Very good; 8 to 10 cubic centimeters water in can.	Good quarter-oil sardines produced by new process; high-temperature processing removed more water from fish than low-temperature processing did.
147b	...do...	...do...	198	900	60	17.1	Stood 16 hours on flake.	23.0	Packed with olive oil and processed 4 hours at 212°.	189	Very good; only about 2 cubic centimeters of water in can.	
148a	Jan. 9	Small, quarter-oil size.	200	900	45	...	Air blast...	32.2	Packed in quarter-pound cans with olive oil; processed 2½ hours at 214°.	190	Appearance and taste very good; very little water in can.	New process produced better quarter-oil pack than frying in oil.
148b	...do...	...do...	...		...	...	...	...	Commercial fried pack...	191	Not as good as 190; fry-bath oil prominent.	
149a	Jan. 11	Medium-large, fat.	150	900	30	6.0	...	...	...	...	...	The higher the air temperature the greater was the loss in weight, other conditions being equal.
149b	...do...	...do...	150	900	60	9.3	Loss at end of 30 minutes, 5.2.	...	...	...	...	
149c	...do...	...do...	175	900	60	11.5	Loss at end of 30 minutes, 7.3.	...	...	...	...	
149d	...do...	...do...	200	900	60	16.7	Loss at end of 30 minutes, 9.8.	...	...	...	...	
149e	...do...	...do...	220	900	60	19.9	Loss at end of 30 minutes, 12.0.	...	Skins broken most due to contact with wire.	...	...	
149f	...do...	...do...	222	900	30	12.4	...	...	...	...	...	

150c	Jan. 14	Medium	175	1,300	60	13.4	Losses at end of 30 minutes, 8.2.		Total loss after standing 21 hours on flake, 21.			Same as for experiment 103.
150b	do	do	200	1,300	60	17.4	Loss at end of 30 minutes, 11.2.		Total loss after standing 20 hours on flake, 24.5.			
150c	do	do	220	1,300	60	22.0	Loss at end of 30 minutes, 13.5.		Total loss after standing 19 hours on flake, 27; the higher the temperature the greater the marring, due to contact of fish with wire flake.			
151a	Jan. 15	Very large, fat	200	1,300	35	7.8	Stood 20 hours on flake.	13.3		192	Very good; physical condition equal to fried pack; taste better.	Better pack produced by new process; 35 minutes cooking, plus standing on tray overnight, dried the fish as much as 60 minutes cooking.
151b	do	do	200	1,300	60		Air blast 30 minutes.	13.6		193	do	
151c	do	do							Commercial fried pack	194	Very good; fry-bath oil prominent.	
152a	Jan. 16	Mixed, small and large.	201	1,300	30	9.1	Stood 22 hours on flake.	16.0		195	Very good; physical condition as good as fried pack; taste and appearance better.	Better pack produced by new process.
152b	do	do	202	1,300	60		Air blast 33 minutes.	16.1		196	do	
152c	do	do							Commercial fried pack	197	Very good	
153a	Jan. 17	Medium	200	1,300	60		Air blast 30 minutes.	17.7		198	Very good; better than fried pack.	Do.
153b	do	do							Commercial fried pack	199	Very good	
154a	Feb. 11	Very large, very fat.	200	1,400	60		30 minutes, air 78°		Excellent; stuck somewhat to wire flake (¾-inch mesh) and less to woven-wire belting.			Better pack produced by new process; oil and juices dripping from fish discolored fish on lower flakes; fish stuck less to woven-wire belting than to wire screening.
154b	do	do	200	1 400	60		do		Same; drippings from flake above discolored fish on lower flakes.	200	Excellent; better than 201 because no fry-bath oil present.	
154c	do	do							Commercial fried pack	201	Very good	
155a	Feb. 12	do	200	1,400	60		30 minutes, air 77°		Fish from top flake taken	202	Excellent	Discoloration due to oil and juices falling on fish remained on fish after canning.
155b	do	do	200	1,400	60		do		Fish from lower flake used; were covered with oil and blood, which had run out of upper flake and dried on surface of fish.	203	Excellent; dripping still on fish; one year later these drippings had spread, but their presence darkened the skins and oil in the can.	
155c	do	do							Commercial fried pack	204	Not as good as 202; fry-bath oil evident.	

[1] Experiments 154a to 206b, unless stated to the contrary, were performed with large experimental cooker and drier having separate cooling tunnel using outdoor air which was blown over the fish at a velocity of about 1,400 feet per minute.

TABLE 42.—*Experimental data on the preparation of California pilchards and Maine herring for canning as sardines by the use of high-temperature, high-velocity air*—Continued

Experiment No.	Date	Fish	Drying, cooking, and canning data: Air temperature, °F.	Air velocity in feet per minute	Time in minutes	Per cent loss in weight	Cooling data	Total per cent loss in weight	Notes	Pack number	Examination of canned product	General results
156a	1924 Feb. 15	Large, fat	300	1,400	30		15 minutes, air 78°		Physical condition good; skins browned somewhat; stuck badly to flakes.			Temperature of 300° instead of 200° removes moisture from fish much more rapidly; thirty minutes at 300° evidently too long; a good flow of cool air cooled fish sufficiently for packing in 15 minutes; high air temperature increased tendency of fish to stick to flake.
156b	do	do	300	1,400	30	25.3	15 minutes, air 80°	25.8	do			
156c	do	do	300	1,400	20	20.5	do		Physical condition good; stuck somewhat to flakes.			
156d	do	do	310	1,400	15	18.8	do		Physical condition good; stuck somewhat to flake, but hardly at all to woven-wire belting.			
156e	do	do	310	1,400	10	12.3	do		Good; would make a good pack; probably would be better to remove more water from the fish.			
157a	Feb. 18	Very large, very fat.	230	1,000	15	4.2			The higher the temperature the more tendency for the fish to crack, turn brown, and stick to the flake; bad at 392°; not bad at 329°.			The higher the temperature (other conditions equal), the more moisture was removed from the fish; 329° for 15 minutes removes about the right amount.
157b	do	do	329	1,000	15	16.4						
157c	do	do	392	1,000	15	20.0						
158a	do	do	325	600	15	9.7			Good; not as well cooked as 158b and 158c.			Other conditions equal, the higher the velocity the greater the moisture loss.
158b	do	do	325	1,400	15	13.7			Tendency to darken and stick to flake shown.			
158c	do	do	325	2,000	15	14.4			Tendency more pronounced than in 158b yet effects not serious.			

159a	Feb. 19	Large, fat	311	1,400	15		15 minutes, air 70°		Enough fish cooked to prepare 304 cans; cooking, cooling, and packing into cans carried on continuously; fish packed within 30 to 40 minutes after being placed in cooker; some skins broken but not in excess of amount broken by frying process.	205	Excellent; firm; abundance of clear yellow oil present; taste and appearance better than fried pack.	Fish were successfully cooked, cooled, and packed continuously, giving an excellent pack better than a similar fried-in-oil product.
159b	do	do							Commerical fried pack	206	Excellent, but not as good as 205.	
160a	do	do	311	1,400	30		15 minutes, air 70°		Turned brown and stuck badly to flakes.			Thirty minutes at 311° too much.
161a	Feb. 25	Large quarter oil	302	1,300	10		10 minutes, air 76°	14.0	Flakes covered with old oil and juices; this marred fish, and there was some sticking; fish looked good.			Good quarter oils were produced, both by rapid and slow cooking and drying; effect of dirty flakes shown.
161b	do	do	200	1,300	60		10 minutes, air 80°	23.0	Excellent condition; flake clean; no sticking.			
162a	do	Small	200	1,300	60		do	20.0	Excellent condition			
163a	Feb. 28	Large, fat, poor condition.	309	1,300	15		15 minutes, air 76°		Enough fish cooked to prepare 289 cans; cooking, cooling, and packing carried on continuously; fish were in can within 30 to 40 minutes after being placed in cooker; fish were very soft to start with and stuck to flakes quite badly.	207	Very good; firm; oil clear and yellow; taste and appearance better than fried fish.	Fish were again successfully cooked, cooled, and packed continuously, giving an excellent pack; better than a similar fried-in-oil product.
163b	do	do							Commercial fried pack; same difficulty encountered with broken skins and sticking to wires of baskets.	208	Very good, but not as good as 207.	
163c	do	do	309	1,300	15		15 minutes, air 76°		Packed in vinegar and spices.	209	Very good	
164a	Mar. 10	Large, poor condition.	310	1,300	30	21.0	Loss, end 15 minutes, 11.3.		Fish darkened by heat and stuck badly to flakes.			Flakes marred fish badly.

TABLE 42.—*Experimental data on the preparation of California pilchards and Maine herring for canning as sardines by the use of high-temperature, high-velocity air*—Continued

Experiment No.	Date	Fish	Drying, cooking, and canning data: Air temperature, °F.	Air velocity in feet per minute	Time in minutes	Per cent loss in weight	Cooling data	Total per cent loss in weight	Notes	Pack number	Examination of canned product	General results
165a	1924 Mar. 10	Mixed, very poor condition.	210	1,300	60	13.6	Loss, end 30 minutes, 9.6; stood 18 hours on flakes.	18.4	Stuck to flakes quite badly; packed with spiced olive oil.	210	Poor tasting; probably due to condition of fish; juices in can "muddy" looking.	Fish that are old and soft stick to flakes more than fresher fish seemed to in other experiments.
166a	Mar. 12	Mixed, fair condition.	210	1,300	90	16.7	Loss end 30 minutes, 11.8; loss end 60 minutes, 15.7; after standing 17 hours on flake.	22.6	Very good			Rate of moisture loss at 210° shown; also effect of standing in air.
166b	do	do	210	1,300	75	11.7	Loss end 15 minutes, 6.3; loss end 45 minutes, 9.4; after standing 17 hours on flake.	19.5	do			
167a	Mar. 13	Medium	310	1,300	15		15 minutes, air about 75°.		Good; did not stick badly			Did not stick to flake
167b	do	do	310	1,300	15		do		do			
168a	do	Medium, fair condition.	307	1,300	15	14.5	After standing 22 hours.	19.4	Packed with spiced olive oil; cooked nicely; some breakage.	211	Very good; fish firm; some water in can.	Good fancy oil packs produced.
168b	do	do	307	1,300	15	14.5	do	19.4	Same, only skins removed from fish before being packed.	212	Same as 211	
168c	do	do	310	1,300	15		Stood on flakes 2 days.		Same notes as 168a	213	Very good; less water in can than 211.	
168d	do	do	310	1,300	15		do		Same notes as 168b	214	Same as 213	

169a	Mar. 14	Medium, lean	310	1,300	15		15 minutes, air about 75°.		Good, except fish stuck to flake quite badly.			Fish stuck to flake badly; lean fish tended to stick worse than fat ones.
170a	do	Medium	310	1,300	15	12.8	After standing 16 hours.	16.5	Good except stuck to flakes when set aside for night; next morning was foggy, air saturated with moisture, fish were moist and did not stick to flake at all; canned with spiced olive oil.	215	Good, except for some water in can.	Humid atmosphere prevented drying of surface of fish and this prevented sticking.
171a	Mar. 17	Small	200	1,300	70	23.4	Loss, end 30 minutes, 14.7.		Good			
172a	Mar. 25	Small, lean	302	1,300	15	16.5			When removed from cooker, skins were dry and fish stuck badly to flake; cloth was spread over fish while warm and fish cooled; moisture diffused to surface and not being removed moistened fish, which then came away from flake without sticking.			Preventing surface from drying out prevented sticking to flake.
172b	do	do	212	1,300	30	20.1			do			
173a	Mar. 26	do	302	1,300	15		10 minutes, air 65°, saturated with moisture.		Skins not tough like fat fish; were moist and did not stick badly to flake.			Where the surface of fish does not dry out there is no sticking.
174a	Apr. 8	do	302	1,300	15		15 minutes, air about 75°.		Stuck to flake very badly.			Fish tended to stick to flake more at higher temperatures; toughening the skins before cooking virtually eliminated sticking to flakes.
174b	do	do	212	1,300	30		do		Stuck, although not as badly as 174a.			
174c	do	do	284	1,300	15		do		Before being cooked, skins were toughened by drying 15 minutes at 130°; same air velocity and position of fish changed once; only very few fish stuck to the flake.			
175a	Apr. 9	do	284	1,300	15		do		Skins toughened before cooking by drying 10 minutes at 140°, position shifted once; tendency to stick to flake almost eliminated.			Fish, the skins of which had been toughened before cooking, did not stick to flake.
175b	do	do	284	1,300	15		do		do			

TABLE 42.—*Experimental data on the preparation of California pilchards and Maine herring for canning as sardines by the use of high-temperature, high-velocity air* —Continued

Experiment No.	Date	Fish	Drying, cooking, and canning data: Air temperature, °F.	Air velocity in feet per minute	Time in minutes	Per cent loss in weight	Cooling data	Total per cent loss in weight	Notes	Pack number	Examination of canned product	General results
176a	1924 Apr. 10	Small, lean	284	1,300	15	------	15 minutes, air about 75°.	------	Skins toughened by drying 15 minutes at 140°, then placed so as to touch each other; did not stick to flakes but did stick some to each other; later were stacked in a basket touching each other; no trouble experienced in separating them next morning.	------	------	Same notes as 129.
177a	Apr. 15	Small quarter-oil size, lean.	200	1,300	15	------	5 minutes, air about 70°.	19.1	Did not stick to flake or to each other.	------	------	Small quarter-oil fish cooked at 200° did not stick to flakes at 300° they did; higher temperature removed water, more rapidly than lower one.
176b	do	do	300	1,300	15	------	Loss end 10 minutes, 20.5; cooled 5 minutes in air.	29.5	Fish stuck to flake and to each other.	------	------	
176c	do	do	200	1,300	15	------	5 minutes, air about 70°.	17.6	Did not stick	------	------	
178a	Apr. 17	Small, lean	290	1,300	15	------	10 minutes, air about 70°.	16.5	Skins first toughened by drying 10 minutes at 140°, position fish shifted once; loss in weight 5.5 per cent; did not stick to flake or to each other.	------	------	Toughening skins virtually eliminated sticking to flakes.
178b	do	do	290	1,300	15	------	do	15.2	Same, only fish scattered heavily on flake so as to touch in many places; came out in excellent shape.	------	------	
178c	do	do	290	1,300	15	------	do	14.1	Skins not toughened; stuck to flake and to each other quite badly.	------	------	

179a	May 2	Small quarter-oil size, poor condition.	200	1,300	15	------	10 minutes, air about 75°.	21.0	Fish scattered thickly on flake so as to touch each other; skins toughened by drying 10 minutes at 140°, position shifted several times; did not stick at all; canned with olive oil in quarter-pound cans and processed 1½ hours at 218°.	216	Good, but too much water in can for fancy pack.	Fish, the skins of which had been toughened before cooking, did not stick to tray; temperature was low, however; indications show that it is necessary to remove lots of water from small fish if a fancy pack of quarter-oils is to be produced.
179b	do	do	200	1,300	20	------	do	25.6	do	217	Good, less water in can than 216, but still not dry enough for fancy pack.	
180a [4]	Sept. 10	Large	320	1,900	15	------	10 minutes, air 65°.	22.3	Very good; stuck some to flake but breakage was less than usually takes place with steamed fish.	------	------	New process produced better pack than regular steaming process did; toughening the skins before cooking did little good in preventing sticking to flake; breakage caused was not as great, however, as the breakage caused by the steaming process.
180b	do	do	320	1,900	15	------	do	------	Skins toughened by drying 10 minutes at 130°, position of fish shifted once; came out in very good shape; did not stick to flake.	218	Very good; not much water in can; fish firmer; appeared and tasted better than 219.	
180c	do	do	------	------	------	------	------	------	Regular commercial pack.	219	Very good	
181a	do	Large, three-quarter-mustard size, fat.	320	1,900	15	------	10 minutes, air 65°.	25.0	Excellent; did not stick; packed with mustard sauce in ¾-pound cans.	220	Excellent; firmer than 219 and less water cooked out in can.	New process produced better three-quarters mustard pack than regular steaming process; cool air acting 10 minutes cooled the fish sufficiently for packing.
181b	do	do	------	------	------	------	------	------	Regular commercial pack.	221	Very good	
182a	do	Large	225	1,900	20	------	10 minutes, air 65°.	12.0	Good	------	------	Higher air temperatures tend to remove more water from the fish; 300° seemed to be a little too high for small fish.
182b	do	do	250	1,900	20	------	do	20.4	Very good	------	------	
182c	do	do	275	1,900	20	------	do	19.7	do	------	------	
182d	do	do	300	1,900	20	------	do	24.6	Very good; fish browned some and stuck to flake more than when cooked at a lower temperature.	------	------	

[4] Experiments 180a to 206b made in Eastport, Me., using experimental cooker and drier erected there. Herring were used, and, unless stated to the contrary, were quarter-oil size, in good condition, brined and cooked whole, then heads removed and packed with cottonseed oil in quarter-pound cans. Processing consisted of placing the cans in boiling water for 2 hours.

TABLE 42.—*Experimental data on the preparation of California pilchards and Maine herring for canning as sardines by the use of high-temperature, high-velocity air*—Continued

Experiment No.	Date	Fish	Drying, cooking, and canning data							Pack number	Examination of canned product	General results
			Air temperature, °F.	Air velocity in feet per minute	Time in minutes	Per cent loss in weight	Cooling data	Total per cent loss in weight	Notes			
	1924											
183a	Sept. 10	Large	275	1,900	15	------	10 minutes, air 65°	19.4	Skins toughened by drying 10 minutes at 140°; position of fish shifted once; came out fine; did not stick to flake or to each other; loss in drying, 8.3 per cent.	------	------	Toughening the skins helped little, if any, in preventing sticking to the flakes.
183b	...do	...do	275	1,900	15	------	15 minutes, air 65°	17.4	Same notes, except fish spread more thickly and loss in drying was 5.6 per cent; fish a little larger, too.	------	------	
184a	Sept. 11	Large, poor condition, had been kept over night.	275	1,900	15	------	10 minutes, air 65°	13.3	Very good; did not stick to flake or to each other and but little more than in 184b.	------	------	New process did not cause as much breakage with old fish as steaming did.
184b	...do	...do	275	1,900	15	------	------	20.8	Skins toughened by drying 10 minutes at 140°; position of fish shifted once; loss in drying 6.6 er cent; very good.	------	------	
184c	...do	...do	------	------	------	------	------	------	Steamed 14 minutes at 212°; fish broke badly, and after drying were not in as good condition as the air-cooked fish.	------	------	

185a	...do....	Medium, large...	275	1,900	15	20.4	Allowed to stand in air.	20.4	But little sticking to flake or to each other.	......	....	Toughening the skins helped but little; new process produced better pack than steaming process.
185b	...do....	.....do...........	275	1,900	15	21.8	.....do..............	....	Skins toughened 10 minutes at 140°; position of fish shifted once; loss in drying, 7.3 per cent; little better than 185a.	222	Very good; physical condition as good and taste and appearance better than 223.	
185c	...do....	.....do...........	....	....	....	....	....	....	Regular commercial pack.	223	....	
186a	Sept. 12	.....do...........	275	2,000	15	18.2	....	....	Good...............	......	....	Other conditions being equal, the higher the air velocity the greater was the moisture loss.
186b	...do....	.....do...........	275	1,400	15	16.2	....	....	.....do............	......	....	
186c	...do....	.....do...........	275	700	15	12.1	....	....	Good, except not fully cooked; blood uncooked at backbone.	......		
187a	...do....	.....do...........	275	1,900	15	19.4	....	....	Good...............	......	....	Other conditions being equal, the higher the temperature the greater was the moisture loss.
187b	...do....	.....do...........	300	1,900	15	24.8	....	....	Good; about like 187a....	......	....	
187c	...do....	.....do...........	325	1,900	15	30.0	....	....	Air too hot; oil darkened where it came out of fish; fish browned somewhat; stuck more to flake than others.	......	....	
188a	...do....	.....do...........	275	1,900	15	....	10 minutes, air 70°...	....	Very good; fish smoked at same time as cooked by putting smoke into air.	224	Very good; lightly smoked	Fish smoked at the same time as they were cooked and dried.
188b	...do....	.....do...........	275	1,900	15	....	.....do..............	22.0	.....do............	225	.....do............	
189a	Sept. 15	Medium, poor condition.	275	1,900	15	....	10 minutes, air 65°...	26.7	Fish cracked and skins broke some but not as badly as steamed fish.	226	Good; better in every way than 227.	New process was not as hard on fish in poor condition as steaming was.
189b	...do....	.....do...........	....	....	....	....	....	....	Regular commercial steamed pack.	227	....	
190a	...do....	Medium..........	275	1,900	15	....	Blast cool air.........	....	Very good; did not stick badly.	228	Good; better in every way than 229.	New process produced better pack.
190b	...do....	.....do...........	....	....	....	....	....	....	Regular commercial steamed pack.	229	Good...............	
191a	...do....	Medium, three-quarters mustard size.	275	1,900	15	....	Blast cool air.........	....	Very good; cooked well....	230	Good; better in every way than 231.	New process produced better three-quarters mustard pack than steaming did.
191b	...do....	.....do...........	....	....	....	....	....	....	Regular commercial pack.	231	Good...............	
192a	Sept. 16	Medium..........	275	1,900	15	....	Blast cool air.........	....	Smoked lightly while being cooked.	232	Good; smoked lightly...	Fish were smoked nicely while being cooked and dried.
193a	...do....	.....do...........	275	1,900	15	....	.....do..............	....	.....do............	233	.....do............	Same as 146a.

TABLE 42.—*Experimental data on the preparation of California pilchards and Maine herring for canning as sardines by the use of high-temperature, high-velocity air*—Continued

Experiment No.	Date	Fish	Drying, cooking, and canning data							Pack number	Examination of canned product	General results
			Air temperature	Air velocity in feet per minute	Time in minutes	Per cent loss in weight	Cooling data	Total Per cent loss in weight	Notes			
	1924											
194a	Sept. 16	Medium, three-quarters mustard size.	275	1,900	15	-------	Blast cool air-------	11.6	Very good; packed with mustard sauce in ¾-pound cans.	234	Good; better than 235--	New process produced better pack.
194b	---do----	-----do--------							Regular commercial pack.	235	----------	
195a	Sept. 17	Small----------	275	1,900	18	-------	Blast cool air-------	-------	"Cut" fish used; smoked lightly; were excellent; packed with olive oil; processed 3 hours.	236	Excellent fancy pack; virtually no water in can.	Excellent fancy pack produced by new process.
195b	---do----	-----do--------	275	1,900	18	-------	-----do-------	-------	Same, but packed with corn oil.	237	-----do-------	
196a	Sept. 18	-----do--------	275	1,900	15	-------	-----do-------	-------	"Cut" fish cooked; packed in olive oil; processed 3 hours.	238	Excellent; very little water in can.	Excellent pack of fancy sardines produced by new process.
197a	Sept. 19	-----do--------	275	1,900	15	-------	-----do-------	-------	"Cut" fish cooked; packed with mustard sauce; processed 3 hours.	239	Very good----------	
198a	Sept. 20	-----do--------	275	1,900	15	-------	-----do-------	-------	"Cut" fish cooked; packed with olive oil; processed 3 hours.	240	Excellent fancy pack; very little water in can.	
199a	---do----	-----do--------	275	1,900	15	-------	-----do-------	-------	Same as 152a, except packed in cottonseed oil with lemon and spices.	241	Excellent----------	
200a	---do----	-----do--------	275	1,900	15	-------	-----do-------	-------	Same as 152a----------	242	Excellent fancy pack; very little water in can.	

201a	---do----	-----do-----------	275	1,900	15	-------	-----do-------------	-------	Same as 153a------------	243	Excellent---------------	
202a	---do----	-----do-----------	275	1,900	15	-------	-----do-------------	-------	"Cut" fish cooked; smoked lightly while being cooked; packed with cottonseed oil; processed 3 hours.	244	-----do---------------	
203a	Sept. 22	Large-----------	------	1,900	15	16.0	-------------------	-------	Temperature gradually raised from 250 to 300°; fish cooked as well as at 275°.	------	----------------------	Gradual change of cooking temperature from 250 to 300° gave excellent results.
204a	Sept. 23	Medium---------	275	1,900	15	24.0	-------------------	-------	Smoked lightly while being cooked; came out in excellent shape.	------	----------------------	
205a	---do----	-----do-----------	------	1,900	15	21.8	-------------------	-------	Temperature gradually dropped from 310 to 240°; cooked as well as 275°.	------	----------------------	Gradual change of cooking temperature from 310 to 240° gave excellent results.
206a	Sept. 26	-----do-----------	356	800	15	25.0	-------------------	-------	Loss, end of 10 minutes, 16.3; fish cooked well but browned considerably; oil cooked out and turned red; stuck badly to flake.	------	----------------------	High temperature and low velocity did not give as good results as lower temperature and high velocity.
206b	---do----	-----do-----------	275	1,900	15	22.0	-------------------	-------	Very good; bright; did not stick to flake.	------	----------------------	
[a] 207a	Dec. 27	Large, fat--------	290	1,700	15	-------	-------------------	-------	Skins toughened by drying, then cooked; stuck somewhat to flake.	245	Very good; much better than 246.	Toughening the skins of fat fish before cooking helped little, if any, as far as sticking is concerned.
207b	---do----	-----do-----------	290	1,700	15	-------	-------------------	-------	Not toughened; stuck about the same amount as dried fish.	------	----------------------	
207c	---do----	-----do-----------	266	1,700	30	24.4	-------------------	-------	Skins toughened by drying 10 minutes at 136°, position shifted once; stuck to flake about the same as other runs.	------	----------------------	
207d	---do----	-----do-----------	------	------	------	-------	-------------------	-------	Commercial fried pack----	246	Fry-bath oil taste, odor, and appearance prominent.	

[a] Experiments 207a to 210 were performed in Monterey, Calif., with small, experimental cooker, using pound-oval pilchards. Same notes apply here as for other experiments with California fish.

TABLE 42.—*Experimental data on the preparation of California pilchards and Maine herring for canning as sardines by the use of high-temperature, high-velocity air*—Continued

Experiment No.	Date	Fish	Drying, cooking, and canning data: Air temperature	Air velocity in feet per minute	Time in minutes	Per cent loss in weight	Cooling data	Total per cent loss in weight	Notes	Pack number	Examination of canned product	General results
208a	1924 Dec. 28	Large, fat	280	2,100	15	30.0			Fish filleted and fillets cooked; clean flake with no oil on it used; fillets stuck somewhat; were darkened and oil oxidized by heat; taste sharp and biting, due to oxidized oil.	247	Physical condition good; darkened oil from surface of fish had darkened the olive oil; taste quite "fishy," probably due to oxidized oil.	New process removed water from fillets rapidly and left them in excellent physical condition. Changes brought about in oil, due to heat, were undesirable. Lower cooking temperature tended to prevent these undesirable changes.
208b	do	do	270	1,700	15	21.4			Fillets cooked; tray oily and fillets did not stick; total loss in weight after standing 18 hours on flake, 32.1 per cent; better appearance and taste than 208a.			
208c	do	do	265	1,700	15	23.0			Same notes as 208b	248	Same notes as 247, except taste and appearance a little better.	
208d	do	do	265	1,700	15				do	249	Same notes as 248	
209a	do	do	290	1,700	15				Brined fish (same ones as used in experiment 161a) were placed in sea water and kept overnight, then removed and cooked; broke badly, being much worse than on previous day.			Brined fish that later had been freshened and allowed to stand broke badly where they touched the flake; toughening the skins of these fish did little or no good in preventing skin breakage.
209b	do	do	290	1,700	15				Same notes as 209a, only skins of fish first toughened by drying; this predrying helped little, if any.			
210a	Dec. 29	do	265	1,700	15				Excellent; did not stick to flake.			Large, fat fish did not stick to flake.

SUMMARIZED SPECIFICATIONS FOR EQUIPMENT

Equipment for carrying out the process should meet the following requirements:

OPERATING CONDITIONS

Air velocity.—For cooking and cooling, 2,000 to 2,200 feet per minute throughout the free spaces over and under the fish, when operated at capacity and at average working temperature.

Air temperature.—For cooking, desired possible variation in entering air, 200° to 400°; permissible drop in temperature, operating at desired velocity and capacity, 50° to 75°; average working temperature, 300° for California pound-oval fish and 275° for Maine quarter-oil fish. For cooling, assume outdoor air to be at a maximum temperature of 80°.

Air quantity.—For cooking, sufficient to meet the conditions specified above, and for cooling, enough to cool the fish to 85°.

Time.—Above requirements are based on the fish being in the cooker 15 minutes and for the same length of time in the cooler, and that the flakes or trucks are handled as specified below. Speed of conveyer handling trucks or individual flakes to be under control, so that the time when the fish are in the cooker and cooler can be varied, as desired, from 10 to 30 minutes.

Water to be evaporated.—For equipment to prepare California pound-oval fish assume a 16 per cent loss in weight, due to evaporation, with a maximum weight of 2.4 pounds of fish per square foot of flake surface, or 15 pounds per flake. For Maine quarter-oil fish assume a 25 per cent loss, with a maximum weight of 1.3 pounds per square foot, or 8.125 pounds per flake (this corresponds to a 16 per cent loss from three-quarters mustard fish flaking 2 pounds per square foot.

Other factors.—Recommendations given in regard to the following items on the pages indicated are to be followed:

Heating air, page 146.
Recirculation of air and control of humidity, page 143.
Continuous cooking, cooling, and packing equipment, pages 141 to 151, and equipment using trucks, pages 151 to 154.
Conveying single flakes, page 147.
Drip pans, page 143.

As far as practicable, all parts of the equipment should be fireproof and well insulated, according to the usual practice for high-temperature installations.

ESTIMATE OF EQUIPMENT AND FUEL REQUIREMENTS FOR PREPARING CALIFORNIA POUND-OVAL FISH

CONTINUOUS COOKING AND COOLING UNIT

Quantity of fish to be handled.—Five tons per hour of "round," small to medium pound-oval pilchards, the "cut" portion only to be cooked.

Number of flakes required.—Data used: Fish in cooker, 15 minutes and same time in cooler; "cut" portion, 66 per cent of "round" weight; weight of "cut" fish per square foot of flake surface, 2 pounds, or 12.5 pounds per 30 by 30 inch flake; weight of fish in cooker at one time is $0.66\times\frac{5\times2{,}000}{4}$ or 1,650 pounds, and the number of flakes is $\frac{1{,}650}{12.5}$, or 132. Same number of flakes required for cooling.

Heat required by cooker.—Calculations made on a per-hour basis. Data used: Temperature of fish, flakes, and other ironwork entering cooker, 50°; leaving, 300° for all iron and 220° for the fish (their temperature goes no higher); weight of flakes, 9 pounds each; weight of flake carrier and chain required for each carrier, 28 pounds; specific heat of iron, 0.13, and of water vapor at 300°, 0.47; specific heat of fish, 0.8; latent heat of evaporation of water at 212°, 970 B. t. u.; maximum weight of fish, 2.4 pounds per square foot of flake surface, or 15 pounds per flake, with a 16 per cent loss in weight due to evaporation. For calculating heat loss from cooker housing, it is assumed that the housing is 12.5 feet high, 3.5 feet wide, and 36 feet long, outside dimensions (1,152 square feet of exposed surface, not including ends) with a loss of 0.5 B. t. u. per square foot per hour per degree difference in temperature between the inside and outside of cooker, the temperature gradient being 300° less 50°, or 250°. Heat required for heating the iron, 4×132×37×250×0.13, or 634,920 B. t. u.; for heating the fish 4×132×15×170×0.8, or 1,077,120 B. t. u.; for evaporating water and heating the evaporated water from 220 to 300°, 4×132×15×0.16×970, plus 4×132×15×0.16×80×0.47, or 1,276,830 B. t. u.; and for loss through cooker housing 1,152×0.5×250, or 144,000 B. t. u.; giving a total of 3,132,870 B. t. u.

Air supply required for cooker.—Data used: Temperature of air entering cooker, 337.5°; drop in cooker, 75°; and cubic feet of dry air required to give one B. t. u. in dropping 1° at 300°, 78.5. (An equal volume of water vapor at 300° and atmospheric pressure gives up about the same amount of heat in dropping 1°. It is about half as heavy as dry air, but its specific heat is twice as large. The amount of water vapor in the air, therefore, is not considered in these approximate calculations.) Air required is $\frac{3,132,870 \times 78.5}{75}$, or 3,279,071 cubic feet per hour, or 54,651 cubic feet per minute.

Size of cooker required.—Assume that the flakes pass from one end of the tunnel to the other twelve times, six times in each direction; that the tunnel is 3 feet wide and 12 feet high, inside dimensions, giving a cross section of 36 square feet; and that the flakes, fish, chains, flake carriers, and drip pans take up 8.5 square feet, leaving 27.5 square feet, or 76.4 per cent of the total cross section free area. This free area will handle 55,000 cubic feet of air per minute at a velocity of 2,000 feet per minute. In each of the 12 runs there must be 11 flakes. A tunnel 36 feet long will handle this number of flakes easily.

Amount of air to be recirculated.—Data used: Volume of 1 pound of water vapor at 300° and atmospheric pressure, 42 cubic feet. Maximum amount of water to be removed from the fish per hour is 4×132×15×0.16, or 1,267.2 pounds. Under the assumed conditions, this is 1,267.2×42, or 53,222 cubic feet of vapor. If the water-vapor content of the air passing through the cooker should be allowed to build up to 20 per cent by volume, or 655,814 cubic feet, but 8.1 per cent would have to be discarded to remove the water vapor as rapidly as it collects. At least 90 per cent, and undoubtedly more, can be recirculated without difficulty.

Total heat required.—It is assumed that heat losses through housing for intake and recirculation ducts, furnace, blower, and other parts of equipment, is twice the amount for the cooker housing—2×144,000, or 288,000 B. t. u.—and that 10 per cent of the air that leaves the cooker is discarded, plus an additional 5 per cent to care for other losses. An approximate value for the heat lost in discarding 15 per cent of the air is obtained as follows: Assume the loss to be 15 per cent of the air supply required at 300°, the specific heat of air to be 0.24, the volume of air per pound at 300° to be 19.1 cubic feet, and that the air had been heated from 50° to 300°. This heat loss, then, is $0.15 \times \frac{3,279,071}{19.1} \times 0.24 \times 250$, or 1,545,112 B. t. u. This value, plus the conduction loss given above (288,000 B. t. u.), plus the heat required for the cooker (3,132,870 B. t. u.), is 4,965,982 B. t. u.

Fuel required.—It is assumed that fuel oil weighing 7.9 pounds per gallon and having a calorific value of 18,500 B. t. u. per pound is used, and that 80 per cent conversion is effected in the furnace. Oil required is $\frac{4,965,982}{18,500 \times 0.8} = 335.5$ pounds, or 42.4 gallons per hour. The fish will give at least 22 cases per ton, or 110 cases for the 5 tons cooked.[73] Fuel oil per case is $\frac{42.4}{110}$ or 0.385 gallon. To be safe, it is assumed 0.5 gallon per case is required.

Fuel required for preparing the fish by the frying-in-oil process.—Calculations are made on a per-hour basis. It is assumed that the amount of heat required per pound of fish dried is 190 B. t. u. (data for drier, B, Table 9, p. 125); that an additional 8.5 per cent loss in the original weight of the "cut" fish takes place in the fry bath, due to evaporation of water; that the fish enter the oil at 100° and leave at 220°; and that 50 per cent of the heat units in the fuel are utilized (a high figure for cannery practice). The heat required for drying the "cut" portion (66 per cent of the "round" weight) of 5 tons of fish is 10,000×0.66×190, or 1,254,000 B. t. u.; for evaporating water is 10,000×0.66×0.085×970, or

[73] A ton of good-quality "round" fish should give about 1,320 pounds of "cut" fish, and at least 1,082 pounds of fish ready for the can. Allowing 15 ounces of prepared fish per can (a high figure), the yield is 1,154 cans, or 24 cases.

544,170 B. t. u.; for heating the fish is $10{,}000\times0.66\times120\times0.8$, or 633,600 B. t. u.; giving a total of 2,431, 770 B. t. u. Fuel required is $\frac{2{,}431{,}770}{18{,}500\times0.5}=262.9$ pounds, or 33.3 gallons per hour. The fuel oil per case is $\frac{33.3}{110}$ or 0.303 gallons. This is 79 per cent of the fuel required for the new process. In this calculation, however, no account is taken of the large heat losses that take place in the frying vat.

Heat to be removed by cooler.—Data used: Temperature of fish entering cooler 220° and of all iron 300°; weight of fish, 13.5 pounds per flake (90 per cent of weight entering cooker); temperature of fish and iron leaving cooler, 85°; and the specific heat of air 0.24, and of iron, 0.13. The heat to be removed per hour from the iron is $4\times132\times37\times215\times0.13$, or 546,031 B. t. u., and from the fish $4\times132\times13.5\times135\times0.8$, or 769,824 B. t. u., giving a total of 1,315,855 B. t. u.

Air required for cooling.—It is assumed that the cooler is the same in size as the cooker; that the flakes pass from one end to the other 12 times, as in the cooker, that the 12 lines of flakes are evenly spaced from top to bottom, with partitions to prevent the air passing over one line from mixing with that of the next; that the free area is the same (27.5 square feet) as in the cross section of the cooker, with the same air velocity, only at an entering temperature of 80°; that at 80°, 56.2 cubic feet of dry air will take up 1 B. t. u. in being heated 1°; and that the average rise in temperature of the air passing over the different lines of flakes is 25°. Under these conditions the quantity of air passing through the cooler is sufficient, as is shown by the following calculations: Air passing through the cooler is $27.5\times2{,}000\times60$, or 3,300,000 cubic feet per hour. This much air takes up, in rising 25°, $\frac{3{,}300{,}000}{56.2}\times25$, or 1,467,971 B. t. u. The amount that must be removed is 1,315,855 B. t. u.

Packing space.—It is assumed that each packer will pack 4½ cases of "oval" fish per hour; that 2 feet of space is required for each packer; that 6 feet of free space should be left between the cooler and first packer and between last packer and where the flakes are elevated to the upper level; and that 22 cases per ton of small to medium "ovals," prepared, will be obtained, or 110 cases per hour. Number of packers required is $\frac{110}{4.5}=25$. Space, however, should be allowed for 5 additional packers as a safety measure. Space required is $30\times2=60$ feet, or 30 feet, since they work on both sides of the moving flakes. Total space required, then, is $30+6+6=42$ feet.

Total weight conveyed.—It is assumed that each flake carrier takes up 2.75 feet (33 inches) of lineal space; that each carrier weighs 8 pounds and each flake 9 pounds; that the chain required for each flake weighs 20 pounds; and that the amount of fish per flake is 15 pounds. Number of flakes on conveyer is 132 in cooker, 132 in cooler, outside on conveyer $\frac{42+42+24}{2.75}=40$; giving a total of 304, of which 14, it is assumed, will have no fish on them. Total weight, then, is $290\times(8+9+20+15)+14\ (8+9+20)=15{,}598$ pounds. Total chain required is $2\times304\times2.75=1{,}672$ feet.

Space occupied by unit.—Total length is about 100 feet, 40 feet of the length being 25 feet wide, 35 feet long, and 10 feet wide, and the rest 7 feet wide, including space for packers on both sides of conveyer. Height is 27 feet.

COOKING UNIT USING TRUCKS

The following calculations apply to a unit using trucks, including only a cooker to handle 5 tons of fish under the same conditions as given above. The flakes, heat, air, and fuel required are assumed to be the same as given in the above calculations.

Number of trucks required.—It is assumed that each truck is 6 feet high and that 15 flakes, each taking 4 inches of space, are placed on each truck. Number of trucks needed is 9.

Size of cooking tunnel.—It is assumed that each truck is 6 feet high and 32 inches square; that the trucks are spaced 6 inches apart in the tunnel; that 6 inches of space are required in the tunnel above the trucks for the conveyer; and that the tunnel used is similar to the one shown in Figure 28, p. 152. Length of tunnel, then, including vestibules, is $\frac{13\times(32+6)}{12}$, or 41 feet 2 inches. Height is 6 feet 6 inches. The width can be approximated as follows: About 27.5 square feet of free area for passage of the required amount of air is needed. If it is assumed that 50 per cent of the cross section occupied by the truck (top of tunnel to bottom) is free area, this amounts to 2.67×6.5×0.5, or 8.7 square feet. There must be provided, then, on the sides of the trucks, 18.8 square feet of free area. Since the tunnel is 6.5 feet high, this amounts to $\frac{18.8}{6.5}$, or 2.80 feet of width. The baffles hinder air movement somewhat, so let it be assumed that the tunnel must be 3.5 feet wider than the trucks, or 6 feet 2 inches in all, inside dimensions. The free area should be spaced equally on both sides of the trucks. The outside dimensions of the tunnel are about 42 feet by 6 feet 8 inches by 7 feet high.

Space occupied by unit.—Total length is about 42 feet, width about 30 feet, and height 8 feet.

ESTIMATE OF EQUIPMENT AND FUEL REQUIREMENTS FOR PREPARING MAINE QUARTER-OIL AND THREE-QUARTERS MUSTARD FISH

COOKING UNIT USING INDIVIDUAL FLAKE CARRIERS

Quantity of fish to be handled.—Three hogsheads (3,600 pounds) of "round," quarter-oil fish on the flakes, or 4 hogsheads (4,800 pounds) if the "cut" portion only is cooked.

Number of flakes required for cooker.—Data used: Fish in cooker 15 minutes; weight of fish per square foot of surface 1 pound, or 6.25 pounds per 30 by 30 inch flake. Flakes required, $\frac{1}{4}\times\frac{3600}{6.25}=144$.

Heat required by cooker.—Calculations made on a per-hour basis. Data used: Temperature of fish, flakes, and other ironwork entering cooker 40°, leaving 275° for all ironwork and 220° for the fish; weight of flakes 9 pounds each and of carrier and chains for each flake 23 pounds; specific heat of iron 0.13, of water vapor at 275°, 0.47, and of fish 0.8; latent heat of evaporation of water at 212°, 970 B. t. u.; maximum weight of fish to be handled, 2 pounds per square foot of flake surface, or 12.5 pounds per flake. However, for calculating the heat required for evaporating water, a maximum weight of 1.3 pounds per square foot of flake surface, or 8.125 pounds per flake, with a 25 per cent loss in weight due to evaporation, is assumed; and for calculating heat loss from cooker housing it is assumed that the housing is 11.5 feet high, 3.5 feet wide, and 38 feet long, outside dimensions (1,140 square feet of exposed surface, not including ends), with a loss of 0.5 B. t. u. per square foot per hour per degree difference in temperature between the air inside and outside of the cooker, the temperature gradient being 275°, less 40°, or 235°.

Heat required for heating the iron is 4×144×32×235×0.13, or 563,098 B. t. u.; for heating the fish, 4×144×12.5×180×0.8, or 1,036,800 B. t. u.; for evaporating water and heating the evaporated water from 220 to 275°, 4×144×8.125×0.25×970, plus 4×144×8.125×0.25×55×0.47, or 1,165,144 B. t. u.; and for loss through cooker housing, 1,140×0.5×235, or 133,950 B. t. u.; giving a total of 2,898,992 B. t. u.

Air supply required for cooker.—Data used: Temperature air entering cooker, 312.5°; drop in cooker, 75°; and cubic feet dry air required to give one B. t. u. in dropping 1° at 275°, 76. Air required is $\frac{2{,}898{,}992\times 76}{75}$, or 2,937,645 cubic feet per hour, or 48,961 cubic feet per minute.

Size of cooker required.—It is assumed that the flakes pass from one end of the tunnel to the other 12 times—6 times in each direction; that the tunnel is 3 feet wide and 11 feet high, inside dimensions, giving a cross section of 33 square feet; and that the flakes, fish, chains, flake carriers, and drip pans take up 8 square feet, leaving 25 square feet, or 75.8 per cent of the total cross section, free area. This free area will handle 50,000 cubic feet of air per minute at a velocity of 2,000 feet per minute. In each of the 12 runs there will have to be 12 flakes. A tunnel 38 feet long will handle this number of flakes easily.

Amount of air to be recirculated.—It is assumed to be at least 90 per cent. A similar calculation to that given on page 220 will show this to be true.

Total heat required.—It is assumed that heat losses through housing for intake and recirculation ducts, furnace, blower, and other parts of equipment is twice the amount for the cooker housing—2×133,950, or 267,900 B. t. u.; and that

10 per cent of the air leaving the cooker is discarded, plus an additional 5 per cent to care for other losses. An approximate value for the heat lost in discarding 15 per cent of the air is obtained as follows: Assume the loss to be 15 per cent of the air supply required at 275°, the specific heat of air to be 0.24, the volume of air per pound at 275° to be 18.3 cubic feet, and that the air had been heated from 40 to 275°. The heat loss, then, is $0.15\times\frac{2,937,645}{18.3}\times0.24\times235$, or 1,358,059 B. t. u. This value, plus the conduction loss given above (267,900 B. t. u.), plus the heat required for the cooker (2,898,992 B. t. u.), is 4,524,951 B. t. u.

Fuel required.—It is assumed that fuel oil weighing 7.9 pounds per gallon and having a calorific value of 18,500 B. t. u. per pound is used, and that 80 per cent conversion is effected in the furnace. Oil required is $\frac{4,524,951}{18,500\times0.8}=305.7$ pounds, or 38.7 gallons per hour. Three hogsheads (3,600 pounds) of quarter-oil fish will give at least 75 cases and probably more nearly 90 cases. If the "cut" portion only is cooked, 4 hogsheads will be handled, yielding a minimum of 100 cases. The oil per case, then, is $\frac{38.7}{75}=0.516$ gallon in the former instance and $\frac{38.7}{100}=0.387$ gallon in the latter. In order to be sure to be on the safe side, it is assumed that 0.75 gallon per case is required when 3 hogsheads of "round" fish are cooked, and 0.6 gallon when 4 hogsheads of "cut" fish are handled.

Fuel required for preparing the fish by the steaming process.—Calculations made on a per-hour basis. It is assumed that the amount of heat required to prepare fish by this process is the same as for the new process. Probably it is more, as steaming and drying are both very wasteful of heat. The heat required is 4,524,951 B. t. u. per hour. It is further assumed that coal costing $7.25 per long ton and having a calorific value of 15,000 B. t. u. per pound is used, and that 50 per cent of the heat units in the coal are made use of. Coal required, then, is $\frac{4,425,951}{15,000}$, or 590 pounds. On the "per case" basis this is $\frac{590}{75}$, or 7.9 pounds of coal per case for cooking "round" fish, and $\frac{590}{100}$, or 5.9 pounds per case for "cut" fish.

Total weight conveyed.—It is assumed that each flake carrier takes 2.75 feet (33 inches) of lineal space; that each carrier weighs 8 pounds and each flake 9 pounds; that the chain required for each flake weighs 15 pounds; and that the amount of fish per flake is 12.5 pounds. Number of flakes on conveyer, 144 in cooker and about 21 out, or 165 in all, 11 of which, it is assumed, will have no fish on them. Total weight, then, is $154\times(8+9+15+12.5)+11\times(8+9+15)=$ 7,205 pounds. Total chain required is $2\times165\times2.75=907.5$ feet.

Space occupied.—Total length is about 75 feet, 40 feet of the length being 25 feet wide and the rest 10 feet wide. Height is 15 feet. It is assumed that the top and bottom lines of flakes will extend about 6 flake-lengths out of the cooker housing. This space, however, is cared for in the above estimate.

COOKING UNIT USING TRUCKS

The following calculations apply to a unit using trucks for cooking 3 hogsheads of "round" quarter-oil fish under the same conditions as given above. The flakes, heat, air, and fuel required are assumed to be the same as in the above calculations.

Number of trucks required.—It is assumed that each truck is 6 feet high and that 18 flakes, each taking 3.5 inches of space, are placed in each truck. Number of trucks needed, 8.

Size of cooking tunnel.—If the same assumptions are made here as those given on page 221 under this same heading and the calculations made, it will be found that the tunnel required is about the same size as the one for handling California pound-oval fish, only 3 feet 2 inches shorter.

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ALASKA FISHERY AND FUR-SEAL INDUSTRIES IN 1926[1]

By Ward T. Bower, *Administrative Officer*

CONTENTS

[1] Appendix IV to the Report of the U. S. Commissioner of Fisheries for 1927. B. F. Doc. 1023.

INTRODUCTION

The bureau's work in Alaska includes two quite different fields of activity—first, the conservation of the fishery resources, and, second, the protection and utilization of the fur-seal herd of the Pribilof Islands. These two industries are of growing importance, and the bureau's conservation work and scientific study have expanded correspondingly. The Commissioner of Fisheries was in Alaska during the greater part of the active salmon-fishing season of 1926 and gave his immediate attention to the problems at hand.

The fisheries regulations were carefully revised in the winter of 1925–26, and amendments were issued during 1926 to meet contingencies that arose from time to time. An adequate patrol was maintained on all the important grounds throughout the active fishing season, and it is believed that violations of the laws and regulations were reduced to a minimum. Eleven patrol vessels owned by the bureau and more than 200 persons participated in this work. An excellent sea-going vessel, 100 feet in length, named the *Brant*, was built and added to the Alaska fleet. Weirs were maintained in eight important salmon streams, at which the fish escaping to the spawning grounds were counted and the relation of escape to catch established. Two salmon hatcheries were operated.

Scientific investigations of the salmon, herring, and clams were conducted. Surveys were made of many of the more important salmon-spawning waters, particularly in the Bristol Bay region, for the purpose of determining the sufficiency of the regulations to bring about an adequate escapement of breeding fish. Through the practical application of such scientific studies the bureau is striving to maintain this great resource without impairment while permitting the use of the balance for the benefit of the American people. Detailed statistics of the fisheries were collected and analyzed, the principal results being published herein. Generally the fisheries were in a very satisfactory condition. The pack of 6,652,882 cases of canned salmon was the largest in the history of the Territory.

At the Pribilof Islands 22,131 fur-seal skins were taken, an increase of 2,271 over the preceding year. To provide for future breeding stock, a reserve of 9,565 3-year-old males was marked. A computation made of the herd indicated that it contained 761,281 animals, an increase of 38,231 over the number in 1925. The work of replacing worn-out buildings, chiefly houses occupied by natives, was continued, and good progress was made in the construction of much needed roads. A very satisfactory patrol of waters of the North Pacific Ocean, including Bering Sea, was carried on by the United States Coast Guard.

As in the past, management of the blue-fox herds at the Pribilof Islands was incidental to sealing work. The foxes on both St. Paul and St. George Islands were fed during the periods when sufficient food could not be obtained by the animals unaided. In the foxing season of 1926–27, 118 blue and 27 white pelts were secured on St. Paul Island and 610 blue and 3 white pelts on St. George Island, a total of 758 and an increase of 33 over the previous season. An ample reserve of foxes was marked and released for future breeding stock.

During the year two public auction sales of fur-seal skins were held at St. Louis by the department's selling agents. At one of these sales fox skins from the Pribilofs also were sold.

Acknowledgment is made of the assistance rendered by members of the bureau's staff in the compilation and preparation of this document.

VISIT OF THE COMMISSIONER OF FISHERIES AND OTHER OFFICIALS TO ALASKA

Commissioner O'Malley was in Alaska during much of the active salmon-fishing period in the summer of 1926, giving personal attention to the important work of conserving the valuable aquatic resources of that Territory. The commissioner was thus able to give immediate consideration to modifications of the fishery regulations necessary because of developments of importance during the fishing season. The value of prompt and authoritative administrative action in this matter is obvious.

The commissioner devoted most of his time to southeastern Alaska, with its multiplicity of fishery problems, but an extensive trip also was made to central Alaska, including Cordova, Seward, Anchorage, and Fairbanks. The bureau's new patrol vessel *Brant* was utilized much of the time for cruising in Alaskan waters. This vessel sailed on its initial voyage from Seattle on July 9, and in addition to Commissioner O'Malley there was aboard Congressman Milton W. Shreve, who accompanied the commissioner on a tour of inspection of the fisheries of Alaska lasting several weeks and extending as far as Fairbanks.

Lawrence Richey, of the office of the Secretary of Commerce, was in Alaska for nearly a month in the summer of 1926, giving attention to various fishery matters, including particularly an examination of salmon-spawning waters tributary to Cook Inlet. Mr. Richey proceeded on the *Brant* as far west as Seward and returned on that vessel with Commissioner O'Malley to Seattle, arriving there on September 15.

Through inadvertence, the visit of United States Senator C. C. Dill, of Washington, to the Pribilof Islands in 1925 was omitted from the corresponding report for that year. Senator Dill was at St. Paul Island on July 1 and 2, 1925, observing sealing operations. Transportation from Seward to the Pribilofs and return to Seward was afforded by the United States Coast Guard cutter *Haida*.

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: (1) Southeast Alaska, embracing all that narrow strip of mainland and the numerous adjacent islands from Portland Canal northwestward to and including Yakutat Bay; (2) 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 (3) 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 areas established in departmental regulations.

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.

ALASKA FISHERIES LEGISLATION

Under date of June 18, 1926, the President approved an act amending the fisheries act of June 6, 1924. This modification of the law made possible the promulgation of regulations liberalizing the conditions under which halibut fishermen may secure herring for bait at times when commercial fishing for herring for other purposes is prohibited. The text of the amendment is as follows:

AN ACT TO AMEND SECTION 1 OF THE ACT OF CONGRESS OF JUNE 6, 1924, ENTITLED "AN ACT FOR THE PROTECTION OF THE FISHERIES OF ALASKA, AND FOR OTHER PURPOSES"

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section 1 of the act of Congress of June 6, 1924, entitled "An act for the protection of the fisheries of Alaska, and for other purposes," is amended so that it will read as follows:

"SECTION 1. That for the purpose of protecting and conserving the fisheries of the United States in all waters of Alaska the Secretary of Commerce from time to time may set apart and reserve fishing areas in any of the waters of Alaska over which the United States has jurisdiction, and within such areas may establish closed seasons during which fishing may be limited or prohibited as he may prescribe. Under this authority to limit fishing in any area so set apart and reserved the Secretary may (a) fix the size and character of nets, boats, traps, or other gear and appliances to be used therein; (b) limit the catch of fish to be taken from any area; (c) make such regulations as to time, means, methods, and extent of fishing as he may deem advisable. From and after the creation of any such fishing area and during the time fishing is prohibited therein it shall be unlawful to fish therein or to operate therein any boat, seine, trap, or other gear or apparatus for the purpose of taking fish; and from and after the creation of any such fishing area in which limited fishing is permitted such fishing shall be carried on only during the time, in the manner, to the extent, and in conformity with such rules and regulations as the Secretary prescribes under the authority herein given: *Provided*, That every such regulation made by the Secretary of Commerce shall be of general application within the particular area to which it applies, and that no exclusive or several right of fishery shall be granted therein, nor shall any citizen of the United States be denied the right to take, prepare, cure, or preserve fish or shellfish in any area of the waters of Alaska where fishing is permitted by the Secretary of Commerce. The right herein given to establish fishing areas and to permit limited fishing therein shall not apply to any creek, stream, river, or other bodies of water in which fishing is prohibited by specific provisions of this act, but the Secretary of Commerce through the creation of such areas and the establishment of closed seasons may further extend the restrictions and limitations imposed upon fishing by specific provisions of this or any other act of Congress: *Provided further*, That the Secretary of Commerce is hereby authorized to permit the taking of fish or shellfish, for bait purposes only, at any or all seasons in any or all Alaskan Territorial waters.

"It shall be unlawful to import or bring into the Territory of Alaska, for purposes other than personal use and not for sale or barter, salmon from waters outside the jurisdiction of the United States taken during any closed period provided for by this act or regulations made thereunder."

Approved, June 18, 1926.

NEW FISHERY REGULATIONS

The regulations for the protection of the fisheries of Alaska, issued December 5, 1925, were amended by the following regulations issued by the Acting Secretary of Commerce under the dates indicated:

[*February 8, 1926*]

SOUTHEASTERN ALASKA AREA

Herring fishery.—Commercial fishing for herring is permitted during the period from February 10 to March 31, 1926, both dates inclusive, in waters open to fishing, provided that during this period such fishing shall not be conducted on the actual spawning grounds of herring.

COPPER RIVER AREA

Clam fishery.—The taking of clams for commercial purposes is prohibited from 6 o'clock postmeridian July 15 to 6 o'clock postmeridian August 31 in each calendar year.

ALASKA PENINSULA AREA

Salmon fishery.—Regulation No. 1 is amended to read as follows: "In the waters of Nelson Lagoon, and thence along the coast to Cape Seniavin, including Herendeen Bay, Port Moller, and waters open to fishing off the mouths of Bear and Sandy Rivers, the 36-hour closed period for salmon fishing prescribed by section 5 of the act of June 6, 1924, is hereby extended to include the periods from 6 o'clock postmeridian of Tuesday of each week to 6 o'clock antemeridian of Thursday of each week and from 6 o'clock postmeridian of Friday of each week to 6 o'clock antemeridian of Saturday of each week, making a total weekly closed period in these waters of 84 hours, which shall be effective throughout the entire salmon fishing season of each year."

[*March 15, 1926*]

BRISTOL BAY AREA

Salmon fishery.—Regulation No. 1 is amended to read as follows: "Commercial fishing for salmon shall be conducted solely by drift gill nets and stake nets. The use of all other forms of fishing gear is prohibited. Commercial fishing for salmon with stake nets shall be limited to beach areas between high and low water marks and shall be confined to the following places: (*a*) Nushagak Bay, (*b*) along the beach in front of Koggiung Indian village on Kvichak Bay, (*c*) along the beach on the east and west side of Egegik near the Indian village, (*d*) along the beach on Ugashik Bay near the Indian village below the Alaska Packers' Association cannery. The total aggregate length of stake nets used by any individual shall not exceed 75 fathoms, measured on the cork line."

Regulation No. 10 (*a*) is amended to read as follows: "All commercial fishing for salmon is prohibited as follows: Nushagak Bay, all waters north of 59° north latitude, except that stake nets limited to beach areas between high and low water marks will be permitted north of 59° north latitude to the old prohibitive markers located at Snag Point."

ALASKA PENINSULA AREA

Herring fishery.—1. Commercial fishing for herring is prohibited in the period from January 1 to May 31, both dates inclusive, and from December 1 to December 31, both dates inclusive, in each calendar year.

2. During the period from June 1 to October 1, both dates inclusive, commercial fishing for herring is prohibited in all waters closed throughout the year to salmon fishing.

3. The closed season herein specified for herring fishing shall not apply to any boat taking not to exceed 60 barrels of herring in any calendar week in waters otherwise open to fishing.

4. Gill nets used in catching herring shall not be of smaller mesh than 3 inches stretched measure.

5. No one shall place, or cause to be placed, across the entrance of any lagoon or bay any net or other device which will prevent the free passage at all times of herring in and out of said lagoon or bay.

[*June 7, 1926*]

PRINCE WILLIAM SOUND AREA

Salmon fishery.—Regulation No. 8 (*e*) prohibiting all commercial fishing for salmon in the waters of Port Fidalgo east of 146° 20′′ west longitude is hereby amended to permit such fishing in these waters in each calendar year prior to 6 o'clock postmeridian July 9.

REGULATION EFFECTIVE IN EACH AREA

Steelhead fishery.—Commercial fishing for steelhead trout shall be subject to the provisions of law and the regulations applicable to commercial fishing for salmon.

[*June 25, 1926*]

COPPER RIVER AREA

Salmon fishery.—Commercial fishing with nets of mesh less than 8½ inches stretched measure between knots is prohibited from 6 o'clock postmeridian June 28 to 6 o'clock postmeridian July 10 in each calendar year within 2 statute miles outside the mouth of each stream, except Eyak River and Mountain Slough. In all waters of this area through July 10 of each year the weekly closed period provided by law is hereby extended to include the period from 6 o'clock antemeridian of Saturday of each week until 6 o'clock postmeridian of the Monday following, making a weekly closed period of 60 hours.

BERING RIVER AREA

Salmon fishery.—Commercial fishing with nets of mesh less than 8½ inches stretched measure between knots is prohibited from 6 o'clock postmeridian June 28 to 6 o'clock postmeridian July 10 in each calendar year within 2 statute miles outside the mouth of each stream. In all waters of this area through July 10 of each year the weekly closed period provided by law is hereby extended to include the period from 6 o'clock antemeridian of Saturday of each week until 6 o'clock postmeridian of the Monday following, making a weekly closed period of 60 hours.

[*July 1, 1926*]

KODIAK AREA

Herring fishery.—Regulation No. 3 is amended to read as follows: "The closed seasons herein specified for commercial herring fishing shall not apply to the taking of herring for bait purposes in waters otherwise open to fishing."

COOK INLET AREA

Herring fishery.—Regulation No. 4 is amended to read as follows: "The closed seasons herein specified for commercial herring fishing shall not apply to the taking of herring for bait purposes in waters otherwise open to fishing."

PRINCE WILLIAM SOUND AREA

Herring fishery.—Regulation No. 2 is amended to read as follows: "The closed seasons herein specified for commercial herring fishing shall not apply to the taking of herring for bait purposes in waters otherwise open to fishing."

SOUTHEASTERN ALASKA AREA

Herring fishery.—Regulation No. 3 is amended to read as follows: "The closed seasons herein specified for commercial herring fishing shall not apply to the taking of herring for bait purposes in waters otherwise open to fishing."

ALASKA PENINSULA AREA

Herring fishery.—Regulation No. 3 of supplementary order No. 251–12–2, issued March 15, 1926, is amended to read as follows: "The closed seasons herein specified for commercial herring fishing shall not apply to the taking of herring for bait purposes in waters otherwise open to fishing."

[*July 6, 1926*]

COPPER RIVER AREA

Salmon fishery.—Commercial fishing with nets of mesh less than 8½ inches, stretched measure, between knots is prohibited from 6 o'clock postmeridian July 6 to 6 o'clock postmeridian July 10 in each calendar year within 2 statute miles outside the mouths of Eyak River and Mountain Slough.

[*July 14, 1926*]

BRISTOL BAY AREA

Salmon fishery.—Regulation No. 5, prohibiting commercial fishing during the remainder of each calendar year after 6 o'clock postmeridian July 25, is hereby amended to prohibit such fishing after 6 o'clock postmeridian July 23.

The 36-hour weekly closed period provided by law is hereby extended to include the period from 6 o'clock postmeridian of Saturday until 6 o'clock postmeridian of the Monday following, making a weekly closed period of 48 hours. The weekly closed period of 60 hours for certain waters of Kvichak Bay remains in effect.

[*August 10, 1926*]

COOK INLET AREA

Salmon fishery.—The heart walls and the bottom strip of wire of the pots of all hand traps shall be removed during the closed period for commercial salmon fishing from 6 o'clock postmeridian August 10 to 6 o'clock antemeridian August 25 of each calendar year.

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[*August 26, 1926*]

RESURRECTION BAY AREA

Salmon fishery.—Regulation No. 3, prohibiting commercial fishing for salmon within 1,700 yards of the mouths of Bear Creek and Resurrection River, is hereby amended so that after August 29, 1926, such fishing is prohibited within 1,000 yards of the mouths of these streams.

[*October 6, 1926*]

COOK INLET AREA

Herring fishery.—Regulation No. 1 is amended to read as follows: "Commercial fishing for herring is prohibited during the period from January 1 to July 14, both dates inclusive, in each calendar year. Commercial fishing for herring, except by set and drift gill nets, is also prohibited from October 15 to December 31, both dates inclusive, in each calendar year. Commercial fishing for herring in Halibut Cove Lagoon is limited to set gill nets not exceeding 50 fathoms in length, hung measure. All such nets shall be anchored in a substantial manner not less than 100 yards apart. Nets operated within areas marked at the north and south ends of Halibut Cove Lagoon shall be anchored at right angles to the line joining the markers. Nets operated between these areas shall be anchored in a general direction paralleling the shore line."

Revised regulations covering the fisheries of Alaska were issued by the Secretary of Commerce under date of December 22, 1926, as follows:

By virtue of the authority vested in the Secretary of Commerce, fishing areas are hereby set apart and regulations governing fishing therein are made effective, as follows:

I. YUKON-KUSKOKWIM AREA

The Yukon-Kuskokwim area is hereby defined to include all territorial coastal and tributary waters of Alaska from Cape Newenham northward to the parallel of 64 degrees north latitude.

1. In the Yukon-Kuskokwim area all commercial fishing for salmon is prohibited at all times: *Provided*, That this prohibition shall not prevent the taking of fish for local food requirements or for use as dog feed.

II. BRISTOL BAY AREA

The Bristol Bay area is hereby defined to include all territorial coastal and tributary waters of Alaska extending from Cape Menshikof to Cape Newenham.

Salmon fishery.—1. Commercial fishing for salmon shall be conducted solely by drift gill nets and stake nets. The use of all other forms of fishing gear is prohibited.

2. Commercial fishing for salmon with stake nets shall be limited to beach areas between high and low water marks and shall be confined to the following places:

(*a*) Nushagak Bay.

(*b*) Along the beach in front of Koggiung Indian village on Kvichak Bay.

(*c*) Along the beach on the east and west side of Egegik near the Indian village.

(*d*) Along the beach on Ugashik Bay near the Indian village below the Alaska Packers Association cannery.

3. The total aggregate length of stake nets used by any individual shall not exceed 75 fathoms measured on the cork line.

4. The total aggregate length of gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 200 fathoms hung measure.

5. King salmon nets shall have a mesh of at least 8½ inches stretched measure between knots, and red salmon nets shall have a mesh of at least 5½ inches stretched measure between knots as measured when actually in use. No red salmon nets shall be over 28 meshes deep.

6. Prior to 6 o'clock antemeridian June 24 in each year commercial fishing for salmon with nets of mesh less than 8½ inches stretched measure between knots is prohibited.

7. Commercial fishing for salmon is prohibited during the remainder of each calendar year after 6 o'clock postmeridian July 23.

8. The trailing of web behind any fishing boat is prohibited above the markers fixing closed waters.

9. The use of motor-propelled fishing boats in catching salmon is prohibited.

10. The use of smelt nets is prohibited in localities where young salmon are migrating.

11. In the waters of Kvichak Bay between the line extending across the bay from the marker on a high point on the east bank of Prosper Creek, about 700 yards above the Koggiung Cannery of the Alaska Packers' Association, to the marker on the opposite side, the course being about north, 44 degrees west, magnetic, and the line extending across the bay from the marker at Graveyard Point, near the mouth of Graveyard Creek, to the marker on the opposite side between the mouths of Squaw and Russian Finn Creeks, the course being about north, 48 degrees west, magnetic, the 36-hour weekly closed period for salmon fishing prescribed by section 5 of the act of June 6, 1924, is hereby extended to include the period from 6 o'clock postmeridian of Saturday of each week to 6 o'clock antemeridian of the Tuesday following, making a weekly closed period of 60 hours.

12. All commercial fishing for salmon is prohibited as follows:

(*a*) Togiak Bay: All waters north of a line from Right Hand Point to Tongue Point.

(*b*) Nushagak Bay: All waters northward of a line from Bradford Point through the southern end of Williams Island to a point on the opposite shore near the old cannery site of the Alaska Packers Association south of Kanulik village, except that stake nets limited to beach areas between high and low water marks will be permitted north of 59 degrees north latitude to the old prohibitive markers located at Snag Point.

(*c*) Kvichak Bay: All waters above a line extending at right angles across Kvichak Bay from the marker on a high point on the east bank of Prosper Creek, about 700 yards above the Keggiung Cannery of the Alaska Packers Association, to the marker on the opposite side, the course being about north, 44 degrees west, magnetic.

(*d*) Ugashik River and Bay: All waters above a line extending at right angles across said river 500 yards below the mouth of King Salmon River.

Steelhead fishery.—Commercial fishing for steelhead trout shall be subject to the provisions of law and the regulations applicable to commercial fishing for salmon.

III. ALASKA PENINSULA AREA

The Alaska Peninsula area is hereby defined to include all territorial coastal and tributary waters of the Alaska Peninsula from Cape Menshikof on the Bering Sea shore and extending in a southwesterly direction to Unimak Pass, thence in a northeasterly direction along the Pacific side of the Alaska Peninsula to Castle Cape (Tuliumnit Point). The waters of Unimak, the Sanak, the Shumagin, and all other adjacent islands are included.

Salmon fishery.—1. In the waters of Nelson Lagoon, and thence along the coast to Cape Seniavin, including Nelson Lagoon, Herendeen Bay, Port Moller, and the fishing grounds off the Bear, Sandy, and Ocean Rivers, the 36-hour closed period for salmon fishing prescribed by section 5 of the act of June 6, 1924, is hereby extended to include the periods from 6 o'clock antemeridian of Wednesday of each week until 6 o'clock antemeridian of the following Thursday, and from 6 o'clock antemeridian of Friday of each week until 6 o'clock antemeridian of the following Saturday, making a weekly closed period in these waters of 84 hours, which shall be effective throughout the entire salmon fishing season of each year.

2. In all other waters of this area the 36-hour closed period for salmon fishing prescribed by section 5 of the act of June 6, 1924, is hereby extended to include the period from 6 o'clock postmeridian of Wednesday of each week until 6 o'clock postmeridian of the Thursday following, making a weekly closed period of 60 hours: *Provided,* That this extension of 24 hours closed period each week shall not be effective after 6 o'clock antemeridian of July 25 in each year.

3. The total aggregate length of gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 200 fathoms hung measure.

4. The use of floating traps for the capture of salmon is prohibited.

5. The use of any trap for the capture of salmon in the waters between Cape Menshikof and Cape Seniavin is prohibited.

6. With the exception of Unga Island, in the waters of which trap fishing for salmon is permitted, the use of traps for the capture of salmon is prohibited in the waters of the Shumagin Islands, the Sanak Islands, and all other islands lying between or adjacent to these two groups.

7. In all waters along the shores of the Alaska Peninsula west of the longitude of Cape Aliaksin, and in the waters of Unga Island, the distance by most direct water measurement from any part of one trap to any part of another trap, shall not be less than 1 statute mile.

8. The use of any trap for the capture of salmon is prohibited in the waters of False Pass (Isanotski Strait) within lines determined by markers erected for that purpose.

9. The use of purse seines for the capture of salmon is prohibited, except that (*a*) in the waters of the Shumagin Islands seines not to exceed 100 fathoms in length and 150 meshes in depth may be used, and (*b*) purse seines are permitted in waters open to commercial fishing between Lagoon Point and Cape Seniavin.

10. In Port Heiden waters the catch of red salmon shall not exceed 35,000 in any calendar year.

11. Commercial fishing for salmon is prohibited during the remainder of each calendar year after 6 o'clock postmeridian August 20.

12. All commercial fishing for salmon is prohibited in Morzhovoi Bay east of 163 degrees 5 minutes west longitude prior to July 25 in each year.

13. All commercial fishing for salmon is prohibited in Cold Bay within a line extending from the eastern extremity of Thin Point to a point at 55 degrees 2 minutes north latitude and 162 degrees 25 minutes west longitude prior to July 25 in each year.

14. All commercial fishing for salmon is prohibited, as follows:

(*a*) Within 1 statute mile of the mouths of Bear, Sandy, and Ocean Rivers.

(*b*) Thin Point Lagoon: All waters within the lagoon and its stream and within a distance of 500 yards outside the entrance to the lagoon.

(*c*) Stepovak Bay and Balboa Bay: All waters of these bays and of their branches and arms, excepting Orzinski (Orzenoi) Bay, within a line from the outer extremity of Kupreanof Point to the outer extremity of Cape Aliaksin. In Orzinski (Orzenoi) Bay beach seines only may be used, and the catch of red salmon shall not exceed 25,000 in any calendar year.

(*d*) All waters between Kupreanof Point and Cape Ikti.

Steelhead fishery.—Commercial fishing for steelhead trout shall be subject to the provisions of law and the regulations applicable to commercial fishing for salmon.

Herring fishery.—1. Commercial fishing for herring is prohibited in the period from January 1 to May 31, both dates inclusive, and from December 1 to December 31, both dates inclusive, in each calendar year.

2. During the period from June 1 to October 1, both dates inclusive, commercial fishing for herring is prohibited in all waters closed throughout the year to salmon fishing.

3. The closed seasons herein specified for commercial herring fishing shall not apply to the taking of herring for bait purposes in waters otherwise open to fishing.

4. Commercial fishing for herring, except for bait purposes, is prohibited from 6 o'clock postmeridian of Saturday of each week until 6 o'clock antemeridian of the Monday following.

5. Gill nets used in catching herring shall not be of smaller mesh than 3 inches stretched measure.

6. No one shall place, or cause to be placed, across the entrance of any lagoon or bay any net or other device which will prevent the free passage at all times of herring in and out of said lagoon or bay.

Clam fishery.—It is prohibited to take for commercial purposes any razor clam measuring less than 4½ inches in total length of shell. Possession of any razor clam of less than this length will be regarded as prima facie evidence of unlawful taking.

IV. ALEUTIAN ISLANDS AREA

The Aleutian Islands area is hereby defined to include all territorial coastal and tributary waters of the Aleutian Islands westward of and including Unimak Pass.

1. The total aggregate length of gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 200 fathoms hung measure.

2. Commercial fishing for salmon is prohibited during the period from 6 o'clock postmeridian August 20 to 6 o'clock postmeridian October 1 in each year.

3. The use of traps and purse seines for the capture of salmon is prohibited.

Steelhead fishery.—Commercial fishing for steelhead trout shall be subject to the provisions of law and the regulations applicable to commercial fishing for salmon.

V. CHIGNIK AREA

The Chignik area is hereby defined to include the territorial coastal and tributary waters of Alaska along the mainland shore from Castle Cape (Tullumnit Point) to Cape Kumnik.

Salmon fishery.—1. The use of purse seines and floating traps for the capture of salmon is prohibited.

2. The total aggregate length of gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 200 fathoms hung measure.

3. The use of motor-propelled gill-net boats in catching salmon is prohibited.

4. The take of salmon within waters in which the runs are tributary to the Chignik River shall not exceed 50 per cent of the total run as determined at the weir in Chignik River operated by the Bureau of Fisheries.

5. Commercial fishing for salmon is prohibited prior to 6 o'clock antemeridian June 15 and after 6 o'clock postmeridian September 15 in each year.

6. Commercial fishing for salmon is prohibited in the waters surrounding Nakchamik and Chankliut Islands.

7. The distance by most direct water measurement from any part of one trap to any part of another trap shall not be less than 1 statute mile, except in Chignik Lagoon, where there shall be a distance interval of not less than 10 statute miles laterally between any two traps on the north shore or on the south shore of Chignik Lagoon. Chignik Island shall be considered as a part of the south shore of the lagoon.

Steelhead fishery.—Commercial fishing for steelhead trout shall be subject to the provisions of law and the regulations applicable to commercial fishing for salmon.

Clam fishery.—It is prohibited to take for commercial purposes any razor clam measuring less than 4½ inches in total length of shell. Possession of any razor clam of less than this length will be regarded as prima facie evidence of unlawful taking.

VI. KODIAK AREA

The Kodiak area is hereby defined to include the waters of the mainland shore extending from Cape Douglas southwestward to Cape Kumnik and the territorial coastal and tributary waters of Alaska surrounding Kodiak and adjacent islands, but excluding the waters embraced within the Afognak Forest and Fish Culture Reserve established by presidential proclamation of December 24, 1892.

Salmon fishery.—1. The use of purse seines and floating traps for the capture of salmon is prohibited.

2. The total aggregate length of gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 200 fathoms hung measure.

3. Commercial fishing for salmon in Alitak Bay and all its branches within a line from Cape Trinity to Cape Alitak prior to 6 o'clock antemeridian June 15 in each year is prohibited.

4. Commercial fishing for salmon within a line from Cape Trinity to Cape Alitak shall be conducted solely by beach seines and traps, but no fishing for salmon shall be permitted inside a line from Bun Point through Turn Island at the entrance of Moser Bay to Akhiok village.

5. The take of salmon within waters in which the runs are tributary to Olga Bay shall not exceed 50 per cent of the total run as determined at the weirs on tributary waters of Olga Bay operated by the Bureau of Fisheries.

6. Commercial fishing for salmon in Karluk waters, extending from Cape Karluk to Cape Kuliuk, prior to 6 o'clock antemeridian June 5 and after 6 o'clock postmeridian September 15 in each year is prohibited. The take of salmon in these waters shall not exceed 50 per cent of the total run as determined at the weir in Karluk River operated by the Bureau of Fisheries.

7. Commercial fishing for salmon between Cape Karluk and Cape Uyak, except by beach seines, and between Cape Uyak and Uyak Postoffice, except by beach seines and gill nets, is prohibited.

8. Commercial fishing for salmon in East Arm, Uganik Bay, within a line from Mink Point to Rock Point and including the sand spit locally known as "The Packer's Spit," is prohibited prior to 6 o'clock antemeridian July 21 in each calendar year.

9. Commercial fishing for salmon in all waters of Kizhuyak Bay within a line from Kekur Point to Inner Point is prohibited prior to 6 o'clock antemeridian July 21 in each calendar year.

10. Commercial fishing for salmon in all waters of Kiliuda Bay within a line from Right Cape to Left Cape is prohibited prior to 6 o'clock antemeridian July 21 in each calendar year.

11. The distance by most direct water measurement from any part of one trap to any part of another trap, except in those waters of Alitak Bay in which the runs are tributary to streams where counting weirs are maintained, shall not be less than 1 statute mile.

12. The use of traps for the capture of salmon is prohibited in all waters of Kodiak Island and adjacent islands eastward and northward from Gull Point, Ugak Bay, to Inner Point, Kizhuyak Bay.

13. All commercial fishing for salmon is prohibited, as follows:

(*a*) Western shore of Kodiak Island: All waters along the western shore of Kodiak Island between Cape Alitak and Cape Karluk.

(*b*) Karluk River: All waters within Karluk River and within 100 yards of its mouth where it breaks through Karluk Spit into Shelikof Strait.

(*c*) Kafiia Bay, on north shore of Shelikof Strait: All waters within a line from Cape Ugyak to Cape Gull.

(*d*) Eagle Harbor, on northeast side of Ugak Bay, southeastern shore of Kodiak Island: All waters within the harbor.

Steelhead fishery.—Commercial fishing for steelhead trout shall be subject to the provisions of law and the regulations applicable to commercial fishing for salmon.

Herring fishery.—1. Commercial fishing for herring is prohibited during the period from January 1 to July 14, both dates inclusive, and from October 15 to December 31, both dates inclusive, in each calendar year.

2. During the period from July 15 to October 1, both dates inclusive, commercial fishing for herring is prohibited in all waters closed throughout the year to salmon fishing.

3. The closed seasons herein specified for commercial herring fishing shall not apply to the taking of herring for bait purposes in waters otherwise open to fishing.

4. Commercial fishing for herring except for bait purposes is prohibited from 6 o'clock postmeridian of Saturday of each week until 6 o'clock antemeridian of the Monday following.

5. Gill nets used in catching herring shall not be of smaller mesh than 2½ inches stretched measure.

6. No one shall place, or cause to be placed, across the entrance of any lagoon or bay any net or other device which will prevent the free passage at all times of herring in and out of said lagoon or bay.

Clam fishery.—It is prohibited to take for commercial purposes any razor clam measuring less than 4½ inches in total length of shell. Possession of any razor clam of less than this length will be regarded as prima facie evidence of unlawful taking.

VII. COOK INLET AREA

The Cook Inlet area is hereby defined to include Cook Inlet, its tributary waters, and all adjoining waters north of Cape Douglas and west of Point Gore. The Barren Islands are included within this area.

Salmon fishery.—1. Commercial fishing for salmon is prohibited from 6 o'clock postmeridian, August 10, to 6 o'clock antemeridian, August 25, and for the remainder of each year after 6 o'clock postmeridian, September 30.

2. The use of purse seines and floating traps for the capture of salmon is prohibited.

3. The distance by most direct water measurement from any part of one trap to any part of another trap shall not be less than 2,500 feet.

4. Twenty-five feet of the heart walls on each side next to the pot and the bottom strip of wire of the pots of all hand traps shall be removed during the closed season for commercial salmon fishing from 6 o'clock postmeridian, August 10, to 6 o'clock antemeridian, August 25, of each calendar year.

5. The total aggregate length of gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 200 fathoms hung measure.

6. All commercial fishing is prohibited, as follows:

(*a*) Within 2 statute miles of the mouths of Kasilof and Kenai Rivers, and within 1 statute mile of all other salmon streams.

(*b*) Turnagain Arm and Knik Arm: All waters above a line from Point Possession to the western limit of the closed area around the mouth of the Susitna River.

(*c*) Chinik Inlet, Kamishak Bay: All waters within the inlet.

(*d*) Kachemak Bay: All waters above a line from Indian Island to a point on the opposite shore one-half mile below the mouth of Swift Creek.

Steelhead fishery.—Commercial fishing for steelhead trout shall be subject to the provisions of law and the regulations applicable to commercial fishing for salmon.

Herring fishery.—1. Commercial fishing for herring is prohibited during the period from January 1 to July 14, both dates inclusive, in each calendar year. Commercial fishing for herring, except by set and drift gill nets, is also prohibited from October 15 to December 31, both dates inclusive, in each calendar year.

2. Commercial fishing for herring in Halibut Cove, including the waters within a line from the light on Ismailof Island to the outermost point on Glacier Spit, is limited to gill nets.

3. Commercial fishing for herring in Halibut Cove Lagoon is limited to set gill nets not exceeding 50 fathoms in length, hung measure. All such nets shall be anchored in a substantial manner not less than 100 yards apart.

4. Nets operated within areas marked at the north and south ends of Halibut Cove Lagoon shall be anchored at right angles to the line joining the markers. Nets operated between these areas shall be anchored in a general direction paralleling the shore line.

5. The closed seasons herein specified for commercial herring fishing shall not apply to the taking of herring for bait purposes in waters otherwise open to fishing.

6. Commercial fishing for herring, except for bait purposes, is prohibited from 6 o'clock postmeridian of Saturday of each week until 6 o'clock antemeridian of the Monday following.

7. The maintaining of a herring pound or the dumping of offal and dead herring in the waters of Halibut Cove and Lagoon is prohibited.

8. Gill nets used in catching herring shall not be of smaller mesh than 3 inches stretched measure.

9. No one shall place, or cause to be placed, across the entrance of any lagoon or bay any net or other device which will prevent the free passage at all times of herring in and out of said lagoon or bay.

Clam fishery.—It is prohibited to take for commercial purposes any razor clam measuring less than 4½ inches in total length of shell. Possession of any razor clam of less than this length will be regarded as prima facie evidence of unlawful taking.

VIII. RESURRECTION BAY AREA

The Resurrection Bay area is hereby defined to include all territorial coastal and tributary waters of the Gulf of Alaska between Point Gore on the west and Cape Fairfield on the east.

Salmon fishery.—1. The total aggregate length of gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 200 fathoms hung measure.

2. No set or anchored gill net shall exceed 300 yards in length, and each shall be set in substantially a straight line: *Provided*, That not to exceed 20 yards of each net may be used as a hook. Only one such hook is permitted on a net. There shall be a distance interval of at least 200 yards, both endwise and laterally, at all times between all set or anchored gill nets operated.

3. King salmon nets shall have a mesh at least 8½ inches stretched measure between knots, and red salmon nets shall have a mesh at least 5½ inches stretched measure between knots, as measured when actually in use.

4. Prior to 6 o'clock antemeridian June 6 in each year, commercial fishing for salmon with nets of mesh less than 8½ inches stretched measure between knots is prohibited.

5. Commercial fishing for salmon is prohibited during the remainder of each calendar year after 6 o'clock postmeridian September 23.

6. In the waters of Resurrection Bay, within a line from Cape Resurrection to the western side of Bear Glacier at its mouth, the 36-hour closed period for salmon fishing prescribed by section 5 of the act of June 6, 1924, is hereby extended to include the period from 6 o'clock postmeridian of Friday of each week until 6 o'clock antemeridian of the Monday following, making a weekly closed period of 60 hours: *Provided*, That this extension shall not be effective after August 23 in each year.

7. Commercial fishing for salmon within 1,700 yards of the mouths of Bear Creek and Resurrection River is prohibited.

Steelhead fishery.—Commercial fishing for steelhead trout shall be subject to the provisions of law and the regulations applicable to commercial fishing for salmon.

Clam fishery.—It is prohibited to take for commercial purposes any razor clam measuring less than 4½ inches in total length of shell. Possession of any razor clam of less than this length will be regarded as prima facie evidence of unlawful taking.

IX. PRINCE WILLIAM SOUND AREA

The Prince William Sound area is hereby defined to include all territorial coastal and tributary waters of the Gulf of Alaska between Cape Fairfield on the west and Point Whitshed on the east.

Salmon fishery.—1. The total aggregate length of gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 200 fathoms hung measure.

2. No salmon fishing boat shall carry or operate more than one seine of any description, and no additional net of any kind shall be carried on such boat. No purse seine shall be less than 125 meshes nor more than 200 meshes in depth, nor less than 90 fathoms nor more than 150 fathoms in length measured on the cork line. For the purpose of determining depths of seines, measurements will be upon the basis of 3½ inches stretched measure between knots. No extension to any seine in the way of leads will be permitted.

3. No set or anchored gill net shall exceed 300 yards in length and each shall be set in substantially a straight line: *Provided*, That not to exceed 20 yards of each net may be used as a hook. Only one such hook is permitted on a net. There shall be a distance interval of at least 200 yards both endwise and laterally at all times between all set or anchored gill nets operated.

4. The use of traps and beach seines for the capture of salmon is prohibited in the waters along the western coast, from the outer point on the north shore of Granite Bay (known as Granite Bay Point) to the light on the south shore of the entrance to Port Nellie Juan.

5. The 36-hour closed period for salmon fishing prescribed by section 5 of the act of June 6, 1924, is hereby extended to include the period from 6 o'clock antemeridian of Saturday of each week until 6 o'clock antemeridian of the Monday following, making a weekly closed period of 48 hours: *Provided*, That this extension shall not be effective after 6 o'clock antemeridian August 23 in each year.

6. Commercial fishing for salmon is prohibited prior to 6 o'clock antemeridian June 6 and after 6 o'clock antemeridian September 21 in each year.

7. Commercial fishing for salmon is prohibited in the period from 6 o'clock antemeridian August 5 to 6 o'clock antemeridian August 23, in each year, except in the waters along the western coast, from the outer point on the north shore of Granite Bay (known as Granite Bay Point) to the light on the south shore of the entrance to Port Nellie Juan.

8. The distance by most direct water measurement from any part of one trap to any part of another trap shall not be less than 1½ statute miles.

9. Commercial fishing for salmon in the waters of Port Fidalgo east of 146 degrees 20 minutes west longitude is prohibited after 6 o'clock antemeridian July 11 in each year.

10. All commercial fishing for salmon is prohibited, as follows:

(*a*) Constantine Harbor: All waters above a line at right angles across the harbor at prominent shore-line points about 1¼ statute miles from the mouth of the large salmon stream flowing into the northeast arm of the harbor.

(*b*) Port Etches: All waters within 1 statute mile of the mouth of the salmon stream flowing into the head of Port Etches.

(*c*) Boswell Bay, indenting Hinchinbrook Island: All waters in the bay west of 146 degrees 8 minutes west longitude.

(*d*) Twin Lake Creek: All waters within 1,000 yards of the mouth of Twin Lake Creek flowing into the southeast arm of Simpson Bay.

(*e*) Robe River, Lowe River, and other unnamed streams flowing into Port Valdez in the immediate vicinity of Valdez: All waters within 1,000 yards of the mouths.

(*f*) Billys Hole, tributary to Long Bay, between Valdez Arm and Unakwik Inlet: All waters within a line from Point Scott to Point Hook and passing just westward of Observation Island.

(*g*) Unakwik Inlet, indenting mainland on north shore of Prince William Sound: All waters north of an east and west line passing through the northern side of the entrance to Jonah Bay.

(*h*) Coghill River, tributary to College Fiord: All waters within 2,000 yards outside of the mouth of the river.

(*i*) Long Bay, tributary to Culross Passage: All waters within the bay.

(*j*) Gumboot Creek, on northwest shore of Eshamy Bay: All waters within 1,000 yards of the mouth of the creek.

(*k*) Eshamy Lagoon and its tributary waters: All waters within the lagoon and its tributaries and within 100 yards outside the narrows at the entrance to the lagoon.

(*l*) Jackpot Bay: All waters within a line extending at right angles across its mouth 2,000 yards below the mouth of the red salmon stream emptying into the bay.

(*m*) Port Bainbridge: All waters in the middle north arm of Port Bainbridge.

(*n*) Bay of Isles, indenting east shore of Knight Island: All waters within the west arm of the bay.

Steelhead fishery.—Commercial fishing for steelhead trout shall be subject to the provisions of law and the regulations applicable to commercial fishing for salmon.

Herring fishery.—1. Commercial fishing for herring is prohibited during the period from January 1 to June 9, both dates inclusive, and from November 1 to December 31, both dates inclusive, of each calendar year.

2. The closed seasons herein specified for commercial herring fishing shall not apply to the taking of herring for bait purposes in waters otherwise open to fishing.

3. Commercial fishing for herring, except for bait purposes, is prohibited from 6 o'clock postmeridian of Saturday of each week until 6 o'clock antemeridian of the Monday following.

4. During the period from June 25 to October 1, both dates inclusive, commercial fishing for herring is prohibited in all waters closed throughout the year to salmon fishing.

5. Gill nets used in catching herring shall not be of smaller mesh than 2¼ inches stretched measure.

6. No one shall place, or cause to be placed, across the entrance of any lagoon or bay any net or other device which will prevent the free passage at all times of herring in and out of said lagoon or bay.

Clam fishery.—1. It is prohibited to take for commercial purposes any razor clam measuring less than 4½ inches in total length of shell. Possession of any razor clam of less than this length will be regarded as prima facie evidence of unlawful taking.

2. The taking of clams for commercial purposes is prohibited from 6 o'clock postmeridian July 15 to 6 o'clock postmeridian August 31 in each calendar year.

Crab fishery.—Dungeness crab (*Cancer magister*). No female of this species shall be taken at any time, and no male of this species measuring less than 6½ inches in greatest width shall be taken for commercial purposes.

X. COPPER RIVER AREA

The Copper River area is hereby defined to include all territorial coastal and tributary waters of Alaska between Point Whitshed on the west and Point Martin on the east, including Egg Islands and the other islands between these points.

Salmon fishery.—1. Commercial fishing for salmon is prohibited from 6 o'clock postmeridian July 10 to 6 o'clock antemeridian August 10 in each year.

2. Prior to 6 o'clock antemeridian May 20 in each year commercial fishing with nets of mesh less than 8½ inches stretched measure between knots is prohibited.

3. From May 20 to July 10, both dates inclusive, the 36-hour closed period for salmon fishing prescribed by section 5 of the act of June 6, 1924, is hereby extended to include the period from 6 o'clock antemeridian of Saturday of each week until 6 o'clock antemeridian of the Monday following, making a weekly closed period of 48 hours.

4. Except as specifically permitted herein, commercial fishing for salmon shall be conducted solely by drift gill nets.

5. Prior to 6 o'clock antemeridian August 10 in each calendar year the total aggregate length of drift gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 250 fathoms hung measure: *Provided*, That during the per.od from 6 o'clock antemeridian May 20 to 6 o'clock postmeridian May 31 any gill net boat on the Copper River flats may carry and operate not to exceed 100 fathoms of net of mesh not less than 8½ inches stretched measure between knots in addition to 250 fathoms of smaller mesh net.

6. Prior to 6 o'clock antemeridian August 10 in each calendar year commercial fishing for salmon by means of gill nets attached to anchored boats or other anchored floating equipment is prohibited.

7. Commercial fishing for salmon is prohibited within 500 yards of the Grass Banks, except that after 6 o'clock antemeridian August 10 in each calendar year such fishing is permitted within 500 yards of the Grass Banks by means of gill nets and stake nets not exceeding 350 fathoms each in length: *Provided*, That all stakes used in connection therewith shall be removed at or before the end of the fishing season. All fishing is prohibited at all times within the sloughs and within 500 yards of their mouths.

Steelhead fishery.—Commercial fishing for steelhead trout shall be subject to the provisions of law and the regulations applicable to commercial fish.ng for salmon.

Clam fishery.—1. It is prohibited to take for commercial purposes any razor clam measuring less than 4½ inches in total length of shell. Possession of any razor clam of less than this length will be regarded as prima facie evidence of unlawful taking.

2. The taking of clams for commercial purposes is prohibited from 6 o'clock postmeridian July 15 to 6 o'clock postmeridian August 31 in each calendar year.

Crab fishery.—Dungeness crab (*Cancer magister*). No female of this species shall be taken at any time, and no male of this species measuring less than 6½ inches in greatest width shall be taken for commercial purposes.

XI. BERING RIVER AREA

The Bering River area is hereby defined to include all territorial coastal and tributary waters of Alaska between Point Martin on the west and Cape Suckling on the east.

Salmon fishery.—1. Commercial fishing for salmon is prohibited from 6 o'clock postmeridian July 10 to 6 o'clock antemeridian August 10 in each year.

2. Prior to 6 o'clock antemeridian June 1 in each year commercial fishing with nets of mesh less than 8½ inches stretched measure between knots is prohibited.

3. From June 1 to July 10, both dates inclusive, the 36-hour closed period for salmon fishing prescribed by section 5 of the act of June 6, 1924, is hereby extended to include the period from 6 o'clock antemeridian of Saturday of each week until 6 o'clock antemeridian of the Monday following, making a weekly closed period of 48 hours.

4. Except as specifically permitted herein, commercial fishing for salmon shall be conducted solely by drift gill nets.

5. Prior to 6 o'clock antemeridian August 10 in each calendar year the total aggregate length of drift gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 250 fathoms hung measure.

6. Prior to 6 o'clock antemeridian August 10 in each calendar year commercial fishing for salmon by means of gill nets attached to anchored boats or other anchored floating equipment is prohibited.

7. After 6 o'clock antemeridian August 10 in each calendar year commercial fishing for salmon is permitted by means of gill nets and stake nets not exceeding 350 fathoms each in length: *Provided*, That all stakes used in connection therewith shall be removed at or before the end of the fishing season.

Steelhead fishery.—Commercial fishing for steelhead trout shall be subject to the provisions of law and the regulations applicable to commercial fishing for salmon.

Clam fishery.—It is prohibited to take for commercial purposes any razor clam measuring less than 4½ inches in total length of shell. Possession of any razor clam of less than this length will be regarded as prima facie evidence of unlawful taking.

XII. SOUTHEASTERN ALASKA AREA

The Southeastern Alaska area is hereby defined to include all territorial coastal and tributary waters of Alaska extending from Dixon Entrance on the south to and including Yakutat Bay on the north.

Salmon fishery.—This area is subdivided into the following districts, wherein regulations shall be effective as follows:

Yakutat district.—All waters of this area west of the one hundred and thirty-eighth meridian of west longitude.

1. The total aggregate length of gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 250 fathoms hung measure.

2. The distance by most direct water measurement from any part of one trap to any part of another trap shall not be less than 1½ statute miles.

3. No salmon fishing boat shall carry or operate more than one seine of any description, and no additional net of any kind shall be carried on such boat. No purse seine shall be less than 200 meshes nor more than 300 meshes in depth, nor less than 150 fathoms nor more than 250 fathoms in length measured on the cork line. For the purpose of determining depths of seines measurements will be upon the basis of 3½ inches stretched measure between knots. No extension to any seine in the way of leads will be permitted.

4. The 36-hour closed period for salmon fishing prescribed by section 5 of the act of June 6, 1924, is hereby extended to include the period from 6 o'clock postmeridian of Friday of each week until 6 o'clock antemeridian of the Monday following, making a weekly closed period of 60 hours.

5. Commerical fishing for salmon in Dry Bay is prohibited prior to June 1 in each year.

6. All commercial fishing for salmon is prohibited, as follows:

(*a*) Ankau Creek and Inlet.

(*b*) Akwe or Ahquay River.

(*c*) The "Basin" above Dry Bay.

Icy Strait-Cross Sound district.—All waters of this area north of the fifty-eighth parallel of north latitude and east of the one hundred and thirty-eighth meridian of west longitude.

1. The total aggregate length of gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 250 fathoms hung measure.

2. The distance by most direct water measurement from any part of one trap to any part of another trap shall not be less than 1½ statute miles.

3. Traps and purse seines are prohibited in Lynn Canal and contiguous waters north of 58 degrees 26 minutes north latitude.

4. No salmon fishing boat shall carry or operate more than one seine of any description, and no additional net of any kind shall be carried on such boat. No purse seine shall be less than 200 meshes nor more than 300 meshes in depth, nor less than 150 fathoms nor more than 250 fathoms in length measured on the cork line. For the purpose of determining depths of seines measurements will be upon the basis of 3½ inches stretched measure between knots. No extension to any seine in the way of leads will be permitted.

5. Commercial fishing for salmon, except by trolling, is prohibited for the remainder of each calendar year after 6 o'clock postmeridian August 6: *Provided*, That such fishing may be carried on by gill nets from 6 o'clock antemeridian September 5 to 6 o'clock postmeridian October 15 in waters open to fishing.

6. Commercial fishing for salmon in Lynn Canal and contiguous waters north of the south end of Kochu Island is prohibited, except that in these

closed waters, including Chilkat Inlet outside of a line from Green Point passing across the southern shore of Pyramid Island and Chilkoot Inlet 1,000 yards outside the mouth of Chilkoot River, such fishing is permitted by gill nets from 6 o'clock antemeridan September 5 to 6 o'clock postmeridian October 15 in each year.

7. Commercial fishing for salmon, except by gill nets, is prohibited in Dundas Bay north of 58 degrees 21 minutes north latitude.

8. Commercial fishing for salmon is prohibited in Port Frederick, northern shore of Chichagof Island, south of an east and west line through Inner Point Sophia: *Provided,* That trolling will be permitted in these waters from November 1 to June 1, both dates inclusive. A portion of the waters closed is in the central district.

9. All commercial fishing for salmon is prohibited, as follows:

(*a*) Glacier Bay: All waters within a line from Point Carolus to Point Gustavus.

(*b*) Taku Inlet: All waters to the eastward of a line beginning on the shore northward of Taku Point at 133 degrees 59 minutes west longitude, thence running due north to the opposite shore, thence following the shore line to the mouth of the Taku River.

Central district.—All waters of this area between the fifty-seventh and fifty-eighth parallels of north latitude.

1. The total aggregate length of gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 250 fathoms hung measure.

2. The distance by most direct water measurement from any part of one trap to any part of another trap shall not be less than 1 statute mile.

3. No salmon fishing boat shall carry or operate more than one seine of any description, and no additional net of any kind shall be carried on such boat. No purse seine shall be less than 200 meshes nor more than 300 meshes in depth, nor less than 150 fathoms nor more than 250 fathoms in length measured on the cork line. For the purpose of determining depths of seines measurements will be upon the basis of 3½ inches stretched measure between knots. No extension to any seine in the way of leads will be permitted.

4. Commercial fishing for salmon, except by trolling, is prohibited for the remainder of each year after 6 o'clock postmeridian August 11.

5. All commercial fishing for salmon is prohibited, as follows:

(*a*) Port Houghton, indenting mainland: All waters in Sanborn Canal.

(*b*) Portage Bay, north end of Kupreanof Island: All waters within the bay and all waters within 1 statute mile outside the entrance to the bay. A portion of the waters closed is in the southern district.

(*c*) Gambier Bay, east coast of Admiralty Island: All waters west of 134 degrees west longitude.

(*d*) Wilson Cove, southwestern shore of Admiralty Island: All waters within the cove.

(*e*) Whitewater Bay, southwestern shore of Admiralty Island: All waters within a line from Point Caution to Woody Point.

(*f*) Chaik Bay, southwestern shore of Admiralty Island: All waters east of 134 degrees 29 minutes west longitude.

(*g*) Warm Spring Bay, eastern shore of Baranof Island: All waters within the bay.

(*h*) Kelp Bay, east coast of Baranof Island: All waters in Middle Arm, and all waters in South Arm west of 134 degrees 57 minutes west longitude

(*i*) Hanus Bay, northeast shore of Baranof Island: All waters in the bay south of a line from Point Hanus to Point Moses.

(*j*) Sitkoh Bay, southeast shore of Chichagof Island: All waters within 1,000 yards of the mouths of all salmon streams.

(*k*) Basket Bay, east coast of Chichagof Island: All waters within the bay.

(*l*) Tenakee Inlet and Freshwater Bay: All waters within a line from North Passage Point to South Passage Point.

(*m*) Salt Lake Lagoon, Takanis Bay, southwest shore of Yakobi Island: All waters in the lagoon and within 500 yards of its mouth.

Stikine River district.—All waters within a line from Babbler Point on the mainland to Woronkofski Point on Woronkofski Island, thence to Middle Craig Point on Zarembo Island, thence to Point Howe on Mitkof Island, thence to Frederick Point on Mitkof Island, thence across Frederick Sound to Horn Cliffs on the mainland, thence along the mainland to Babbler Point.

1. Commercial fishing for salmon shall be conducted solely by trolling and by drift gill nets which shall not exceed 250 fathoms in length each.

2. Commercial fishing for salmon, except by trolling, is prohibited during the period from 6 o'clock postmeridian June 10 to 6 o'clock postmeridian June 30 in each year.

3. The 36-hour closed period for salmon fishing prescribed by section 5 of the act approved June 6, 1924, is hereby extended to include the period from 6 o'clock antemeridian of Saturday of each week to 6 o'clock antemeridian of the Monday following, making a weekly closed period of 48 hours.

Prince of Wales Island district.—All waters of the west coast of Prince of Wales Island and adjacent islands from Cape Chacon northward to Point Baker, and within a line from Point Baker to Point Colpoys, thence to Middle Craig Point on Zarembo Island, thence to Woronkofski Point on Woronkofski Island, thence to Babbler Point on the mainland, thence to Watkins Point on Cleveland Peninsula, thence following the watershed between Ernest Sound and Behm Canal to and including Lemesurier Point, thence to Tolstoi Point on Prince of Wales Island, thence following the watershed on Prince of Wales Island to Cape Chacon.

1. The total aggregate length of gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 250 fathoms hung measure.

2. The distance by most direct water measurement from any part of one trap to any part of another trap shall not be less than 1 statute mile.

3. Traps are prohibited in Tuxekan Passage between 55 degrees 46 minutes north latitude and 55 degrees 52 minutes north latitude, and in all waters within one-half statute mile of the southern point of Tuxekan Island.

4. No salmon fishing boat shall carry or operate more than one seine of any description, and no additional net of any kind shall be carried on such boat. No purse seine shall be less than 200 meshes nor more than 300 meshes in depth, nor less than 150 fathoms nor more than 250 fathoms in length, measured on the cork line. For the purpose of determining depths of seines measurements will be upon the basis of 3½ inches stretched measure between knots. No extension to any seine in the way of leads will be permitted.

5. Commercial fishing for salmon, except by trolling, is prohibited from 6 o'clock postmeridian August 22 to 6 o'clock postmeridian September 14 in each year, and for the remainder of each year after 6 o'clock postmeridian October 15; and in addition commercial fishing for salmon, except by trolling, is prohibited in all waters of the west coast of Prince of Wales Island and adjacent islands from Cape Chacon northward to Point Baker, thence eastward to Point Colpoys from January 1 to 6 o'clock postmeridian July 14 in each year.

6. All commercial fishing for salmon is prohibited, as follows:

(*a*) Thorne and Tolstoi Bays, indenting the eastern shore of Prince of Wales Island: All waters within a line from Tolstoi Point to Thorne Head.

(*b*) McHenry Inlet, southwest coast of Etolin Island: All waters within 1,000 yards of the salmon streams emptying into the head of McHenry Inlet.

(*c*) Rocky Bay, west coast of Etolin Island: All waters within 1 statute mile of the head of the bay.

(*d*) Thoms Place, indenting the southwestern shore of Wrangell Island, Zimovia Strait.

(*e*) Olive Cove, indenting the northeastern shore of Etolin Island.

(*f*) Anita Bay, opening into Zimovia Strait, Etolin Island.

(*g*) Barnes Lake, at head of Lake Bay, northeast coast of Prince of Wales Island: All waters in Barnes Lake and within 50 yards outside its entrance.

(*h*) Whale Passage, northeast coast of Prince of Wales Island: All waters within 1,000 yards from mouths of all salmon streams.

(*i*) Salmon Bay, northeast coast of Prince of Wales Island: All waters within the bay and all waters within 1 statute mile of the mouth of the bay.

(*j*) Red Bay, north shore of Prince of Wales Island: All waters south of a true east and west line passing through the north shore of Dead Island.

(*k*) Hole in the Wall, west coast of Prince of Wales Island: All waters within the outermost points of the cove.

(*l*) Shipley Bay, west coast of Kosciusko Island: All waters east of 133 degrees 32 minutes 30 seconds west longitude.

(*m*) Sarkar Cove, west coast of Prince of Wales Island, tributary to El Capitan Passage: All waters inside of a line across the entrance.

(*n*) Naukati Bay, west coast of Prince of Wales Island: All waters within the bay.

(*o*) Stancy Creek, west coast of Prince of Wales Island: All waters within 1 statute mile of the mouth of the creek.

(*p*) Trocadero Bay, west coast of Prince of Wales Island: All waters in the bay east of a true north and south line passing through the eastern extremity of the peninsula just south of Copper Mine.

(*q*) North Bay, northeast coast of Dall Island: All waters within 1,000 yards of the mouths of all salmon streams.

(*r*) Kasook Inlet, southern coast of Sukkwan Island: All waters within 1 statute mile of head of inlet.

(*s*) Hetta Inlet, west coast of Prince of Wales Island: All waters north of a line running east, magnetic, from Eek Point to the opposite shore.

(*t*) Nutkwa Lagoon, west coast of Prince of Wales Island: All waters within the lagoon and within 500 yards of the foot of the rapids at the outlet of the lagoon at mean low water.

Southern district.—All waters south of the fifty-seventh parallel of north latitude, exclusive of the Stikine River and Prince of Wales Island districts herein described.

1. The total aggregate length of gill nets on any salmon fishing boat, or in use by such boat, shall not exceed 250 fathoms, hung measure.

2. The distance by most direct water measurement from any part of one trap to any part of another trap shall not be less than 1 statute mile.

3. No salmon fishing boat shall carry or operate more than one seine of any description, and no additional net of any kind shall be carried on such boat. No purse seine shall be less than 200 meshes nor more than 300 meshes in depth, nor less than 150 fathoms nor more than 250 fathoms in length, measured on the cork line. For the purpose of determining depths of seines, measurements will be upon the basis of 3½ inches, stretched measure, between knots. No extension to any seine in the way of leads will be permitted.

4. Commercial fishing for salmon, except by trolling, is prohibited from 6 o'clock postmeridian August 18 to 6 o'clock postmeridian September 14 in each year, and for the remainder of each calendar year after 6 o'clock postmeridian October 15.

5. All commercial fishing for salmon is prohibited, as follows:

(*a*) Hidden Inlet, indenting mainland: All waters in the inlet north of 55 degrees north latitude.

(*b*) Fillmore Inlet, indenting mainland: All waters east of 130 degrees 30 minutes west longitude.

(*c*) Ray Anchorage, east coast of Duke Island: All waters in Ray Anchorage.

(*d*) Very Inlet, indenting mainland: All waters within the inlet.

(*e*) Boca de Quadra, indenting mainland: All waters within 1 statute mile of the mouth of Sockeye Creek.

(*f*) George Inlet, southern coast of Revillagigedo Island: All waters north of a line from Bat Point to Tsa Cove.

(*g*) Smeaton Bay, indenting mainland: All waters in Wilson and Bakewell Arms east of 130 degrees 40 minutes west longitude.

(*h*) Rudyerd Bay, indenting mainland: All waters in the north arm within 2 statute miles of the mouths of all salmon streams.

(*i*) Walker Cove, indenting mainland, tributary to Behm Canal: All waters within a line from Ledge Point to Hut Point.

(*j*) Chickamin River: All waters within a line from Fish Point to Trap Point.

(*k*) Yes Bay, Cleveland Peninsula: All waters within the bay and all waters outside the entrance within 1,000 yards of a line from Bluff Point to Syble Point.

(*l*) Shrimp Bay, west coast of Revillagigedo Island: All waters east of a line running south from Dress Point to the opposite shore.

(*m*) Traitors Cove, west coast of Revillagigedo Island: All waters of the cove within a line 50 yards outside the neck of the salt-water lagoon.

(*n*) Naha and Moser Bays, west shore of Revillagigedo Island: The waters of Long Arm and Moser Bay inside of a line from Cod Point to the opposite shore at 131 degrees 40 minutes west longitude and the waters of Naha Bay inside of a line extending due north from Cod Point.

(*o*) Moira Sound, east coast of Prince of Wales Island: All waters in South Arm, Frederick Cove, Kegan Cove, and within 1,000 yards of the mouths of all salmon streams in Johnson Cove.

(*p*) Cholmondeley Sound, east coast of Prince of Wales Island: All waters in Dora Bay and Sunny Cove.

(*q*) Skowl Arm, Prince of Wales Island: All waters within a line from Old Kasaan village to Khayyam Point.

(*r*) Kasaan Bay, east coast of Prince of Wales Island: All waters north of a line from Sandy Point to the east shore of the bay.

(*s*) Bradfield Canal: All waters of Bradfield Canal between a line from Point Warde to the point at the east side of the entrance to Fools Inlet and a north and south line at 131 degrees 47 minutes west longitude.

(*t*) Blake Channel: All waters of Blake Channel south of 56 degrees 14 minutes 30 seconds north latitude.

(*u*) Wrangell Narrows: All waters between Point Alexander and Prolewy Point.

(*v*) Barrie Creek, north of Point Barrie, southwest shore of Kupreanof Island: All waters within 1 statute mile of the mouth of the creek.

(*w*) Hamilton Bay, west coast of Kupreanof Island: All waters east of 133 degrees 49 minutes west longitude.

(*x*) Three Mile Arm, east coast of Kuiu Island: All waters within 1,000 yards of the mouths of all salmon streams.

(*y*) Seclusion Harbor, east coast of Kuiu Island: All waters within the outermost points of the harbor.

(*z*) Port Beauclerc, southeastern coast of Kuiu Island: All waters within 1,000 yards of the mouths of all salmon streams tributary to Port Beauclerc.

(*aa*) Affleck Canal, southeastern coast of Kuiu Island: All waters within 1,000 yards of the mouths of all salmon streams tributary to Affleck Canal.

(*bb*) Tebenkof Bay, west coast of Kuiu Island: All waters in north arm of bay.

(*cc*) Bay of Pillars, west coast of Kuiu Island: All waters in south arm of bay.

(*dd*) Security Bay, northwest shore of Kuiu Island: All waters within 1,000 yards of all salmon streams.

(*ee*) Saginaw Bay, northwest coast of Kuiu Island: All waters of the bay inside of a line beginning at the point of land at the northwest side of the entrance to Halleck Harbor and passing in a southwesterly direction at right angles to the general trend of the bay to the opposite shore.

(*ff*) Red Bluff Bay, east coast of Baranof Island: All waters in the bay; the waters of Falls Creek Bay are included.

(*gg*) Gut Bay, east coast of Baranof Island: All waters of the bay.

(*hh*) Redfish Bay, southwest shore of Baranof Island: All waters above a true east and west line passing through the southern end of the Second Narrows.

(*ii*) Still Harbor, west coast of Baranof Island: All waters in the harbor.

(*jj*) Port Banks, off Whale Bay, west coast of Baranof Island: All waters in Port Banks.

(*kk*) Redoubt Bay, west coast of Baranof Island: All waters within 1,000 yards of the mouth of the stream flowing from Redoubt Lake.

Steelhead fishery.—Commercial fishing for steelhead trout shall be subject to the provisions of law and the regulations applicable to commercial fishing for salmon.

Herring fishery.—1. During the period from June 1 to October 15, both dates inclusive, commercial fishing for herring is prohibited in all waters closed throughout the year to salmon fishing.

2. Commercial fishing for herring is prohibited during the period from January 1 to May 31, both dates inclusive, and from October 1 to December 31, both dates inclusive, in each calendar year.

3. The closed seasons herein specified for commercial herring fishing shall not apply to the taking of herring for bait purposes in waters otherwise open to fishing.

4. Commercial fishing for herring, except for bait purposes, is prohibited from 6 o'clock postmeridian of Saturday of each week until 6 o'clock antemeridian of the Monday following.

5. No one shall place, or cause to be placed, across the entrance to any lagoon or bay any net or other device which will prevent the free passage at all times of herring in and out of said lagoon or bay.

6. All commercial fishing, including bait fishing, for herring is prohibited throughout the year in the waters of Kanalku Bay, Admiralty Island.

Clam fishery.—It is prohibited to take for commercial purposes any razor clam measuring less than 4½ inches in total length of shell. Possession of any razor clam of less than this length will be regarded as prima facie evidence of unlawful taking.

Shrimp fishery.—Commercial fishing for shrimps is prohibited in the period from March 15 to April 30, both dates inclusive, in each year.

Crab fishery.—Dungeness crab (*Cancer magister*). No female of this species shall be taken at any time, and no male of this species measuring less than 6½ inches in greatest width shall be taken for commercial purposes.

GENERAL REGULATIONS

By virtue of the authority conferred by the acts approved June 6, 1924, and June 26, 1906, the following regulations shall be effective in all waters of Alaska, including the special areas already described above:

1. During closed periods all salmon traps within the areas affected shall be closed in accordance with the method prescribed by section 5 of the act of June 6, 1924, and in addition the spillers of all driven traps shall be raised to within 4 feet of the capping and the spillers of floating traps shall be raised to within 4 feet of the surface within 36 hours after the beginning of any seasonal closed period. Within 36 hours after the beginning of any seasonal closed period the tunnels from pots to spillers of all traps shall be entirely disconnected. In respect to traps not provided with spillers, the requirements in regard to spillers shall apply to the pots.

2. All persons engaged in fishery operations are warned to give due regard to all markers erected by the Department of Commerce.

3. In waters where a rack or weir is maintained by the Bureau of Fisheries for the purpose of counting salmon ascending to the spawning grounds, records of the catch of salmon shall be furnished daily by all operators to the local representative of the Bureau of Fisheries in charge, and upon notification by the Commissioner of Fisheries or his authorized representative that an excessive proportion of the run is being taken so that the escapement of any species is less than the 50 per cent specified by section 2 of the act of June 6, 1924, all commercial fishing operations shall at once be discontinued and shall not be resumed until permission therefor is granted by the Commissioner of Fisheries or his duly authorized representative. And if in any year it shall appear that the run of salmon in such waters has diminished, there shall be required a correspondingly increased escapement, and upon notification by the Commissioner of Fisheries or his authorized representative all commercial fishery operations shall cease and shall not be resumed until such increased escapement has been secured.

4. The driving of salmon downstream and the causing of salmon to go outside the protected area at the mouth of any salmon stream are expressly prohibited.

5. During the inspection of the salmon fisheries by the agents and representatives of this department, they shall have at all times free and unobstructed access to all canneries, salteries, and other fishing establishments and to all hatcheries.

6. All persons, companies, or corporations owning, operating, or using any stake net, set net, trap net, pound net, or fish wheel for taking salmon or other fishes shall cause to be placed in a conspicuous place on said trap net, pound net, stake net, set net, or fish wheel the name of the person, company, or corporation owning, operating, or using same, together with a distinctive number, letter, or name, which shall identify each particular stake net, set net, trap net, pound net, or fish wheel, said lettering and numbering to consist of black figures and letters, not less than 6 inches in length, painted on white ground.

7. If in the process of curing salmon bellies the remaining edible portion of the fish is not used, such action will be regarded as wanton waste within the meaning of section 8 of the act of June 26, 1906, and those who engage in this practice will be reported for prosecution as provided for in the act.

8. These regulations do not apply to the Afognak Reservation, fishing within which is prohibited, except by resident natives, by the terms of the law and Executive order creating it.

9. The taking of salmon for fox feed shall be considered as commercial fishing and subject to all of the limitations in respect thereto.

10. Any increase in the amount of fishing gear employed or any expansion of fishery operations in any district in any season shall, in the discretion of the Secretary of Commerce, result in the immediate imposition of such additional restrictions as may appear necessary.

11. These regulations shall be subject to such change or revision by the Secretary of Commerce as may appear advisable from time to time. They shall be in full force and effect immediately from and after January 1, 1927.

ALASKA FISHERY OPERATIONS IN AREAS LEASED FOR FUR FARMING

The act approved July 3, 1926, conveys authority to the Secretary of the Interior to lease, under certain conditions, public lands in Alaska for fur farming and for other purposes. The act contains items of application and interest in connection with fur-seal and fishery matters, as follows:

* * * this Act shall not be held nor construed to apply to the Pribilof Islands, declared a special reservation by the Act of Congress approved April 21, 1910: *And provided further,* That any permit or lease issued under this Act shall reserve to the Secretary of the Interior the right to permit the use and occupation of parts of said leased areas for the taking, preparing, manufacturing, or storing of fish or fish products, or the utilization of the lands for purposes of trade or business, to the extent and in the manner provided by existing laws or laws which may be hereafter enacted.

The foregoing exempts the Pribilof Islands from the provisions of the act. The law, however, has bearing in respect to fishery operations on shore within the leased areas. Permits are necessary from the Secretary of the Interior to use any such leased areas in connection with the fishery industry. In addition, permits will be necessary from the Secretary of the Interior in the case of fish traps extending from the shore lines of such leased areas. As bearing upon this matter, the position has been taken that leases by the Department of the Interior for fur farming will not prevent the driving or extension of fish traps from the shore lines of such leased areas, provided they are proper under the fishery laws and regulations, but permission to place and operate such traps must be secured from the Secretary of the Interior.

AFOGNAK RESERVE

Salmon-fishing permits for Afognak waters were granted to 76 natives and residents of Afognak Island and certain adjacent islands during the season of 1926. Operations were carried on at eight localities and were under the supervision of a fisheries warden. All fishing was by means of beach seines with the exception of one gill net, which was operated for a short time at Malina Bay. Fishing began June 15 except at Little Afognak and Paramanof Bay, where it was not permitted until June 22. No fishing for red salmon was permitted at Litnik Bay. The total commercial catch was 297,738 salmon, an increase of 103,371 over the catch in 1925. The catch of cohos increased 1,078, humpbacks 62,498, and reds 41,063, while the catch of chums decreased 1,255 and kings 13. The entire catch of salmon was sold to the Kadiak Fisheries Co., Katmai Packing Co., and Kodiak Island Fishing & Packing Co. Prior to the opening of the fishing season all streams were marked 500 yards off their mouths and no fishing was permitted above the markers.

A weir for fish-cultural purposes was maintained at Litnik River below the Afognak hatchery. Counting of ascending red salmon began June 1 and was discontinued August 28, when it was decided to close the weir in order to prevent the ascent of cohos to the lake.

The total number of red salmon counted through the weir was 22,250, with a small number still below the weir when counting was discontinued.

ANNETTE ISLAND FISHERY RESERVE

The Annette Island Packing Co. again operated in the Annette Island Fishery Reserve in 1926 under its lease from the Department of the Interior. Data regarding fishery 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 there.

In 1926 the total number of fish taken from traps within the reserve was 928,308 of all species, on which royalties amounting to $10,050.65 were paid. The case tax on canned salmon under the Territorial law, which is payable to the Metlakatla Indians, amounted to $2,852.51; trap fees on eight traps, at $200 each, amounted to $1,600; and rental of cannery buildings was $3,000. In addition, $40,055.51 was paid to 174 natives for labor, $3,850.90 for lumber and piling, and $12,056.08 for fish taken by seines, making a grand total of $73,465.65 disbursed by the Annette Island Packing Co. to the natives for 1926 operations. The corresponding disbursements during the preceding year were $61,348.22.

ALASKA FISHERY INTELLIGENCE SERVICE

As has been the practice for several years, the bureau continued to report by telegraph to the important points in southeastern and central Alaska the prices of fresh fish (chiefly halibut) at Ketchikan. During the closed season on halibut the service was discontinued, as the quantities of other fresh fish sold are negligible during that period.

STREAM MARKING

The chief feature of the marking of streams each season to show waters not open to fishing consists of the replacement of markers that have disappeared or become defaced. In the course of this work additional streams also are measured and marked, and in the near future all of the districts will have been covered. As changes are made in a few instances in the limits of areas closed by regulations, the markers are changed accordingly. It is a large undertaking to mark more than a thousand streams and thereafter to renew and maintain the markers each season.

STREAM GUARDS

The bureau employed 141 men as stream guards in 1926. Of these, 84 were stationed in southeastern Alaska, 36 in central, and 21 in western Alaska. The period of employment ranged from two to five months.

In southeastern Alaska 31 furnished their own launches and were assigned to patrol larger bodies of water or in the vicinity of several streams. Some of the other guards who were stationed at camps on shore provided themselves with rowboats, in some cases having outboard motors. Four guards were placed on chartered patrol boats and two were detailed to assist in tagging salmon released from traps.

In central Alaska 14 guards, of whom 5 furnished their own boats, were stationed at various points in the Bering River, Copper River, and Prince William Sound districts, 6 in Cook Inlet, 9 in the Kodiak-Afognak district, 2 at Chignik, and 5 in the Ikatan-Shumagin district.

In western Alaska 19, of whom one furnished his own boat, were in Bristol Bay and one each on the Yukon and Kuskokwim Rivers.

There were also five special employees engaged in scientific work, one on herring in central Alaska, three on salmon investigations in the central district, and one tagging troll-caught salmon in southeastern Alaska.

In addition there were 5 statutory employees of the bureau in southeastern Alaska, 9 in central, and 3 in western. There were also 32 persons on the bureau's vessels and 21 on the 12 boats chartered in the various districts.

The foregoing makes a grand total of 216 persons identified with fishery-protective work in Alaska in 1926, as compared with 185 in 1925.

VESSEL PATROL

Eleven vessels owned by the bureau were operated in fishery-patrol work in Alaska in 1926. Of these the *Brant* was used in southeastern and central Alaska; the *Widgeon*, *Murre*, and *Auklet* in southeastern Alaska; the *Kittiwake* in Cook Inlet and Prince William Sound; the *Sea Gull* on Copper River flats; the *Blue Wing* at Kodiak and Afognak Islands; the *Ibis* at Chignik; the *Merganser* in the Ikatan-Shumagin region; the *Scoter* in Bristol Bay; and the *Tern* on the Yukon River. The *Petrel* was out of commission during the season on account of a defective engine. The *Sea Gull* was destroyed by fire on June 18.

The *Brant* was an important addition to the Alaska fleet. This vessel was launched at North Bend, Oreg., on June 3 and on July 9 sailed from Seattle for Alaska. It is the largest of the bureau's Alaska vessels, being 100 feet in length, 21 feet in breadth, and of sturdy and seaworthy construction capable of offshore duty under all weather conditions. A 225-horsepower full Diesel engine gives a normal cruising speed of about 10½ knots. The vessel has modern and complete auxiliary equipment, including wireless, and comfortable accommodations for six persons in addition to the crew of nine.

A small power vessel, the *Red Wing*, was transferred to the bureau from the Department of Agriculture for use in the Kodiak-Afognak district, but on account of the necessity of installing another engine was not in commission during the season. This vessel is approximately 40 feet in length and about 11 feet in breadth, of heavy seaworthy type, and has sleeping accommodations for five persons.

Launch *No. 43*, assigned to the Afognak hatchery, was used during part of the season in connection with the fishery patrol in the Kodiak-Afognak region. During the early part of July the *Eider* transported Dr. C. H. Gilbert from Ikatan to Seward.

The following chartered vessels were used in fisheries patrol: *Gloria*, *Murrelet*, *Diana*, *Igloo*, *Valkyrie*, and *America First* in southeastern Alaska; *Pilot*, *Prospector*, and *King U-109* in Prince William Sound; *Auk* in the Ikatan-Shumagin district; and *Robin* on the Kuskokwim River. Nine small boats in Bristol Bay were

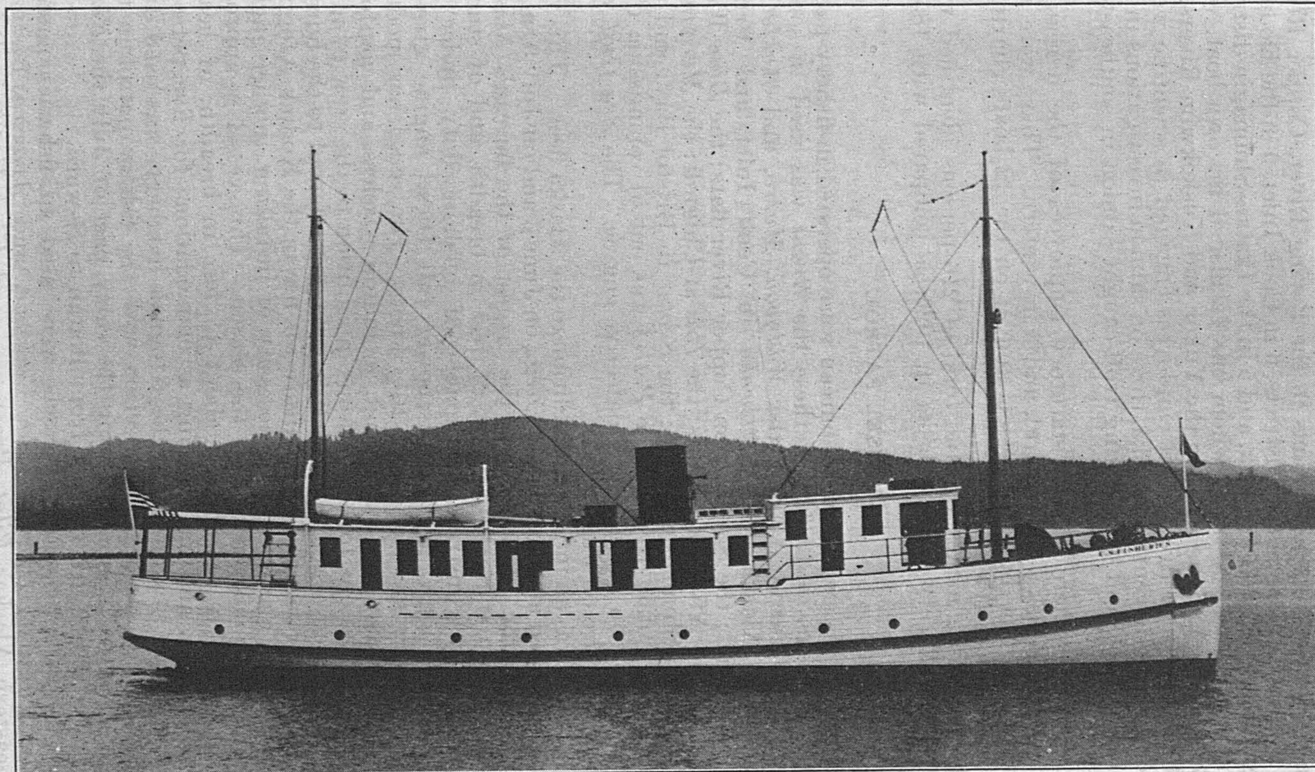

FIG. 1.—Alaska fisheries patrol vessel *Brant*

operated by the bureau in predatory-fish destruction and salmon-patrol during the season in that district. In addition, in the southeastern district the *T-433* was chartered for work in tagging troll-caught salmon.

COMPLAINTS AND PROSECUTIONS

During the season of 1926 four salmon traps were seized in southeastern Alaska for illegal fishing during the weekly closed period. A trap of the Northwestern Fisheries Co., near Porpoise Island, was seized on June 27. Subsequently it was condemned and sold for $1,375, and the watchman was fined $100 and costs of $13. A trap of P. E. Harris & Co., near Hawk Inlet, and one of the Alaska Pacific Fisheries, near Funter Bay, were seized on July 11. On trial the watchmen were found not guilty, but the traps were still in the custody of the United States marshal at the end of the season. A trap of Libby, McNeill & Libby, near Douglas Island, was seized at 6.53 p. m., August 6, for fishing in the closed season. In the previous year the season for fishing ended at midnight, August 6, but this year it was advanced 6 hours to 6 p. m. Some misunderstanding occurred regarding this change, in view of which fact and as seizure was made so close to the new earlier ending for the year's fishing the case was dropped.

Final court action has not been taken in the case of a trap seized in 1924 from the Alaska Pacific Fisheries, and the case is still pending.

In the southeastern district, also, five boats, with crews of seven men, were arrested for trolling on Sunday near Biorka Island. On trial at Sitka, the members of the crews were fined $10 each and costs of $1.45. The boats were returned to the owners. The *Mary V*, a salmon purse seiner, was seized for fishing inside the closed waters at Hawk Inlet. Following condemnation proceedings, the boat was sold for $575. The *Rainier* and *Kotor*, salmon seine boats, were seized on September 20 for fishing within 100 yards of each other at the head of Keete Inlet. On trial the crews, who were all Indians, pleaded guilty and were fined $10 each and costs of 46 cents. The boats and gear were released. The *Silver Wave* and *902 T*, also salmon seiners with Indian crews, were seized on September 27 for fishing within 100 yards of each other near Hydaburg. On trial all pleaded guilty and the four members of the crew of the *Silver Wave* were fined $15 each and costs of 92 cents. The boats and gear were released. The *Empress* and *Mildred II*, herring seine boats, were seized on July 10 for fishing within 100 yards of each other at Bay of Pillars. As it appeared that the boats originally were properly located but had drifted closer together, the seiners were cautioned regarding future operations and their boats were released.

Various reports of illegal herring fishing during the closed seasons and also of unlawful halibut fishing were received but on investigation could not be substantiated, and no action was taken by the bureau.

In the Copper River district prosecutions were instituted against the Cordova Packing Co. and the Pioneer Packing Co. for having in their possession undersized clams. Fines of $25 each were imposed on the companies. Two fishermen were fined $5 and $10 for fishing in closed waters of the Copper River flats. In a case brought against the Pioneer Sea Foods Co. by another fisherman for setting a net within the prohibited distance of another net, the company was found not guilty of the charge.

The *St. Nicholas* and *Commodore* were seized on July 8 for illegal commercial herring fishing during the closed season at Port Chatham in the Cook Inlet region. On trial the defendants in the case, Ivan Botica, James C. Kelley, and S. Feinson, pleaded guilty and were fined $100 each. The boats and gear were released.

In a case originating in 1924 against Libby, McNeill & Libby for illegal fishing of a trap during the weekly closed period, which was disposed of in 1926, the company was fined $50 on each of four counts.

In the Kodiak district two fishermen were arrested for fishing on Sunday in Raspberry Strait. On trial they pleaded guilty and one was fined $100 and the other $10. The gear seized was released to the owners.

In the Bristol Bay district two fishermen for Libby, McNeill & Libby were arrested for fishing in closed waters and were fined $50 each and costs. Two independent fishermen were arrested on the same charge but released with a warning, and the case against another independent fisherman was dismissed, as it was shown he had been fishing for dog feed.

ROBBERY OF FISH TRAPS

There still continue to be complaints of robbery of fish traps in southeastern Alaska. A number of the larger canning companies established a patrol of 17 launches and a few other companies took similar action individually to protect their traps in 1926. While a number of cases of this so-called piracy were reported but few arrests were made.

It is believed that the holding of the court in the trial of the case of United States *v.* Val Klemm et al., at Ketchikan, September 16 and 17, 1926, will do much to curtail the extensive robbing of fish traps hereafter. The defendants were sentenced to three years in the Federal penitentiary. The following is extracted from the charge by Judge Reed to the jury in this case:

> When fish are impounded—that is, inclosed—in a trap and separated from the sea by said trap, so that they are in the actual personal or constructive possession of a person, they become subject to larceny, and any person who takes, steals, and carries away fish that have been impounded in a trap, with intent to convert them to his own use and deprive the owner and possessor thereof, is guilty of larceny. When fish are impounded in a trap belonging to any person, he has a special property in them by reason of having the fish impounded in a trap.

It is said that prior to this case the impression had prevailed generally that trap operators had no legal rights in fish alive in the traps until they were actually removed from the water.

TERRITORIAL LICENSE TAX

Fisheries license taxes were collected by the Territory under the general revenue law of 1921, as amended in 1923 and 1925. A statement from W. G. Smith, Territorial treasurer, under date of April 14, 1927, gives the collections made to that date for the year 1926.

It was stated that collections under the several schedules were fairly complete, with the exception of pack taxes due from a few of the smaller canneries and salteries and those due from certain of the larger salmon canneries on net income, as well as approximately $10,600 outstanding under the whale oil and fertilizer tax schedule.

Fishery license taxes collected by Territory for fiscal year ended December 31, 1926

Schedule	Division No. 1	Division No. 2	Division No. 3	Total
Salmon canneries (pack)	$156,535.05		$434,496.27	$591,031.32
Clam canneries			290.58	290.58
Salteries	2,240.84	$36.10	3,769.17	6,046.11
Cold-storage plants	1,820.00		510.00	2,330.00
Fresh-fish dealers	6,187.76		11.90	6,199.66
Fish-oil works and fertilizer and fish-meal plants	25,968.34		1,021.04	26,989.38
Fish traps	111,899.10		54,827.26	166,726.36
Gill nets	757.00	16.00	5,149.00	5,922.00
Seines	6,265.00		2,590.00	8,855.00
Total	311,673.09	52.10	502,665.22	814,390.41
Salmon canneries (net income), not possible of segregation as to judicial division				35,610.06
Total collections				850,000.47

On January 25, 1926, the United States Supreme Court refused the petition of the Pacific American Fisheries for a rehearing of the case involving the validity of the Alaska graduated pack tax on canned salmon, and the decision of that court on December 7, 1925, upholding the Territory's right to levy such a tax stands.

BRISTOL BAY DISTRICT

Operations in the Bristol Bay region during the season of 1926 consisted primarily of the enforcement of the Alaska fishery laws and regulations, collection of data relating to commercial fishing for and packing of salmon, observation of the salmon run and escapement to the spawning grounds, construction and operation of a salmon-counting weir on the Ugashik River, and the destruction of predatory fishes. The work was organized by Agent Dennis Winn and was under his personal supervision until the 1st of June, when Mr. Winn returned to his duties in southeastern Alaska, and Warden A. T. Looff assumed full charge.

Agent Dennis Winn and 20 special employees secured in the States were transported to the Bristol Bay district in May on vessels of the Alaska Packers Association, Alaska-Portland Packers Association, Columbia River Packers Association, Naknek Packing Co., Red Salmon Canning Co., and Libby, McNeill & Libby. These, together with one patrolman employed locally, Warden A. T. Looff, and the engineer of the *Scoter*, who had remained in the district over the preceding winter, comprised the Bristol Bay force for the 1926 season. Supplies and other equipment for the bureau's use also were transported to Bristol Bay on vessels of the above companies. At the end of the season return transportation to the States was furnished by them for 12 men, while 10 others left via Kanatak and Iliamna Lake, passage being secured on regular transportation steamers.

Immediately on arrival of the crews work was begun on putting in order all boats and other equipment at the bureau's marine ways at Naknek, and a party of 10 men, headed by Henry McFadden, was detailed to the installation of a salmon-counting weir in the Ugashik River. This work is discussed in the special section on salmon weirs. Markers at the mouths of all salmon streams also were inspected and placed in proper condition. Prior to the opening of the red-salmon season at 6 a. m., June 26, preparations were made for the patrol of the commercial fishing grounds. Mr. Looff's report on operations during the season is as follows:

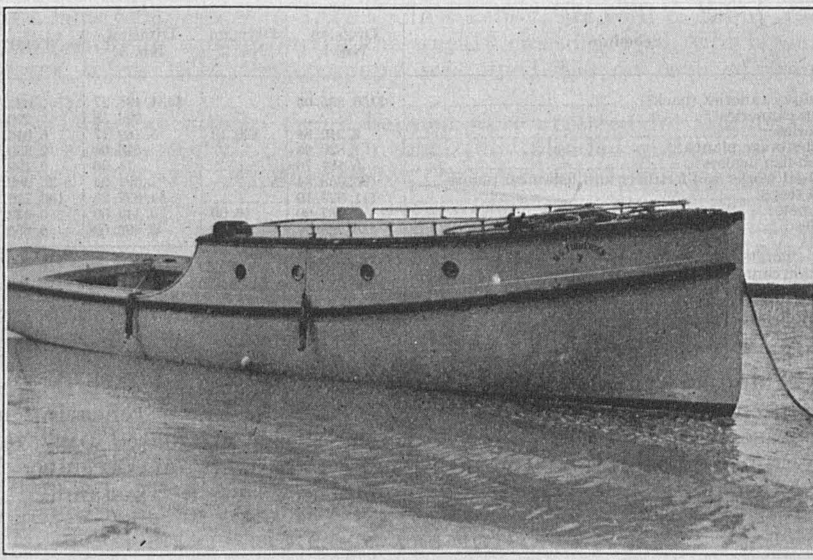

FIG. 2.—Shallow-draft patrol boat, Bristol Bay

GENERAL REPORT OF SEASON'S OPERATIONS

PATROL

The patrol vessel *Scoter*, nine launches, and one rowboat were used in the patrol of the waters of Bristol Bay during the fishing season of 1926. These boats cruised a distance of 11,546 miles. Three cases of violation of the Alaska fisheries laws and regulations were reported and tried before the local United States commissioner, two cases being by boats owned and operated independently by local Alaskans and the third by Libby, McNeill & Libby. The patrol fleet was assigned to the various sections of Bristol Bay, as follows:

Ugashik River and Bay.—Launch *No. 5*, John Monson and Z. V. Hurt; launch *No. 6*, C. M. Hatton and Arthur Larsen; and launch *No. 8*, Henry McFadden and P. E. Hamm, when not engaged in connection with operation of the Ugashik weir.

Egegik.—Clarence Olsen with a rowboat.

Naknek River.—Launch *No. 2*, Alf Christensen and Ivan Merchant.

Kvichak Bay between Naknek and Koggiung.—Launch *No. 7*, Gus Severson and Arthur Mesford.

Kvichak River.—Launch *No. 1*, Henry Looff and Charles Turner, and O. B. Millett with his own launch.

Nushagak Bay and River.—Launch *No. 3*, Eric Fenno and W. J. Kelly.

Igushik River.—Launch *No. 4*, Hector McAllister.

The patrol boat *Scoter*, with Warden A. T. Looff on board, patrolled all waters of Bristol Bay.

In conjunction with the patrol, data were collected in regard to the extent of fishing operations and the run of salmon in the various rivers. In all, 909 fishing boats were operated by the canneries and 36 by independent fishermen, local whites, and natives, who owned the boats and gear and sold their catch to the canneries. These local residents operated 100 stake nets, of which 20 were for commercial purposes, the catch being sold to the canneries; the remaining nets were for local food and dog feed.

The Nushagak section was the only one in which commercial fishing for king salmon was carried on before the beginning of the red season. A patrol was begun there June 1, while in other sections it was established shortly before the opening of the red-salmon season. The red salmon began to appear in all rivers on June 5, and native stake nets took fair numbers during the period preceding the opening of the commercial fishing season, but in no place did a real run occur before June 26.

RUNS OF SALMON

Kvichak River.—At the opening of the season, at 6 a. m. on June 26, few fish were in evidence and catches were light. The escapement during the weekly closed period, from 6 p. m. June 26 to 6 a. m. June 28, was small, as few fish were running. On June 28 catches were small and few fish were in evidence. This condition continued until the beginning of the weekly closed period, at 6 p. m. July 3. On July 4 a heavy run struck in, and a good escapement occurred during the closed period.

When fishing was resumed on July 5, large catches were made, and the run continued heavy on July 6, when the canneries placed their boats on a limit. On July 7 and 8 the run fell off and the boat limit was removed. On July 9 the run increased again, but on July 10 it fell off, and it continued light during the weekly closed period, from 6 p. m. July 10 to 6 a. m. July 12. A heavy run again struck in on July 12 but fell off a little on July 14. From July 15 the run was light until the end of the season, at 6 p. m. July 23.

During the heavy runs almost the entire catch consisted of red salmon, but from July 15 there was a steady increase in the percentage of chums, until by July 21 they constituted fully 40 per cent of the catch, the remainder being nearly all reds, with a few humpbacks and silvers.

Naknek River.—On the opening date catches were small for the most part, and few fish were noticed jumping in the river. A good run struck in on June 27, and a good escapement occurred during the weekly closed period. On June 28 good catches were made from the outer fishing grounds, in the vicinity of the mouth of the Egegik River, but few were in evidence around the mouth of the Naknek River. Fishing continued good on the outer grounds, and on July 3 a heavy run struck in and a heavy escapement occurred during the weekly closed period, from 6 p. m. July 3 to 6 a. m. July 5.

When fishing was resumed on July 5 the heavy run was still on, and by July 6 the canneries began to fly limit flags. The run continued heavy until July 13, on which date few fish were in evidence around the mouth of the Naknek River, although good catches were reported by Naknek boats fishing in the upper Kvichak Bay waters. A heavy escapement took place during the weekly closed period from 6 p. m. July 10 to 6 a. m. July 12. On July 14 few fish were in evidence and catches were small, this condition continuing until July 19, when a small run of fish appeared. A fair escapement occurred during the weekly closed period, but when fishing was resumed on July 19 the last small run was over and very light catches were made to the end of the season.

Egegik River.—A heavy run of fish appeared on the opening date (June 26), which continued until July 10, when a slight falling off was noticed. Few fish were in evidence until July 11, but on July 12 a heavy run came again, continuing until July 20, after which the run fell off to almost nothing. The escapement of salmon up the Egegik River was enormous.

Ugashik River.—Very few fish were in evidence on the opening date, all fish in evidence in the river; but from June 30 to July 3 good catches were noted during the weekly closed period, and most of the fleet lay at anchor on June 28 because of rough weather. On June 29 catches were small, with no fish in evidence in the river; but from June 30 to July 3 good catches were made north of Cape Greig, though few fish appeared in the river. A fair escapement occurred during the weekly closed period, from 6 p. m. July 3 to 6 a. m. July 5. On July 5 good catches were made north of Cape Greig, and a heavy run of fish entered the river on the 6th and 7th. On July 8 the run into the river fell off, but good catches continued to be made on the fishing grounds outside. A heavy run again struck in on the 13th, continuing until the 16th, when it began to fall off, very few fish being in evidence after July 18.

Nushagak River.—At the opening of the season very few fish were in evidence and only light catches were made. A fair escapement occurred during the weekly closed season, but on June 28 a heavy run struck in on the Flounder Flat fishing grounds, and heavy catches were made. This run appeared only on Flounder Flat, and no large catches were reported from any other quarter on this date. On the 29th the run was again light everywhere, and only fair catches were reported until a heavy run again struck in on Flounder Flat on July 3. Several boats delivered 3,000 fish between the time when the run started and the beginning of the weekly closed period at 6 p. m. A heavy escapement took place during the closed period.

When fishing was resumed on July 5, it was reported that the run was light on the outer fishing grounds, but good catches were made on the upper grounds. A good run set in on July 6 and continued until the 15th when a noticeable decline took place. On July 16 many humpback salmon appeared with the red salmon. No heavy run occurred after that date, although good catches of red salmon were made up to the end of the season.

Igushik River.—Catches were small at the opening of the season and no salmon were noticed in the river. During the weekly closed period a few fish were seen jumping in the river. On June 28 and 29 light catches were made, and on June 30 a fair run occurred, but it was slack on July 1 and 2. A heavy run of fish began on July 3, and a good escapement occurred during the closed period. The heavy run was still on when fishing was resumed on July 5 and continued until the 14th, when it fell off, though fair catches were made until the 17th. A fair escapement occurred during the closed period, from 6 p. m. July 17 to 6 a. m. July 19, after which few fish were in evidence and catches were small.

TOGIAK OPERATIONS

Exploratory fishing operations were carried on by the Alaska Packers Association in the Togiak section of the Bristol Bay district. For this purpose the schooner *Metha Nelson* was towed to Togiak Bay and anchored off the north end of Hagemeister Island for use as a salmon-salting station. Two fishing boats were transferred from the company's allotment in the Nushagak section to carry on operations at Togiak. Fish also were bought from independent native fishermen, who operated two fishing boats. All fishing was carried on by drift gill nets, and great difficulty was experienced in using this type of gear effectively on account of the clearness of the water and the many rocks. The writer was unable to visit the section during the fishing season but made a trip later. Fishermen reported that a fair run of red and chum salmon passed up the Togiak River during the fishing season. The pack of the *Metha Nelson* was 170 barrels of reds and 40 barrels of chums.

DESTRUCTION OF PREDATORY FISHES

As the full force was engaged in preparation for the patrol and the construction of a salmon-counting weir in the Ugashik River, it was not possible to do any work in destroying predatory fishes before the opening of the commercial fishing season. On July 31, at the close of the season, H. B. Looff and an assistant started up Egegik River, stopping at the rapids below the outlet of Becharof Lake and the head of Little Becharof Lake investigating a number of tributary streams en route. Camp was made on August 9 at Crooked Creek, but fishing for Dolly Varden trout proved unsuccessful, due to the great numbers of salmon and the quantity of salmon spawn in the streams. The run in this section is thought to have been the largest for many years, judging from reports received from the oldest resident natives.

Camp was moved to Ugashik Creek on August 13, where salmon were found in much smaller numbers and trout were plentiful. Hand lines were used and good catches made. After the Ugashik weir was dismantled on August 25 the men engaged on that work began fishing for Dolly Varden trout between the upper and lower Ugashik Lakes. This work was continued with good results until August 29, when camp was moved to Ugashik Creek and the work continued where Mr. Looff had been operating. Mr. Looff and his assistant then returned to Becharof Lake to make a survey of the spawning grounds and store all equipment for the winter. Fishing was continued at Ugashik Creek until September 16, when equipment was stored and both parties left for Kanatak to take passage for the States.

As a result of these operations 19,687 Dolly Varden trout were destroyed, all but 36 of which were taken in the Ugashik district. Dolly Vardens were found spawning from the latter part of August until the latter part of September in the smaller tributaries, in most cases near their sources.

TIKCHIK LAKES DISTRICT

Hon. Frank A. Waskey, the first Delegate to Congress from Alaska, has written two very interesting letters to Agent Dennis Winn in regard to fishery conditions in the Tikchik Lakes, which form a part of the headwaters of the Nushagak River, Bristol Bay district. Mr. Waskey has been a resident of the district many years and has taken a keen interest in conditions there. His assistance was regarded as very valuable in connection with Warden A. T. Looff's investigation of the Tikchik Lakes district in the fall of 1923. The following extracts from Mr. Waskey's letters contain pertinent and valuable information:

I believe it was during the summer of 1921 that you [Agent Winn] questioned me near Dillingham as to whether many red salmon spawned in the Tikchik Lakes. I answered that the number was negligible. You thought, I believe, that these lakes may have been an important spawning ground for red salmon in times past and probably had potentialities for the future. I was quite sure at the time that these lakes and their tributary and outlet waters were important as spawning grounds only for humpback salmon. Since that time I have been compelled by several lines of evidence to change the opinion then held.

This evidence consists partly of what I have been told by the Tikchik natives regarding the quantity of red salmon formerly spawning in these waters, and particularly in the Tikchik River proper. If you will refer to the map which accompanies the report of Mr. A. T. Looff,[2] who visited a portion of the Tikchik country in 1923, you will note the mouth of the Tikchik River, which flows into the northeast corner of Lake Nuyakuk. The Nuyakuk River, which on most maps is erroneously called the Tikchik River, flows from the southeast corner of Lake Nuyakuk and enters the Nushagak River at the village of Koliganek, about 70 miles below. The Tikchik River heads in two unmapped and almost unknown lakes, named Uppnuk and Nishlik. These lakes are not, and I believe never were, important salmon lakes, but the Tikchik River itself is to-day a producer of red-salmon fry in great numbers.

Incidentally it should be mentioned that the geographical nomenclature of the Alaskan Innuit is always descriptive. The word Tikchik is a corruption of an Innuit word which means "stink," and was so applied to this river because each summer for a time after the red salmon had spawned the water was so offensive in taste and smell that the natives then residing there could not use it for any domestic purpose. As it is a matter of common knowledge that the primitive Alaskan native is not overfastidious in such matters, one can imagine what a great quantity of dead salmon there must have been to so pollute the waters of this quite large and swift stream.

To-day the most used spawning beds in the river commence at a point about 5 miles above Lake Nuyakuk and continue almost without interruption for 25 miles or more to beyond the point where the two streams from Lakes Uppnuk and Nishlik join. A few red salmon spawn in the lower 5 miles of the Tikchik, as do great quantities of humpback salmon every other year. A few red salmon also reach each of the two lakes mentioned.

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[2] Published in Alaska Fishery and Fur-Seal Industries in 1924. B. F. Doc. 992, pp. 108–112.

The second line of evidence from which one may deduce that there is truth in what the natives claim for the Tikchik in former years is what I have been told by credible eye witnesses of the way in which the Nushagak River was fished in the early days of the salmon industry in Bristol Bay. It was stated that for many years after canning operations began the Nushagak River was regularly fished as far upstream as Angel Bay, 30 miles above the present limit stakes.

The third line of evidence is what I personally observed in 1925, when I know that there was a very large run of red salmon into the Tikchik Lakes in comparison with the escapement of recent years. I would estimate that more than 500,000 red salmon entered Lake Nuyakuk during 1925. During July and early in August I heard reports from both white men and natives of the unprecedented number of red salmon ascending Nushagak River. When I ascended it on August 20, spent and dead red salmon were to be seen in numbers from Portage Creek up. The first considerable number of live red salmon were found in a nearly dry slough 6 miles above the village of Ekwok, 80 miles above Snag Point, where 110 red salmon were counted in one spawning group.

The Nushagak River, from head of tidewater below Portage Creek to Koliganek 150 miles above Snag Point, is an anastomosing stream, with two or more main channels paralleling roughly the flood plain, which is from 2 to 5 or more miles wide. Within this flood plain there is a veritable network of cross sloughs connecting the several main channels. From the point where spawning red salmon were first observed to the mouth of the Nuyakuk, a distance of about 70 miles, red salmon were observed in the nearly dry cross sloughs wherever there was a heavy seepage from the gravel above.

The edges of the river and the bars everywhere were covered with dead and dying humpbacks. This year's run of humpbacks is even larger than that of 1920. A few dead chum and king salmon also were seen. According to the natives at the several villages along the river, the run of chum salmon was light, except very early in the season. The king run was less than usual, and the silver run so far is very light. The native caches were already full of dried fish, mostly reds, but they were still taking a few reds chiefly with spear.

The size of these reds is particularly noticeable. My observation of the Wood River reds this summer was that they were larger than usual, and these Nushagak reds are noticeably larger than those of the Wood River. The number of reds spawning below Koliganek, 70 miles from Lake Nuyakuk, came as a great surprise to me. It is known that a few red salmon spawn each year in Wood River below Aleknagik Lake. The writer assumes that these river-hatched fish form a part of the fingerlings which reach salt water as one-year fish.

The writer has for many years been a purchaser of dried salmon for dog feed at various points in western Alaska. I know of no dried red salmon that are superior in flesh or oil to those taken above the rapids of Nuyakuk River and from Nuyakuk Lake during the height of the run. I have seen fish taken from Lake Nuyakuk as bright and firm as salt-water fish. All this is mentioned that you may better realize the value of a worth-while effort to restore this run of red salmon.

* * * * * * *

For your information I am submitting herewith estimate of red salmon that spawned in Nushagak River below Koliganek and in Nuyakuk Lake and a rough guess at the number of such fish passing other points during the 1926 season. While the numbers submitted do not, except in detached instances, represent actual counts, yet I feel that the figures are worthy of consideration, particularly as I have in all instances made liberal deductions from the original totals. Had this run of red salmon not been so almost unbelievably large, and to me so unexplainable, I would not have taken the trouble to attempt an estimate of the number of fish. Neither would I have had the presumption to present these figures to you as in any way reliable. But this run is so great that I can not but feel that the Bureau of Fisheries should have some cognizance of it:

Estimated number of red salmon—	
Spawning in Nushagak River below Koliganek	120,000
Spawning in lower 30 miles of Nuyakuk River	80,000
Passing into Nuyakuk Lake	900,000
Passing into Mulchatna River	40,000
Passing up Nushagak River above Koliganek	50,000
Spawning in tributaries of the Nushagak between the Mulchatna River and Koliganek	10,000
Total	1,200,000

I respectfully suggest that you have an observer on the Tikchik waters during 1927, and that during both 1927 and 1928 you arrange to have fingerlings taken at various points along the Nushagak River, this for the purpose of checking my report of the number of ascending red salmon during the present season as well as for scientific study. I believe that examinations of scales from the descending fingerlings and the ascending mature fish, taken over a series of years from well above tidewater, within the Nushagak River, may add not a little to the known facts regarding red salmon. Such a study might also confirm the belief that the salmon originating in the distant Tikchik waters are much superior in size, color, and flesh to the Wood River salmon.

With regard to the run of humpbacks, I hesitate to put on paper my estimated figures. I have never seen in any part of Alaska anything to equal the numbers of dead and dying salmon in the water and stranded along the shores, islands, and bars of the Nushagak and Nuyakuk Rivers from August 23 to September 5. At any time prior to September 1 many ascending humpbacks were to be seen. I shall content myself with stating one fact concerning the present year's run of humpback salmon. For any given mile of shore line of the Nushagak River, from Koliganek to Portage Creek, a distance of approximately 95 miles, over 5,000 humpbacks were stranded. This, you will understand, is for one shore line only of the channel or of the islands; some of the island bars were literally covered with the carcasses of the spent humpbacks. The above figure of 5,000 per mile was arrived at by actual count of the fish for distances of 1,000 feet at various points along the river and by many observations and counts over shorter distances. At the same time many floaters were in the river. Even larger numbers were to be found in 65 out of the 70 miles length of the Nuyakuk River. Conditions in the lower 30 miles of the Nuyakuk River were similar to those on the channels and islands of the Nushagak. While the upper end of the Nuyakuk is chiefly one channel, the number of dead fish per mile was probably in excess of the number per mile in the anastomosing part of the Nuyakuk.

It would seem that if the descending fingerlings from this run of humpback salmon at all coincide with the descending red fingerlings from the run of 1925 or 1926, then the probable great number of humpback fingerlings would be a potent factor in increasing the number of red fingerlings that will escape their natural enemies while en route to the sea.

EXAMINATION OF THE SNAKE RIVER LAKE SYSTEM

The Snake River Lake system is the smallest of the four important lake systems tributary to Nushagak Bay. It consists of a small glacier-fed lake almost surrounded by mountains, known as the Snake River Lake, and the Snake River, which flows through an extensive swamp, known as the Snake River Marsh, into Nushagak Bay. An attempt was made by Warden A. T. Looff, in August and September, 1925, to explore this water system; and again in February, 1926, he set out for the Snake River Lake, traveling by dog team direct from Dillingham to the lake. Warden Looff's reports on these two trips are as follows:

In making the trip to the Snake River district by boat the writer left Nushagak with a power skiff at 9 a. m. on August 29, 1925, and arrived at the edge of the Snake River flats at noon. After waiting two hours for the tide the flats were crossed and the mouth of the river entered at 3 p. m. Camp was made at 10 p. m. at a point about 60 miles up river, as it was too dark to see further. The following day the trip was continued. At 1 p. m. clear water was reached, and about a mile farther shallow water was encountered at the foot of the Snake River rapid, which extends for a distance of about 4 miles below the outlet of the Snake River Lake. The remainder of the day was spent in making an examination of the rapid and attempting to take the boat through, but this proved impossible and camp was established at the foot of the rapid. The crest of one of the largest tides of the season was barely perceptible at the foot of the rapid. While en route up the river its course was mapped and the work checked on the return trip.

On September 1 the writer walked to Snake River Lake and examined red-salmon spawning grounds along the southeast shore. From the outlet

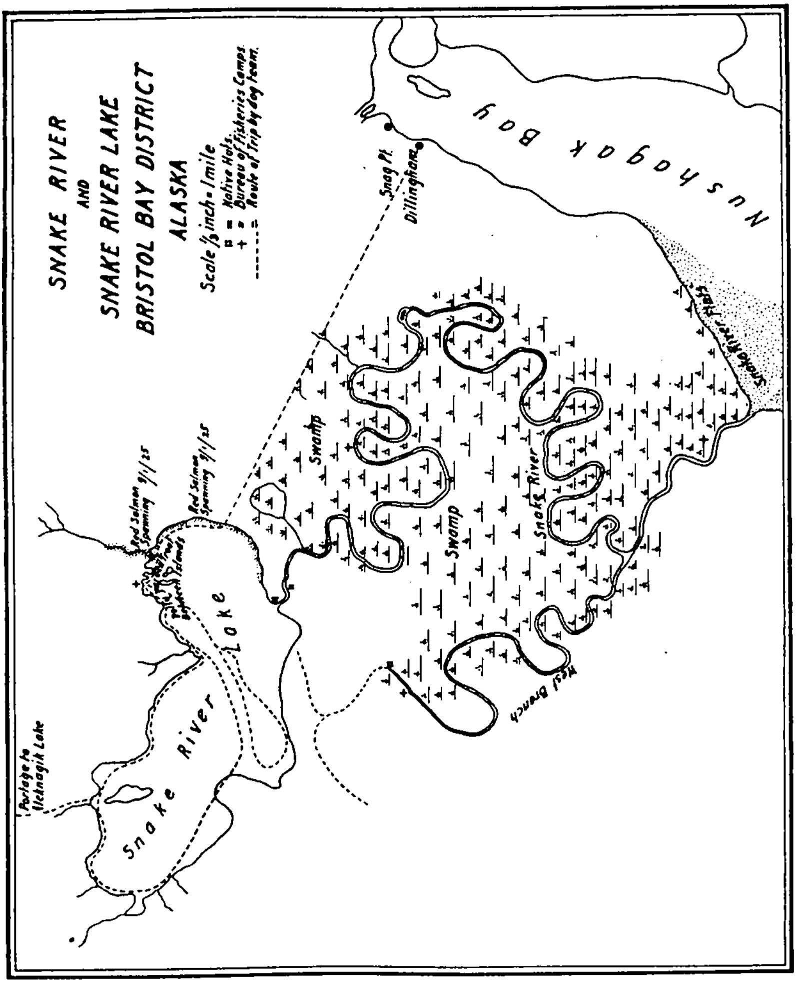

FIG. 3

of the lake for a distance of about 6 miles along the east shore it was estimated that about 30,000 red salmon were spawning in exceptionally good gravel. This subsequently proved to be the most suitable spawning area in the lake.

Having heard from natives at Nushagak that Snake River Lake has two outlets, an attempt was made on September 2 to enter it by ascending the west branch of Snake River. This branch was ascended for a distance of about 30 miles, when it had become so small that all hope of entering the lake by it was abandoned. After walking a short distance up along the stream to get a better view of its headwaters, the return trip was begun at noon on September 3, and Nushagak was reached at 11 a. m. the following day.

On the next trip to Snake River Lake the writer left Dillingham by dog team at 8.30 a. m. February 4, 1926, and reached a point on the east shore of the lake, about 2 miles above its outlet, at 1 p. m. The shore was then followed in a northwesterly direction for about 3 miles and a base camp established. The following forenoon was spent in fishing for Dolly Varden trout through the ice near camp, 13 being caught. During the afternoon a tributary entering Snake River Lake on the north shore about 4 miles above the lake outlet was examined by walking up a distance of about 3 miles. This is the largest tributary and is about 5 miles long, with its source in the mountains. In its lower reaches the stream has an average width of 15 feet and an average depth of 2 feet. For the first mile it has a good gravel bottom, but farther up it is rocky.

On February 6 the writer left camp with a dog team at 7 a. m. and, driving on the ice, followed the north shore to the head of the lake, thence along the south shore to a point opposite the camp, returning across the lake and reaching camp at 3.30. The average depth of the ice was 12 inches.

On February 7 a heavy snowstorm, with high wind, occurred, and the day was spent in camp. On February 8 the writer left camp at 9 a. m. and drove across the lake to the point on the south shore, where work had been left off two days before. The trip was then continued along the south shore, but about 3 miles above the outlet open water was encountered. After an unsuccessful attempt to encircle this open water he returned to camp. The mapping of the district was completed with this trip, and on February 9 the return to Dillingham was made.

A general description of the district is as follows: Snake River Lake is about 13 miles in length, with an average width of about 4 miles. It is almost entirely surrounded by high mountains, which are especially steep along the south shore, where many very small streams flow into the lake. A number of small tributaries also enter along the north shore. Only one native family lives in the district, and it remains there only during the winter season.

The distance from the outlet of Snake River Lake to the mouth of Snake River, as the crow flies, is only about 20 miles, but following the meanderings of the stream it is fully 100 miles. Excepting about 4 miles of rapids immediately below the outlet of the lake, the river winds in most amazing loops through an extensive swamp region to Nushagak Bay. On the map of the district, which is submitted, many of the lesser loops of the river are not shown, but the general trend is correct.

INSPECTION OF ILIAMNA AND LAKE CLARK SPAWNING AREAS IN 1926

In the fall of 1926 Agent Dennis Winn made a trip over the district covered by him in 1925. His report on this inspection was as follows:

For the purpose of making the annual inspection of the spawning areas in the Iliamna and Lake Clark districts the writer left Juneau on August 17, 1926, proceeding on regular commercial steamer to Seward, thence via the Alaska Railroad to Anchorage, from which place transportation was furnished by the bureau's patrol vessel *Kittiwake* to Iliamna Bay via Seldovia. Iliamna was reached on August 23, and the following morning the survey of the spawning grounds of Iliamna Lake was begun with the launch *Marie R.* On account of heavy wind, harbor was made for the night in Goose Bay. Some salmon were noted spawning near its entrance, and a few thousand spawners were seen along the shores of the bay and the lake shore near its entrance.

The first objective was the locating of a satisfactory site for a counting weir. Leaving Goose Bay in heavy weather on the morning of August 25, calls were made at Newhalen River camps, where the natives reported an extremely heavy run. All were through fishing and had their fish stored in winter quarters. Four families of reindeer men had put up 190 bundles (7,600 salmon); one reindeer man at Eagle Bay had put up 27 bundles (1,080 salmon), and 120 bundles (4,800 salmon) were dried at roadhouse portage for home use and dog feed. Red salmon were seen breaking water over the entire lower Newhalen, but the water was too discolored for intelligent estimating.

From signs and the reports of native fishermen it is thought that the run here must have been an exceptionally large one.

After the storm subsided an inspection was made of several locations in the Kvichak River, as far down as Horseshoe Bend, which were not suitable for weir purposes. At the entrance to Kaskonak Flats a feasible and suitable location was found for the weir, and measurements and depths were secured. Good numbers of humpbacks were seen spawning over the flats. They appear to be increasing perceptibly each year. The return was then made to the lake, and, on account of bad weather, refuge was taken in Big Mountain Island Harbor for the night.

The following morning a trip was made to Belinda Creek, where two families of reindeer natives were camped. Their cache contained about 130 bundles (5,200 red salmon), or about the same amount that they usually put up in good years. Few fish were seen in the small creek, and it is believed that the natives take nearly its entire yield for their home use. Weather conditions were unfavorable for landing at Kokhonak Creek, but a trip was made up Copper River with Evinrude and dory, the water being very low. More spawning than formerly was in progress in the lower reaches of the river and slightly less in the upper reaches in comparison with good years. The escapement compared favorably with 1923 and was slightly in excess of that year, but in no way equal to 1922 and considerably less than 1921. Good spawning was in progress, and the available area was fairly well covered, which, taken in connection with the numbers dead on the bars and beaches, shows conclusively an ample seeding. No extensive schoolings were noticed in this district. Some excess seeding was evidenced by small lots of early eggs being dug up by late spawners, but this was not extensive. Numerous bear trails, with fresh tracks, were seen, but no animals were encountered. A white family living on Copper River dried 30 bundles (1,200 salmon) for dog feed. An outstanding feature of the run here was the large size of the salmon in comparison with last year. It was estimated that about 200,000 red salmon had spawned, or about 25 per cent over 1923. This, however, is only about 70 per cent of 1921.

On returning to Kokhonak Creek, weather was favorable and it was entered with the launch. Water was also low here, and the river could be crossed on the bars at practically any point. There were not as many dead spent fish as at Copper River, but there was a considerable number dead along the shores. Compared with Copper River, greater numbers of spawners were seen all along the stream. The spawning areas were well covered, and practically the entire stream bottom was worked over by the salmon. No loss was noted from overseeding, but loss from this cause will occur later, due to the numbers schooling in the eddies along the river in addition to those already on the spawning grounds. Every eddy and hole along the stream bank and back of large rocks in the stream contained schools of a few hundred to several thousand red salmon. The large size of the salmon here was noticeable, too, and measurements were made of many dead specimens, which were 28, 29, and 30 inches long. Fishing camps had been established by several families of reindeer natives on the side of the bluff where the creek empties into the lake. Their catch for home consumption and dog feed was 157 bundles (6,280 salmon). No fishing was being carried on at the time of this visit. The estimated escapement into this stream was 250,000 red salmon, or 20 per cent over that of 1923, which is considered ample and comparable with the escapement of 1921.

Shelter from rain and high winds was taken for the night in Kokhonak Point Harbor. On the morning of August 29 a start was made to Woody Islands, but the wind increased and refuge was taken in Chekok Harbor. In the afternoon the trip was continued to the Woody Island Lakes. With the exception of 1922, spawning here has always been small. More salmon were noted in the island lakes and also along the shoreline in Iliamna Lake than for the last three years. The season is early here, and estimates were based on the dead fish on the shores after spawning. It is thought that about 2,000 red salmon had spawned or were spawning in the lakes and entrance, which is comparable with 1923. The night was spent in Goose Bay.

An investigation was next made of Chekok Creek and the spring ponds tributary thereto. A few salmon were spawning in the creek mouth, and several small schools were seen ascending the stream. A beaver dam, with fresh workings, was found about three-fourths mile upstream. It was about 50 feet long, with an opening about 4 feet wide. It had no effect on the ascent of the salmon and no action was taken at the time. It is probable that the beavers and also the barrier will be entirely removed in the spring, when it will be permissible to take beaver for fur. The large spring pond about 3 miles up Chekok Creek contained about 300 red salmon, and about 200 more were schooling at the entrance. The main stream was very sparsely seeded. It is thought that not over 5,000 red salmon entered this stream, including its tributaries.

All of the streams along this northwest shore, including Pedro Bay, Knutson Bay, Kinney Creek, and the small streams in the vicinity of Roadhouse Portage and Eagle Bay, received their quota of spawning salmon. These streams, with the exception of Kinney Creek, are small but important, with from 1,000 to 2,000 red salmon each. Mr. Kinney reported the greatest run in his district since 1918, but observations did not bear this out. The run in this locality was comparable with 1923.

A trip was made to Newhalen River to arrange for packers over the portage to Lake Clark. Arrangements were also made for a boat on the Newhalen side of the portage for a trip upriver. The trip over the portage was made on August 31 in heavy rain, and camp was established on the Newhalen side with everything wet and disagreeable.

On September 1 the trip was continued to Tarnalia Point. On the way upriver salmon were noted in good numbers breaking water for a few miles in the lower and upper reaches of the river, and on the return trip, on September 6, red salmon were appearing over the entire stream. Some good schools were noticed in the river, but the water was too badly discolored for an intelligent estimate of their number.

Many new fish villages had been established along the river, but all were deserted at the time of this visit. The heavy early run permitted the natives to get their supply of salmon cured for home use and dog feed near the beginning of the season, after which they moved back to their winter quarters at Nondalton. All reported the heaviest run since 1922, and possibly even larger than that year. On the trip up the lake some salmon were noted schooling at various points along the south shore, and large schools were in the vicinity of Tarnalia Point. Tarnalia Creek had broken into the lake over the flats through several channels, which seemed to hold more attraction for the salmon, as there were large schools at each channel mouth. Before breaking into channels, this stream was not suitable for spawning salmon. No spawning was noted in the east or upper portion of the lake, although in the west or lower end it was nearly over. All local families on the lake had discontinued fishing and removed their nets from the water, having obtained sufficient salmon for their own use. Locals along the west end of the lake had dried 140 bundles (5,600 salmon) for home use, and at the lower end of the lake they had 708 bundles (28,320 salmon).

Continuing the trip to the head of Little Lake Clark, a stop was made at Current Creek. This stream has changed its bed many times over the flat valley extending back several miles from its outlet and enters the lake through several small channels along about ½ mile of shore line. No salmon were seen in the vicinity, but spawning here is not extensive, and only near the headwaters several miles back is any spawning possible. The salmon had not reached here yet.

The streams at the head of Little Lake Clark and Big River, at the entrance to Lake Clark, were in flood, but no salmon had as yet made their appearance this far up the lake. Along the north shore and beginning a few miles from Little Lake Clark, salmon were breaking occasionally. Brown Carlson, at whose home the night was spent, stated that the fish had reached his place only about two weeks before, and they were only then en route to the head of the lake. Observations bore out this statement. Mr. Carlson had obtained all the fish needed for home use and dog feed in a few days. He regarded the run as the best since 1918.

The north shore was inspected as far as Kegik Creek on September 3, and salmon were noted breaking in numerous places along the lake shore. Kegik Creek was also in flood and discolored. Salmon were seen outside, but none in the stream, though possibly they had passed up to Kegik Lake. Two beaver dams, one partly and the other entirely complete, were found about 2 miles above the outlet. They were about 300 feet long and backed the water over about half a mile of flat, but the height of the water offered no barrier to the salmon. However, as the water spilled evenly over the entire length of the dam, it was thought the ascent would be difficult in low water, and a section of about 30 feet was broken out. Beaver workings were noted in all streams throughout the flats. It is believed that the opening of the beaver season in the spring will remove this menace to the ascent of salmon, but all streams where beaver are reported should be inspected each year.

On September 4 a trip was made over the portage to Kegik Lake. More salmon were in evidence here than ever had been noted before. Almost the entire west shore or head of the lake was well covered with salmon. Around the mouth of the four small creeks it was estimated there were 2,000, 5,000, 10,000, and 10,000 red salmon, respectively, and salmon also were milling along the lake shore between the streams preparatory to spawning, and were jumping in the lake over a quarter of a mile from shore. None had entered the creeks as yet or had begun spawning. It was estimated that at least 50,000 red salmon were in sight from the shore, which, of course, does not represent all the salmon that entered the lake, but only the early fish. This is a late-spawning area, and salmon had reached it only two weeks before. Also, no check was possible around the lake, as the sides are almost perpendicular bluffs. The return was made to Tarnalia Point and the portage reached on September 6.

Only a casual inspection was made of Taziminia, but apparently there was an adequate supply of salmon for thoroughly seeding the 8 miles of river available for spawning below the falls.

Return was made by way of the portage to Iliamna Lake, and thence by launch to Iliamna Village. A rumor was investigated that some local white men contemplated beaver farming, using salmon streams for the purpose. Those interested were advised that the idea should not be encouraged, as such operations will not be permitted.

More salmon were reported in Pile Bay tributaries than for the past six years. The numbers were not large, but the increase is most encouraging. Red salmon in Iliamna River were not numerous—fewer than in 1923 but more than in 1921. It was estimated that about 10,000 salmon spawned in the stream. Local whites and natives had dried 407 bundles (16,280 red salmon) for home use and dog feed.

The inspection as a whole was very satisfactory and encouraging. The escapement was the best since 1918, with the exception of 1922, and except in a few areas the numbers were considered adequate for proper seeding. Not all of the available area was covered, however, and some good areas were but sparsely covered, as compared with other good years. Certain areas will receive ample numbers one year and few another, while other areas are satisfactorily seeded every year; although a year like 1925 would be an exception to this latter rule, as there were not enough salmon to cover the grounds of any area. As the result of observations year after year it appears that even in a satisfactory year, such as this, as much suitable area remains vacant as is used for spawning.

It is believed that Lake Clark received the larger portion of the escapement this year, while in 1921, 1922, and 1923 the greater bulk of the escapement appeared to center in Iliamna Lake. Returns from this year's spawning will also probably be better because the water in the lakes was low, with consequent less likelihood of the water receding and leaving the spawning beds bare, as occasionally occurs. The streams emptying into Iliamna Lake also were low and securely bedded, thus eliminating most of the shallow sloughs, where in some years great losses undoubtedly occur when the water recedes after the eggs are deposited, and leaves them dry.

Throughout the district the local whites and natives took their full supply of salmon early when the fish were good, and discontinued fishing, except for occasional fresh salmon for themselves and their dogs. Rehabilitation of the runs has also caused the reestablishment of fishing camps by the natives. Several camps had been located at Kokhonak Creek and along the Newhalen River, and one near the mouth of the Kegik River on Lake Clark. Camps and villages formerly existed at these places but were discontinued, primarily on account of scarcity of salmon. The total number of red salmon dried by local whites and natives in the Iliamna and Lake Clark districts was 1,909 bundles (76,360 fish). Probably the number used fresh and the few barrels salted would bring the total catch to 100,000 salmon, which is about the average number used in years when salmon are plentiful.

One feature, which the natives reported had never occurred before, was the appearance of humpback salmon along the north shore of Iliamna Lake. A few were seen near the Iliamna-Newhalen portage, and natives had taken several in red-salmon nets. There could not have been a large number, but it is deemed possible that both humpback and silver salmon are increasing in numbers as a result of the short commercial fishing season, which ends before either of these species makes its appearance in numbers in Bristol Bay. A closer check on this matter will be possible next year through the installation of a counting weir in the Kvichak River. A decided increase in the number of humpbacks spawning on the flats is apparent from the bureau's inspections in other years and also from the reports of launch operators who have been navigating the river for many years.

KUSKOKWIM RIVER

All commercial fishing for salmon for export from Alaska was prohibited in the Kuskokwim River and the area off its mouth. Stream Guard Charles McGonagal was again stationed on the river during the fishing season to observe operations. No violations of the law or regulations were reported. Operations included only the salting of red salmon and the drying of chums for dog feed. The amounts of these products were 31 barrels of pickled reds and 479 tons of dried chums. There were 15 whites and 155 natives engaged in the fishery. Apparatus in use consisted of 25 wheels, 124 gill nets of 6,200 fathoms, and miscellaneous small boats.

YUKON RIVER

Fishing in Yukon River waters for export from Alaska is prohibited, but operations were carried on as usual to supply local needs and particularly the market for dried salmon for dog feed throughout the interior of Alaska. Inspector C. F. Townsend and one stream guard were on duty at the fishing grounds throughout the season. Reports indicate that the season was unusually favorable for the preparation of an excellent product, and that the run of kings was the heaviest in years. An unusually heavy run of humpbacks occurred, and there was also a fair run of chums. On account of extremely high water, the catch of salmon on the Tanana River was small.

Products of the Yukon and Tanana fisheries were as follows: 38½ barrels of pickled chums, 91½ barrels pickled kings, 600 pounds kippered kings, 97,164 pounds dried kings, and 723,000 pounds dried chums. Apparatus consisted of 188 wheels, 50 gill nets of 769 fathoms, 1 launch, and a number of small boats; 32 whites and 228 natives were engaged in the fishery.

KARLUK SALMON COUNT

Counts of ascending spawning salmon were made at a weir in the Karluk River, located at approximately the same position as in preceding seasons. The weir was completed by May 14, and the first fish passed through on May 20. A considerable run began on June 2, and counting was continued through October 14, when 2,533,412 red salmon, 5,917 kings, 15,071 humpbacks, and 18,254 cohos had been counted through. After the 1st of October the run of red salmon fluctuated and appeared to be about over; but after orders had been given for the removal of the weir more reds appeared in the river, and a considerable number had not yet ascended when counting was discontinued.

The departmental regulations prohibited commercial fishing for salmon in Karluk waters before 6 a. m. June 15 and after 6 p. m. September 15, and in addition from August 21 to September 5 the weekly closed period in the district was extended from 6 p. m. Saturday to 6 a. m. Wednesday of each week in order to permit a larger percentage of the red salmon to escape. The commercial take of red salmon from the Karluk run was 2,131,616, or 46 per cent of the total. Ray S. Wood was in charge of counting operations at the Karluk weir, under the direction of H. H. Hungerford.

A special study of the run at Karluk was made during the season by Dr. W. H. Rich. A large migration of red salmon fingerlings down river was noted in May, June, and July. Approximately 47,000 of the early migrants were marked by clipping two fins. A temporary web weir was constructed about 8 miles below Karluk Lake, more particularly for the handling of humpbacks if they ascended in any considerable numbers; but as the run was very small there was no great need of this supplementary weir, and its operation was discontinued. On July 19, 100 ascending red salmon were marked at the lower weir by attaching a piece of white tape to their tails. At the upper weir 52 of the salmon thus marked were noted, the time of ascending the intervening 16 miles varying from 2 to 9 days. Some of the marked salmon probably lost the tape and others may have passed through the weir unnoticed.

ALITAK SALMON COUNT

Weirs chiefly for counting red salmon were again maintained in two streams tributary to Olga Bay. The one at the upper station was completed on May 16 and the cannery-station weir on May 20. Red salmon began to ascend on May 22 and continued until September 30, when the weirs were removed. There were also a few red salmon that had not ascended at that time. At the upper station the escapement was 789,947 reds and at the cannery station 105,142 reds, a total of 895,089. In addition, 10,866 cohos and 663 humpbacks were counted through the upper station weir and 2,900 cohos and 8,327 humpbacks through the cannery-station weir, a total of 13,766 cohos and 8,990 humpbacks. As these latter species spawn chiefly elsewhere, the counts at the weirs do not indicate the total escapement. There is also a run of red salmon into Horse Marine Lagoon, where no counting weir is maintained. It was estimated that approximately 25,000 red salmon spawned in the lake and streams at its head, which bring the figures for the total escapement of reds in Alitak Bay waters to considerably over 900,000.

Commercial fishing in Alitak Bay and its tributary waters was prohibited prior to 6 a. m. June 15, to which time there had been an escapement of 80,537 red salmon. The commercial catch approached the recorded escapement on July 31, and a trap in Moser Bay was ordered closed at 6 p. m. on July 31. Another trap in the same waters was closed at 6 p. m. August 7, and both remained closed until 6 a. m. August 16. The total reported catch of red salmon in the district was 323,596. No commercial fishing was carried on after September 18.

Homer H. Whitford was in charge of operations for the bureau.

CHIGNIK SALMON COUNT

Work on the erection of the weir in Chignik River was begun on April 30 at a point about 20 rods above its location in the preceding year, where the water was from 2 to 5 feet in depth and the river about 450 feet wide. An unusually large migration of red-salmon fingerlings was noted during the construction of the weir and continued into August.

Red salmon began to pass through the weir on June 1, but did not come in considerable numbers until June 8. At no time during the season was there a large run. As a result of a flood, the river became roily, and the weir was so damaged that counting of fish was discontinued from June 20 to July 6, when repairs were completed. Estimates were made of the daily escapement during this period. Counting was discontinued on September 25, as the water again became too roily to see the fish and the run virtually was over. The total number of red salmon that passed through the weir was 960,314. In addition, 1,682 kings and 78,923 coho salmon were counted. There was a good run of humpbacks, which spawned along the whole length of the river.

On June 15 commercial fishing by the three canneries that have fished this district in past seasons began, in addition to which the *Salmon King*, a floating cannery, anchored at Chignik on June 17 and fished from June 18 to July 15. By departmental regulations, no commercial fishing is permitted after September 15. On account of the large percentage of the run of red salmon which was being taken, the four traps in Chignik Lagoon were closed on July 3 for the remainder of the season, and three traps in Chignik Bay were closed during a part of the fishing season. The total commercial catch of red salmon from the Chignik run was 440,989. The work at Chignik was under the immediate supervision of Warden Charles Petry.

MORZHOVOI SALMON COUNT

The counting of salmon ascending to spawning grounds was inaugurated at Morzhovoi Bay in 1926 by the construction of a weir on a stream about one-fourth mile above the point where it flows into the middle lagoon. The weir was 42 feet long over all and crossed the stream at a point where the banks were about 7 feet high with an average water depth of 2 feet. The pickets were driven into the ground for a distance varying from 18 to 36 inches, and a trench was dug along the lower face of the weir on the upstream side, against which sod was packed, with gravel over it to weight it. Two braces were placed in the center of the weir, one on each side of the channel, and the capping anchored to them on one end and to mud sills on each shore end, firmly embedded in the abrupt banks. Assistance was rendered by the King Cove cannery of the Pacific American Fisheries in transporting materials for the weir.

The weir was completed on May 8, and a stream guard was stationed there on June 18, but salmon did not begin to pass through until June 22. None but reds passed through until August 17. The last red was counted on August 30 and the weir was removed on September 3, a total of 13,590 reds, 3 kings, and 176 cohos having passed through. Cohos were still running at the time the weir was removed. Some red salmon spawned in the stream below the weir.

This work was under the supervision of Assistant Agent L. G. Wingard.

THIN POINT LAGOON SALMON COUNT

Salmon counting was inaugurated in 1926 at Thin Point Lagoon by the construction of a weir at the lake outlet above the lagoon. Considerable trouble was experienced in finding a suitable site on account of the short course of the stream that flows from the lake into the lagoon. The site selected was in the lake itself, where a V-shaped weir, about 150 feet long, was erected, the ends touching the lake shore and extending out into the lake. It was protected by a small point that extends into the lake. The water was shallow, from 6 to 30 inches, except in one deeper hole, and the current was sluggish, except in a northeasterly wind. During the season the

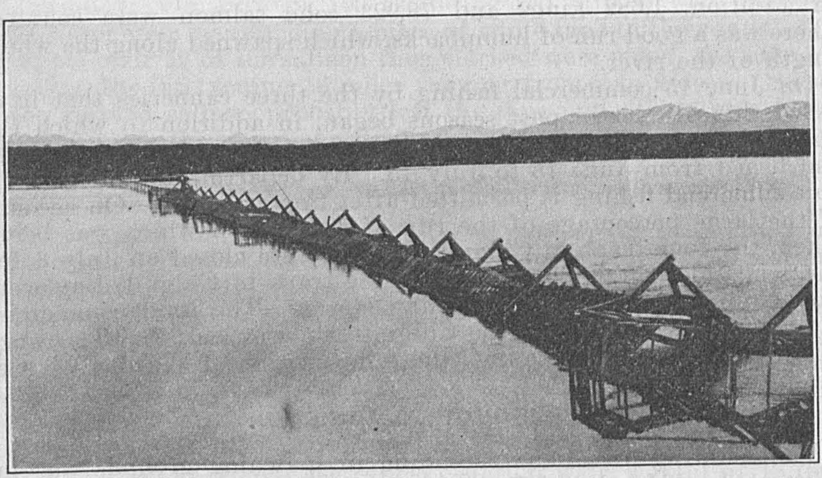

Fig. 4.—Salmon-counting weir, Ugashik River

extremely warm weather melted Frosty Peak Glacier to such an extent that the stream flowing from it broke a new channel into Thin Point Lake and deposited a considerable amount of sediment at the outlet and along the left shore lead of the weir. No damage was done to the weir, but the resulting discoloration made it difficult to see and count the salmon.

The weir was completed by July 1, and the first red salmon were counted through on July 10, the last on August 28. The total escapement counted was 8,772 reds and 57 cohos. Some cohos were still in the lagoon when the weir was removed on September 1 and would probably ascend later. The escapement was regarded as poor as compared with other years. Many fish perished on the flats, due, it is thought, to the low water and the silt from the glacial stream, which clogged their gills.

The work at this place was under the supervision of Assistant Agent L. G. Wingard.

UGASHIK SALMON COUNT

A salmon-counting weir was erected in the Ugashik River in 1926. Agent Dennis Winn selected the site in the previous season, and the weir was constructed about 50 miles up the river, a short distance below the outlet of the first Ugashik Lake. At this point the river is 770 feet wide, with an average depth of 3 feet. The bottom is gravel, and the water is perfectly clear. The largest tides from Bristol Bay barely reach the weir. Immediately below the weir site the river widens into a shallow mud-bottomed lagoon, below which the water is too badly discolored to permit counting the fish.

The weir consists of a picket fence on stringers, supported by tripods for about 360 feet across the main current of the river, with a 6-foot wire-netting fence, about 370 feet long, to the eastern bank and another about 40 feet long to the west bank, with a wing to permit the passage of boats up and down the river along the west bank. Six counting gates were built in the weir for the passage of salmon.

The first red salmon passed through on June 15, although not all of the counting gates were erected until June 20. The run continued through August 12, when the dismantling of the weir was begun. The total count of salmon was 786,775 reds, 278 chums, 17 humpbacks, 46 kings, and 27 cohos.

Henry McFadden was in charge of operations at this weir during the season.

ANAN SALMON COUNT

In 1926 a weir for the counting of salmon was again installed in Anan Creek. It was completed May 12, and a few steelhead trout made their appearance at that time, but the run of humpback salmon did not begin until June 12. From that date until August 31 a total of 121,780 humpbacks passed through the weir. In addition, 106 kings, 586 reds, 835 cohos, 75 chums, and 647 steelhead trout were counted during the time the weir was operated.

Walter J. Larson was in charge of the erection of the weir as well as of counting operations.

SALMON TAGGING

With a view to throwing further light on migration routes and to develop other information, the tagging and releasing of adult salmon was again undertaken in southeast Alaska in 1926. The total number tagged was 13,530, of which 13,082 were from traps and 448 were troll-caught fish.

The numbers of salmon tagged and released from traps, and the localities where operations were carried on, were as follows: Tree Point, 650 fish; Kanagunut Island, 844; Gravina Island, 659; Point Colpoys, 1,036; Cape Bendel, 3,297; Marble Bluffs, 999; Inian Islands, 2,000; Stephens Passage, 1,499; Cape Chacon, 500; and Cape Muzon, 1,598; a total of 13,082. Of these, 2,297 were red salmon, 820 chums, 614 cohos, and 9,351 humpbacks. Warden A. J. Suomela was in immediate charge of this work.

In order to secure data in respect to the trolling industry, Hugo W. Frederickson, a temporary employee, was engaged to tag and release troll-caught salmon in the Baranof Island region of southeast Alaska in 1926. As a result, 448 salmon, of which 360 were cohos and 88 kings, not seriously injured when caught, were tagged and released.

Complete returns on recaptures have not been received, but a separate report on the work will be published.

SALMON LIFE-HISTORY STUDIES

Important studies of the life history of the Pacific salmons, particularly the red salmon, were continued in Alaska in 1926 by Dr. C. H. Gilbert, of Stanford University, Calif., and Dr. Willis H. Rich, chief investigator of salmon fisheries, assisted by Seymour P. Smith. This work was conducted chiefly in the Karluk region. It included a thorough survey of Karluk Lake and the marking of approximately 47,000 young red salmon migrating from Karluk Lake to the sea. Extensive collections of scales of salmon were made in various parts of Alaska for scientific study in relation to life-history problems. These activities are covered fully in another publication.

OBSERVATIONS ON THE ESCAPEMENT OF SALMON

The act of June 6, 1924, states that it is the intent and policy of Congress that in all waters of Alaska in which salmon run there shall be an escapement of not less than 50 per cent thereof. Accordingly, in various parts of Alaska observations were made during the progress and at the conclusion of salmon runs of 1926 to secure information as to the escapement to the spawning grounds.

Generally speaking, surveys showed that satisfactory numbers of salmon ascended the streams for breeding purposes, although there were occasional exceptions, including more particularly the Copper River. Some changes in the regulations regarding fishing operations were made during the season to insure adequate escapements to the spawning grounds.

Southeastern Alaska.—Reports indicate a good escapement of red salmon in the Icy Strait region and other parts of the northern portion of southeastern Alaska. In general, the escapement throughout the Wrangell district was less than in the previous year. This was especially true in certain sections, notably along the Cleveland Peninsula shore from Lemesurier Point through Union Bay, Ernest Sound, Bradford Canal, Eastern Passage, Zimovia Strait, and along the Etolin Island shore from Abraham Island to Chicagof Pass. Poor catches were made in these waters, and spawning streams examined from time to time showed a light escapement.

Other areas showed marked improvement over 1925, particularly Kah Sheets Bay, where an excellent red-salmon escapement occurred. In fact, fishermen reported this the heaviest run for the last 12 seasons. Sarkar Cove showed up well in respect to both reds and cohos. Conditions in Barrie Creek were good, all species being on a par with 1925. There was a large escapement of humpbacks in Petersburg Creek. From Point Baker to Point Colpoys, and through Snow Pass, Kashevarof Strait, and along the east coast of Prince of Wales Island in Clarence Strait, the escapement generally was good. Along the central and southern shores on the west coast of the Prince of Wales Island region the escapement was excellent, although extreme low water, due to lack of rain, proved a serious hindrance at times to the ascent of spawning salmon. This handicap was also true to some extent in nearly all streams, especially small streams in the Wrangell district and to the south. Rains in the latter part of August relieved this situation. In the general region centering at Ketchikan, a substantial increase in reds over the last few years was observed and a satisfactory escapement of this species was reported.

Copper River district.—The escapement of breeding salmon to Copper River waters was unsatisfactory. This stream has been depleted through overfishing in former years or from other cause, and sharp curtailment of fishing through regulatory measures has been necessary in order to begin restoration of the runs to their former abundance. Apparently this stream is in less satisfactory condition than any other large salmon stream in Alaska.

FIG. 5.—Spent salmon on spawning beds, western Alaska

Prince William Sound district.—Reports indicate that in some streams there was a satisfactory escapement of red salmon to the spawning grounds. In particular, improvement was noted in the Eshamy region. In some sections the escapement seemed to be somewhat less than in previous seasons. The escapement of humpback salmon to spawning beds in some places was satisfactory and in others not equal to that of former seasons. Some further restrictions in respect to fishing may be necessary to improve the escapement to certain waters.

Cook Inlet district.—Investigations showed a bountiful seeding of red salmon spawning grounds in certain waters tributary to Cook Inlet. In other streams there was a good escapement, although salmon experienced difficulty in reaching the spawning beds in some places on account of low stages of the water. Certain places showed a large escapement of pink and chum salmon. On the whole, the escapement of salmon in the Cook Inlet district in 1926 was satisfactory.

Kodiak district.—Generally speaking, there was a satisfactory escapement of salmon to spawning grounds in the Kodiak region. This was particularly true of the Karluk River, where there was an excellent escapement. Other streams showed improvement over former years, although in some cases the runs were not as extensive as had been anticipated.

Alaska Peninsula district.—Investigations of spawning escapements in the Alaska Peninsula district were made by Assistant Agent L. G. Wingard. With the exception of a few places, the escapement generally was good. At some points the streams would have absorbed larger numbers of spawning fish had it not been for low stages of the water, which prevented their ascent to the spawning grounds. Heavy rains later on improved this condition.

Bristol Bay district.—In August and September Agent Dennis Winn made an extended trip over certain important areas tributary to the Bristol Bay district to observe the escapement of spawning salmon. The regions visited were substantially the same as those covered for a number of years previous, and comparisons with former conditions were thus possible. The inspection showed a satisfactory escapement of salmon generally throughout the region covered. Except in a few places, the number of salmon that escaped was considered sufficient for a proper seeding of the beds. In fact, the escapement was considered the best since 1918, with the exception only of 1922.

HATCHERIES

EXTENT OF OPERATIONS

Salmon propagation in Alaska, exclusive of Territorial activities, was carried on at two Government-owned hatcheries, situated at Afognak and McDonald Lake, and two privately owned hatcheries—that of the Alaska Packers Association at Heckman Lake and the Northwestern Fisheries Co. at Hugh Smith Lake.

Operations of Federal and private hatcheries in Alaska in 1926

Location of hatchery	Red or sockeye salmon		
	Eggs taken in 1925	Salmon liberated in 1925-26	Eggs taken in 1926
Afognak	11,000,000	10,075,000	[1] 21,250,000
McDonald Lake	39,680,000	27,392,200	[2] 30,760,000
Heckman Lake (Fortmann)	16,920,000	15,990,000	[3] 21,420,000
Hugh Smith Lake (Quadra)	20,240,000	19,345,000	20,000,000
Total	87,840,000	72,802,200	93,430,000

[1] Also 2,060,000 steelhead-trout eggs and 4,212,000 humpback-salmon eggs were collected.
[2] Shipped 5,241,130 eyed eggs to Seattle and 1,717,760 to the Territorial hatchery at Ketchikan.
[3] At the Fortmann hatchery 4,183,000 humpback-salmon fry were released in 1925-26 and 6,640,000 eggs of this species were taken in 1926.

AFOGNAK

At the Federal salmon hatchery at Afognak 10,075,000 No. 1 fingerling red salmon were distributed from the 11,000,000 eggs collected in 1925, a loss of 8.4 per cent. During the month of April

2,060,000 steelhead-trout eggs were collected at Litnik Lake for shipment to the States. Of these, 1,023,360 eyed eggs were shipped to Seattle on June 2, but a marked rise in the water temperature caused the incubation of the remainder of the eggs to advance so rapidly that they could not be shipped. The 850,000 fry resulting were deposited in local waters during the month of June.

The collection of red-salmon eggs began July 27, 1926, and ended September 10, with a total take of 21,250,000. A collection of humpback-salmon eggs was also made between August 30 and September 7, in which period 4,212,000 eggs of this species were secured. The destruction of predatory trout was carried on throughout the greater part of the year, approximately 35,950 Dolly Vardens being taken.

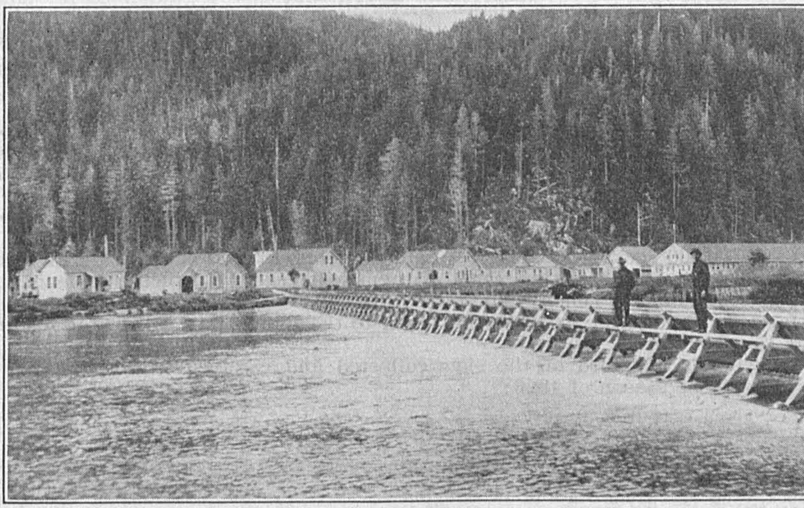

FIG. 6.—McDonald Lake hatchery

MCDONALD LAKE

At the Federal salmon hatchery on McDonald Lake 27,392,200 red-salmon fry and fingerlings were released from March to July, 1926, from the 39,680,000 eggs taken in 1925. In addition, a shipment of 8,645,760 eyed eggs had been made to the States in November, 1925, making the net loss on the total take 9 per cent.

Egg taking in 1926 began on September 6 and ended on September 29, with a total take of 30,760,000 red-salmon eggs. During the month of October, 5.241,130 eyed eggs were shipped to Seattle for distribution in the State of Washington, and 1,717,760 eyed eggs were sent to the Territorial hatchery at Ketchikan.

HECKMAN LAKE (FORTMANN)

The Alaska Packers Association liberated 15,990,000 red-salmon fry from its Fortmann hatchery on Heckman Lake in 1926, which were hatched from 16,920,000 eggs taken in 1925, a loss of 5.5 per cent. In addition, 4,183,000 humpback-salmon fry hatched from eggs collected in 1925 were released. In 1926 egg taking began on August 24 and ended on November 18, during which time 21,420,000 red-salmon eggs and 6,640,000 humpback-salmon eggs were taken. Notification has been given by the company that after the fry hatched from these eggs are released in 1927 the hatchery will be closed.

HUGH SMITH LAKE (QUADRA)

The Northwestern Fisheries Co. liberated 19,345,000 red-salmon fry from its hatchery near Boca de Quadra in 1926, hatched from 20,240,000 eggs taken in 1925, a loss of 4 per cent. In 1926 the take of eggs was 20,000,000.

TERRITORIAL HATCHERIES

Under date of December 3, 1926, Edwin Wentworth, superintendent of hatcheries for the Alaska Territorial Fish Commission, submitted the following summary of operations at stations in 1926:

At Ketchikan hatchery 9,729,000 humpback-salmon fry were liberated from 11,415,000 eggs—5,479,000 in the hatchery creek, free-swimming, and 4,250,000 to Ponds Bay salt-water feeding pond, where 31,470 were marked the latter part of July before liberating.

Of the 2,000,000 eyed chinook eggs received from the State of Washington, 1,789,000 fingerlings were liberated, ranging from 2½ to 6 inches in length.

About 100,000 sockeye fingerlings, hatched from 165,000 eggs, are still being held and fed, and at this time some of them will measure 5 inches in length.

Of 265,000 chum-salmon fry hatched from 320,000 eggs 65,000 were liberated in Hatchery Creek and 200,000 were taken to the Ponds Bay salt-water feeding pond.

Following is a record of the eggs collected and received at the Ketchikan hatchery in the season of 1926:

Sockeye, green eggs from Quadra	1,320,000
Sockeye, green eggs from Ward Cove	300,000
Sockeye, eyed eggs from Yes Bay	1,717,760
Humpback, green eggs from Ward Cove	150,000
Humpback, green eggs from Lucky Cove	1,510,000
Chinook, eyed eggs from State of Washington	2,000,000

At Cordova the sockeye-salmon fry were planted in ponds during March, 1926; 7,300,000 of these fry were fed in ponds until liberated, the last being liberated early in November. There were no eggs collected at the Cordova station this year.

At the Seward hatchery the sockeye-salmon fry from the 4,460,544 eggs taken in 1925 were held and fed in inclosures in Grouse Lake and liberated on July 14, the number being 4,085,727. In 1926 there were collected at the Seward hatchery 3,164,000 sockeye eggs. The number of trout destroyed at the two traps near Seward totaled 3,717. At the Grouse Lake trap 472 sockeye salmon passed through, and at the Bear Lake trap, 7,308. At Robe Lake stream trap 11,789 sockeye salmon were tallied through and 26,029 trout destroyed.

HATCHERY REBATES

The owners of private salmon hatcheries in Alaska, who are also packers of canned salmon, receive a rebate on license fees and taxes of every nature on their catch and pack of salmon at the rate of 40 cents per 1,000 king or red salmon fry liberated by them in Alaskan waters.

Rebates credited to private salmon hatcheries, fiscal year ended June 30, 1926

Owner	Location	Red-salmon fry liberated	Rebate due
Alaska Packers Association	Heckman Lake	15,990,000	$6,396
Northwestern Fisheries Co	Hugh Smith Lake	19,345,000	7,738
Total		35,335,000	14,134

GENERAL STATISTICS OF THE FISHERIES

The total number of persons engaged in the fisheries of Alaska in 1926 was 28,052, or 367 more than in 1925. The total investment in the fisheries was $74,557,522, an increase of 11 per cent. The investment in the salmon industry was $62,367,459, an increase of $6,965,452 over 1925. The products of the fisheries were valued at $54,669,882, an increase of $14,631,137, or 36.5 per cent.

Summary of persons engaged, investment, and products of the Alaska fisheries in 1926

Items	Southeast Alaska		Central Alaska		Western Alaska		Total	
	Number	Value	Number	Value	Number	Value	Number	Value
PERSONS ENGAGED								
Whites	7,465		4,613		4,230		16,308	
Natives	3,182		1,095		723		5,000	
Chinese	385		311		424		1,120	
Japanese	704		577		276		1,557	
Filipinos	1,414		656		548		2,618	
Mexicans	156		85		816		1,057	
Negroes	10		34		219		263	
Kanakas	33		21		10		64	
Miscellaneous	27		4		34		65	
Total	13,376		7,396		7,280		28,052	
INVESTMENT								
Salmon canning		$26,574,925		$15,728,010		$18,232,615		$60,535,550
Salmon mild curing		1,429,652		3,860				1,433,512
Salmon pickling				66,778		189,555		256,333
Salmon drying, smoking, and dry salting						32,494		32,494
Salmon by-products		109,570						109,570
Halibut fishery		3,491,892		53,863				3,545,755
Herring fishery		3,805,571		2,980,984		21,840		6,808,395
Cod fishery				253,279				253,279
Clam fishery				354,288				354,288
Crab fishery		28,956		9,318				38,274
Shrimp fishery		315,752						315,752
Whale fishery				451,063		419,961		871,024
Trout fishery				3,296				3,296
Total		35,756,318		19,904,739		18,896,465		74,557,522
PRODUCTS								
Salmon:								
Canned..cases	3,058,055	17,642,766	2,146,485	14,918,339	1,448,342	13,518,899	6,652,882	46,080,004
Mild cured ......pounds	4,380,000	1,042,367	189,600	27,949			4,569,600	1,070,316
Pickled...do	56,800	4,340	460,500	45,432	1,096,300	123,908	1,613,600	173,680
Fresh.....do	2,268,573	221,111	5,550	660			2,274,123	221,771
Frozen....do	3,769,395	356,049	250	11			3,769,645	356,060
Dried, smoked, and dry salted ......pounds	75,018	7,263	22,775	1,662	1,778,764	208,050	1,876,557	216,975
Fertilizer.do	936,000	25,348	541,300	12,991			1,477,300	38,339
Oil.....gallons	28,014	11,854	24,990	9,996			53,004	21,850

Summary of persons engaged, investment, and products of the Alaska fisheries in 1926—Continued

Items	Southeast Alaska		Central Alaska		Western Alaska		Total	
	Number	Value	Number	Value	Number	Value	Number	Value
PRODUCTS—con.								
Halibut:								
Fresh..pounds..	4,518,507	$559,585					4,518,507	$559,585
Frozen....do....	8,357,726	948,094	1,514,164	$114,875			9,871,890	1,062,969
Herring:								
Fresh for bait ......pounds..	24,823	319	989,950	14,403			1,014,773	14,722
Frozen for bait ......pounds..	1,220,165	10,278					1,220,165	10,278
Pickled for food—								
Scotch cure ....pounds..	1,576,050	116,701	14,053,180	1,421,729			15,629,230	1,538,430
Norwegian cure.pounds..	19,400	7,761	15,300	1,460	120,800	$12,600	155,500	21,821
Kippered.do....	450	45					450	45
Spiced....do....	6,500	750					6,500	750
Dry salted ......pounds..	11,440	763					11,440	763
Meal or fertilizer.pounds..	21,699,635	619,400	1,009,246	27,591			22,708,881	646,991
Oil.....gallons..	2,857,299	1,273,765	108,372	46,924			2,965,671	1,320,689
Cod:								
Dry salted ......pounds..			752,280	37,142			752,280	37,142
Stockfish.do....			175,415	25,084			175,415	25,084
Tongues..do....			3,233	192			3,233	192
Frozen...do....	9,809	294					9,809	294
Pickled...do....			391,004	15,585			391,004	15,585
Fresh.....do....	973	20					973	20
Whale:								
Oil.....gallons..			408,400	245,041	593,550	356,130	1,001,950	601,171
Sperm oil.do....					5,150	2,060	5,150	2,060
Fertilizer ......pounds..			408,000	12,240	2,412,000	57,930	2,820,000	70,170
Whalebone ......pounds..			1,000	500	20,000	850	21,000	1,350
Pickled meat ......pounds..					101,278	5,063	101,278	5,063
Clams......cases..			38,422	254,236			38,422	254,236
Crabs:								
Canned...do....			25	300			25	300
Meat..pounds..	155,395	58,409	4,250	1,488			159,645	59,897
Whole in shell ....dozen..	1,133	1,349	35	70			1,168	1,419
Shrimp..pounds..	490,185	195,828					490,185	195,828
Trout:								
Fresh.....do....	39,585	5,511	2,097	414			41,682	5,925
Frozen....do....	10,595	921	31,917	3,378			42,512	4,299
Pickled...do....			400	32			400	32
Sablefish:								
Fresh.....do....	170,004	7,635					170,004	7,635
Frozen...do....	495,836	22,668					495,836	22,668
Pickled...do....	16,584	930					16,584	930
Rockfishes, frozen ....pounds..	16,857	511					16,857	511
Flounders, frozen ....pounds..	11,532	326					11,532	326
Smelt, frozen ....pounds..	14,228	1,707					14,228	1,707
Total......		23,144,668		17,239,724		14,285,490		[1] 54,669,882

[1] These figures represent the value of the manufactured product. It is estimated that the value of the catch to the fishermen was approximately $14,500,000. The round weight of the salmon catch landed by the fishermen was approximately 550,900,495 pounds, and the corresponding figures for herring were approximately 144,448,524 pounds. The cod figures given above do not include the offshore catch from waters adjacent to Alaska, which amounted to 7,697,085 pounds of dry-salted cod and 14,000 pounds of tongues, having a total value of $409,490, landed at ports of the Pacific Coast States.

SALMON

In 1926 the catch of salmon in Alaska as a whole showed an increase of nearly 51 per cent over that of 1925, due chiefly to the large run of humpback salmon in central Alaska and of reds in the western district. In southeastern Alaska the catch increased 4.3 per cent, in central Alaska it increased 116 per cent, and in western Alaska 143.8 per cent. There was a considerable increase for the whole of Alaska in the number of fathoms of seines and the number of traps operated, each increasing 17 per cent, while the number of fathoms of gill nets used decreased 13 per cent. The chief increase in the amount of gear occurred in southeastern Alaska. In the central district there was also a considerable increase, but in the western district there was a marked decrease in the amount of gear used, the number of fathoms of gill net (the chief form of apparatus used) being 20 per cent less than in 1925, while this district showed the largest percentage of gain in catch.

In southeastern Alaska operators are adopting more and more the use of floating fish traps in place of driven traps; in this section particularly there is a constant increase in the number of independent traps operated by other than salmon canneries, there being 95 in 1925 and 141 in 1926. For all of Alaska, out of a total of 639 traps used in the salmon industry in 1926, 486 were operated by salmon canneries and 153 by individuals and companies not operating canneries. The comparable total of these independent traps in 1925 was 120. The modified regulations effective in 1926 extended the lateral distance interval between traps in southeastern Alaska south of 58° north latitude from not less than 1,800 feet to a minimum of 1 statute mile. The lateral distance interval of not less than 1½ statute miles was continued in the southeastern area north of 58°.

CATCH AND APPARATUS

The total number of seines used in the salmon industry of Alaska in 1926 was 632, of which 157 were beach seines and 475 purse seines. The beach seines aggregated 18,320 fathoms of webbing and the purse seines 81,181 fathoms. The number of gill nets used was 2,955, having a total length of 296,564 fathoms. There were 254 driven traps and 385 floating traps—a total of 639.

Southeastern Alaska was accredited with 409 seines, or a total of 72,656 fathoms of webbing, an increase of 26 seines, or 7,589 fathoms, over the number in 1925; also with 184 gill nets, aggregating 25,050 fathoms, a reduction of 6 nets but an increase of 4,179 fathoms, when compared with the quantity used in the previous season; and with 114 driven and 367 floating traps, 44 fewer driven traps but 119 more floating traps than were operated in 1925.

Corresponding figures for central Alaska show 210 seines, or 24,045 fathoms, as compared with 125 seines, or 17,575 fathoms, in 1925; 993 gill nets, or 55,045 fathoms, as compared with 855 gill nets, or 47,484 fathoms, in 1925, an increase of 138 nets and 7,561 fathoms. The number of traps operated was 136 driven and 18 floating, as compared with 128 and 8, respectively, in 1925.

In western Alaska 13 seines, or 2,800 fathoms of webbing, were used, an increase over the number shown in 1925 of 3 seines, or 300 fathoms of webbing. A total of 1,778 gill nets was used, having an aggregate length of 216,469 fathoms, a decrease of 559 nets, or 56,077 fathoms in quantity of webbing used. Four driven traps were operated, the same number as in 1925.

Seines caught 22 per cent of the salmon taken in 1926, gill nets 23 per cent, and traps 53 per cent, while lines and wheels took the remaining 2 per cent.

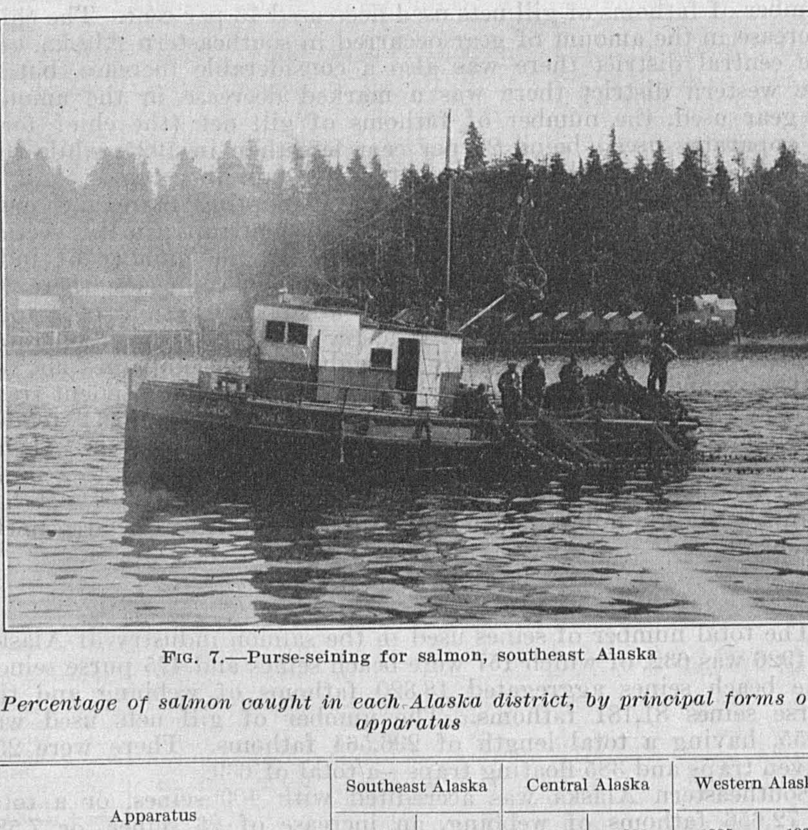

FIG. 7.—Purse-seining for salmon, southeast Alaska

Percentage of salmon caught in each Alaska district, by principal forms of apparatus

Apparatus	Southeast Alaska		Central Alaska		Western Alaska	
	1925	1926	1925	1926	1925	1926
Seines	32	24	42	32	3	5
Gill nets	2	1	4	3	91	91
Traps	64	73	54	65	2	1
Lines	2	2				
Wheels					4	3

The total catch of salmon in 1926 was 96,907,627, an increase of 32,661,236, or 50.8 per cent, over the number taken in 1925. Southeastern Alaska showed a gain of 1,716,301, while central Alaska gained 17,558,328 and western Alaska 13,386,607. The catch by species shows that cohos increased 181,228, humpbacks 18,213,799, and reds 15,163,829, while chums decreased 669,642, and kings 227,978.

Salmon taken in 1926, by apparatus and species, in each geographic section of Alaska

Apparatus and species	Southeast Alaska	Central Alaska	Western Alaska	Total
Seines:				
Coho, or silver	128,141	128,422		256,563
Chum, or keta	3,101,172	794,349	59,629	3,955,150
Humpback, or pink	6,546,197	7,190,857	515,841	14,252,895
King, or spring	1,503	509	17,406	19,418
Red, or sockeye	362,385	2,213,851	503,037	3,079,273
Total	10,139,398	10,327,988	1,095,913	21,563,299
Gill nets:				
Coho, or silver	166,317	245,792	15,337	427,446
Chum, or keta	63,066	25,160	923,468	1,011,694
Humpback, or pink	36,494	121,898	288,041	446,433
King, or spring	17,679	41,802	80,944	140,425
Red, or sockeye	250,082	654,891	19,423,727	20,328,700
Total	533,638	1,089,543	20,731,517	22,354,698
Traps:				
Coho, or silver	493,617	588,197		1,081,814
Chum, or keta	2,829,926	2,330,751	15,364	5,176,041
Humpback, or pink	25,363,662	12,895,461		38,259,123
King, or spring	15,147	52,321	6,519	73,987
Red, or sockeye	1,420,135	5,399,724	161,667	6,981,526
Total	30,122,487	21,266,454	183,550	51,572,491
Lines:				
Coho, or silver	390,318			390,318
Chum, or keta	5,473			5,473
Humpback, or pink	2,191			2,191
King, or spring	330,296			330,296
Red, or sockeye	903			903
Total	729,181			729,181
Wheels:				
Coho, or silver			2,000	2,000
Chum, or keta			660,947	660,947
King, or spring			24,511	24,511
Red, or sockeye			500	500
Total			687,958	687,958
Total:				
Coho, or silver	1,178,393	962,411	17,337	2,158,141
Chum, or keta	5,999,637	3,150,260	1,659,408	10,809,305
Humpback, or pink	31,948,544	20,208,216	803,882	52,960,642
King, or spring	364,625	94,632	129,380	588,637
Red, or sockeye	2,033,505	8,268,466	20,088,931	30,390,902
Grand total	41,524,704	32,683,985	22,698,938	96,907,627

CANNING

CHANGES IN CANNERIES

The Haines Packing Co. reopened its plant at Letnikof Cove, which had been closed in 1925. The Stuart Corporation took over the Northland Packing Co., which operated the plant of the Sunrise Packing Co. at Ketchikan in 1925. The Stuart Corporation also operated its floating plant at Ketchikan. The Sunny Point Packing Co. purchased all of the property of the Sanborn-Cutting Co. at Kake and of the Thlinket Packing Co. at Funter Bay, and operated the plants in 1926. The sale by the Thlinket Packing Co. of its plant at Funter Bay, which had been operated since 1902, marks the retirement of one of the oldest and best known concerns in the southeast Alaska canning industry.

The International Packing Co., which in 1925 brought its floating cannery into the central district after the discontinuance of operations in western Alaska, confined its activities to Ugashik waters and Makushin Bay in 1926. Pajoman and Trout built a new plant at Iron Creek on Raspberry Island in 1926, with the intention of installing cannery machinery, but leased it for herring operations instead. L. J. Hull and I. M. Foster, of the Alitak Packing Co., acquired the interest of Capt. John T. Jones in the Robinson Packing Co., which operates the floating cannery *Azalea* in Zachar Bay, but continued to operate under the same name. The floating plant of the Orca Packing Co. was operated at Pete Dahl Slough on Copper River flats during the early part of the season and later was taken

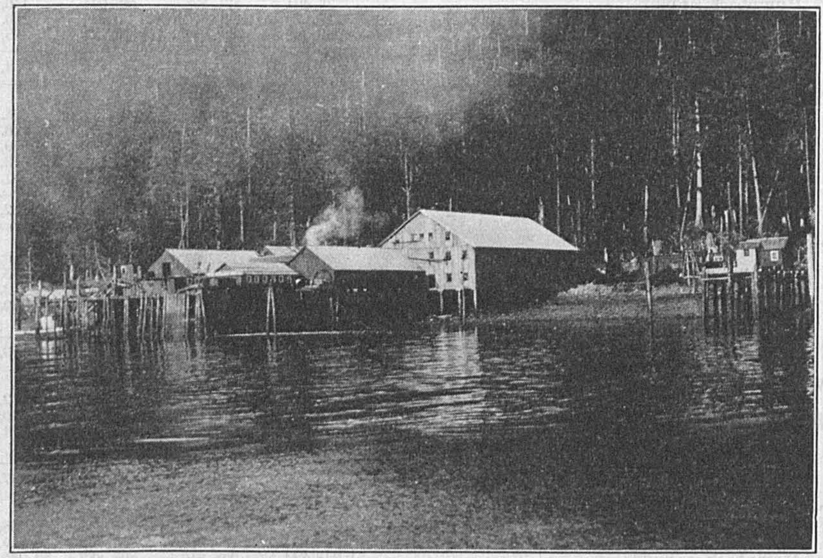

FIG. 8.—Salmon cannery, southeast Alaska

to Cordova for the humpback and silver salmon runs. The plants of the Unakwik Inlet Packing Co. at Unakwik Inlet and the Hemrich Packing Co. at Kukak Bay were again leased and operated by the Pacific American Fisheries and the Seashore Packing Co., respectively, in 1926.

NEW CANNERIES

A new one-line cannery was built and operated at Nakat Inlet in southeastern Alaska by the Tongass Packing Co., which formerly operated salmon traps in the district under the name of the Tongass Fish Co.

Six salmon canneries were operated for the first time in the central district in 1926. A new plant was that of J. A. Magill, at Anchorage, operating under the name of the Alaska General Fisheries. The Cordova Packing Co. prepared a pack of canned salmon at its clam cannery, which was formerly the salmon cannery of the Hillery Scott Co. The Crosby Fisheries (Inc.) purchased the steamer *H. B. Lovejoy*, renamed it *Salmon King*, and equipped it as a floating salmon cannery, which was operated at Chignik and in two localities on Kodiak Island during the season. The Kodiak Fisheries Co. built a new cannery on Shearwater Bay, Kadiak Island, and the San Juan Fishing and Packing Co. put a line of salmon-canning machinery in its herring plant at Uganik Bay. The Strawberry Point Packing Co. enlarged its clam cannery at Boswell Bay and installed additional machinery for the canning of salmon.

CANNERIES NOT OPERATED

The Alaska Herring & Sardine Co. did not operate its salmon cannery at Port Walter in 1926. The plant of the Beauclaire Packing Co. at Port Beauclerc was burned just before the opening of the canning season, and the plant of the Hoonah Packing Co. at Gambier Bay was closed in 1926.

The Arctic Packing Co. is being dropped from the list of idle plants because of the improbability of its being reopened. The Bainbridge Fisheries Co., at Flemming Island, and the Kamishak Packing Co., at Kamishak Bay, are being dropped, as it is reported that plants no longer exist at these locations.

Two plants of the Alaska Packers Association—one on the Naknek River and one on Nushagak Bay—were closed in 1926.

The following canneries were closed during the season of 1926 but may be reopened:

Southeastern Alaska:	
Alaska Herring & Sardine Co	Port Walter.
Alaska Sanitary Packing Co	Cape Fanshaw.
Hoonah Packing Co	Hoonah. Gambier Bay.
Northwestern Fisheries Co	Roe Point. Santa Ana.
Central Alaska:	
Alaska Packers Association	Kasilof.
Kodiak Island Fishing & Packing Co	Seward.
Northwestern Fisheries Co	Seldovia. Orca.
Pajoman and Trout	Raspberry Island.
Western Alaska:	
Alaska Packers Association	Naknek River. Nushagak Bay.
Alaska Salmon Co	Kvichak Bay.
Fidalgo Island Packing Co	Herendeen Bay.
Nelson Lagoon Packing Co	Nelson Lagoon.
Phoenix Packing Co	Herendeen Bay.

TOTAL CANNERIES OPERATED

There were 132 canneries operated in Alaska in 1926—61 in southeastern, 43 in central, and 28 in western—which was 1 less in southeastern, 6 more in central, and 2 less in western than in 1925, a net gain of 3 plants.

Companies that canned salmon in Alaska, number and location of canneries operated, and number of traps owned by each, 1926

[New canneries indicated by (*)]

Company	Canneries		Traps		
	Number	Location	Driven	Floating	Total
Southeast Alaska:					
Alaska Consolidated Canneries	6	Boca de Quadra	2	3	5
		Chomly	2	3	5
		Pybus Bay	2	3	5
		Rose Inlet	2	6	8
		Tenakee	1	8	9
		Yes Bay	2	6	8
Alaska Packers Association	2	Loring	3	2	5
		Wrangell		8	8
Annette Island Packing Co.	1	Metlakatla	5	3	8
Astoria & Puget Sound Canning Co.	1	Excursion Inlet	3	4	7
F. C. Barnes Co.	1	Lake Bay	1	3	4
Bayview Packing Co.	1	Bay View (Klawak)			
Beegle Packing Co.	1	Ketchikan	1	6	7
Burnett Inlet Packing Co.	1	Burnett Inlet		5	5
Deep Sea Salmon Co.	1	Port Althorp		17	17
Charles W. Demmert Packing Co	1	Bay View (Klawak)		2	2
Douglas Island Packing Co.	1	Douglas			
Fidalgo Island Packing Co.	2	Bay of Pillars	5		5
		Ketchikan	4	2	6
George Inlet Packing Co.	1	George Inlet	1	3	4
Haines Packing Co.	1	Letnikof Cove			
P. E. Harris & Co.	1	Hawk Inlet		7	7
Hetta Packing Co.	1	Coppermount			
Hidden Inlet Canning Co.	1	Hood Bay		5	5
Karheen Packing Co.	1	Karheen	4	2	6
Libby, McNeill & Libby	3	Ketchikan (floating)		2	2
		Taku Harbor	12	2	14
		Yakutat			
Mountain Point Packing Co.	1	Wrangell Narrows		2	2
Geo. T. Myers & Co.	1	Chatham	4		4
Nakat Packing Corporation	4	Hecota Island		9	9
		Hidden Inlet	1	9	10
		Union Bay		7	7
		Waterfall		10	10
New England Fish Co.	2	Ketchikan		1	1
		Noyes Island		6	6
North Pacific Trading & Packing Co.	1	Klawak		6	6
Northwestern Fisheries Co.	5	Boca de Quadra	3	3	6
		Dundas Bay		4	4
		Hunter Bay		5	5
		Kasaan	3	3	6
		Shakan	2	3	5
Pacific American Fisheries	1	Excursion Inlet	5	4	9
Petersburg Packing Co.	1	Petersburg	4	7	11
Point Warde Fisheries	1	Point Warde		2	2
Pure Food Fish Co.	1	Ketchikan	3		3
Pyramid Packing Co.	1	Sitka		6	6
Red Salmon Packers Association	1	Dry Bay and Situk River (floating).			
Sea-Coast Packing Co.	1	Craig		7	7
Sebastian Stuart Fish Co.	1	Tyee	2	3	5
J. L. Smiley & Co.	1	Ketchikan	4	8	12
Starr-Collinson Packing Co.	1	Moira Sound		4	4
Straits Packing Co.	1	Skowl Arm			
Stuart Corporation, The	2	Ketchikan (Pioneer plant), floating.			
		Ketchikan (Sunrise plant)	1	6	7
Sunny Point Packing Co.	3	Funter Bay		9	9
		Kake		10	10
		Ketchikan	5	7	12
Superior Fisheries Co.	1	Tenakee	4	1	5
Tongass Packing Co.	1	Nakat Inlet *		3	3
Ward's Cove Packing Co.	1	Ward Cove	1	1	2
Central Alaska:					
Alaska General Fisheries	1	Anchorage *	2		2
Alaska Packers Association	3	Alitak	2		2
		Chignik	3		3
		Karluk	2		2
Alaska Year Round Canneries Co.	1	Seldovia	5		5
Alitak Packing Co.	1	Lazy Bay	3		3
Carlisle Packing Co.	1	Cordova	5		5

Companies that canned salmon in Alaska, number and location of canneries operated, and number of traps owned by each, 1926—Continued

[New canneries indicated by (*)]

Company	Canneries		Traps		
	Number	Location	Driven	Floating	Total
Central Alaska—Continued.					
Columbia River Packers Association	1	Chignik	4		4
Cook Inlet Packing Co	1	Seldovia	6		6
Copper River Packing Co	1	McClure Bay	2	4	6
Cordova Packing Co	1	Cordova *			
Crosby Fisheries (Inc.)	1	Chignik and Kodiak Island (floating) *			
Emel Packing Co	1	Valdez	3		3
Fidalgo Island Packing Co	1	Port Graham	7		7
Gorman & Co	2	Anchorage	8		8
		Drier Bay		2	2
P. E. Harris & Co	1	Isanotski Strait	4		4
Hoonah Packing Co	1	Bering River			
Kadiak Fisheries Co	2	Kodiak		4	4
		Shearwater Bay *			
Katmai Packing Co	1	Uzinki			
W. A. Keller	1	Deep Creek	1		1
Kodiak Island Fishing & Packing Co.	1	Uganik Bay			
Libby, McNeill & Libby	1	Kenai	18		18
Moore Packing Co	1	Orca Inlet	2		2
North Coast Packing Co	1	Ninilchik	5		5
Northern Light Packing Co	1	Mountain Slough			
Northwestern Fisheries Co	3	Chignik	3		3
		Kenai	9		9
		Uyak			
Orca Packing Co	1	Cordova (floating)			
Pacific American Fisheries	3	Ikatan	5		5
		King Cove	9		9
		Unakwik Inlet		2	2
Pioneer Packing Co	1	Cordova		4	4
Pioneer Sea Foods Co	1	do		1	1
Robinson Packing Corporation	1	Zachar Bay			
San Juan Fishing & Packing Co.	2	Evans Bay	9		9
		Uganik Bay *	1		1
Seashore Packing Co	1	Kukak Bay			
Shepard Point Packing Co	1	Shepard Point	1	3	4
Shumagin Packing Co	1	Squaw Harbor	3		3
Strawberry Point Packing Co	1	Boswell Bay *			
Western Alaska:					
Alaska Packers Association	7	Egegik River			
		Kvichak Bay (2)			
		Naknek River (2)			
		Nushagak Bay			
		Ugashik River			
Alaska Portland Packers Association.	2	Naknek River			
		Nushagak Bay			
Alaska Salmon Co	1	Wood River			
Bristol Bay Packing Co	1	Kvichak Bay			
Carlisle Packing Co	1	Kvichak River			
Columbia River Packers Association.	1	Nushagak Bay			
Everett Packing Co	1	Herendeen Bay			
International Packing Co	1	Ugashik River and Makushin Bay (floating).			
Libby, McNeill & Libby	6	Egegik River			
		Ekuk			
		Koggiung			
		Libbyville			
		Lockanok			
		Nushagak			
Nakat Packing Corporation, The	1	Nakeen			
Naknek Packing Co	1	Naknek River			
Northwestern Fisheries Co	2	do			
		Nushagak			
Pacific American Fisheries	1	Port Moller	4		4
Red Salmon Canning Co	2	Naknek River			
		Ugashik River			

LOSSES AND DISASTERS

The Beauclaire Packing Co. cannery at Port Beauclerc burned on June 3. It was reported to have been a total loss, with the exception of a few shore buildings. Other losses in southeastern Alaska were the power boats *Buster*, of the Sunny Point Packing Co., and *Discovery*, of the Fidalgo Island Packing Co., the mess house of the Wards Cove Packing Co., and miscellaneous fishing equipment and small boats belonging to a number of companies, in all totaling approximately $95,000. Seventeen lives were lost—6 shoresmen by disease and 2 each by drowning and by accidents, 3 fishermen were drowned, 3 were killed in accidents, and 1 died of disease.

In the central district the new plant of the Kadiak Fisheries Co. at Shearwater Bay was wrecked by a windstorm after the end of the fishing season. The loss was estimated at $24,000. The salmon and

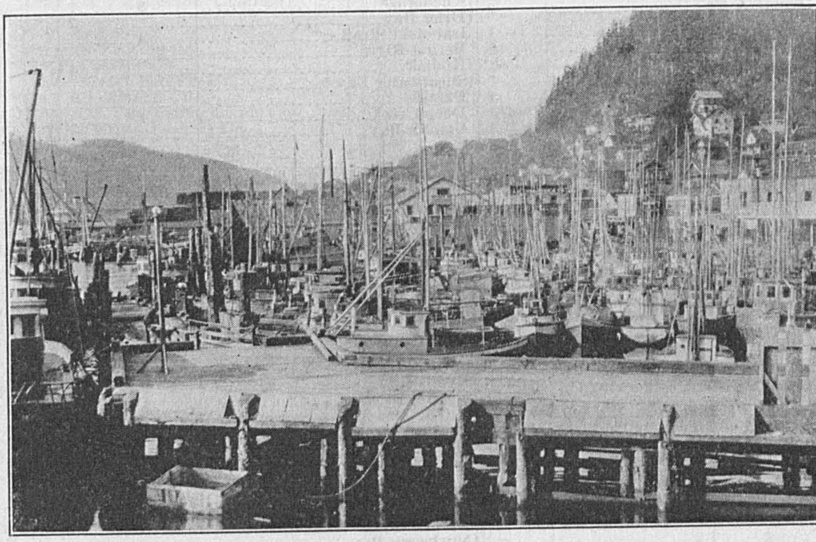

FIG. 9.—Fleet of fishing boats at Ketchikan, Alaska

clam cannery of the Strawberry Point Packing Co. at Cordova was burned on October 18, with a loss of approximately $21,500. Other losses in the district consisted of the gas boat *Uncle John*, belonging to the Moore Packing Co., and miscellaneous small boats and fishing equipment of a number of companies, totaling in all approximately $57,900. Thirteen lives were lost—1 fisherman and 2 shoresmen were drowned and 1 fisherman and 9 shoresmen died of disease.

In the western district fishing gear valued at $9,547 was lost and 19 lives were lost—1 fisherman and 4 shoresmen drowned, 1 fisherman and 9 shoresmen died of disease, and 1 fisherman and 3 shoresmen were killed accidentally.

STATISTICS

In 1926, 132 canneries were operated in Alaska, 3 more than in 1925. The active investment in the industry was $60,535,550, a gain of $6,992,006, or 13 per cent, over 1925. The increase in southeast Alaska was $949,285, or 3.7 per cent; in central Alaska $3,787,122, or 31.7 per cent; and in western Alaska $2,255,599, or 14 per cent.

Employment was given to 21,906 persons, as compared with 21,805 in 1925, an increase of 101. White employees increased 80, natives 340, Filipinos 376, Negroes 9, and miscellaneous (including Kanakas) 14, while Chinese decreased 131, Japanese 5, Porto Ricans 130, and Mexicans 452.

The total pack of canned salmon was 6,652,882 cases, valued at $46,080,004. This was an increase of 2,192,945 cases, or 49 per cent, and an increase in value of $14,090,473, or 44 per cent. The output in southeastern Alaska increased from 2,802,414 cases to 3,058,055, or 9 per cent; central Alaska from 1,052,593 cases to 2,146,485, or 104 per cent; and western Alaska from 604,930 cases to 1,448,342, or 139 per cent. The increase was attributable to the large run of reds in western Alaska, combined with the immense run of humpbacks in central Alaska. In Alaska as a whole the pack of reds increased from 1,059,676 cases to 2,157,087, or 103.6 per cent; kings from 49,978 cases to 52,476, or 5 per cent; humpbacks from 2,110,593 cases to 3,338,349, or 58 per cent; and cohos from 161,010 cases to 202,527, or 25.8 per cent. The only decrease was in the pack of chums, of which species 902,443 cases were packed, as against 1,078,680 in 1925, a decrease of 176,237 cases, or 16.3 per cent.

Persons engaged in the Alaska salmon-canning industry in 1926

Occupation and race	Southeast Alaska	Central Alaska	Western Alaska	Total
Fishermen:				
Whites	1,367	962	2,031	4,360
Natives	1,329	319	75	1,723
Japanese		1		1
Filipinos	16			16
Mexicans	6			6
Kanakas	4			4
Miscellaneous [1]	1			1
Total	2,723	1,282	2,106	6,111
Shoresmen:				
Whites	2,362	1,365	1,821	5,548
Natives	1,436	649	215	2,300
Chinese	377	311	424	1,112
Japanese	658	548	275	1,481
Filipinos	1,383	653	548	2,584
Mexicans	145	85	816	1,046
Porto Ricans	8	3	9	20
Kanakas	29	21	10	60
Negroes	7	33	215	255
Miscellaneous [1]	17	1	25	43
Total	6,422	3,669	4,358	14,449
Transporters:				
Whites	706	384	120	1,210
Natives	44	31		75
Chinese	5			5
Japanese	14	28	1	43
Filipinos	5	1		6
Negroes	1	1	4	6
Miscellaneous [1]	1			1
Total	776	445	125	1,346
Total:				
Whites	4,435	2,711	3,972	11,118
Natives	2,809	999	290	4,098
Chinese	382	311	424	1,117
Japanese	672	577	276	1,525
Filipinos	1,404	654	548	2,606
Mexicans	151	85	816	1,052
Porto Ricans	8	3	9	20
Kanakas	33	21	10	64
Negroes	8	34	219	261
Miscellaneous [1]	19	1	25	45
Grand total	9,921	5,396	6,589	21,906

[1] Hawaiians, Koreans, etc.

Investment in the Alaska salmon-canning industry in 1926

Items	Southeast Alaska		Central Alaska		Western Alaska		Total	
	Number	Value	Number	Value	Number	Value	Number	Value
Plants operated	61	$6, 252, 982	43	$3, 866, 646	28	$5, 872, 153	132	$15,991,781
Operating capital		9, 252, 959		5, 962, 332		4, 678, 135		19, 893, 426
Wages paid		4, 135, 858		2, 976, 136		4, 004, 284		11, 116, 278
Vessels:								
Power, over 5 tons	412	2, 794, 340	109	1, 364, 773	90	2, 070, 617	611	6, 229, 730
Net tonnage	7, 893		5, 423		23, 717		37, 033	
Sailing	2	90, 000	3	125, 000	5	226, 000	10	441, 000
Net tonnage	3, 750		5, 865		9, 450		19, 065	
Barges	3	25, 000					3	25, 000
Net tonnage	1, 620						1, 620	
Launches	216	268, 083	191	232, 298	34	81, 307	441	581, 688
Seine boats	155	13, 064	99	11, 777	5	300	259	25, 141
Gill net boats	67	3, 187	75	17, 990	1, 116	477, 127	1, 258	498, 304
Rowboats and skiffs	1, 129	55, 801	567	32, 206	137	10, 452	1, 833	98, 459
Lighters and scows	379	396, 760	214	189, 246	161	369, 331	754	955, 337
House boats	49	31, 537	4	3, 665	31	74, 105	84	109, 307
Pile drivers	66	431, 548	34	188, 579	21	66, 216	121	686, 343
Pile pullers	8	59, 624					8	59, 624
Apparatus:								
Purse seines	401	312, 056	63	19, 847	10	11, 500	474	343, 403
Fathoms	71, 936		6, 645		2, 500		81, 081	
Beach seines	8	1, 152	117	38, 542	3	1, 000	128	40, 694
Fathoms	720		15, 455		300		16, 475	
Gill nets	183	42, 772	984	71, 475	1, 577	270, 088	2, 744	384, 335
Fathoms	24, 900		54, 560		206, 100		285, 560	
Traps, driven	114	881, 848	134	576, 493	4	20, 000	252	1, 478, 341
Traps, floating	367	1, 526, 354	18	51, 005			385	1, 577, 359
Total		26, 574, 925		15, 728, 010		18, 232, 615		60, 535, 550

Output and value of canned salmon in Alaska in 1926 [1]

Product	Southeast Alaska		Central Alaska		Western Alaska		Total	
	Cases	Value	Cases	Value	Cases	Value	Cases	Value
Coho, or silver:								
½-pound flat	4, 280	$58, 905	6, 074	$58, 452			10, 354	$117, 357
1-pound flat	5, 328	55, 009	11, 297	101, 264			16, 625	156, 273
1-pound tall	86, 781	724, 475	86, 938	688, 412	1, 829	$14, 046	175, 548	1, 426, 933
Total	96, 389	838, 389	104, 309	848, 128	1, 829	14, 046	202, 527	1, 700, 563
Chum, or keta:								
½-pound flat	1, 058	7, 621	309	1, 854			1, 367	9, 475
1-pound flat	551	2, 755	48, 431	261, 527			48, 982	264, 282
1-pound tall	616, 788	3, 076, 825	195, 068	969, 966	40, 238	198, 381	852, 094	4, 245, 172
Total	618, 397	3, 087, 201	243, 808	1, 233, 347	40, 238	198, 381	902, 443	4, 518, 929
Humpback, or pink:								
½-pound flat	39, 832	345, 855	20, 003	145, 678			59, 835	491, 533
1-pound flat	3, 810	24, 030	78, 351	454, 591			82, 161	478, 621
1-pound tall	2, 115, 057	11, 301, 223	1, 045, 826	5, 541, 094	35, 470	175, 056	3, 196, 353	17, 017, 373
Total	2, 158, 699	11, 671, 108	1, 144, 180	6, 141, 363	35, 470	175, 056	3, 338, 349	17, 987, 527
King, or spring:								
½-pound flat	1, 534	22, 180	1, 790	28, 404			3, 324	50, 584
1-pound flat	5, 148	60, 694	5, 702	67, 665	275	2, 750	11, 125	131, 109
1-pound tall	3, 997	34, 405	16, 191	158, 746	17, 839	169, 402	38, 027	362, 553
Total	10, 679	117, 279	23, 683	254, 815	18, 114	172, 152	52, 476	544, 246
Red, or sockeye:								
½-pound flat	33, 558	485, 380	29, 707	464, 643	18, 916	299, 645	82, 181	1, 249, 668
1-pound flat	19, 838	247, 302	76, 966	832, 013	7, 525	85, 628	104, 329	1, 164, 943
1-pound tall	120, 495	1, 196, 107	523, 832	5, 144, 030	1, 326, 250	12, 573, 991	1, 970, 577	18, 914, 128
Total	173, 891	1, 928, 789	630, 505	6, 440, 686	1, 352, 691	12, 959, 264	2, 157, 087	21, 328, 739
Grand total	3, 058, 055	17, 642, 766	2, 146, 485	14, 918, 339	1, 448, 342	13, 518, 899	6, 652, 882	46, 080, 004

[1] Cases containing ½-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 forty-eight 1-pound cans to the case.

Output of canned salmon in Alaska, in cases, 1921 to 1926[1]

Product	1921	1922	1923	1924	1925	Average for 5-year period, 1921–1925	1926	Percentage of increase or decrease in 1926, as compared with 5-year average
Coho, or silver:								
½-pound flat	4,084	22,237	13,866	8,059	7,145	11,078	10,354	−6.54
1-pound flat	7,918	12,099	10,151	5,403	7,223	8,559	16,625	+94.24
1-pound tall	94,553	141,657	140,090	170,139	146,642	138,616	175,548	+26.64
Total	106,555	175,993	164,107	183,601	161,010	158,253	202,527	+27.98
Chum, or keta:								
½-pound flat	608	3,698	6,356	346	3,051	2,812	1,367	−51.39
1-pound flat	-------	6,185	16	630	-------	1,366	48,982	+3,485.80
1-pound tall	254,887	556,035	519,250	1,027,512	1,075,629	686,663	852,094	+24.09
Total	255,495	565,918	525,622	1,028,488	1,078,680	690,841	902,443	+30.63
Humpback, or pink:								
½-pound flat	1,292	42,736	29,363	21,365	34,005	25,752	59,835	+132.35
1-pound flat	-------	30,879	9,428	13,095	185	10,717	82,161	+666.64
1-pound tall	422,692	1,584,808	2,409,338	2,566,823	2,076,403	1,812,013	3,196,353	+76.40
Total	423,984	1,658,423	2,448,129	2,601,283	2,110,593	1,848,482	3,338,349	+80.60
King, or spring:								
½-pound flat	4,061	3,770	5,466	1,501	2,755	3,511	3,324	−5.33
1-pound flat	19,192	3,967	7,281	9,500	8,828	9,754	11,125	+14.06
1-pound tall	21,741	22,923	25,596	22,647	38,395	26,260	38,027	+44.81
Total	44,994	30,660	38,343	33,648	49,978	39,525	52,476	+32.77
Red, or sockeye:								
½-pound flat	60,831	171,896	121,775	31,947	68,901	91,070	82,181	−9.76
1-pound flat	71,108	121,449	159,271	110,352	28,757	98,187	104,329	+6.26
1-pound tall	1,633,859	1,777,313	1,578,450	1,305,596	962,018	1,451,447	1,970,577	+35.77
Total	1,765,798	2,070,658	1,859,496	1,447,895	1,059,676	1,640,705	2,157,087	+31.47
Grand total	2,596,826	4,501,652	5,035,697	5,294,915	4,459,937	4,377,805	6,652,882	+51.97

[1] The number of cases shown has been put upon the common basis of forty-eight 1-pound cans per case.

Relative importance of each species of canned salmon within each district in 1926

District	Coho	Chum	Humpback	King	Red	Total, all species
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Southeast Alaska	3.2	20.2	70.6	0.3	5.7	100
Central Alaska	4.9	11.3	53.3	1.1	29.4	100
Western Alaska	.1	2.8	2.4	1.3	93.4	100
All Alaska	3.0	13.6	50.2	.8	32.4	100

Relative importance of each district in the production of each species of salmon canned in 1926

District	Coho	Chum	Hump-back	King	Red	Total, all species
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Southeast Alaska	47.6	68.5	64.7	20.4	8.1	46.0
Central Alaska	51.5	27.0	34.3	45.1	29.2	32.2
Western Alaska	.9	4.5	1.0	34.5	62.7	21.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

Average annual price per case of forty-eight 1-pound cans of salmon, 1916 to 1926

Product	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926
Coho, or silver	$5.34	$8.76	$9.15	$11.27	$9.13	$5.63	$5.47	$5.74	$6.83	$9.72	$8.40
Chum, or keta	3.34	6.14	6.27	6.82	4.19	3.68	3.98	4.65	4.68	4.44	5.01
Humpback, or pink	3.64	6.44	6.58	8.35	5.47	4.21	4.34	4.86	4.93	5.28	5.39
King, or spring	5.36	10.40	9.85	13.13	10.97	10.22	8.08	8.56	8.89	11.91	10.37
Red, or sockeye	6.04	9.48	9.44	12.98	13.05	8.96	9.24	9.27	9.53	13.12	9.89

PACK IN CERTAIN DISTRICTS

Statistics of the salmon pack are again presented for subdivisions of the three main districts of Alaska, and comparison is made with similar statistics for 1925. These districts are described as follows:

Bristol Bay.—The Bering Sea shore, east and north of the Ugashik River.

Port Moller and Herendeen Bay.—Port Moller, Herendeen Bay, and Nelson Lagoon.

Ikatan-Shumagin Islands.—False Pass, Ikatan Bay, King Cove, and the Shumagin Islands.

Chignik.—Canneries located at Chignik.

Kodiak-Afognak Islands.—Kodiak, Spruce, and Raspberry Islands.

Cook Inlet.—The shores of Cook Inlet.

Prince William Sound.—Extends from Resurrection Bay to Point Whitshed, except that the pack of fish taken in the Copper River district by canneries at and near Cordova is omitted.

Copper and Bering Rivers.—Extends from Point Whitshed to Bering River and includes the pack by canneries at Cordova from fish not credited to Prince William Sound.

Yakutat and Dry Bay.—Extends from Yakutat Bay to and including Dry Bay.

Icy Strait Lynn Canal.—West coast of Baranof and Chichagof Islands, the shores of Cross Sound, Icy Strait, Lynn Canal, and Stephens Passage, south to Taku Harbor. Only part of the pack at Taku Harbor is credited to this district, as some of it originated elsewhere.

Chatham Strait-Frederick Sound.—Includes part of the Taku cannery pack and the Petersburg Packing Co.'s pack, in addition to the packs of all canneries on both shores of Chatham Strait and its bays from Point Augusta to Cape Ommaney, and through Frederick Sound and its bays northward to Taku Harbor, including Kake.

Sumner Strait–Dixon Entrance.—Extends southward from Petersburg and eastward from Port Beauclerc to Cape Chacon and Dixon Entrance, and includes all canneries on the mainland and intervening islands from the Stikine River to Portland Canal.

West coast, Prince of Wales Island.—Territory west and south of a line from Cape Chacon to Point Baker and Cape Ommaney.

Pack of canned salmon in Alaska in 1926, by districts [1]

District	Coho	Chum	Humpback	King	Red	Total	Percentage of increase or decrease from 1925
	Cases	*Cases*	*Cases*	*Cases*	*Cases*	*Cases*	
Bristol Bay	1,829	34,500	13,271	14,477	1,300,752	1,364,829	+140.13
Port Moller and Herendeen Bay		5,378		3,637	51,916	60,931	+72.99
Ikatan-Shumagin Islands	19,492	118,062	227,757	2,176	197,488	564,975	+187.13
Chignik	3,466	25,727	35,765	141	44,203	109,302	+37.46
Kodiak-Afognak Islands	18,335	33,324	252,907	123	230,009	534,698	+76.51
Cook Inlet	18,922	7,117	31,240	14,541	122,053	193,873	+74.93
Prince William Sound	11,457	59,938	618,698	125	15,094	705,312	+120.76
Copper and Bering Rivers	32,637		12	6,577	21,681	60,907	+37.22
Yakutat and Dry Bay	19,419	218	7,851	5,116	15,620	48,224	+37.05
Icy Strait-Lynn Canal	17,902	122,898	328,242	1,974	69,341	540,357	+61.78
Chatham Strait-Frederick Sound	7,960	182,040	419,404	398	11,807	621,609	+37.70
Sumner Strait-Dixon Entrance	37,526	219,532	1,086,381	2,981	70,233	1,416,653	−8.59
West coast, Prince of Wales Island	13,582	93,709	316,821	210	6,890	431,212	−.18
Total	202,527	902,443	3,338,349	52,476	2,157,087	6,652,882	+49.17

[1] Pack reduced to the basis of forty-eight 1-pound cans per case.

FIG. 10.—Drift gill-net fisherman at Taku, southeast Alaska

MILD CURING

In 1926 the salmon mild-cure industry of Alaska was maintained at about the level of production of the previous year. The industry gave employment to 1,549 persons (1,280 whites and 269 natives), or 14 more than the number employed in 1925. The investment of $1,433,512, which was almost wholly in the southeastern district, was $64,913 less than in 1925.

The total output of mild-cured salmon in 1926 was 4,569,600 pounds, valued at $1,070,316, as compared with 5,217,600 pounds, valued at $1,085,466 in 1925, a decrease of 648,000 pounds in quantity, with a decrease in value of only $15,150. The pack consisted of 738,400 pounds of cohos, 76,000 pounds of humpbacks, 800 pounds of sockeyes, and 3,754,400 pounds of kings. In units of 800-pound tierces, the pack consisted of 923 tierces of cohos, 95 tierces of humpbacks, 1 tierce of reds, and 4,693 tierces of kings.

Persons engaged, investment, and products of Alaska salmon mild-curing industry in 1926

Items	Southeast Alaska		Central Alaska		Total	
	Number	Value	Number	Value	Number	Value
PERSONS ENGAGED						
Fishermen:						
Whites	1,202		4		1,206	
Natives	260				260	
Total	1,462		4		1,466	
Shoresmen:						
Whites	47				47	
Natives	9				9	
Total	56				56	
Transporters: Whites	27				27	
Grand total	1,545		4		1,549	
INVESTMENT						
Plants operated	12	$8,378	1	$500	13	$8,878
Operating capital		422,724		2,000		424,724
Vessels:						
Power, over 5 tons	23	119,300			23	119,300
Net tonnage	458				458	
Launches	802	805,000	1	500	803	805,500
Row boats	301	10,550	2	210	303	10,760
Lighters and scows	3	3,350			3	3,350
Apparatus:						
Gill nets (150 fathoms)	1	150			1	150
Trap (driven)			1	650	1	650
Lines	6,020	60,200			6,020	60,200
Total		1,429,652		3,860		1,433,512
PRODUCTS (POUNDS)						
Coho, or silver	738,400	105,118			[1] 738,400	105,118
Humpback, or pink			76,000	5,250	[2] 76,000	5,250
King, or spring	[3] 3,641,600	937,249	[4] 112,800	22,649	[5] 3,754,400	959,898
Red, or sockeye			800	50	[6] 800	50
Total	4,380,000	1,042,367	189,600	27,949	4,569,600	1,070,316

[1] 923 tierces.
[2] 95 tierces.
[3] 4,552 tierces.
[4] 141 tierces.
[5] 4,693 tierces.
[6] 1 tierce.

PICKLING

The pickled-salmon industry, which is carried on chiefly in western Alaska, showed a considerable increase over recent years. This was due primarily to the larger run of red salmon in the central and western districts. The Westward Packing Co.'s floating saltery, which was reported sold at the end of the 1925 season, again operated in Bristol Bay in 1926. Both central and western Alaska showed increases in the investment in the industry.

Fewer persons were reported engaged in the industry, but the total investment increased from $203,000 in 1925 to $256,333 in 1926. Products in southeastern Alaska declined from 94,900 pounds in 1925 to 56,800 pounds in 1926, while central Alaska increased from 229,200 pounds to 460,500 pounds and western Alaska increased from 305,500 pounds to 1,096,300 pounds. The total output in 1926 was 1,613,600 pounds, valued at $173,680, as compared with 629,600 pounds in 1925, valued at $84,731, an increase in 1926 of 156 per cent in quantity and 105 per cent in value.

Persons engaged, investment, and products of Alaska salmon-pickling industry in 1926

Items	Southeast Alaska		Central Alaska		Western Alaska		Total	
	Number	Value	Number	Value	Number	Value	Number	Value
PERSONS ENGAGED								
Fishermen:								
Whites			21		34		55	
Natives			14				14	
Total			35		34		69	
Shoresmen:								
Whites			1		19		20	
Natives					13		13	
Total			1		32		33	
Grand total			36		66		102	
INVESTMENT								
Plants operated			6	$14,650	3	$104,125	9	$118,775
Operating capital				17,008		68,690		85,698
Vessels:								
Power, over 5 tons			2	11,000			2	11,000
Net tonnage			45				45	
Launches			17	13,100	1	300	18	13,400
Gill net boats					19	10,950	19	10,950
Rowboats			40	2,455	3	300	43	2,755
Lighters and scows			3	950	1	1,500	4	2,450
Apparatus:								
Beach seines			29	5,145			29	5,145
Fathoms			1,845				1,845	
Purse seines			1	400			1	400
Fathoms			100				100	
Gill nets			9	970	27	3,390	36	4,360
Fathoms			485		3,400		3,885	
Trap, driven			1	1,100			1	1,100
Wheels					3	300	3	300
Total				60,778		189,555		256,333
PRODUCTS (POUNDS)								
Coho, or silver	24,000	2,300	48,100	8,882	11,200	1,044	83,300	12,226
Chum, or keta			48,500	5,062	34,700	2,616	83,200	7,678
Humpback, or pink	32,800	2,040	90,900	7,160	6,600	462	130,300	9,662
King, or spring			5,800	596	49,400	6,157	55,200	6,753
Red, or sockeye			267,200	23,732	994,400	113,629	1,261,600	137,361
Total	56,800	4,340	460,500	45,432	1,096,300	123,908	1,613,600	173,680

FRESH SALMON

In 1926 the fresh-salmon business of Alaska represented no independent investment, being incidental to other phases of the fishery industry. The total production was 2,274,123 pounds of all species, valued at $221,771, comparable with 2,620,017 pounds valued at $223,907 in 1925, a decrease of 13 per cent in quantity but less than 1 per cent in value. Of this total all but 5,550 pounds, valued at $660, was produced in southeastern Alaska.

Products of the Alaska fresh-salmon industry in 1926

Species	Pounds	Value
Coho, or silver	672,429	$39,692
Chum, or keta	25,383	1,496
Humpback, or pink	2,513	75
King, or spring	1,570,808	180,226
Red, or sockeye	2,990	282
Total	2,274,123	221,771

FREEZING

No independent investment was credited to the salmon-freezing business in Alaska in 1926, the operations being wholly incidental to other lines of the fishery industry. There was an increase in production of 1,197,022 pounds, or 47 per cent, over 1925, the total output in 1926 being 3,769,645 pounds, valued at $356,060, as compared with 2,572,623 pounds, valued at $170,663, in 1925.

Products of the Alaska frozen-salmon industry in 1926

Species	Pounds	Value
Coho, or silver	1,457,487	$124,719
Chum, or keta	572,166	32,232
Humpback, or pink	285	14
King, or spring	1,739,707	199,095
Total	3,769,645	356,060

DRY-SALTING, DRYING, AND SMOKING

In southeastern Alaska one concern prepared dry-salted salmon, and in central Alaska a number of operators dried small amounts of salmon for fox feed. All of these operations were incidental to other lines of business. In the fishery of the Yukon, Tanana, and Kuskokwim Rivers, which is carried on principally by natives, 1,778,164 pounds of salmon were dried, valued at $207,900; and in addition 600 pounds of kippered salmon, valued at $150, were prepared. In this western district 42 whites and 383 natives engaged in the fishery, and the apparatus used consisted of 210 wheels, valued at $21,000; 174 gill nets of 6,969 fathoms, valued at $6,969; with 25 skiffs, valued at $2,525, and 2 launches, valued at $2,000; a total investment of $32,494.

Production of dry-salted, dried, and smoked salmon in Alaska in 1926

Product	Southeast Alaska		Central Alaska		Western Alaska		Total	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
Dry-salted:								
Coho, or silver	46,855	$4,781					46,855	$4,781
Chum, or keta	5,995	240					5,995	240
Humpback, or pink	4,498	186					4,498	186
King, or spring	11,778	1,271					11,778	1,271
Red, or sockeye	5,892	785					5,892	785
Total	75,018	7,263					75,018	7,263
Dried and smoked:								
Coho, or silver			4,250	$325			4,250	325
Chum, or keta			4,000	400	1,681,000	$195,755	1,685,000	196,155
Humpback, or pink			13,600	792			13,600	792
King, or spring			175	70	97,164	12,145	97,339	12,215
Red, or sockeye			750	75			750	75
Total			22,775	1,662	1,778,164	207,900	1,800,939	209,562
Kippered: King, or spring					600	150	600	150
Grand total	75,018	7,263	22,775	1,662	1,778,764	208,050	1,876,557	216,975

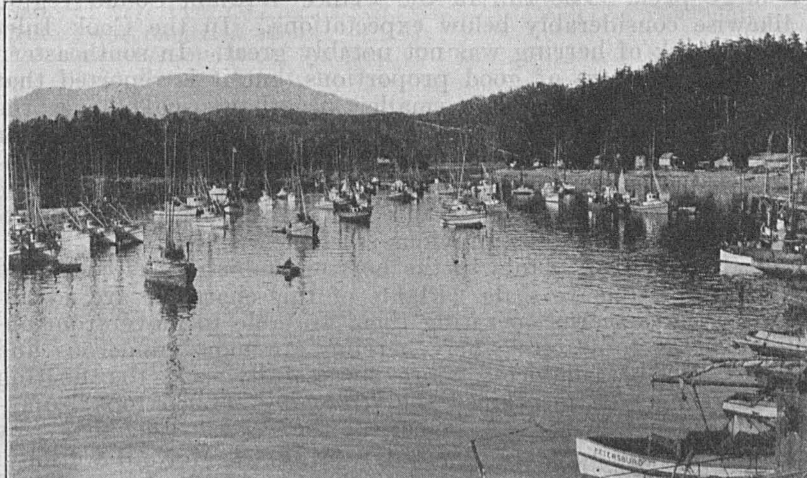

FIG. 11.—Salmon-trolling boats, southeast Alaska

BY-PRODUCTS

Two companies in southeastern Alaska engaged primarily in the preparation of salmon by-products, while three salmon canneries in central Alaska manufactured salmon oil and fertilizer as well. The investment, credited wholly to southeastern Alaska, totaled $109,570, and 35 white shoresmen and 3 white transporters were reported engaged in the industry. The total production was 1,477,300 pounds of fertilizer, valued at $38,339, and 53,004 gallons of oil, valued at $21,-850, comparable with 1,432,625 pounds of fertilizer, valued at

$41,807, and 40,680 gallons of oil, valued at $18,330, in 1925, or an increase of 3 per cent in amount of fertilizer and 30 per cent in quantity of oil in 1926.

Production of salmon oil and fertilizer in Alaska in 1926

Districts	Oil		Fertilizer	
	Gallons	*Value*	*Pounds*	*Value*
Southeast Alaska	28,014	$11,854	936,000	$25,348
Central Alaska	24,990	9,996	541,300	12,991
Total	53,004	21,850	1,477,300	38,339

HERRING

The herring industry in Alaska in 1926 suffered a decline in comparison with operations in 1925, which were the largest in the history of the Territory. The decline in 1926 was due to several causes, chief of which was the unexpected failure of herring to materialize in anything like normal numbers in the Afognak region, where a number of floating plants and shore stations were prepared for a large pack. The run in the Prince William Sound region was likewise considerably below expectations. In the Cook Inlet region the pack of herring was not notably great. In southeastern Alaska the runs were of good proportions, but it is reported that the fish averaged considerably smaller size than usual; hence the proportion packed for food purposes was smaller, and the number used in the manufacture of meal and oil was correspondingly increased. Market conditions also had important bearing on the situation. There was a considerable carry-over from the unprecedentedly large pack of the previous season.

The use of floating plants in the herring industry has continued upon a rather extensive scale. Plants of this character are advantageous, as the concerns operating them are able to move from unprofitable fields to waters where herring are more numerous and operations can be conducted more successfully. Of the floating plants there may be mentioned the *Rosamond* (1,035 tons), operated by the North American Fisheries; the *Esther* (222 tons), by Ottar Hofstad; the *Salvator* (385 tons), by Libby, McNeill & Libby; the *Donna Lane* (1,597 tons), by the Utopian Fisheries Co.; and the *ZR3* (1,596 tons), by the Nassau Fish Co. (formerly the Atlantic & Pacific Packing Co.). The last-named company also operated the *La Merced* (1,342 tons), formerly used by the Alaska Consolidated Fisheries. Small floating plants were also operated by a number of other concerns in various localities.

There is considerable agitation to prevent the use in southeastern Alaska of the increasingly large proportion of the herring catch for the manufacture of meal or fertilizer and oil; it is computed that upward of 90 per cent was so used in 1926. The herring of that district, however, are much smaller in size than those of the central district, and, except in certain localities and limited seasons, are not so suitable for the preparation of food products. All but three of the plants manufacturing by-products also prepared food products.

The output of Scotch-cured herring in southeastern Alaska in 1926 was only 1,576,050 pounds, or but one-third of the amount prepared in the preceding year; while the production of by-products was 21,699,635 pounds of meal and 2,857,299 gallons of oil, as against 15,176,646 pounds of meal or fertilizer and 2,061,398 gallons of oil in 1925.

Of the herring packed in central Alaska, approximately 2,500,000 pounds of Scotch-cured product were prepared in the Prince William Sound district, a like amount in the Kodiak–Afognak district, and slightly over 9,000,000 pounds in the Cook Inlet region. The Kodiak-Afognak district produced only one-fifth as much as was packed there in 1925; Cook Inlet produced about 9,000,000 pounds, as against 10,000,000 in 1925; and Prince William Sound produced 2,500,000 pounds, as against over 6,000,000 in 1925.

In southeastern Alaska 20 concerns handled herring. Among the larger operators were the following:

Reduction plants:	
National Fish Co	Hood Bay.
Puget Sound Reduction Co	Port Armstrong.
Saltery: Ness Fish Co	Petersburg.
Saltery and reduction plants:	
Alaska Consolidated Canneries	Saginaw Bay.
Alaska Herring & Sardine Co	Little Port Walter.
Arentsen & Co	Big Port Walter.
Baranof Packing Co	Red Bluff Bay.
Buchan & Heinen Packing Co	Port Armstrong.
Chatham Strait Fish Co	New Port Walter.
Killisnoo Fisheries	Killisnoo.
Marine Packing & Reduction Co	Washington Bay.
Northwestern Herring Co	Port Conclusion.
Storfold & Grondahl Packing Co	Washington Bay.
Warm Springs Bay Packing Co	Warm Springs Bay.

Also four cold-storage plants froze herring for bait.

In central Alaska operations centered chiefly in three localities, namely, Prince William Sound, with 10 operators; Cook Inlet, with 38 operators; and the Kodiak–Afognak district, with 15 operators. In Prince William Sound the following companies operated:

Reduction plant: Alaska By-Products Co	Port Benny.
Salteries:	
B. F. M. Packing Co	Seward.
Latouche Packing Co	Latouche.
Utopian Fisheries Co	Floating plant.
Saltery and reduction plants:	
Drier Bay Packing Co	Drier Bay.
Everett-Pacific Fisheries	Thumb Bay.
Franklin Packing Co	Port Ashton.
W. J. Imlach Packing Co	Sawmill Bay.
San Juan Fishing & Packing Co	Evans Bay.
S. Sklaroff & Sons	Crab Bay.

The more important operators in Cook Inlet were the following, all of whom prepared Scotch-cured herring:

Colberg Bros	Seldovia.
Crescent Herring Co	Do.
Drier Bay Packing Co	Halibut Cove.
Chas. Engstrom	Do.

S. Feinson	Seldovia.
Fidalgo Island Packing Co	Halibut Cove and Port Graham.
E. A. Gissberg	Halibut Cove.
Hanson & Jacobsen	Do.
Hazel Packing Co	Floating plant.
Herring Bay Packing Co	Seldovia.
Ottar Hofstad	Floating plant.
E. Jacobsen	Halibut Cove.
Jacobsen & Stemland	Do.
Hans Johnson & Co	Do.
Latouche Packing Co	Do.
Libby, McNeill & Libby	Floating plant.
Nassau Fish Co	Do.
Norstedt & Co	Do.
North American Fisheries	Do.
Fred M. O'Neill	Portlock City.
Reese & Buvick	Halibut Cove.
E. Sandvick	Do.
San Juan Fishing & Packing Co	Tutka Bay.
Shuyak Packing Co	Halibut Cove.
E. Sivertson	Do.
S. Sklaroff & Sons	Homer Spit.
H. Sundsby	Halibut Cove.
Thompson & Sundsby	Do.
Ursin & Co	Do.
Utopian Fisheries	Floating plant.
Fritz Waage	Halibut Cove.

The chief operators in the Kodiak-Afognak district were the following, all of whom prepared Scotch-cured herring:

Karl Armstrong	Three Saints Bay.
Caw Packing Co	Raspberry Island.
Crescent Herring Co	Shuyak Strait.
Franklin Packing Co	Floating plant.
Ottar Hofstad	Do.
W. J. Imlach Packing Co	Uzinki.
Kodiak Herring Co	Floating plant.
Nassau Fish Co	Do.
North American Fisheries	Do.
San Juan Fishing & Packing Co	Shuyak Island.
Shuyak Packing Co	Shuyak Strait.
S. Sklaroff & Sons	Port Williams.
Svendson & Shaw Packing Co	Shuyak Island.
Utopian Fisheries	Floating plant.

George A. Rounsefell, scientific assistant of the bureau, continued throughout 1926 the biological investigation of the Alaska herring which he had begun in 1925.

STATISTICAL SUMMARY

The herring industry in Alaska employed 2,101 persons in 1926, as compared with 1,839 in 1925. The number of plants increased from 54 in 1925 to 61 in 1926, and the investment from $6,108,494 to $6,808,395, or 11 per cent. The products were valued at $3,554,489 in 1926, as compared with $3,852,449 in 1925, a decrease of $297,960, or slightly less than 8 per cent. Scotch-cured herring declined from 33,925,975 pounds in 1925 to 15,629,230, or less than half of the production in the preceding year. Herring for bait decreased from 7,086,840 pounds in 1925 to 2,234,938 pounds in 1926. Meal or fertilizer increased 32 per cent in quantity and value, and oil 26 per cent in quantity and 32 per cent in value over the production in 1925.

Persons engaged, investment, and products of Alaska herring industry in 1926

Items	Southeast Alaska		Central Alaska		Western Alaska		Total	
	Number	Value	Number	Value	Number	Value	Number	Value
PERSONS ENGAGED								
Fishermen:								
Whites	282		378				660	
Natives			8		8		16	
Total	282		386		8		676	
Shoresmen:								
Whites	519		742		1		1,262	
Natives	14		37		10		61	
Chinese	2						2	
Japanese	2						2	
Total	537		779		11		1,327	
Transporters:								
Whites	16		80				96	
Natives			1				1	
Negroes	1						1	
Total	17		81				98	
Grand total	836		1,246		19		2,101	
INVESTMENT								
Plants operated	15	$1,379,768	45	$580,829	1	$11,000	61	$1,971,597
Operating capital		1,724,594		1,459,293		8,000		3,191,887
Vessels:								
Power, over 5 tons	47	548,169	82	704,280			129	1,252,449
Net tonnage	1,383		6,369				7,752	
Barges	2	7,000	1	9,800			3	16,800
Net tonnage	3,550		385				3,935	
Sailing			1	20,000			1	20,000
Net tonnage			1,035				1,035	
Launches, under 5 tons	5	10,100	24	21,750	2	1,600	31	33,450
Row boats and skiffs	39	2,298	127	8,995	8	400	174	11,693
Lighters and scows	19	12,014	20	23,475			39	35,489
House boats	14	26,733	1	2,000			15	28,733
Pile drivers	2	2,103	1	4,000			3	6,103
Apparatus:								
Purse seines	46	92,792	47	100,585			93	193,377
Fathoms	8,800		7,690				16,490	
Beach seines			4	3,000			4	3,000
Fathoms			510				510	
Gill nets			325	29,277	42	840	367	30,117
Fathoms			15,235		700		15,935	
Pound seines			2	700			2	700
Pounds			15	13,000			15	13,000
Total		3,805,571		2,980,984		21,840		6,808,395
PRODUCTS (POUNDS)								
Fresh, for bait	24,823	319	989,950	14,403			1,014,773	14,722
Frozen, for bait	1,220,165	10,278					1,220,165	10,278
Pickled for food:								
Scotch cure	1,576,050	116,701	14,053,180	1,421,729			15,629,230	1,538,430
Norwegian	19,400	7,761	15,300	1,460	120,800	12,600	155,500	21,821
Kippered	450	45					450	45
Spiced	6,500	750					6,500	750
Dry-salted	11,440	763					11,440	763
Meal or fertilizer	21,699,635	619,400	1,009,246	27,591			22,708,881	646,991
Oil ... gallons	2,857,299	1,273,765	108,372	46,924			2,965,671	1,320,689
Total		2,029,782		1,512,107		12,600		3,554,489

HALIBUT

A prosperous season was experienced in the Alaska halibut fishery in 1926, the quantity of halibut landed being greater than in the previous year. Although the season was successful from the standpoint of production, the gain appears to have come about, in part at least, through more intensive fishing and by reason of increased operations on farther distant and previously less exploited banks, notably in the Kodiak region and northeastward toward Cape St. Elias. Grounds to the westward of Kodiak, as far as the Shumagins, may soon be the scene of more active halibut fishing, particularly as the average catch per skate of gear grows less in waters longer fished and closer to ports of delivery. It is probable that an increased number of vessels will be equipped for these more extended operations.

The annual closed season of three months on halibut, from November 16 to February 15 (as required by the North Pacific halibut treaty, which first became effective in the fall of 1924), has continued to meet with widespread approval. It appears to be a highly constructive conservation measure and beneficial from every angle of consideration.

The International Fisheries Commission continued in 1926 its scientific investigation of the Pacific halibut fishery. This important work is under the immediate direction of Will F. Thompson, who for years has been prominently indentified with this and other marine biological inquiries. The work is progressing satisfactorily and has resulted in securing much valuable data. Extensive field activities were conducted by a number of scientific assistants, and laboratory work was carried on at the commission's headquarters at the University of Washington in Seattle. The halibut vessel *Scandia* (79 tons) was chartered and made several important cruises from Seattle to British Columbia and Alaskan waters. An important feature of the field work was the tagging and releasing of several thousand halibut to determine the extent of their migrations. Other of the more important lines which the investigation is taking include a study of spawning habits, rates of growth, and racial characteristics, as well as experiments to determine the effectiveness of various kinds of gear, particularly different sizes of hooks, and the compilation and study of statistical records. Preliminary findings already have been of great value, and further results of much importance will follow.

Only landings at Alaskan ports are shown in the statistics for the Alaska halibut industry, and hence do not represent the entire catch from the banks off the coast of Alaska, as a large portion of the landings at ports in British Columbia, as well as at Seattle, come from those waters. The landings in Alaska totaled 14,390,397 pounds, valued at $1,622,554, an increase of 3,418,746 pounds and $738,171 over 1925, or 31 per cent in quantity and 83 per cent in value. The total investment in the halibut industry in 1926 was $3,545,755, as compared with $3,503,921 in 1925. Persons engaged in the fishery in 1926 numbered 871, an increase of 10 over the preceding year.

Persons engaged, investment, and products of the Alaska halibut fishery in 1926

Items	Southeast Alaska		Central Alaska		Total	
	Number	Value	Number	Value	Number	Value
PERSONS ENGAGED						
Whites	851		15		866	
Natives	5				5	
Total	856		15		871	
INVESTMENT						
Shore property		$373,330		$20,000		$393,330
Operating capital		1,021,872		33,863		1,055,735
Vessels:						
Power, over 5 tons	166	1,800,000			166	1,800,000
Net tonnage	3,478				3,478	
Launches	119	249,500			119	249,500
Dories	151	6,040			151	6,040
Apparatus: Trawls	833	41,150			833	41,150
Total		3,491,892		53,863		3,545,755
PRODUCTS (POUNDS)						
Fresh (including local)	4,518,507	559,585			4,518,507	559,585
Frozen	8,357,726	948,094	1,514,164	114,875	9,871,890	1,062,969
Total	12,876,233	1,507,679	1,514,164	114,875	14,390,397	1,622,554

COD

In Alaskan waters cod fishing is conducted both from shore stations and by an offshore fleet, which operates entirely from ports in the States. In the following statistics Alaska is credited only with the operations from shore stations and with vessels that land their catches in Alaska or engage in transporting products from the shore stations.

In 1926 the shore-station cod fleet consisted of two vessels—the *City of Papeete* (370 tons), belonging to the Alaska Codfish Co., and the *El Hurd* (25 tons), belonging to A. Grosvold. The offshore fleet, which is listed elsewhere, comprised seven vessels of the Union Fish Co., two each of the Robinson Fisheries Co., the Pacific Coast Codfish Co., and the Alaska Codfish Co., and one belonging to Capt. J. A. Matheson. The *Progress*, operated last year by the Union Fish Co., was sold; and the *Alice*, of the Robinson Fisheries Co., was replaced by the *John A*, operated in 1925 by the Pacific Coast Codfish Co.

STATISTICAL SUMMARY

The cod industry of Alaska gave employment to 94 persons in 1926, 19 less than in 1925. The decrease was due directly to the nonoperation of shore stations by the Union Fish Co. It is said that the profitable operation of cod shore stations is becoming increasingly difficult each year. The investment amounted to $253,279, as compared with $467,530 for 1925. Dry-salted, frozen, and fresh cod, stockfish, and tongues, aggregating 1,332,714 pounds, valued at $78,317, were the products of this fishery. Comparable figures for 1925 are 2,853,942 pounds valued at $128,803. The products of the offshore fishery were reported to be 7,711,085 pounds of dry-salted cod and tongues, valued at $409,490. The offshore fishery employed 348 persons.

Persons engaged, investment, and products of Alaska cod industry in 1926

Items	Southeast Alaska		Central Alaska		Total	
PERSONS ENGAGED	*Number*	*Value*	*Number*	*Value*	*Number*	*Value*
Fishermen:						
Whites			87		87	
Natives			5		5	
Total			92		92	
Shoresmen: Whites			2		2	
Grand total			94		94	
INVESTMENT						
Shore stations			22	$115,684	22	$115,684
Operating capital				43,005		43,005
Wages paid				23,414		23,414
Vessels:						
Power, over 5 tons			1	15,000	1	15,000
Net tonnage			25		25	
Sailing			1	7,966	1	7,966
Net tonnage			370		370	
Launches			10	39,243	10	39,243
Power dories			20	5,900	20	5,900
Row boats			24	1,325	24	1,325
Apparatus:						
Trawl lines			26	1,505	26	1,505
Hooks			8,400		8,400	
Hand lines			278	237	278	237
Total				253,279		253,279
PRODUCTS (POUNDS)						
Dry-salted cod			752,280	37,142	752,280	37,142
Stockfish			175,415	25,084	175,415	25,084
Tongues			3,233	192	3,233	192
Frozen	9,809	$294			9,809	294
Pickled			391,004	15,585	391,004	15,585
Fresh	973	20			973	20
Total	10,782	314	1,321,932	78,003	1,332,714	78,317

Offshore cod fleet in 1926

Name	Rig	Net tonnage	Operators
Glendale	Schooner	281	Alaska Codfish Co., San Francisco, Calif.
Maweema	do	392	Do.
Fanny Dutard	do	252	J. A. Matheson, Anacortes, Wash.
Charles R. Wilson	do	328	Pacific Coast Codfish Co., Seattle, Wash.
C. A. Thayer	do	390	Do.
Wawona	do	413	Robinson Fisheries Co., Anacortes, Wash.
John A	do	235	Do.
Golden State	Power schooner	223	Union Fish Co., San Francisco, Calif.
Louise	Schooner	328	Do.
Beulah	do	328	Do.
Galilee	do	339	Do.
Mary G	Power sloop	21	Do.
Pirate	do	30	Do.
Union Flag	do	7	Do.

WHALES

The American Pacific Whaling Co., formerly the North Pacific Sea Products Co., operated its plant at Akutan as usual and opened a new plant at Port Hobron, Sitkalidak Island, early in the year.

Employment was given to 324 whites and 31 natives, and 581 whales were taken, consisting of 179 finbacks, 383 humpbacks, 15 sulphur bottoms, 2 sperm, and 2 right whales.

The investment in the whaling industry of Alaska was $871,024, and the products were as follows: 1,001,950 gallons of whale oil, valued at $601,171; 5,150 gallons of sperm oil, valued at $2,060; 929 tons of fertilizer from meat, valued at $55,740; 481 tons of bone fertilizer, valued at $14,430; 101,278 pounds of pickled meat, valued at $5,063; and 21,000 pounds of whalebone, valued at $1,350, a total value of products of $679,814 and an increase of about 9 per cent over 1925, when products were valued at $624,959.

CLAMS

The forecast of a reduction in the output of clams in central Alaska because of depletion of the beds, made by H. C. McMillin, scientific assistant of the bureau, who was engaged in surveys of the Alaska clam beds in 1924 and 1925, was fulfilled in the pack of 1926. Operations were carried on only in central Alaska. Four plants were engaged exclusively in canning clams and four salmon canneries also handled clams. With the exception of one plant at Kukak Bay, all of these were in the so-called "Cordova" district.

The clam investigation, under way for some time, was continued in the season of 1926 by H. C. McMillin in Alaska and elsewhere on the Pacific coast. Dr. F. W. Weymouth, of Stanford University, has been identified with this undertaking. Observations indicate a decreasing daily production on beds that were subject to heavy commercial digging before authority was secured by law to apply adequate conservation regulations.

The investment in the industry in 1926 was $354,288, and the number of persons engaged was 409, of which 392 were whites and 17 natives. The investment in 1925 was $672,244 and 623 persons were engaged in the industry. The output in 1926 was 38,422 cases, containing 985,056 pounds, valued at $254,236, a decrease of about 52 per cent in quantity and 48 per cent in value from 1925, when 75,279 cases valued at $492,051 were packed.

Products of the Alaska clam industry in 1926

Items	Cases	Pounds	Value
Minced:			
½ pound cans (48 to case)	28,240	677,760	$174,376
10 ounce cans (48 to case)	10,080	302,400	78,771
1 pound cans (48 to case)	7	336	49
Whole:			
1 pound cans (48 to case)	95	4,560	1,040
Total	38,422	985,056	254,236

SHRIMP

Some attention had been given, in both 1924 and 1925, to the study of the shrimp fishery in southeastern Alaska, but Warden Frank W. Hynes was directed to make a thorough investigation during the season of 1926. His report has been submitted and, following some further investigations, will be published as a separate document. It discusses in detail the distribution of the shrimp, methods of taking, and the processing of the product, and also contains a brief history of the development of the industry in Alaska. The fishery has been carried on for but little over 10 years, the first commercial operations having been begun in 1915; only one company operated until 1918, when three additional concerns entered the field. No great expansion has occurred in recent years, but it seems probable that the industry may continue satisfactorily on the present basis. Three small plants were operated in 1926—two at Wrangell and one at Petersburg, in the vicinity of which places the more important grounds are situated.

The investment in the shrimp industry in 1926 was $315,752, as compared with $318,353 in 1925. Of the total, $7,200 represents the value of plants, $233,557 the cost of operations and wages, and $74,995 value of boats and apparatus. Employment was given to 163 persons, of whom 31 were whites, 85 natives, 1 Chinese, 30 Japanese, 10 Filipinos, 5 Mexicans, and 1 negro. Products consisted of 490,185 pounds of shrimp meat, valued at $195,828, as compared with 519,535 pounds, valued at $207,315, in 1925, a decrease of approximately 5½ per cent in both quantity and value.

CRABS

Crab products were prepared at two plants in southeastern Alaska (the Alaskan Glacier Sea Food Co., which handled chiefly shrimp, and the Northern Sea Food Co., both at Petersburg) and one (the Cordova Shellfish Co.) at Cordova, in central Alaska. The investment totaled $38,274, and 28 whites, 1 native, and 2 Filipinos were employed. Products consisted of 159,645 pounds of cold-packed meat, valued at $59,897; 1,168 dozen crabs in the shell, valued at $1,419; and 25 cases of ½-pound cans, valued at $300. The total value of products in 1926 was $61,616, as compared with $53,357 in 1925, a gain of 15 per cent.

TROUT

Trout operations (except at one plant in central Alaska, having an investment of $3,296 and employing 7 whites and 1 native) were incidental to other branches of the fisheries. The products were as follows: Dolly Vardens, 32,377 pounds frozen, valued at $3,447; 36,652 pounds fresh, valued at $5,303; and 2 barrels pickled, valued at $32; a total of 69,429 pounds, valued at $8,782; steelheads, 10,135 pounds frozen, valued at $852, and 5,030 pounds fresh, valued at $622, a total of 15,165 pounds, valued at $1,474. The total production of both species was 84,594 pounds, valued at $10,256, an increase of 59 per cent in quantity and 67 per cent in value.

MISCELLANEOUS FISHERY PRODUCTS

Minor species of fish are taken in small quantities, chiefly in connection with the halibut fishery. In 1926 such products were as follows: Sablefish, 170,004 pounds fresh, valued at $7,635; 495,836 pounds frozen, valued at $22,668; and 16,584 pounds pickled, valued at $930; rockfishes, 16,857 pounds frozen, valued at $511; flounders, 11,532 pounds frozen, valued at $326; and smelt, 14,228 pounds frozen, valued at $1,707. All of these products were from southeastern Alaska.

FUR-SEAL INDUSTRY

PRIBILOF ISLANDS

GENERAL ADMINISTRATIVE WORK

In the calendar year 1926, 22,131 fur-seal skins were taken on the Pribilof Islands, of which 16,231 were taken on St. Paul Island and 5,900 on St. George Island. Seven thousand seven hundred and eighty-three of the sealskins taken were blubbered on St. Paul Island before being salted. An ample reserve of 3-year-old male seals for future breeding stock was made. Careful attention was given to the feeding and general management of the fox herds. The by-products plant on St. Paul Island was not operated. Some surplus oil prepared at the plant in previous years was shipped to the States and sold.

The construction of new concrete dwellings for the natives on St. Paul Island was continued. Progress was made on the construction of a number of new buildings for general station purposes on both St. Paul and St. George Islands, some of the structures being completed. Progress was made on road work on both islands.

The general supplies for the islands were transported from Seattle on the U. S. S. *Vega*, which was made available through the courtesy of the Navy Department. Commercial vessels and the bureau's power schooner *Eider* also transported miscellaneous minor supplies at various times.

An effective patrol was maintained by the United States Coast Guard in Bering Sea and in other waters of the North Pacific Ocean frequented by the fur seals. While engaged in this work, the Coast Guard vessels incidentally rendered valuable assistance to the bureau in connection with its work on the Pribilof Islands.

Great Britain and Japan continued the policy of recent years of having their shares of sealskins taken on the Pribilof Islands sold by the United States Government, which results in the payment to them of money instead of the actual delivery of sealskins.

VISIT OF REPRESENTATIVE OF JAPANESE GOVERNMENT

Mr. Keishi Ishino, of the Imperial Fisheries Bureau of Japan, visited the Pribilof Islands for the purpose of making general observations in regard to sealing matters. Mr. Ishino reached St. Paul Island by the Japanese fisheries patrol vessel *Hakuho Maru* on June 20. This vessel left on June 21 for the purpose of making various fisheries investigations in Bering Sea and a trip to Unalaska. Mr. Ishino remained at St. Paul Island, leaving there for St. George Island on the *Eider* on July 18. On July 30 he left St. George Island on the *Hakuho Maru* and arrived at St. Paul Island the next day, leaving on the same day for Japan. Mr. Ishino had previously spent some time making observations at the Pribilofs in the sealing season of 1923.

PURCHASE AND TRANSPORTATION OF SUPPLIES

The general supplies for the Pribilof Islands and for the power schooner *Eider* were shipped from Seattle on the U. S. S. *Vega*. The *Vega* left Seattle on July 26 and arrived at the Pribilof Islands on August 4, a stop having been made at Dutch Harbor to land supplies for the *Eider*. Approximately 1,800 tons of general cargo

FIG. 12.—*Eider* on winter trip to Pribilof Islands

and about 250,000 feet of lumber were discharged at the Pribilof Islands in record-breaking time. The vessel left the Pribilofs on August 14 and arrived at Bremerton, Wash., on August 21. The supplies were purchased at Seattle by Assistant Agent Albert K. Brown.

During the year a number of minor shipments of supplies were made to the Pribilof Islands from Seattle. One was taken by the *Eider* on its trip north from Seattle in March. In May approximately 30 tons, chiefly perishable foodstuffs, were shipped on the steamship *Victoria* to Akutan, where the *Eider* received them. The *Victoria* took another lot in October, delivery being made to the *Eider* at Unalaska. A few other small shipments were made from Seattle and Bellingham at various times.

POWER SCHOONER "EIDER"

At the beginning of the year the *Eider* was at Seattle undergoing repairs. These were completed early in March, when the vessel, having taken aboard a full cargo of general stores at Seattle and Bremerton, proceeded to Port Townsend, departing from that place on March 20 for Alaska. After making stops at Ketchikan and Seward, the *Eider* reached headquarters at Unalaska on April 5.

During April two trips were made to the Pribilof Islands, one via King Cove, where passengers and mail were taken aboard for the islands. In May three trips were made to the Pribilofs. Trips also were made to King Cove and Akutan, and one into Bering Sea in answer to a call for medical assistance from the schooner *Wawona*, a cod-fishing vessel from Seattle.

In June two trips were made to the Pribilof Islands, these trips including three calls at Ikatan and one at Akutan. A trip was made to Seward in the latter part of June and first part of July. Later in July and in August the vessel was engaged in transporting mail, freight, and passengers between Unalaska and the Pribilof Islands. During the latter part of August a trip was made to St. Michael; on the return, stops were made at St. Paul and St. George Islands, and Unalaska was reached on September 9. Later in September a trip was made to the Pribilof Islands.

One trip was made to the Pribilof Islands in October, on which a full cargo of perishable supplies was transported, these having been delivered at Unalaska by the S. S. *Victoria*. A number of Pribilof Islands employees also were transported from Unalaska to Akutan at the end of the month for transfer to the S. S. *Victoria*. In November two trips were made to the Pribilofs, when the landing of fall supplies was completed. A trip was also made to Biorka Island, upon the request of the local United States marshal at Unalaska in connection with a criminal case. In December one trip was made to the Pribilofs, when a number of foxes were exchanged between St. Paul and St. George Islands.

During the year the *Eider* traveled 14,400 nautical miles.

ROADS

St. Paul Island.—About 1 mile of the road between the village and Zapadni was cleared of rocks and boulders and leveled, so that trucks and tractors can reach the Zapadni killing field. In the past, when weather conditions made it impossible to use boats to transport seal-skins from Zapadni to the village, it was necessary to lengthen the seal drives in order that the skins might be taken at a place where they would be accessible to the village salt-houses.

Improvements were made to the road between the village and Ice House Lake, and also to the roads in the village, including the building of some new roadway. Work was continued on the road from the village to Northeast Point, and the sodding and planking of the fill along this road at Halfway Point was completed.

At the scoria deposit, near Ice House Lake, sand and vegetation was cleared from an area large enough to make available sufficient scoria to provide for road requirements for 1927.

St. George Island.—Considerable work was done on a tractor road to North rookery. It is planned to extend the road later to Staraya Artil rookery. When completed the road will assist in the shortening of seal drives.

NEW BUILDINGS AND OTHER IMPROVEMENTS

ST. PAUL ISLAND

Ten of the twelve dwellings for the use of natives on St. Paul that were begun in 1925 were fully completed and ready for occu-

FIG. 13.—New concrete residence for white employees, St. Paul Island

pancy in May, 1926. Two other dwellings, for which the foundations were completed in 1925, and eight additional new ones were brought to the point where they could be completed in the winter of 1926–27. The foundations of two more were poured in 1926, in order that work might proceed on them early in 1927, regardless of whether or not the ground was still frozen. All these buildings are for the use of natives and are of concrete construction.

The laundry building and the meat house for the white employees of the station, having reached a point where repairs were no longer economical, were torn down and replaced by two new buildings. Installation of new equipment was deferred until the winter of 1926–27. The laundry is to be provided with a hot-water boiler, gasoline engine, and a washer and dryer; the meat house with a Frigidaire machine.

A new building was constructed at Southwest Point for the use of natives engaged in feeding and trapping foxes.

The barn for domestic livestock, which was begun in 1925, was completed. It was built and equipped along modern lines.

An old motor sailer, obtained from the Navy Department several years ago, was reconditioned and a 16 horsepower Atlas engine installed. The boat will be available for landing supplies.

A large amount of work was done in removing vegetation from Ice House Lake and sodding its margin. This lake is the source of the potable water supply for the village. A windmill was erected at one side of the lake, but owing to the shortage of some minor equipment it was not placed in operation. At the village a number of additional buildings were connected with the general water-supply system and an additional hydrant was installed.

ST. GEORGE ISLAND

The dwelling for white employees, begun in 1925, was completed and the construction of another was started. The old "Government" house was torn down.

The construction of a new barn, begun previous to 1926, was completed and the old barn was demolished. The construction of a new warehouse was commenced.

BY-PRODUCTS PLANT

The by-products plant on St. Paul Island was not operated in 1926, there being sufficient products on hand to take care of the requirements of the islands for the year.

A quantity of surplus oil produced at the plant in former years was shipped from St. Paul Island in August on the U. S. S. *Vega*, which delivered it at Bremerton, Wash. The oil, which amounted to 3,518 gallons, was subsequently sold at 37½ cents per gallon. From the gross proceeds ($1,319.25), certain expenses in connection with the sale, amounting to $16.82, were deducted and the balance ($1,302.43) was delivered to the disbursing clerk, Department of Commerce, for transfer to the general fund of the United States Treasury.

NATIVES

CENSUS

The annual census, taken as of December 31, 1926, showed 202 native residents on St. Paul Island and 142 on St. George Island. In addition, a number of natives whose homes are on the Pribilof Islands were away temporarily at the Salem Indian Training School at Chemawa, Oreg., and elsewhere.

During the year there were 7 births and 2 deaths on St. Paul Island and 5 births and 3 deaths on St. George Island.

MEDICAL SERVICES

Two physicians were stationed at the islands throughout the year. The dentist who entered on duty there in April, 1925, remained until the latter part of June, when he was compelled to leave on account of illness. During the period of his detail he performed services on both St. Paul and St. George Islands.

SCHOOLS

St. Paul Island.—The 1925–26 school year began on September 14, 1925, and closed on April 30, 1926. In the senior school 26 pupils were enrolled and in the junior school 28, a total of 54 children.

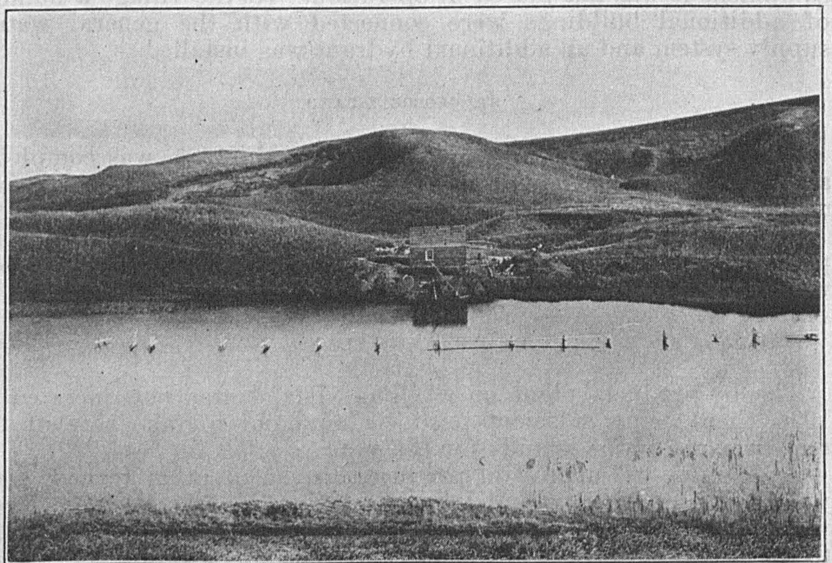

FIG. 14.—Chief source of water supply, St. Paul village

St. George Island.—The school year began on September 21, 1925, and ended on May 21, 1926. In the senior school 9 boys and 15 girls were enrolled and in the junior school 8 boys and 6 girls, a total of 38 children.

ATTENDANCE AT SALEM INDIAN TRAINING SCHOOL, CHEMAWA, OREG.

On January 1, 1926, seven natives of St. Paul Island (four boys and three girls) were in attendance at the Salem Indian School at Chemawa, Oreg. During the year one boy (Abraham S. Merculieff, from St. Paul Island) entered the school and three of those in attendance at the beginning of the year left, only one of whom (Auxenty Stepetin) returned to the Pribilof Islands. The five in attendance at the end of 1926 were Mariamna Merculieff, Kleopatra Krukoff, Tatiana Krukoff, Mamant Emanoff, and Abraham S. Merculieff.

SAVINGS ACCOUNTS

Certain of the Pribilof Islands natives have funds in the custody of the United States Commissioner of Fisheries. Throughout 1926 these funds were kept on deposit with the Washington Loan & Trust Co., Washington, D. C., and interest was paid at the rate of 3 per cent per annum, calculated on monthly balances. An account for the St. Paul Church was opened and three accounts for natives were closed during the year. A summary of the accounts as a whole for the year 1926 is shown in the statement that follows:

On hand, Jan. 1, 1926	$11,427.85
Interest earned from Jan. 1 to Dec. 31, 1926	337.74
Deposited by natives in 1926	1,584.12
	13,349.71
Withdrawn by natives in 1926	630.00
On hand, Dec. 31, 1926	12,719.71

An itemized statement of the account, showing the individual accounts, follows:

Savings accounts of the Pribilof Islands natives in the custody of the United States Commissioner of Fisheries, as trustee, December 31, 1926

Borenien, Zoya [1]	$281.89	Merculief, Daniel	$577.67
Bourdukofsky, Martha	107.93	Merculief, Erena	577.64
Bourdukofsky, Peter	.90	Merculief, George	381.18
Fratis, Agrippina [2]	110.91	Merculief, jr., George	402.69
Fratis, Akalina [2]	537.51	Merculief, Joseph	206.13
Fratis, Martha [2]	110.89	Merculief, Nicolai G	354.84
Fratis, Iuliania [2]	110.89	Merculief, Polyxenia	131.64
Gromoff, Iuliana	304.11	Merculief, Tatiana	577.67
Kochutin, Alexandra	4,555.43	Pankoff, Agrippina	156.66
Krukoff, Ekaterina	111.37	Pankoff, Maria M[elovidov]	8.70
Lekanof, Sophia M	388.16	St. Paul Church [3]	1,507.50
Lestenkof, Michael	323.21	Sedick, Lavrenty	57.21
Mandregan, Alexandra M	12.14	Sedick, Leonty	57.21
Melovidov, Anton	4.35	Sedick, Marina	.38
Merculieff, Makary	46.08	Shane, Michael	102.20
Merculieff, Mariamna [2]	76.85	Tetoff, Vikenty M[elovidov]	128.17
Merculief, Alexandra	409.15	Zacharof, Emanuel	.45

[1] Deceased.
[2] Not living on island in 1926.
[3] New account.

PAYMENTS FOR TAKING SEALSKINS

The resident natives of the Pribilof Islands were paid in cash for their work in taking sealskins. A flat rate of 75 cents was allowed for each sealskin taken, and bonuses were allowed for special work. Since the work of taking sealskins is collective in character, the amount earned on each island, on the basis of 75 cents per skin, was divided among the resident native sealers in accordance with ratings based on skill and ability. The men were divided into classes, each man in a given class receiving an equal amount. Payments were made as shown below:

St. Paul Island.—For the 16,231 sealskins taken on St. Paul Island, $12,173.25 was paid; and, in addition, $100 was allowed two foremen for special services. A statement of the earnings follows:

Payments to St. Paul Island natives for taking sealskins, calendar year 1926

Classification	Number of men	Share of each	Total
First class	30	$267.00	$8,010.00
Second class	10	213.00	2,130.00
Third class	10	169.50	1,695.00
Fourth class	2	132.00	264.00
Fifth class	1	74.25	74.25
Foreman (additional compensation)			50.00
Do			50.00
Total			12,273.25

St. George Island.—For the 5,900 sealskins taken on St. George Island, $4,425 was paid, and in addition $100 was allowed two foremen for special services. Ten men, who were temporarily detailed to St. Paul Island to assist with sealing operations, were paid $50 each in addition to their shares in the disbursement made for taking sealskins on St. George Island. A statement of the earnings follows:

Payments to St. George Island natives for taking sealskins, calendar year 1926

Classification	Number of men	Share of each	Total	Classification	Number of men	Share of each	Total
First class	19	$154.50	$2,935.50	Foreman (additional compensation)			$45.00
Second class	7	123.75	866.25	Additional amount paid for sealing work on St. Paul Island, 10 men at $50 each			500.00
Third class	4	93.00	372.00	Total	38		5,025.00
Fourth class	2	61.50	123.00				
Fifth class	3	32.25	96.75				
Sixth class	3	10.50	31.50				
Foreman (additional compensation)			55.00				

PAYMENTS FOR TAKING FOX SKINS

The natives are paid $5 in cash for each fox skin taken on the Pribilof Islands. For the season of 1925–26 these payments amounted to $430 for the 86 skins taken on St. Paul Island and $3,195 for the 639 skins taken on St. George Island, a total of $3,625.

FUR-SEAL HERD

QUOTA FOR KILLING

The plans of the Department of Commerce in connection with sealing operations for 1926 provided for the reservation of 9,500 3-year-old male seals for future breeding purposes. The reserve was to be made on the basis of 7,500 on St. Paul Island and 2,000 on St. George Island. The remaining 3-year-old males that could be secured were to be killed.

KILLINGS OF SEALS

In 1926, 22,131 seals were killed (including 1 seal found dead, whose skin was preserved for commercial purposes), of which 16,231 were on St. Paul Island and 5,900 on St. George Island. Of these, 20,557 were listed as 3-year-old males. Details in regard to the killings are shown in the following tabulations:

Seal killings on Pribilof Islands in 1926

ST. PAUL ISLAND

Date	Serial No. of drive	Hauling ground	Skins secured
May 21	1	Sea Lion Rock (Sivutch)	98
June 11	2	Reef and Gorbatch	75
15		From seal dying as a result of reserving operations	1
16		From seals dying as a result of reserving operations	2
20		do	3
20		From seal killed for food	1
21		From seals dying as a result of reserving operations	9
23	3	Zapadni and Little Zapadni	116
26		From seals dying as a result of reserving operations	22
27	4	Tolstoi and Lukanin	244
28	5	Zapadni and Little Zapadni	144
29	6	Polovina, Polovina Cliffs, and Little Polovina	181
July 1	7	Tolstoi, Lukanin, and Kitovi	224
2	8	Reef and Gorbatch	809
3	9	Zapadni and Little Zapadni	433
4	10	Polovina, Little Polovina, and Polovina Cliffs	190
5	11	Vostochni and Morjovi	420
6	12	Tolstoi, Lukanin, and Kitovi	427
7	13	Reef and Gorbatch	1,355
8	14	Zapadni and Little Zapadni	474
9	15	Polovina, Polovina Cliffs, and Little Polovina	177
10		Found in salt	3
10	16	Vostochni and Morjovi	1,152
11	17	Tolstoi, Lukanin, and Kitovi	570
July 12	18	Reef and Gorbatch	1,573
13	19	Zapadni and Little Zapadni	405
14	20	Polovina, Little Polovina, and Polovina Cliffs	115
15	21	Vostochni and Morjovi	600
16	22	Tolstoi, Lukanin, and Kitovi	432
17	23	Reef and Gorbatch	1,027
18	24	Zapadni and Little Zapadni	363
19	25	Polovina, Polovina Cliffs, and Little Polovina	163
20	26	Vostochni and Morjovi	472
21	27	Tolstoi, Lukanin, and Kitovi	125
22	28	Reef and Gorbatch	1,106
23	29	Zapadni and Little Zapadni	353
24	30	Polovina, Polovina Cliffs, and Little Polovina	87
25	31	Vostochni and Morjovi	649
26	32	Tolstoi, Lukanin, and Kitovi	311
27	33	Reef and Gorbatch	565
28	34	Zapadni and Little Zapadni	160
29	35	Polovina, Polovina Cliffs, and Little Polovina	48
31		From seal dying as a result of reserving operations	1
Aug. 24		From seal found dead	1
Oct. 20	36	Reef and Gorbatch	231
21	37	Tolstoi, Lukanin, and Kitovi	74
26	38	Zapadni and Little Zapadni	30
28	39	Vostochni and Morjovi	210
		Total	16,231

ST. GEORGE ISLAND

Date	Serial No. of drive	Hauling ground	Skins secured
June 4	1	Staraya Artil	23
15	2	East	48
24	3	East Reef and East Cliffs	41
29	4	do	195
July 2	5	Staraya Artil	64
3	6	North	312
4	7	East	169
7	8	Staraya Artil	204
8	9	North	531
9	10	East Reef and East Cliffs	317
12	11	Staraya Artil	303
13	12	North Rookery	504
14	13	East Reef and East Cliffs	151
17	14	Staraya Artil	150
18	15	North	368
July 19	16	East Reef and East Cliffs	627
20	17	Zapadni	56
22	18	Staraya Artil	333
23	19	North	338
24	20	East Reef and East Cliffs	310
27	21	Staraya Artil	224
28	22	North	129
29	23	East Reef and East Cliffs	179
31	24	North	42
Oct. 20	25	do	169
28	26	do	88
Nov. 12	27	do	25
		Total	5,900

AGE CLASSES OF SEALS

The age class of a male seal belonging to the Pribilof Islands herd is determined from the length of its body. The classification was derived from measurements of a large number of pups branded in 1912 and killed in subsequent years. The limits of the various age classes are shown in the table following:

Age classes of male seals, Pribilof Islands

Age	Length of summer seals	Length of fall seals	Age	Length of summer seals	Length 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 1926

[On basis of classification shown in preceding table]

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	Total
Yearling males	9		9	2		2	11		11
2-year-old males	852	33	885	31		31	883	33	916
3-year-old males	14,285	5,492	19,777	498	282	780	14,783	5,774	20,557
4-year-old males	480	59	539	11		11	491	59	550
5-year-old males	1		1				1		1
Cows [1]	58	34	92	4		4	62	34	96
Total	15,685	5,618	21,303	546	282	828	16,231	5,900	22,131

[1] Cows unavoidably and accidentally killed and found dead.

It should be stated that some of the seals recorded in the above tabulation as 2-year-olds and 4-year-olds probably were 3-year-olds. The killings were confined, as far as possible, to 3-year-old males. Not all of the male seals of this age fall within the length limits assigned for the 3-year-old class.

RESERVING OPERATIONS

In order to make the annual provision for the future breeding stock of male seals, 9,565 3-year-olds were marked by shearing a patch of fur. On St. Paul Island 7,558 animals and on St. George Island 2,007 were marked. On each island the marking operations were begun on June 14 and ended on July 31. The following tabulation gives further details in regard to the marking operations:

Marking of 3-year-old male seals for breeding reserve, Pribilof Islands, 1926

ST. PAUL ISLAND

Date	Hauling ground driven	Number of seals marked	Date	Hauling ground driven	Number of seals marked
June 14	Polovina	41	24	Polovina and Little Polovina	103
15	Vostochni	598	25	Vostochni and Morjovi	317
16	Reef and Gorbatch	816	26	Reef and Gorbatch	1,038
17	Tolstoi	342	30	Vostochni and Morjovi	1,250
17	Lukanin	23	July 15	do	278
18	Zapadni and Little Zapadni	176	30	do	377
19	Polovina	69	31	Reef and Gorbatch	443
20	Vostochni and Morjovi	828			
21	Reef and Gorbatch	762		Total	7,558
22	Tolstoi	97			

ST. GEORGE ISLAND

Date	Hauling ground driven	Number of seals marked	Date	Hauling ground driven	Number of seals marked
June 14	North and Staraya Artil	175	July 1	Zapadni	163
18	do	85	10	do	269
19	East Reef and East Cliffs	158	20	do	42
23	North and Staraya Artil	216	30	do	145
24	East Reef and East Cliffs	102	31	North	90
25	Zapadni	158			
28	North and Staraya Artil	404		Total	2,007

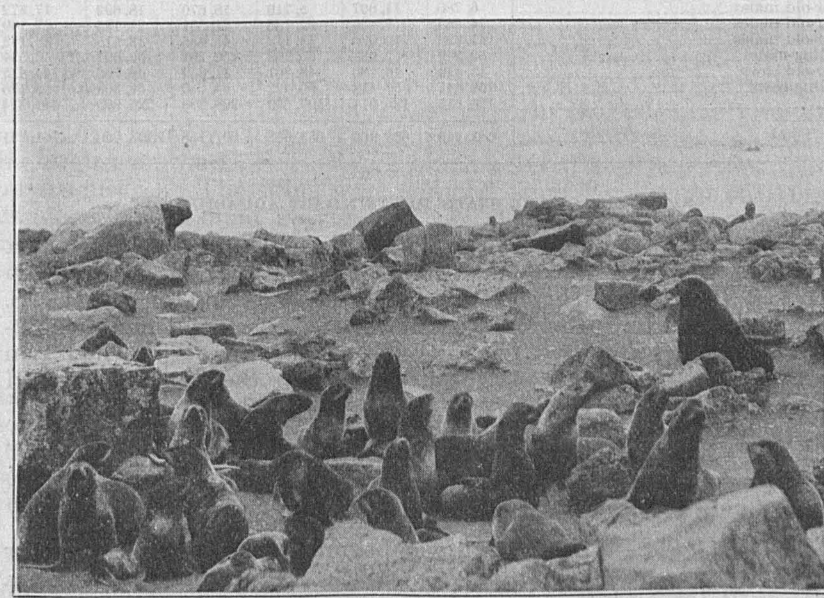

FIG. 15.—Fur-seal harem, Pribilof Islands, Alaska

COMPUTATION OF FUR-SEAL HERD

The computation of the size of the fur-seal herd in 1926 was made by Edward C. Johnston, who has had immediate charge of this phase of the work in recent years, beginning with 1921. His report for 1926 will be found on pages 330 to 336 of this document. Following is a comparative statement of the numerical strength of the various elements of the herd in the years 1915 to 1926, inclusive.

General comparison of computations of the seal herd on the Pribilof Islands, 1915 to 1926

Classes	1915	1916	1917	1918	1919	1920
Harem bulls	2,151	3,500	4,850	5,344	5,158	4,066
Breeding cows	103,527	116,977	128,024	142,915	157,172	167,527
Surplus bulls			8,977	17,110	9,619	6,115
Idle bulls	673	2,632	2,706	2,444	2,239	1,161
6-year-old males		11,167	15,397	13,755	8,991	4,153
5-year-old males	11,271	15,494	14,813	11,941	5,282	5,007
4-year-old males	15,848	15,427	16,631	7,114	5,747	5,667
3-year-old males	18,282	19,402	19,507	9,117	13,596	10,749
2-year-old males	23,990	24,169	26,815	30,159	33,081	39,111
Yearling males	30,307	33,645	38,013	41,595	46,444	51,074
2-year-old cows	23,990	24,245	26,917	30,415	33,287	39,480
Yearling cows	30,306	33,646	38,018	41,608	46,447	51,081
Pups	103,527	116,977	128,024	142,915	157,172	167,527
Total	363,872	417,281	468,692	496,432	524,235	552,718

Classes	1921	1922	1923	1924	1925	1926
Harem bulls	3,909	3,562	3,412	3,516	3,526	4,034
Breeding cows	176,655	185,914	197,659	208,396	226,090	244,114
Surplus bulls	3,301	2,346	1,891	2,043	3,558	2,002
Idle bulls	747	508	312	390	311	423
6-year-old males	3,991	3,771	4,863	8,489	4,105	13,434
5-year-old males	4,729	6,080	10,612	5,132	16,792	16,812
4-year-old males	6,780	11,807	5,710	18,670	18,692	17,872
3-year-old males	14,668	7,459	22,786	21,551	21,185	17,189
2-year-old males	41,893	40,920	43,112	45,685	43,515	38,183
Yearling males	50,249	52,988	55,769	59,291	52,091	56,514
2-year-old cows	43,419	46,280	48,801	51,359	49,786	44,415
Yearling cows	54,447	57,413	60,422	64,240	57,309	62,175
Pups	176,655	185,914	197,659	208,396	226,090	244,114
Total	581,443	604,962	653,008	697,158	723,050	761,281

SHIPMENT OF FUR SEALS TO STEINHART AQUARIUM

Pursuant to a request from the director of the Steinhart Aquarium, San Francisco, for a number of fur seals for exhibition purposes, there were shipped from St. Paul Island on the U. S. Coast Guard cutter *Bear*, on August 26, one 4-year-old male, one 2-year-old female, and two female pups. The animals reached San Francisco on September 13. Unfortunately the two pups died shortly after their arrival.

DEVELOPMENT OF FOX HERDS ON PRIBILOF ISLANDS

FEEDING

St. Paul Island.—Fox feeding was begun the middle of November and was carried on at the village, Northeast Point, Southwest Point, Halfway Point, and Zapadni. As usual, cooked food was used.

St. George Island.—In addition to cooked food, preserved seal carcasses were fed on this island. The feeding of foxes was begun in the first part of November.

FOX-TRAPPING SEASON OF 1926–27

During the season 728 blue and 30 white fox pelts were taken on St. Paul and St. George Islands, a total of 758. The total number taken in the preceding season was 725.

On St. Paul Island the take consisted of 118 blue and 27 white pelts, and on St. George Island of 610 blue and 3 white pelts.

On St. Paul Island there were marked and released for breeding stock 125 male and 108 female blue foxes and on St. George Island 205 male and 202 female blue foxes. The figures for St. Paul Island include the 20 foxes brought from St. George Island in December, 1926. The foxes transferred from St. Paul Island to St. George Island at the same time are included in the figures of foxes released on the latter island. The stock remaining on the islands at the close of the season included, in addition to those marked and released, the animals that were not captured at all during trapping operations.

REINDEER

Counts of the reindeer on each island at the end of 1926 showed approximately 250 animals on St. Paul Island and 50 on St. George Island. During the year 20 reindeer were killed for food, 10 on each island.

FUR-SEAL SKINS

SHIPMENTS

In the calendar year 1926 one shipment of 22,073 fur-seal skins was made from the Pribilof Islands, as follows: From St. Paul Island, 546 taken in the calendar year 1925 and 15,685 taken in 1926; from St. George Island, 224 taken in the calendar year 1925 and 5,618 taken in 1926. The shipment was made from the islands in August on the U. S. S. *Vega*, which arrived at Bremerton, Wash., on August 21. The skins were shipped from Bremerton on August 24 via Puget Sound Navigation Co., Union Pacific, and Wabash Railroad to St. Louis, Mo., where they were delivered to the bureau's selling agents on September 3.

SALES

In 1926 a total of 22,676 fur-seal skins taken on the Pribilof Islands were sold at two public auction sales. There were also sold at special sales 695 fur-seal skins taken on these islands. In the detailed statements which follow, the sales of other sealskins sold by the Department of Commerce for the account of the Government are included, in order that the records may be complete.

Public auction sale, May 24, 1926.—At this sale 14,427 sealskins taken at the Pribilof Islands, dressed, dyed, and machined, sold for $430,446; 175 other sealskins taken at the Pribilof Islands, consisting of 149 raw salted, 20 washed and dried, and 6 dressed, sold for a total of $302; 1 raw salted skin from a seal shipped to the Steinhart Aquarium brought $1 and 7 confiscated sealskins, $7; a grand total of $430,756. Of the dressed, dyed, and machined skins, 11,207 were dyed black, 2,751 logwood brown (Bois de Campêche), and 469 golden chestnut (Châtaigne d'Or).

Public auction sale, October 11, 1926.—At this sale 8,071 sealskins taken at the Pribilof Islands, dressed, dyed, and machined, sold for $308,841; 3 others from those islands sold, dressed, for $3; 151 Japanese sealskins, dressed, dyed, and machined, sold for $4,394.50;

30 raw salted Japanese sealskins for $7.50; 1 confiscated sealskin, dressed, dyed, and machined, for $41; and 4 pieces of confiscated sealskin, dressed and dyed, for $1; a grand total of $313,288. Of the 8,071 Pribilof Islands sealskins sold dressed, dyed, and machined, 6,767 were dyed black, 1,250 logwood brown (Bois de Campêche), and 54 golden chestnut (Châtaigne d'Or). The 151 dressed, dyed, and machined Japanese sealskins were dyed black.

The 181 Japanese sealskins sold on October 11, 1926, were the United States Government's share of sealskins taken by the Japanese Government in 1924 and 1925, delivered pursuant to the provisions of the North Pacific Sealing Convention of July 7, 1911.

Special sales.—In the calendar year 1926, 627 dressed, dyed, and machined sealskins were sold at special sale for $19,990.05 and 68 raw salted skins for $1,520.06. All were skins taken at the Pribilof Islands. Of the dyed skins, 100 were black and 527 logwood brown.

The following tables give further details in regard to all sales of fur-seal skins by the Department of Commerce for the account of the Government in 1926:

Sale of fur-seal skins at St. Louis, Mo., May 24, 1926

11,207 DRESSED, DYED, AND MACHINED PRIBILOF ISLANDS SKINS, DYED BLACK

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
1	45	Large	$51.50	$2,317.50
2	45	do	58.50	2,632.50
3	45	Large; scarred, faulty, etc	38.00	1,710.00
4	45	do	38.50	1,732.50
5	90	Medium	47.00	4,230.00
6	90	do	49.50	4,455.00
7	90	do	50.00	4,500.00
8	90	do	50.50	4,545.00
9	90	do	49.50	4,455.00
10	90	do	52.50	4,725.00
11	0	do	52.00	4,680.00
12	85	do	52.00	4,420.00
13	90	Medium; scarred, faulty, etc	36.00	3,240.00
14	90	do	33.00	2,970.00
15	90	do	31.50	2,835.00
16	90	do	34.00	3,060.00
17	90	do	31.50	2,835.00
18	90	do	35.50	3,195.00
19	90	do	35.00	3,150.00
20	90	Small medium	37.50	3,375.00
21	90	do	37.00	3,330.00
22	90	do	36.50	3,285.00
23	90	do	36.50	3,285.00
24	90	do	35.50	3,195.00
25	90	do	35.50	3,195.00
26	90	do	36.50	3,285.00
27	90	Small medium; scarred, faulty, etc	24.50	2,205.00
28	90	do	23.50	2,115.00
29	90	do	26.00	2,340.00
30	90	do	26.00	2,340.00
31	90	do	23.50	2,115.00
32	90	do	23.50	2,115.00
33	90	do	22.00	1,980.00
41	25	1 wig, 5 extra large, 19 large	53.50	1,337.50
42	80	Large	63.00	5,040.00
43	80	do	64.50	5,160.00
44	80	do	65.50	5,240.00
45	80	Large; scarred, faulty, etc	41.50	3,320.00
46	38	do	43.50	1,653.00
47	90	Medium	44.50	4,005.00
48	90	do	47.50	4,275.00
49	90	do	46.00	4,140.00
50	90	do	49.00	4,410.00
51	90	do	49.50	4,455.00
52	90	do	49.50	4,455.00
53	90	do	49.50	4,455.00
54	90	do	51.00	4,590.00

Sale of fur-seal skins at St. Louis, Mo., May 24, 1926—Continued

11,207 DRESSED, DYED, AND MACHINED PRIBILOF ISLANDS SKINS, DYED BLACK

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
55	90	Medium	$47.50	$4,275.00
56	90	do	47.50	4,275.00
57	90	do	50.50	4,545.00
58	90	do	47.00	4,230.00
59	90	do	50.50	4,545.00
60	90	do	49.50	4,455.00
61	90	do	50.50	4,545.00
62	90	do	50.00	4,500.00
63	90	do	50.00	4,500.00
64	90	do	50.50	4,545.00
65	90	do	50.00	4,500.00
66	90	do	50.00	4,500.00
67	90	do	47.00	4,230.00
68	90	do	51.00	4,590.00
69	90	do	51.00	4,590.00
70	42	do	52.50	2,205.00
71	90	Medium; scarred, faulty, etc	33.50	3,015.00
72	90	do	31.50	2,835.00
73	90	do	31.50	2,835.00
74	90	do	30.00	2,700.00
75	90	do	30.00	2,700.00
76	90	do	30.50	2,745.00
77	90	do	31.00	2,790.00
78	90	do	32.00	2,880.00
79	90	do	30.50	2,745.00
80	90	do	29.00	2,610.00
81	90	do	30.00	2,700.00
82	90	do	28.50	2,565.00
83	90	do	27.50	2,475.00
84	90	do	30.00	2,700.00
85	90	do	30.00	2,700.00
86	90	do	32.50	2,925.00
87	90	do	29.50	2,655.00
88	90	Small medium	32.00	2,880.00
89	90	do	31.00	2,790.00
90	90	do	31.00	2,790.00
91	90	do	30.00	2,700.00
92	90	do	28.00	2,520.00
93	90	do	28.50	2,565.00
94	90	do	28.50	2,565.00
95	90	do	29.00	2,610.00
96	90	do	29.50	2,655.00
97	90	do	28.00	2,520.00
98	90	do	28.50	2,565.00
99	90	do	28.00	2,520.00
100	90	do	29.00	2,610.00
101	90	do	27.50	2,475.00
102	90	do	28.00	2,520.00
103	90	do	28.50	2,565.00
104	90	do	29.00	2,610.00
105	55	do	28.50	1,567.50
106	90	Small medium; scarred, faulty, etc	19.00	1,710.00
107	90	do	20.00	1,800.00
108	90	do	18.50	1,665.00
109	90	do	19.00	1,710.00
110	90	do	19.50	1,755.00
111	90	do	18.50	1,665.00
112	90	do	18.00	1,620.00
113	90	do	18.00	1,620.00
114	90	do	18.00	1,620.00
115	90	do	18.50	1,665.00
116	90	do	18.50	1,665.00
117	90	do	18.50	1,665.00
118	90	do	18.50	1,665.00
119	90	do	18.50	1,665.00
120	90	do	19.00	1,710.00
121	90	do	18.00	1,620.00
122	90	do	19.00	1,710.00
123	60	do	19.50	1,170.00
124	50	III; 25 medium, 25 small medium	11.75	587.50
125	50	III small medium	10.50	525.00
130	62	5 large, 31 medium, 26 small medium	36.50	2,263.00
131	27	2 extra large, 25 large; scarred, faulty, etc	23.50	634.50
132	90	Medium; scarred, faulty, etc	14.00	1,260.00
133	90	do	14.50	1,305.00
134	90	do	15.00	1,350.00
135	32	do	14.00	448.00
136	90	Small medium; scarred, faulty, etc	8.00	720.00
137	90	do	12.50	1,125.00

Sale of fur-seal skins at St. Louis, Mo., May 24, 1926—Continued

11,207 DRESSED, DYED, AND MACHINED PRIBILOF ISLANDS SKINS, DYED BLACK

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
138	90	Small medium; scarred, faulty, etc	$12.00	$1,080.00
139	88	do	12.00	1,056.00
140	25	III large	7.00	175.00
141	45	III medium	7.50	337.50
142	45	do	8.00	360.00
143	45	do	8.00	360.00
144	31	do	9.00	279.00
145	45	III small medium	8.00	360.00
146	45	do	8.50	382.50
147	45	do	8.50	382.50
148	30	do	10.50	315.00
149	17	IV; 5 medium, 12 small medium	5.50	93.50
	11,207			367,114.50

2,751 DRESSED, DYED, AND MACHINED PRIBILOF ISLANDS SKINS, DYED LOGWOOD BROWN (BOIS DE CAMPÊCHE)

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
151	29	Large	$45.50	$1,319.50
152	63	Medium	36.00	2,268.00
153	51	do	31.50	1,606.50
154	45	do	33.00	1,485.00
155	45	do	35.00	1,575.00
156	45	do	34.50	1,552.50
157	45	do	35.50	1,597.50
158	45	do	35.50	1,597.50
159	45	do	36.50	1,642.50
160	45	do	34.00	1,530.00
161	45	do	37.50	1,687.50
162	45	do	35.50	1,597.50
163	36	do	35.50	1,278.00
164	46	17 large, 29 medium; scarred, faulty, etc	21.50	989.00
165	42	Medium; scarred, faulty, etc	20.00	840.00
166	45	do	20.00	900.00
167	45	do	20.00	900.00
168	45	do	20.50	922.50
169	45	do	20.00	900.00
170	45	do	20.50	922.50
171	45	do	20.00	900.00
172	45	do	20.00	900.00
173	45	do	20.00	900.00
174	33	do	22.50	742.50
175	45	Small medium	19.00	855.00
176	29	do	19.50	565.50
177	45	do	18.00	810.00
178	45	do	17.50	787.50
179	45	do	19.50	877.50
180	45	do	18.00	810.00
181	45	do	18.50	832.50
182	45	do	18.50	832.50
183	45	do	17.00	765.00
184	45	do	18.00	810.00
185	45	do	19.00	855.00
186	45	do	19.00	855.00
187	30	do	20.00	600.00
188	36	do	19.50	702.00
189	43	Small medium; scarred, faulty, etc	14.00	602.00
190	46	do	14.50	667.00
191	45	do	13.50	607.50
192	45	do	13.00	585.00
193	45	do	14.00	630.00
194	45	do	14.00	630.00
195	45	do	13.00	585.00
196	45	do	13.00	585.00
197	45	do	12.50	562.50
198	45	do	14.00	630.00
199	45	do	13.00	585.00
200	45	do	12.50	562.50
201	41	do	13.00	533.00
211	21	1 extra large, 4 large, 14 medium, 2 small medium	34.00	714.00
212	24	4 large, 12 medium, 8 small medium	27.00	648.00
213	25	4 large, 8 medium, 13 small medium	25.50	637.50
214	35	1 large, 34 medium; scarred, faulty, etc	15.50	542.50
215	19	2 large, 17 medium; scarred, faulty, etc	17.00	323.00
216	29	1 large, 14 medium, 14 small medium; scarred, faulty, etc	12.50	362.50
217	40	3 large, 24 medium, 13 small medium; scarred, faulty, etc	14.00	560.00

Sale of fur-seal skins at St. Louis, Mo., May 24, 1926—Continued

2,751 DRESSED, DYED, AND MACHINED PRIBILOF ISLANDS SKINS, DYED LOGWOOD BROWN (BOIS DE CAMPÊCHE)

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
218	19	5 medium, 14 small medium	$18.50	$351.50
219	45	Small medium; scarred, faulty, etc	8.00	360.00
220	42	.....do	10.50	441.00
221	44	.....do	9.50	418.00
231	27	2 large, 12 medium, 13 small medium; scarred, faulty, etc	9.50	256.50
232	36	4 large, 21 medium, 11 small medium; scarred, faulty, etc	10.00	360.00
233	23	8 medium, 15 small medium	15.50	356.50
234	36	Small medium; scarred, faulty, etc	9.00	324.00
235	25	III; 11 medium, 14 small medium	5.50	187.50
236	26	III small medium	4.00	104.00
	2,751			56,172.00

469 DRESSED, DYED, AND MACHINED PRIBILOF ISLANDS SKINS, DYED GOLDEN CHESTNUT (CHÂTAIGNE D'OR)

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
241	24	Medium	$27.00	$648.00
242	35	4 large, 31 medium; scarred, faulty, etc	19.00	665.00
243	33	Medium; scarred, faulty, etc	18.00	594.00
244	20	5 Medium, 15 small medium; scarred, faulty, etc	16.50	330.00
245	45	Small medium	22.00	990.00
246	40	Small medium; scarred, faulty, etc	13.50	540.00
247	38	.....do	15.00	570.00
251	14	1 large, 9 medium, 4 small medium; scarred, faulty, etc	15.50	217.00
252	37	4 large, 20 medium, 13 small medium; scarred, faulty, etc	16.00	592.00
253	25	4 large, 17 medium, 4 small medium; scarred, faulty, etc	17.00	425.00
254	32	5 large, 18 medium, 9 small medium; scarred, faulty, etc	16.00	512.00
255	37	3 large, 20 medium, 14 small medium; scarred, faulty, etc	13.00	481.00
256	35	3 large, 16 medium, 16 small medium; scarred, faulty, etc	13.50	472.50
257	30	III; 2 large, 28 medium	2.50	75.00
258	24	III small medium	2.00	48.00
	469			7,159.50

175 MISCELLANEOUS PRIBILOF ISLANDS SKINS

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
259	6	Dressed; faulty	$1.50	$9.00
260	29	Raw salted; faulty	2.00	58.00
261	60	.....do	1.50	90.00
262	60	.....do	1.75	105.00
264	20	Washed and dried; faulty	2.00	40.00
	175			302.00

1 SKIN TAKEN FROM SEAL SHIPPED TO STEINHART AQUARIUM

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
263	1	Raw salted; faulty	$1.00	$1.00

7 CONFISCATED SKINS

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
265	6	Raw salted	$1.00	$6.00
266	1	Parchment	1.00	1.00
	7			7.00

48765—27——7

Sale of fur-seal skins at St. Louis, Mo., October 11, 1926

6,767 DRESSED, DYED, AND MACHINED PRIBILOF ISLANDS SKINS, DYED BLACK

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
1	70	Large	$60.50	$4,235.00
2	70	do	66.50	4,655.00
3	34	7 extra large; 27 large	66.00	2,244.00
4	70	Large; scarred, faulty, etc	41.00	2,870.00
5	23	3 extra large; 20 large; scarred, faulty, etc	39.50	908.50
6	80	Medium	50.00	4,000.00
7	80	do	49.00	3,920.00
8	80	do	49.50	3,960.00
9	80	do	49.50	3,960.00
10	80	do	52.00	4,160.00
11	80	do	51.00	4,080.00
12	80	do	50.50	4,040.00
13	80	do	50.00	4,000.00
14	80	do	52.00	4,160.00
15	80	do	52.50	4,200.00
16	80	do	50.50	4,040.00
17	80	do	50.50	4,040.00
18	80	do	49.00	3,920.00
19	80	do	50.00	4,000.00
20	80	do	50.50	4,040.00
21	80	do	49.50	3,960.00
22	37	do	50.00	1,850.00
23	80	Medium; scarred, faulty, etc	32.50	2,600.00
24	80	do	33.50	2,680.00
25	80	do	33.00	2,640.00
26	80	do	34.00	2,720.00
27	80	do	33.50	2,680.00
28	80	do	33.50	2,680.00
29	80	do	33.50	2,680.00
30	80	do	33.00	2,640.00
31	80	do	33.50	2,680.00
32	80	do	34.50	2,760.00
33	46	do	34.00	1,564.00
34	46	do	34.00	1,564.00
35	90	Small medium	36.50	3,285.00
36	90	do	36.00	3,240.00
37	90	do	37.00	3,330.00
38	90	do	37.00	3,330.00
39	90	do	36.00	3,240.00
40	90	do	36.00	3,240.00
41	90	do	37.00	3,330.00
42	60	do	36.50	2,190.00
43	90	Small medium; scarred, faulty, etc	24.50	2,205.00
44	90	do	23.00	2,070.00
45	90	do	24.50	2,205.00
46	90	do	23.50	2,115.00
47	90	do	24.50	2,205.00
48	90	do	23.50	2,115.00
49	90	do	24.00	2,160.00
50	75	do	24.50	1,837.50
51	48	III; 12 medium, 36 small medium	9.50	456.00
52	70	22 extra large; 48 large	69.00	4,830.00
53	70	Large	69.50	4,865.00
54	70	do	69.50	4,865.00
55	70	22 extra large; 48 large; scarred, faulty, etc	37.50	2,625.00
56	69	Large; scarred, faulty, etc	36.00	2,484.00
57	80	Medium	45.00	3,600.00
58	80	do	45.00	3,600.00
59	80	do	46.00	3,680.00
60	80	do	44.50	3,560.00
61	80	do	46.00	3,680.00
62	80	do	45.50	3,640.00
63	80	do	47.00	3,760.00
64	80	do	46.50	3,720.00
65	80	do	46.00	3,680.00
66	80	do	45.50	3,640.00
67	80	do	44.00	3,520.00
68	30	do	45.00	1,350.00
69	80	Medium; scarred, faulty, etc	32.00	2,560.00
70	80	do	31.00	2,480.00
71	80	do	31.00	2,480.00
72	80	do	31.00	2,480.00
73	55	do	31.50	1,732.50
74	50	do	31.50	1,575.00
75	90	Small medium	32.00	2,880.00
76	90	do	31.50	2,835.00
77	90	do	31.50	2,835.00
78	90	do	31.00	2,790.00

Sale of fur-seal skins at St. Louis, Mo., October 11, 1926—Continued

6,767 DRESSED, DYED, AND MACHINED PRIBILOF ISLANDS SKINS, DYED BLACK

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
79	90	Small medium	$32.00	$2,880.00
80	60	do	32.00	1,920.00
81	53	do	31.50	1,669.50
82	90	Small medium; scarred, faulty, etc	22.00	1,980.00
83	90	do	22.00	1,980.00
84	90	do	22.00	1,980.00
85	90	do	22.50	2,025.00
86	90	do	22.50	2,025.00
87	86	do	22.50	1,935.00
88	31	III; 1 extra extra large; 3 extra large; 6 large; 21 medium	8.00	248.00
89	34	III, small medium	8.00	272.00
	6,767			258,345.00

1,250 DRESSED, DYED, AND MACHINED PRIBILOF ISLANDS SKINS DYED LOGWOOD BROWN (BOIS DE CAMPÊCHE)

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
91	24	2 extra large; 22 large	$56.50	$1,356.00
92	40	Medium	41.00	1,640.00
93	40	do	44.00	1,760.00
94	40	do	43.50	1,740.00
95	40	do	44.50	1,780.00
96	40	do	45.50	1,820.00
97	40	17 large; 23 medium	49.00	1,960.00
98	40	Medium	44.50	1,780.00
99	40	do	44.50	1,780.00
100	40	do	46.50	1,860.00
101	40	do	47.00	1,880.00
102	40	do	46.50	1,860.00
103	41	do	46.50	1,906.50
104	40	13 large; 27 medium	47.00	1,880.00
105	40	Medium	44.50	1,780.00
106	40	do	45.00	1,800.00
107	35	do	44.50	1,557.50
108	40	5 large; 26 medium; 9 small medium	47.50	1,900.00
109	30	6 large; 17 medium; 7 small medium	45.50	1,365.00
110	46	32 medium, 14 small medium	41.00	1,886.00
111	46	Small medium	32.00	1,472.00
112	40	do	36.50	1,460.00
113	40	do	38.00	1,520.00
114	34	do	39.00	1,326.00
115	57	do	39.00	2,223.00
116	37	1 large, 25 medium, 11 small medium; scarred, faulty, etc	26.50	980.50
117	29	2 large, 15 medium, 12 small medium; scarred, faulty, etc	23.00	667.00
118	16	1 large, 7 medium, 8 small medium; scarred, faulty, etc	23.00	368.00
119	45	1 large, 44 medium; scarred, faulty, etc	31.00	1,395.00
120	45	14 medium, 31 small medium; scarred, faulty, etc	28.00	1,260.00
121	9	III, 3 medium, 6 small medium	8.50	76.50
122	27	3 large, 24 medium; scarred, faulty, etc	21.50	580.50
123	33	Small medium; scarred, faulty, etc	18.50	610.50
124	16	III, 1 medium, 15 small medium	6.00	96.00
	1,250			49,326.00

54 DRESSED, DYED, AND MACHINED PRIBILOF ISLANDS SKINS, DYED GOLDEN CHESTNUT (CHÂTAIGNE D'OR)

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
125	25	5 large, 20 medium; scarred, faulty, etc	$25.00	$625.00
126	25	8 medium, 17 small medium; scarred, faulty, etc	21.00	525.00
127	4	III, 1 medium, 3 small medium	5.00	20.00
	54			1,170.00

3 DRESSED PRIBILOF ISLANDS SKINS

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
128	3	Faulty	$1.00	$3.00

Sale of fur-seal skins at St. Louis, Mo., October 11, 1926—Continued

151 SKINS RECEIVED FROM JAPANESE GOVERNMENT UNDER TREATY PROVISIONS, DRESSED, DYED, AND MACHINED, BLACK

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
131	59	6 extra large, 25 large, 28 medium	$37.00	$2,183.00
132	38	8 extra large, 30 large; scarred, faulty, etc	27.00	1,026.00
133	43	41 medium, 2 small medium; scarred, faulty, etc	24.50	1,053.50
134	11	III, 1 extra large, 6 large, 4 medium	12.00	132.00
	151			4,394.50

30 SKINS RECEIVED FROM JAPANESE GOVERNMENT UNDER TREATY PROVISIONS RAW SALTED

135	30	Skins	$0.25	$7.50

1 SKIN AND 4 PIECES OF SKIN, CONFISCATED

136	1	Extra large; dressed, dyed, and machined, black	$41.00	$41.00
138	4 pieces	Dressed and dyed ... for lot		1.00
				42.00

Special sales of Pribilof Islands sealskins in 1926

Date	Number of skins	Description	Price per skin	Total
		Dressed, dyed, and machined, logwood brown (Bois de Campêche)		
Jan. 11	29	8 medium, 21 small medium; scarred	$18.70	$542.30
11	50	11 medium, 39 small medium	29.40	1,470.00
18	100	64 medium, 36 small medium	35.00	3,500.00
18	62	Small medium	28.50	1,767.00
18	36	do	30.50	1,098.00
20	62	do	28.50	1,767.00
25	30	do	30.50	915.00
28	124	do	28.50	3,534.00
Mar. 25	34	do	30.50	1,037.00
		Dressed, dyed, and machined, black		
Mar. 27	75	Medium	46.32	3,474.00
27	25	Small medium	35.43	885.75
		Raw salted		
Dec. 29	9		14.525	130.73
29	59		23.548	1,389.33
	695			21,510.11

Comparative values, by sizes and grades, with percentages each size, of Pribilof sealskins sold at public auction in 1926

Classes and sales	Grade	Number	High	Low	Average	Total	Total number	Average price	Total price	Percentage
DYED BLACK										
Wig:										
May 24	I and II	1	$53.50	$53.50	$53.50	$53.50	1	$53.50	$53.50	0.01
Extra extra large:										
Oct. 11	III	1	8.00	8.00	8.00	8.00	1	8.00	8.00	.02
Extra large:										
May 24	I and II	5	53.50	53.50	53.50	267.50	7	44.93	314.50	.06
	Scarred, faulty, etc	2	23.50	23.50	23.50	47.00				
Oct. 11	I and II	29	69.00	66.00	68.28	1,980.00	57	51.71	2,947.50	.84
	Scarred, faulty, etc	25	39.50	37.50	37.74	943.50				
	III	3	8.00	8.00	8.00	24.00				
Large:										
May 24	I and II	354	65.50	36.50	60.99	21,589.00	612	50.27	30,767.00	5.46
	Scarred, faulty, etc	233	43.50	23.50	38.64	9,003.00				
	III	25	7.00	7.00	7.00	175.00				
Oct. 11	I and II	355	69.50	60.50	66.80	23,714.00	568	55.82	31,706.00	8.39
	Scarred, faulty, etc	207	41.00	36.00	38.38	7,944.00				
	III	6	8.00	8.00	8.00	48.00				
Medium:										
May 24	I and II	2,858	52.50	36.50	49.32	140,956.50	5,516	38.95	214,837.25	49.22
	Scarred, faulty, etc	2,462	36.00	14.00	29.34	72,223.00				
	III	191	11.75	7.50	8.54	1,630.25				
	IV	5	5.50	5.50	5.50	27.50				
Oct. 11	I and II	2,227	52.50	44.00	48.39	107,760.00	3,577	42.28	151,237.50	52.86
	Scarred, faulty, etc	1,317	34.50	31.00	32.80	43,195.50				
	III	33	9.50	8.00	8.55	282.00				
Small medium:										
May 24	I and II	2,241	37.50	27.50	31.20	69,926.50	5,071	23.89	121,142.25	45.25
	Scarred, faulty, etc	2,578	26.00	8.00	18.96	48,891.00				
	III	240	11.75	8.00	9.41	2,258.75				
	IV	12	5.50	5.50	5.50	66.00				
Oct. 11	I and II	1,253	37.00	31.00	34.31	42,994.50	2,564	28.25	72,446.00	37.89
	Scarred, faulty, etc	1,241	24.50	22.00	23.24	28,837.50				
	III	70	9.50	8.00	8.77	614.00				
All classes:										
May 24							11,207	32.76	367,114.50	100.00
Oct. 11							6,767	38.18	258,345.00	100.00

Comparative values, by sizes and grades, with percentages each size, of Pribilof sealskins sold at public auction in 1926—Continued

Classes and sales	Grade	Number	High	Low	Average	Total	Total number	Average price	Total price	Percentage
DYED GOLDEN CHESTNUT (CHÂTAIGNE D'OR)										
Large:										
May 24	Scarred, faulty, etc.	24	$19.00	$13.00	$15.96	$383.00	26	$14.92	$388.00	5.54
	III	2	2.50	2.50	2.50	5.00				
Oct. 11	Scarred, faulty, etc.	5	25.00	25.00	25.00	125.00	5	25.00	125.00	9.26
Medium:										
May 24	I and II	24	27.00	27.00	27.00	648.00	221	15.82	3,496.00	47.12
	Scarred, faulty, etc.	169	19.00	13.00	16.44	2,778.00				
	III	28	2.50	2.50	2.50	70.00				
Oct. 11	Scarred, faulty, etc.	28	25.00	21.00	23.86	668.00	29	23.21	673.00	53.70
	III	1	5.00	5.00	5.00	5.00				
Small medium:										
May 24	I and II	45	22.00	22.00	22.00	990.00	222	14.75	3,275.50	47.34
	Scarred, faulty, etc.	153	17.00	13.00	14.62	2,237.50				
	III	24	2.00	2.00	2.00	48.00				
Oct. 11	Scarred, faulty, etc.	17	21.00	21.00	21.00	357.00	20	18.60	372.00	37.04
	III	3	5.00	5.00	5.00	15.00				
All classes:										
May 24							469	15.27	7,159.50	100.00
Oct. 11							54	21.67	1,170.00	100.00
DYED LOGWOOD BROWN (BOIS DE CAMPÊCHE)										
Extra large:										
May 24	I and II	1	34.00	34.00	34.00	34.00	1	34.00	34.00	.04
Oct. 11	I and II	2	56.50	56.50	56.50	113.00	2	56.50	113.00	.16
Large:										
May 24	I and II	41	45.50	25.50	40.62	1,665.50	71	30.90	2,194.00	2.58
	Scarred, faulty, etc.	30	21.50	9.50	17.62	528.50				
Oct. 11	I and II	63	56.50	45.50	50.75	3,197.50	71	47.73	3,388.50	5.68
	Scarred, faulty, etc.	8	31.00	21.50	23.88	191.00				
Medium:										
May 24	I and II	602	37.50	15.50	34.28	20,638.00	1,199	26.52	31,800.50	43.58
	Scarred, faulty, etc.	586	22.50	9.50	18.95	11,102.00				
	III	11	5.50	5.50	5.50	60.50				
Oct. 11	I and II	681	49.00	41.00	45.02	30,660.50	814	41.93	34,132.50	65.12
	Scarred, faulty, etc.	129	31.00	21.50	26.67	3,440.50				
	III	4	8.50	6.00	7.88	31.50				

Small medium:										
May 24	I and II	642	34.00	15.50	18.79	12,064.50				
	Scarred, faulty, etc.	798	14.50	8.00	12.40	9,898.00	1,480	14.96	22,143.50	53.80
	III	40	5.50	4.00	4.53	181.00				
Oct. 11	I and II	247	47.50	32.00	37.74	9,321.00				
	Scarred, faulty, etc.	95	28.00	18.50	23.47	2,230.00	363	32.21	11,692.00	29.04
	III	21	8.50	6.00	6.71	141.00				
All classes:										
May 24							2,751	20.42	56,172.00	100.00
Oct. 11							1,250	39.46	49,326.00	100.00
MISCELLANEOUS	*Description*									
May 24	Dressed	6	1.50	1.50	1.50	9.00				
	Raw salted	149	2.00	1.50	1.70	253.00	175	1.73	302.00	100.00
	Washed and dried	20	2.00	2.00	2.00	40.00				
Oct. 11	Dressed	3	1.00	1.00	1.00	3.00	3	1.00	3.00	100.00

DISPOSITION OF FUR-SEAL SKINS TAKEN AT PRIBILOF ISLANDS

On January 1, 1926, 32,531 fur-seal skins taken at the Pribilof Islands were on hand. Of these, 770 were at the Pribilof Islands, 31,748 at St. Louis, Mo., 11 at Washington, and 2 temporarily shipped to Kansas City, Mo. In 1926, 22,131 Pribilof skins were secured at the islands and 23,373 were disposed of, leaving 31,289 on hand on December 31, 1926. The follwing tables show further details in regard to sealskins taken on the Pribilof Islands, as well as details in regard to other Government-owned sealskins under the control of the Department of Commerce:

Summary of Government-owned fur-seal skins in the custody of Fouke Fur Co., St. Louis, Mo., calendar year 1926

Description	On hand Jan. 1	Receipts in 1926	Disposed of in 1926	On hand Dec. 31
Taken on Pribilof Islands:				
Calendar year 1923	1,538		[1] 1,538	
Calendar year 1924	11,120	[2] 2	[1] 11,122	
Calendar year 1925	19,090	[3] 770	[4] 10,725	9,135
Calendar year 1926		[3] 21,303		21,303
Skins from Pribilof Islands seals shipped from Steinhart Aquarium		1	[1] 1	
United States' share of Japanese sealskins:				
Season of 1924		94	[1] 94	
Season of 1925		87	[1] 87	
Confiscated skins	7	1	[5] 8	
Total	31,755	22,258	23,575	30,438

[1] Sold.
[2] Returned from Kansas City, Mo.
[3] Shipped from Pribilof Islands.
[4] 10,711 sold; 12 shipped to Washington; 2 charged off account error in count.
[5] Sold; in addition four pieces of sealskin were confiscated and sold.

Summary of all fur-seal skins handled on Pribilof Islands, calendar year 1926

Island	Balance on hand Jan. 1	Number taken	Total handled	Number shipped	Balance on hand Dec. 31
St. Paul	546	16,231	16,777	16,231	546
St. George	224	5,900	6,124	5,842	282
Total	770	22,131	22,901	22,073	828

Summary of all Government-owned fur-seal skins under control of Department of Commerce, calendar year 1926

Description	On hand Jan. 1	Receipts in 1926	Sales in 1926	Balance on hand, Dec. 31
Taken on Pribilof Islands:				
Calendar year 1918, held for reference purposes	7			7
Calendar year 1923	1,541		1,538	3
Calendar year 1924	11,123		11,122	1
Calendar year 1925	19,860		[1] 10,713	9,147
Calendar year 1926		22,131		22,131
Miscellaneous skins held for reference purposes	4			4
Skins from Pribilof Islands seals shipped to Steinhart Aquarium		1	1	
United States' share of Japanese sealskins:				
Season of 1924		94	94	
Season of 1925		87	87	
Confiscated skins	7	1	[2] 8	
Total	32,542	22,314	[1] 23,563	[3] 31,293

[1] Includes two charged off account error in count.
[2] In addition four pieces of sealskin were confiscated and sold.
[3] 828 skins at Pribilof Islands; 30,438 in custody Fouke Fur Co.; 27 in custody Washington office, Bureau of Fisheries.

SHIPMENT AND SALE OF FOX SKINS

The 67 blue and 19 white fox skins taken on St. Paul Island in the season of 1925–26 and the 638 blue and 1 white fox skins taken on St. George Island in the same season were placed aboard the U. S. S. *Vega* for shipment in August. These 725 skins were delivered at Bremerton, Wash., on August 21, and were then forwarded by express to St. Louis, Mo., where they were delivered to the bureau's selling agents on August 28.

Of these skins, 125 blues were sold at public auction at St. Louis on October 11, 1926. At the same sale there were also disposed of the 340 blue-fox skins that remained on hand from the Pribilof Islands take of the season 1924–25. These 465 skins sold for $24,740, an average of $53.20 per skin, the maximum price obtained being $132 per skin for a lot of four. The average price at the last preceding sale for the Government's account (September 24, 1925) of Pribilof Islands blue-fox skins was $48.62.

There were also sold at the same time three blue-fox pelts taken from animals included in a shipment of foxes made from the Pribilof Islands in 1925 and which died en route. The skins brought $1.50.

Further details are given in the following table:

Sale of 468 blue-fox skins at St. Louis, Mo., October 11, 1926

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
		Taken season 1925–26		
200	2	Extra extra fine	$99.00	$198.00
201	5	Extra fine	76.00	380.00
202	2	Fine dark silvery	89.00	178.00
203	7	Fine	61.00	427.00
204	10	I dark	55.00	550.00
205	8	do	46.00	368.00
206	10	do	50.00	500.00
207	10	do	51.00	510.00
208	12	do	49.00	588.00
209	9	I blue	45.50	409.50
210	6	I silvery	56.00	336.00
211	16	II dark	40.00	640.00
212	7	II blue	32.00	224.00
213	9	II part I	35.50	319.50
214	12	II low part II	25.50	306.00
	125			5,934.00
		Taken season 1924–25		
215	4	Extra extra fine	81.00	324.00
216	6	Extra fine	81.00	486.00
217	8	Fine	72.00	576.00
218	4	Dark silvery	70.00	280.00
219	8	I dark	57.00	456.00
220	12	II dark	34.00	408.00
221	12	I dark	52.00	624.00
222	10	II dark	37.50	375.00
223	8	I blue	52.50	420.00
224	10	II blue	33.50	335.00
225	6	I part II dark	47.00	282.00
226	7	II low	20.00	140.00
227	7	III and IV	5.50	38.50
228	4	Extra extra fine	111.00	444.00
229	6	Extra fine	82.00	492.00
230	6	Fine	73.00	438.00
231	10	I dark	58.00	580.00
232	14	II dark	36.00	504.00
233	8	I dark	53.50	428.00
234	10	II dark	35.00	350.00
235	12	I blue	42.00	504.00
236	10	II blue	33.00	330.00
237	8	I part II	40.00	320.00
238	4	Extra extra fine	95.00	380.00

Sale of 468 blue-fox skins at St. Louis, Mo., October 11, 1926—Continued

Lot No.	Number of skins	Trade classification	Price per skin	Total for lot
		Taken season 1924-25—Continued		
239	4	Extra fine	$73.50	$294.00
240	8	Fine	71.00	568.00
241	10	I dark	49.00	490.00
242	10	do	46.00	460.00
243	12	I blue	45.00	540.00
244	12	II blue	40.00	480.00
245	7	I dark	55.00	385.00
246	9	I part II	47.50	427.50
247	4	Silvery	52.00	208.00
248	4	Extra extra fine	89.00	356.00
249	12	I dark	64.00	768.00
250	12	do	57.00	684.00
251	4	Extra extra fine	132.00	528.00
252	5	Extra fine	112.00	560.00
253	5	I dark	91.00	455.00
254	5	do	89.00	445.00
255	5	II dark	65.00	325.00
256	4	Fine	85.00	340.00
257	8	I part II	64.00	512.00
258	4	Silvery	104.00	416.00
259	2	II low	25.00	50.00
	340			18,806.00
		Taken from animals that died in transit		
260	3	Skins	.50	1.50
	468			24,741.50

The remaining 580 blue and the 20 white pelts of the Pribilof Islands take of the season of 1925–26 will be sold later.

FUR-SEAL PATROL

UNITED STATES COAST GUARD

The United States Coast Guard employed five of its vessels in the patrol of the North Pacific Ocean, including Bering Sea, for the protection of fur seals in 1926.

The detail of the vessels was virtually the same as in the preceding year. The *Snohomish* patrolled the coastal waters from the southern boundary of Washington to Dixon Entrance, southeastern Alaska. The *Unalga* patrolled waters between Dixon Entrance and Unalaska and in Bering Sea. The *Algonquin* and *Haida* proceeded from Seattle to Unalaska, patrolling en route, and then engaged in patrol work in Bering Sea.

The *Bear*, while detailed primarily for the usual annual expedition to the Arctic Ocean, served as a patrol vessel while in the waters frequented by the fur seals.

The seal patrol extended as far westward as Attu, the westernmost island of the Aleutian Chain, and was maintained as long as there was any necessity for it.

BUREAU OF FISHERIES

On April 24 the fisheries vessel *Auklet* left Juneau for Sitka to take part in the seal patrol work in southeastern Alaska. The work was continued until June 10.

SEALING PRIVILEGES ACCORDED ABORIGINES

The North Pacific Sealing Convention of July 7, 1911, permits Indians and other aborigines dwelling on the coasts of the waters designated by the convention to take sealskins under certain specified conditions.

There have been authenticated by the Government 1,075 sealskins taken in 1926 by Indians in the waters off the coasts of Washington and southeast Alaska. The details are as follows:

Washington.—One thousand and thirty-five skins were taken, of which 291 were from male seals, 715 from females, and 29 from unborn pups. These skins were authenticated for the Bureau of Fisheries by Dr. Carl B. Boyd, superintendent of the Neah Bay Indian Agency, Neah Bay, Wash., who has done this work for a number of years past.

Southeast Alaska.—Forty skins were taken, of which 36 were from male seals, 3 from females, and 1 from an unborn pup.

An official report received by the bureau stated that 2,824 sealskins were taken by the natives of British Columbia in 1926.

JAPANESE SEALSKINS DELIVERED TO THE UNITED STATES

The North Pacific Sealing Convention of July 7, 1911, provides that 10 per cent of the sealskins taken by the Japanese Government within the areas defined by the convention shall be turned over to the United States Government, unless the number of seals frequenting the Japanese islands falls below 6,500, enumerated by official count.

In May there was delivered at St. Louis, Mo., the United States Government's share of fur-seal skins taken by the Japanese Government in 1924 and 1925. The share consisted of 94 skins for 1924 and 87 for 1925, a total of 181 skins. The skins were not segregated by year of take. They were sold at public auction on October 11, 1926. Before being sold, 151 were dressed, dyed, and machined. The remaining 30 were sold in the raw salted condition. Details of the sale are given on page 322.

The United States Government's share of fur-seal skins taken by the Japanese Government in 1926 was 132. They had not been received in this country at the end of the year.

SEIZED SEA-OTTER SKINS

Two sea-otter skins, which had been taken unlawfully in the vicinity of Sanak Island, Alaska, were delivered to the bureau. These skins will be sold for the account of the Government. They were surrendered through the United States Customs, following an investigation by the Department of Justice.

SESQUICENTENNIAL AT PHILADELPHIA

An appropriate exhibit of sealskins and blue and white fox skins, illustrative of the products of the Pribilof Islands, was included in the bureau's exhibit at the Philadelphia Sesquicentennial. Two coats made from Pribilof Islands sealskins also were shown.

COMPUTATION OF FUR SEALS, PRIBILOF ISLANDS, 1926

By Edward C. Johnston

The numerical strength of the Pribilof Islands fur-seal herd, as of August 10, 1926, was computed from an actual count of the harem and idle bulls on all the rookeries, made at the height of the breeding season, the count of pups on one rookery, and information derived from the work of previous years.

BULLS

The harem and idle bull count on St. Paul Island was made on July 16, 17, and 18, and on St. George Island on July 19 and 20.

For the first time since 1920 an actual count was made of the bulls on Sivutch rookery. In 1925 the number of harem bulls was estimated at 190. In 1926 there were counted 279 harem bulls. As only 17 of these were estimated to be 6-year-olds, the 1925 estimate probably was too low.

Number of harem and idle bulls, approximate ratio of idle bulls to harem bulls, and average harem, 1926

Rookery	Date	Harem bulls	Idle bulls	Total	Approximate ratio of idle bulls to harem bulls	Average harem
St. Paul Island:						
Kitovi	July 17	212	37	249	1:6	38.08
Lukanin	do	94	3	97	1:31	41.53
Gorbatch	do	276	31	307	1:9	74.27
Ardiguen	do	38	3	41	1:13	51.03
Reef	do	605	82	687	1:7	68.06
Sivutch	do	279	34	313	1:8	45.16
Lagoon	do	3		3		36.33
Tolstoi	do	376	45	421	1:8	64.47
Zapadni	July 18	322	23	345	1:14	72.34
Little Zapadni	do	185	17	202	1:11	64.18
Zapadni Reef	do	18		18		22.89
Polovina	July 16	166	27	193	1:6	50.43
Polovina Cliffs	do	118	11	129	1:11	38.84
Little Polovina	do	45	10	55	1:5	37.09
Morjovi	do	87	4	91	1:22	34.49
Vostochni	do	654	41	695	1:16	51.07
Total		3,478	368	3,846	1:9	57.26
St. George Island:						
North	July 19	191	18	209	1:11	85.05
Staraya Artil	do	136	12	148	1:11	90.00
Zapadni	July 20	42	4	46	1:11	41.14
South	do	15		15		27.00
East Reef	July 19	47	4	51	1:12	79.21
East Cliffs	do	125	17	142	1:7	85.02
Total		556	55	611	1:10	80.88
Total (both islands)		4,034	423	4,457	1:10	60.51

The increase in number of harem bulls on St. Paul Island over the 1925 computation was 375, and on St. George Island 133, a total of 508. A total of 414 bulls, estimated 6 years old, was observed in charge of harems; but it is very probable that the actual number of 6-year-old harem bulls was more than large enough to make up for the increase. A total of 4,034 harem bulls was counted. The number in 1925 was 3,526.

The number of idle bulls increased from 283 on St. Paul Island in 1925 to 368 in 1926, and from 28 on St. George Island in 1925 to 55 in 1926, a total increase for both islands of 112. The approximate ratio of idle bulls to harem bulls was 1 to 11 for St. Paul Island in 1925 and 1 to 9 in 1926; 1 to 15 for St. George Island in 1925 and 1 to 10 in 1926. The approximate ratio for both islands was 1 to 11 in 1925 and 1 to 10 in 1926. It will be noted that each comparison shows a trend toward a more favorable ratio of idle to harem bulls.

Four dead bulls were observed during the progress of the work.

SIX-YEAR-OLD BULLS

A count was made of bulls iron-branded as 3-year-olds in 1923, and also of bulls of the same size but not branded. On St. Paul Island 73 branded animals maintained harems and on St. George Island 29, a total of 102 6-year-olds. On St. Paul Island there were 202 harem bulls that appeared to be 6 years old, and on St. George Island 110, a total of 312 unmarked 6-year-olds. A total of 414, or about 10 per cent of the harem bulls, were 6 years old.

In 1925 only seven bulls that appeared to be 6 years old were found. There probably were many more, and the low estimate was caused by the fact that there was no standard by which to judge whether an animal was 6 years old or not. In 1926 there was a sufficient number of animals known to be 6 years old, to which unmarked bulls could be compared.

6-year-old bulls that maintained harems in 1926

Rookery	Iron-branded	Un-branded	Total
St. Paul Island:			
Kitovi	5	17	22
Lukanin		7	7
Gorbatch	7	14	21
Ardiguen		2	2
Reef	13	36	49
Sivutch	1	16	17
Lagoon		1	1
Tolstoi	17	34	51
Zapadni	8	21	29
Little Zapadni	5	15	20
Zapadni Reef		3	3
Polovina	3	7	10
Polovina Cliffs	3	5	8
Little Polovina	3	2	5
Morjovi		3	3
Vostochni	8	19	27
Total	73	202	275
St. George Island:			
North	14	37	51
Staraya Artil	8	34	42
Zapadni	1	8	9
South		4	4
East Reef	1	8	9
East Cliffs	5	19	24
Total	29	110	139
Total (both islands)	102	312	414

AVERAGE HAREM

The pups were not counted in 1926; consequently the average harem is only estimated. On account of the increase in number of harems, due to the influx of 6-year-old bulls, and the fact that there was no evidence of any unusual increase of cows, the estimated average harem was based upon the average annual increase of cows in the years 1916 to 1922. The pups were all counted in 1916 and again in 1922, and the average annual increase of cows was found to be 8 per cent. This percentage of increase has been applied to the 1925 figures to secure the number of cows in 1926, except in the case of Lagoon rookery, where the pups actually were counted. This rookery has been declining steadily for a number of years and soon will disappear.

Computation of breeding cows, based on annual increase of 8 per cent, and of average harems, in 1926

Rookery	Breeding cows		Harem bulls, 1926	Average harem		
	1925	1926		1926	1925	Increase (+) or decrease (−) in 1926 from 1925
St. Paul Island:						
Kitovi	7,475	8,073	212	38.08	47.01	−8.93
Lukanin	3,615	3,904	94	41.53	43.03	−1.50
Gorbatch	18,981	20,499	276	74.27	80.77	−6.50
Ardiguen	1,796	1,939	38	51.03	46.06	+4.97
Reef	38,126	41,176	605	68.06	75.20	−7.14
Sivutch	11,666	12,599	279	45.16	61.40	−16.24
Lagoon	152	[1] 109	3	36.33	30.39	+5.94
Tolstoi	22,445	24,240	376	64.47	68.64	−4.17
Zapadni	21,569	23,294	322	72.34	68.04	+4.30
Little Zapadni	10,995	11,874	185	64.18	65.06	−.88
Zapadni Reef	382	412	18	22.89	34.76	−11.87
Polovina	7,751	8,371	166	50.43	47.26	+3.17
Polovina Cliffs	4,244	4,583	118	38.84	42.87	−4.03
Little Polovina	1,546	1,669	45	37.09	36.81	+.28
Morjovi	2,779	3,001	87	34.49	34.74	−.25
Vostochni	30,929	33,403	654	51.07	45.82	+5.25
Total	184,451	199,146	3,478	57.26	59.44	−2.18
St. George Island:						
North	15,041	16,244	191	85.05	108.21	−23.16
Staraya Artil	11,334	12,240	136	90.00	114.48	−24.48
Zapadni	1,600	1,728	42	41.14	55.16	−14.02
South	375	405	15	27.00	41.62	−14.62
East Reef	3,448	3,723	47	79.21	76.62	+2.59
East Cliffs	9,841	10,628	125	85.02	96.48	−11.46
Total	41,639	44,968	556	80.88	98.44	−17.56
Total (both islands)	226,090	244,114	4,034	60.51	64.12	−3.61

[1] Pups counted in 1926.

The average harem shows a decrease for the whole herd from 64.12 in 1925 to 60.51 in 1926. The St. George average harem decreased from 98.44 in 1925 to 80.88 in 1926.

Very few of the 6-year-old harem bulls had more than four or five cows. Most of them were around the margins of the harem areas and were not strong enough to fight a more mature bull or to protect and hold any large number of cows. Consequently the average harem for all the bulls over 6 years old actually was considerably in excess of the computed figures. Lagoon rookery is a good example of this. There were three bulls on the rookery and they were well separated. One, a 6-year-old, had one cow; another, a little over 6 years old, had five cows, and one old bull had 103 cows.

This is the first year in which any results of the branding of the breeding reserve have appeared. A further increase of harem bulls should occur in 1927, although about 1,500 fewer 3-year-olds were reserved by marking in 1924 than in 1923.

PUPS AND COWS

The number of pups in 1926 was determined in the same manner as the number of cows—by applying an 8 per cent increase to the 1925 figures.

Distribution of pups on the Pribilof Islands August 10, 1926, and comparison with distribution in 1925

Rookery	1926				1925, total pups	1926, increase
	Living pups	Dead pups	Total pups	Per cent dead pups		
St. Paul Island:						
Kitovi	7,954	119	8,073	1.47	7,475	598
Lukanin	3,819	85	3,904	2.17	3,615	289
Gorbatch	20,323	176	20,499	.86	18,981	1,518
Ardiguen	1,893	46	1,939	2.39	1,796	143
Reef	40,575	601	41,176	1.46	38,126	3,050
Sivutch	12,292	307	12,599	2.44	11,666	933
Lagoon	109		[1] 109		152	43
Tolstoi	23,903	337	24,240	1.39	22,445	1,795
Zapadni	22,893	401	23,294	1.72	21,569	1,725
Little Zapadni	11,577	297	11,874	2.50	10,995	879
Zapadni Reef	409	3	412	.80	382	30
Polovina	8,243	128	8,371	1.53	7,751	620
Polovina Cliffs	4,498	85	4,583	1.85	4,244	339
Little Polovina	1,627	42	1,669	2.51	1,546	123
Morjovi	2,940	61	3,001	2.02	2,779	222
Vostochni	32,708	695	33,403	2.08	30,929	2,474
Total	195,763	3,383	199,146	1.70	184,451	14,695
St. George Island:						
North	16,017	227	16,244	1.40	15,041	1,203
Staraya Artil	11,924	316	12,240	2.58	11,334	906
Zapadni	1,709	19	1,728	1.12	1,600	128
South	398	7	405	1.72	375	30
East Reef	3,667	56	3,723	1.51	3,448	275
East Cliffs	10,470	158	10,628	1.49	9,841	787
Total	44,185	783	44,968	1.74	41,639	3,329
Total (both islands)	239,948	4,166	244,114	1.70	226,090	18,024

[1] Pups counted in 1926.

St. Paul Island had 199,146 pups and St. George Island 44,968, a total of 244,114 for the herd. This is an increase of 18,024 over 1925.

During the harem count the rookeries were examined as to dead pups and the number did not appear unusual. The same percentage of dead pups was applied to each rookery as was found in 1922. This gives a total of 4,166 dead pups.

COMPLETE COMPUTATION

Following is a summary of the method used to arrive at the complete computation for 1926, together with a recapitulation of the herd. It will be noted that the increase in the total number of seals over 1925 was 38,231, or 5.29 per cent. The increase in 1925 over 1924 was 25,892, or 3.71 per cent.

Complete computation of fur seals, Pribilof Islands, as of August 10, 1926

Class	St. Paul Island	St. George Island	Total
Pups, estimated	199,146	44,968	244,114
Breeding cows, 3 years old and over, *by inference*	199,146	44,968	244,114
Harem bulls, counted	3,478	556	4,034
Idle bulls, counted	368	55	423
Yearlings, male and female, estimated:			
Females born in 1925	92,226	20,819	113,045
Natural mortality, 45 per cent	41,502	9,368	50,870
Yearling females, Aug. 10, 1926	50,724	11,451	62,175
Males born in 1925	92,225	20,820	113,045
Natural mortality, 50 per cent	46,112	10,410	56,522
Yearling males beginning 1926	46,113	10,410	56,523
Yearling males killed 1926	9		9
Yearling males, Aug. 10, 1926	46,104	10,410	56,514
2-year-olds, male and female, estimated:			
Yearling females, Aug. 10, 1925	47,445	9,864	57,309
Natural mortality, 22.5 per cent	10,675	2,219	12,894
2-year-old females, Aug. 10, 1926	36,770	7,645	44,415
Yearling males, Aug. 10, 1925	43,124	8,967	52,091
Yearling males killed fall 1925	1		1
Yearling males end of 1925	43,123	8,967	52,090
Natural mortality, 25 per cent	10,781	2,241	13,022
2-year-olds beginning 1926	32,342	6,726	39,068
2-year-olds killed 1926	852	33	885
2-year-old males, Aug. 10, 1926	31,490	6,693	38,183
3-year-old males, estimated:			
2-year-old males, Aug. 10, 1925	37,170	6,345	43,515
2-year-old males killed fall 1925	26		26
2-year-old males end of 1925	37,144	6,345	43,489
Natural mortality, 15 per cent	5,571	952	6,523
3-year-olds beginning 1926	31,573	5,393	36,966
3-year-olds killed 1926	14,285	5,492	19,777
3-year-old-males, Aug. 10, 1926	(1)	(1)	17,189
4-year-old males, estimated:			
3-year-old males, Aug. 10, 1925	20,002	1,183	21,185
3-year-old males killed fall 1925	504	224	728
3-year-old males end of 1925	19,498	959	20,457
Natural mortality, 10 per cent	1,950	96	2,046
4-year-old males beginning 1926	17,548	863	18,411
4-year-old males killed 1926	480	59	539
4-year-old males, Aug. 10, 1926	17,068	804	17,872

[1] Apparently a large number of 3-year-olds credited to St. Paul Island hauled out on St. George Island.

Complete computation of fur seals, Pribilof Islands, as of August 10, 1926—Continued

Class	St. Paul Island	St. George Island	Total
5-year-old males, estimated:			
4-year-old males, Aug. 10. 1925	16,817	1,875	18,692
4-year-old males killed fall 1925	11		11
4-year-old males end of 1925	16,806	1,875	18,681
Natural mortality, 10 per cent	1,681	187	1,868
5-year-old males beginning 1926	15,125	1,688	16,813
5-year-old males killed 1926	1		1
5-year-old males, Aug. 10, 1926	15,124	1,688	16,812
6-year-old males, estimated:			
5-year-old males, Aug. 10, 1925	15,046	1,746	16,792
5-year-old males killed, fall of 1925			
5-year-old males end of 1925	15,046	1,746	16,792
Natural mortality, 20 per cent	3,009	349	3,358
6-year-old males beginning 1926	12,037	1,397	13,434
6-year-old males killed 1926			
6-year-old males, Aug. 10, 1926	12,037	1,397	13,434
Surplus bulls, 7 years and over, estimated:			
6-year-old males, Aug. 10, 1925	3,841	264	4,105
6-year-old males killed fall 1925			
6-year-old males end 1925	3,841	264	4,105
Natural mortality, 20 per cent	768	53	821
7-year-old males beginning 1926	3,073	211	3,284
7-year-old males killed 1926			
7-year-old males, Aug. 10, 1926	3,073	211	3,284
Surplus bulls, Aug. 10, 1925	3,352	206	3,558
Natural mortality, 30 per cent	1,005	62	1,067
Remaining surplus for 1926	2,347	144	2,491
Breeding bulls of 1925	3,386	451	3,837
Natural mortality, 30 per cent	1,015	136	1,151
1925 bulls remaining 1926	2,371	315	2,686
Breeding bulls 1926	3,846	611	4,457
1925 bulls remaining, deducted	2,371	315	2,686
Increment of new bulls in 1926	1,475	296	1,771
7-year-old males computed for 1926	3,073	211	3,284
Surplus bulls computed for 1926	2,347	144	2,491
Total theoretical surplus bull stock 1926	5,420	355	5,775
New increment of breeding bulls deducted	1,475	296	1,771
Surplus bulls in 1926	3,945	59	4,004
50 per cent deducted for losses due to fighting, natural causes, and errors in loss percentage in previous years	1,973	29	2,002
Surplus bulls, Aug. 10, 1926	1,972	30	2,002

RECAPITULATION

Pups	244,114	5-year-old males	16,812
Cows	244,114	6-year-old males	13,434
Harem bulls	4,034	Surplus bulls	2,002
Idle bulls	423	Total, 1926	761,281
Yearling females	62,175		
Yearling males	56,514	Total, 1925	723,050
2-year-old females	44,415	Numerical increase, 1926	38,231
2-year-old males	38,183	Per cent increase, 1926	5.29
3-year-old males	17,189		
4-year-old males	17,872		

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FISHERY INDUSTRIES IN THE UNITED STATES, 1926 [1]

By Oscar E. Sette

Assistant in Charge, Division of Fishery Industries

CONTENTS

REVIEW OF CONDITIONS IN THE FISHERY INDUSTRIES, 1926

According to the most recent statistics available for the various geographical sections of the United States and Alaska, the fisheries and fishery industries employ nearly 190,000 persons and property and equipment to the value of over $210,000,000. The annual sales of fishery products by fishermen amount to over 3,000,000,000 pounds, valued at nearly $109,000,000. The output of canned fishery products and by-products in 1926 was valued at more than $98,000,000. In the foreign trade of the United States the domestic exports of fishery products amounted to more than $20,000,000 and the imports for consumption were in excess of $50,000,000.

The year 1926 was one of continued growth of the fisheries. Vessel landings at New England ports were larger than in any previous year of which we have record, due largely to the greatly increased haddock and mackerel yields. The Seattle landings of fish also were increased, as compared with the previous year. The canning industry, with an unusually large pack in Alaska, produced fishery products with the highest value on record. The by-products industry was adversely affected by a failure in the menhaden supply, but other branches had a good output. In our foreign trade the imports were larger and the exports smaller than in the previous year, indicating some losses in foreign markets but an expansion in the domestic markets.

[1] Appendix V to the Report of the United States Commissioner of Fisheries for 1927. Bureau of Fisheries Doc. 1025.

Statistical summary of fisheries of the United States and Alaska

Sections	Persons engaged	Capital invested	Products	
	Number		*Pounds*	*Value*
New England States, 1924	24,513	$28,561,824	406,822,165	$18,818,132
Middle Atlantic States, 1921–1925	53,574	39,821,342	666,137,511	25,615,453
South Atlantic States, 1923	16,298	8,505,259	228,747,930	5,087,340
Gulf States, 1923	17,793	10,535,905	160,324,042	8,096,650
Pacific Coast States, 1925	22,270	28,651,490	610,993,424	24,580,524
Mississippi River division, 1922	19,122	7,345,034	105,733,734	4,503,521
Great Lakes, 1922	8,039	12,046,458	108,732,443	6,689,611
Lake of the Woods and Rainy Lake, 1922	123	139,955	1,677,999	110,022
Alaska, 1926	28,052	74,557,522	728,185,986	15,179,814
Total various years, 1921–1926	189,784	210,164,789	3,017,355,234	108,681,067

NOTE.—In the statistics for the Pacific Coast States in this table the persons and investment are for 1922 and the products are for 1925.

It has been apparent for some years that the greatest opportunity for progress in the fishery industries was in developing methods of bringing fresh fishery products to the consumer in the freshest possible condition. The development of fish filleting has been an important step in this direction, and during the past year the output of fillets has continued to increase. The methods of suitably freezing fillets and packaging frozen fillets and other frozen fish in such a way as to permit their distribution and sale in much the same way as other package goods have progressed and promise to have favorable effects on the fish trade. Carbon dioxide ice has been used on a commercial scale in shipping small and large quantities of frozen fish and doubtless will be found regularly useful for making shipments under certain conditions. Notwithstanding these improvements, there are many serious technological problems as yet unsolved. The most urgent of these is the necessity of keeping fish in a fresh, wholesome condition from the time the fishermen take it from the water until it reaches the consumer. Means of satisfactorily utilizing waste from market fishes need also to be found, and general improvements in the by-products industries are necessary if the industry is to maintain its existence.

The acute condition at present existing in the menhaden industry deserves mention. Severe losses have been suffered in this industry in recent years. They are due in part to the fluctuations in the supply of menhaden and in part to the lack of efficient technological processes in the industry. Nothing is more vital to an industry than its supply of raw materials, yet there is utter dearth of information on the abundance of menhaden. A biostatistical study of menhaden, such as is being made on the mackerel (see p. 339), is urgently needed. Such an investigation would give an understanding of the causes of scarcity or abundance of menhaden and permit us to foresee the supply from one year to the next. With such predictive information available, the losses in operation in a poor year could be minimized through reduction of operating expenses. With additional savings by means of increased efficiency in the technological process of reducing menhaden to meal and oil, it is believed that the industry, now in a precarious condition, might prosper. The serious condition in this industry, which produces quantities of valuable protein feedstuffs and nitrogenous fertilizers in addition to the animal oils, can not but be viewed with concern.

SUMMARY OF OPERATIONS

STATISTICS

Monthly and annual statistics were collected and published regularly during 1926, as follows: The collection and monthly publication of the statistics of the landings of fish by vessels at the ports of Boston and Gloucester, Mass., Portland, Me., and Seattle, Wash., with publications of annual bulletins summarizing these landings for the year; monthly publication of statistics on the cold-storage holdings of frozen fish, collected by the Bureau of Agricultural Economics, Department of Agriculture; collection of the statistics of quarterly production, consumption, and holdings of oils in the fishery industries, for the use of the Bureau of the Census; collection and publication of the statistics on the production of canned fishery products and by-products of the United States and Alaska for 1926; collection of statistics on the shad and alewife fisheries of the Potomac River for 1926; collection of statistics of the shad fishery of the Hudson River for 1926; and the securing of statistics on the quantities and value of sponges handled by the Tarpon Springs Sponge Exchange.

In the general canvass work of the division the statistics on Maryland and Virginia were collected, compiled, and are published herewith. With the completion of the above-mentioned statistics, the following geographical sections will have been canvassed for the years indicated: New England States, 1924; New York, New Jersey, Pennsylvania, and Delaware, 1921; Maryland and Virginia, 1925; South Atlantic and Gulf States, 1923; Pacific Coast States, 1922; Great Lakes and Mississippi River and tributaries, 1922. In addition to these, yield statistics are available in this report on the Pacific Coast States, 1925; Great Lakes, 1925; and the State of Connecticut, 1926.

The bureau's program of securing the much-needed statistics of the fisheries through the agency of State collection has made considerable progress during the last year. The system of collecting statistics of the Pacific Coast States, begun in 1923, has been continued and bears fruit in the publication in this report of the statistics for 1924 and 1925. This makes four successive years now available. Through the cooperation of the Tariff Commission, which compiled State statistics on the fisheries of the Great Lakes in connection with tariff surveys, it has been possible to present in this report the statistics on the fishery yield of the Great Lakes and the Lake of the Woods for the years 1913 to 1925. The State of Connecticut also has cooperated in detailing one of its officers to the collection of statistics for the past three years, which makes possible the inclusion in this report of statistics for that State for the years 1924 to 1926. It is hoped that more of the States will enter this field, so that eventually we may have complete annual statistics of our fisheries.

Statistics of the mackerel fishery.—The collection of special statistics on the mackerel fisheries was continued during the year. They included the taking of accurate data on the date, locality of capture, and the size of each fare of mackerel landed, and the measurements of a sample of the mackerel landed. Altogether, data were secured on over 1,200 of the 2,800 fares landed, and more than 26,000 mackerel were measured.

This work was carried on in close cooperation with the division of scientific inquiry, and many biological data also were secured. Incomplete analysis of the data, both statistical and biological, indicates that the unusually large runs of mackerel in 1925 and 1926 were due almost entirely to one successful spawning season, provisionally determined to be that of 1923. Very few mackerel belonging to other age groups were present in the catch.

By continuing the collection of these data in future years, it will be possible to determine how many years a successful crop of mackerel, like that of 1923, will continue to furnish good catches. It will also enable us to detect another good spawning season as soon as its progeny first appear in the catch. These two lines of evidence will be of predictive value; and by so foreseeing the coming years' catches the fishermen may outfit intelligently for the mackerel season and the industry may be guarded from loss in buying, freezing, and selling this species. It may be possible thus to stabilize the market and save outfitting costs at ill-advised times.

TECHNOLOGICAL INVESTIGATIONS

In its technological work the Bureau of Fisheries is endeavoring to improve present practices and to develop new equipment, methods, and products within the fisheries industries and to bring about proper utilization of wastes and by-products. To accomplish these ends, investigations are made and science, in many forms, is applied to the problems at hand. Information thus gained is made available to the industry, and its application is directed until it becomes an integral part of the same. There are but few more fruitful fields for scientific work than the fisheries industries, and much must be done before they can be placed on the same plane of efficiency with other food-producing industries. Properly carried out, work along these lines can be expected to, and actually does, yield large returns.

The bureau's policy is to select broad, fundamental studies on urgent problems which promise to be of the greatest value to the largest number and which are possible with the funds and personnel available for the purpose. In such work the direct results obtained are not the only results. A successful investigation gives general confidence in what science can do for the fisheries industries and leads to independent initiative. Moreover, the principles developed in one investigation frequently are applicable to the solution of other problems.

Utilization of by-products.—The annual production of fish meal in the United States approximates 100,000 tons, valued in excess of $3,250,000. It is estimated that in the production of this fish meal about 23,000 tons of nitrogenous material, with a value of about $1,000,000, are wasted. The bureau has been working upon this problem and has developed a method for decreasing losses of protein and oil in press liquors now discarded in the menhaden industry. Moreover, this method gives better oil and should help materially in diminishing pollution from these liquors in certain coastal waters. In connection with this work the bureau made a careful study of the menhaden industry. This showed that certain steps should be taken to lessen production costs and improve the products obtained, and the nature of these improvements has been pointed out to the industry. As an example of this work, it has been found that the bilge water from the steamers, instead of polluting waters can be made a source of profit by extracting the materials that otherwise are objectionable in polluting coastal waters.

As soon as funds for the purpose become available the bureau intends to demonstrate to the industry that fishing and manufacturing operations can be carried out with considerable less labor than is expended at present. Certain lines of research, if carried out, undoubtedly will show the industry how to prepare better meal and oil at no increase in cost. Conditions in the menhaden industry have reached the stage where it is necessary that improvements be made if the industry is to continue its existence.

Looking at waste utilization in the fishing industry from a broad viewpoint, it is estimated that enough material to yield about 45,000 tons of fish meal, valued at $3,000,000, is now being thrown away. Valuable oil, too, can be recovered from this material. The bureau is endeavoring to bring about better utilization of this material, and a temporary laboratory has been established at Reedville, Va., for the study of by-products problems.

Filleting of fish is becoming a very large business, with considerable quantities of waste now collecting at different localities. The bureau recently has completed experiments showing how this material can be converted into excellent fish meal in such a manner that the operations can be carried out in such congested centers as New York or Boston without objectionable odors.

One problem demanding solution is that of handling with profit small quantities of waste (1 to 5 tons per day) such as collect in many places. At present many fish markets are put to a considerable expense for hauling their waste away. One city alone is reported to pay $15,000 annually for this purpose.

The salmon industry in Alaska has large quantities of waste material now unutilized, due to the fact that no profitable way of handling the material under the conditions that exist there has been evolved. The canning season is very short, and large quantities of waste collect in a very short time. The overhead cost of the usual method for converting this into meal and oil have been too great to make the undertaking profitable. There is urgent need for a study of this problem. The shrimp industry, too, is throwing away material that could be converted into meal, valued at hundreds of thousands of dollars.

Preserving quality in fresh fish.—Fish and shellfish are very perishable, even more so than other foods of a similar nature, and unless especial precautions are taken they deteriorate very rapidly. The demand for these products in a fresh condition can be increased greatly by improving the methods for getting them into the consumer's hands throughout the United States in the very best condition. Practices are now followed in handling fresh fish, both at sea and after they are landed, which do not assure the highest quality of the product. That bruises and heat injure fish is well known. The importance of these factors as a cause of deterioration is now more generally recognized than formerly, however. One of the bureau's technologists has been studying this problem intensively in the New England district for several months, both ashore and afloat.

The bureau has cooperated with the fishermen and boat owners in developing newer and better methods of handling the catch and in properly storing it until it reaches land. Plans also have been worked out for redesigning the methods of handling fishery products in the largest wholesale fish market in the country.

The bureau has made a new and important contribution to the proper methods of handling fishery products through the issuance of a handbook on the refrigeration of fish (B. F. Document No. 1016). This contains a history of the industry and a discussion of important scientific principles involved; changes that take place in the fish in the fresh state and during freezing and holding; design, construction, and equipment of fish freezers; practical freezing methods; methods of brine freezing; transportation of frozen fish; and many other points essential to the proper understanding of the industry and its problems.

That money properly spent in technological work brings large returns is evidenced by the bureau's work on brine freezing. The bureau imported the first brine-freezing equipment into the United States and made the first demonstrations of this process. To-day brine freezing is being developed upon an extensive scale.

Net preservation.—Fishing gear used by the fishermen in the United States is valued at about $14,000,000. It is probable that most of this gear must be replaced at least once in four years and much of it more often. It is evident that to increase the life of this gear would lower the cost of landing fish. Many fishermen are put to considerable expense in having to remove growths that collect upon their netting when it is allowed to remain in the water. They must also keep extra gear to replace that removed for cleaning. At times bad weather prevents them from removing the netting, and during this time, frequently due to the heavy weight of fouling growths on the net, it is washed away by the storms.

The bureau has attacked the problem of net fouling by marine growth and the preservation of the twine itself. This research work showed copper oleate to be an excellent preservative and antifouling agent and to have given excellent results commercially. There is need, however, for less expensive treatments that last longer. The bureau has developed new copper mixtures which are cheaper, last longer, and have proven excellent in commercial trials. This work is still in progress. The materials are being tried commercially by fishermen at several points in New Jersey and Virginia. In addition, over 70 new test lines, covering a wide range of chemical combinations are now being conducted at Beaufort, N. C. So far, these studies have been confined largely to salt water. Fresh-water fishermen have special problems with their nets, and it is hoped that this phase of the work can be taken up in the near future.

Nutritive value of fish and shellfish.—Research in recent years has shown fish and shellfish to have especially high nutritive values. The liver oils of certain fish, of which the cod is the most prominent example, are now our most valuable source of vitamins A and D. A study by the bureau showed that sea foods are especially rich in iodine, being, in a great many cases, 50 to 200 times as rich in this important element as other common food products. They should be especially valuable, therefore, in the dietary as a preventative of goiter, many kinds of which have been proven to be due to the lack of sufficient iodine in food. The proteins of fish are of high quality. Information is lacking upon this important subject, however, and therefore the bureau has been carrying out fundamental studies upon the nutritive value of different fish proteins. A document is to be published in the near future giving the results of some of this work.

A document, entitled "Nutritive Value of Fish and Shellfish" (Document No. 1000), was published recently to assist the fishing industry in promoting the use of fish and shellfish by the public. This was written in nontechnical language and contains chapters by experts on the chemical composition, mineral constitutents, vitamins, oils and fats, and the protein value of aquatic foods.

Sardine canning.—The most recent technological publication of the bureau is Preparation of Fish for Canning as Sardines (Document No. 1020). In this document are discussed critically the methods now employed throughout the world in canning sardines, and it points out the advantages and disadvantages of various methods. A report is then given of the research carried out by the bureau during the past several years aimed at improving existing practices and developing new ones. It deals with the changes that take place in oil used for frying sardines, the behavior of the fish under different frying conditions, development of new methods of frying fish, and upon the development of a new process for preparing the fish. This new process gives a better product at a lower cost than any process now in use. It is now being adopted commercially, a plant having been installed recently which is capable of producing 1,500 cases of fish per day. This is operating successfully, and it is estimated that the cost of production is at least 10 cents per case less than in the process previously used by the company.

Research associates.—The bureau is arranging to provide research associate facilities, similar to those now provided by the Bureau of Standards, whereby firms or groups having special technological problems to solve will furnish the investigator and pay his salary and expenses, the investigations to be carried out in cooperation with the bureau's experts in its laboratories and under its control. This makes available to the industry library, laboratory, and consultation facilities which they are unable to obtain elsewhere and should be of great help to them and to the bureau in evolving processes and special lines of research which the limited funds and personnel of the bureau do not permit.

MERCHANDISING OF FISHERY PRODUCTS

Market survey of New York City.—In 1925 the bureau resumed its surveys of the fishery trade of representative cities and conducted a survey of the wholesale trade in fresh and frozen fishery products in New York City. The complete report of this survey appears in Bureau of Fisheries Document No. 996.

During the year 1924 there were 87 wholesale establishments engaged in handling 394,000,000 pounds, or more than 19,000 carloads, of fresh and frozen fishery products of 106 varieties, with a wholesale value of about $30,000,000. These products were received from every fish-producing region of the North American Continent north of Mexico. The round portion, exclusive of oyster and clam shells, amounted to 346,000,000 pounds. Of this amount, 271,000,000 pounds, or 79 per cent, were consumed in the metropolitan area; 67,000,000 pounds, or 19 per cent, were distributed to other States;

4,000,000 pounds, or 1 per cent, were used on railroads and steamships departing from New York City; and 4,000,000 pounds, or 1 per cent, were exported. The population of Greater New York in 1924 was about 8,500,000, giving a per capita consumption of these products of 31.8 pounds.

The bulk of the trade, or 70 per cent, is based on 31 varieties. Twenty varieties, or 20 per cent, were of moderate importance, and 55 varieties, or 10 per cent, were in small demand.

The wholesale fish trade in New York City is conducted on the lower east side of Manhattan Island, along the East River, in the area known as Fulton Fish Market. This market has no direct rail communication with any freight or express terminal, but for the accommodation of fishing smacks and steam trawlers there are two piers extending into the East River from the rear of the market.

New York City is the second most important fishing port on the Atlantic coast. Direct landings of fresh fish by fishing vessels of over 5 tons net at the market piers during 1924 amounted to over 35,000,000 pounds, being exceeded only by the landings at Boston, Mass.

Due to the isolation of this market from rail facilities, and being in the congested district, problems of intracity transportation have become acute. During 1924 about 322,000,000 pounds, or 82 per cent of the total tonnage of fresh and frozen fishery products received in New York City, arrived by rail at 16 terminals. A study of the movement of these goods from terminals to the wholesale market revealed that 10 per cent of these products were carted over 10 miles from the terminal to the market; 2 per cent, 5 to 6 miles; 38 per cent, 3 to 4 miles; 4 per cent, 2 to 3 miles; 38 per cent, 1 to 2 miles; and 8 per cent, less than 1 mile. Based on a transportation charge of 20 cents per 100 pounds, about $644,000, or about 2 per cent of the wholesale value of the fishery products sold in 1924, were expended in cartage charges for fishery goods moving between rail terminals and the wholesale market.

Fresh and frozen fish in package form.—As a result of the demand for more convenient forms of retailing fresh fish, a new and improved method of preparing fish for the market has been developed. This consists in placing the edible portions of fish in packages of suitable sizes for retail purchase. Fish put up in this manner are termed "package fish." Package fish are put up at production points, and the development of this phase of production promises to be the most important advance in fresh and frozen fish distribution since the introduction of refrigeration. It began in a small way in 1921, with filleting of haddock and has expanded since to other varieties of fish as well as to other ways of cutting the fish for packing, though filleted haddock is still the most important product in this class.

Recognizing the importance of this development, a survey was made to determine its present nature and extent. During the course of the survey firms engaged in this trade were interviewed in Portland, Me., Boston, Gloucester, and Provincetown, Mass., and in New York City, these being the principal localities where package fish are produced on the Atlantic coast.

During 1926, 17,800,000 pounds of fresh and frozen package-fish products were produced in the cities canvassed. These, in round weight, would amount to about 45,000,000 pounds. The prepared products consisted of 14,600,000 pounds of haddock, 1,400,000 pounds of cod, 800,000 pounds of hake, cusk, and pollock, 800,000 pounds of flounder and sole, and 200,000 pounds of mackerel.

The products are merchandised as fillets, steaks, pan-dressed, and as sticks, any form of which consists of the edible portion of the fish exclusive of all or most of the waste material. Some fillets, steaks, or otherwise prepared fresh-fish products are wrapped individually in parchment paper; while others are not wrapped, but sheets of waxed or parchment paper are inserted between the layers when they are packed in containers.

Frozen fillets are placed on pieces of stiff, waxed cardboard and then wrapped in parchment paper. They also are packed in 1-pound and 5-pound cartons, lined with parchment paper, and then the carton is wrapped in transparent glassine paper. Skinned whiting sticks are packed in 1-pound cartons. Frozen products, in 10-pound blocks are wrapped in parchment paper and then in heavy brown paper.

The commonest type of container for the fresh prepared products is a circular tin can, about 12½ inches in diameter, made in sizes capable of holding 10 to 35 pounds of fish. The lids are self-locking and are held on by friction. Another popular type of container for the fresh-fish products is a flat, rectangular can, about 18 inches long and 10 inches wide, the height depending upon the capacity, which is usually 20 to 30 pounds. The lid is held on by bending over a tab on each of the two long sides, which previously have been inserted through slots in the lid.

There are standard shipping cases for each type of tin container. They are made of wood and hold one, two, and three containers with sufficient space remaining in each box for the amount of ice necessary for refrigeration en route.

Fish products known as "sticks," which are crosswise cuts of fillets, are prepared by some dealers. They are packed in 5 and 10 pound containers. The 5-pound package consists of a wooden lard tray filled with sticks and covered with a second tray, and then the whole is wrapped first in a sheet of waxed paper and then in a sheet of parchment paper. The 10-pound package is a wooden box 11½ inches long, 5 inches wide, and 5 inches high. For shipping out of town, these packages are packed in a box in amounts up to 100 pounds and then covered with ice for refrigerating en route. Frozen package fish usually are packed in insulated, corrugated, strawboard containers for car-lot shipments. For less than car lots, this container is packed in a second strawboard case. No ice is used for shipping frozen fish in these insulated cases, as refrigeration is obtained from the coldness of the frozen fish.

The wrappers, cartons, containers, and shipping cases are printed with the trade names of the product and the name and address of the producer. Tin containers have lithographed labels. Some dealers print recipes for cooking the product on the wrappers or cartons. Such labeling of fresh-fish products constitutes an important advance in fish merchandising, as it encourages the establishment and maintenance of standard quality.

The distribution area for package-fish products, other than fish sticks, is largely between the Appalachian Mountains and the Mississippi River. Fish sticks are distributed largely in Maine. New Hampshire, and Vermont.

During the past year there has been a tendency to pack smoked-fish products attractively. Several firms now put up smoked sardines, smoked haddock, and other like products in 1-pound packages, wrapped in transparent paper.

PUBLICATIONS OF THE DIVISION

During the calendar year 1926 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., nor the monthly publication of the cold-storage holdings of frozen fish.

DOCUMENTS

Wholesale trade in fresh and frozen fishery products and related marketing considerations in New York City. By R. H. Fiedler and J. H. Matthews. 8°, 37 pp., 13 illus. Document No. 996.

Fishery industries of United States, 1924. By Oscar E. Sette. 8°, 192 pp. Document No. 997.

Further experiments on preservation of fish nets [with bibliography]. By Harden F. Taylor and Arthur W. Wells. 8°, 31 pp., 19 illus. Document No. 998.

Nutritive value of fish and shellfish [with bibliography]. By E. D. Clark, R. W. Clough, Donald K. Tressler, Arthur D. Holmes, Harden F. Taylor, and E. V. McCollum. 8°, 54 pp. Document No. 1000.

Fishery industries of United States, 1925. By Oscar E. Sette. 8°, 124 pp. Document No. 1010.

STATISTICAL BULLETINS

Statement, by fishing grounds, of quantities and values of certain fishery products landed at Seattle, Wash., by American fishing vessels during the calendar year 1925. Statistical Bulletin No. 686.

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 calendar year 1925. Statistical Bulletin No. 687.

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 1925. Statistical Bulletin No. 688.

Canned fishery products and by-products of the United States and Alaska, 1925. Statistical Bulletin No. 695.

Fisheries of Alaska, 1925. Statistical Bulletin No. 699.

Fisheries of New England States, 1924. Statistical Bulletin No. 703.

CANNED FISHERY PRODUCTS AND BY-PRODUCTS OF THE UNITED STATES AND ALASKA IN 1926

The output of canned fishery products in 1926 was valued at $86,193,240 and the by-products at $12,133,110, making the total value of the output of these industries $98,326,350. This was the greatest value in recent years, exceeding 1925 by 3 per cent and 1921 by 79 per cent. The increase was due mostly to the larger pack of salmon in Alaska.

Comparative statistics of the value of canned fishery products and by-products of the United States and Alaska, 1921 to 1926

Year	Canned products	By-products (including menhaden)	Total
1921	$46,634,706	$8,351,827	$54,986,533
1922	60,464,947	11,390,693	71,855,640
1923	72,445,205	12,634,590	85,079,795
1924	72,104,589	10,308,990	82,478,579
1925	80,577,138	14,600,198	95,177,336
1926	86,193,240	12,133,110	98,326,350

CANNED PRODUCTS

The value of canned products in 1926 was 7 per cent greater than the previous year. Salmon, as usual, was the most important item, contributing 65 per cent of the total value; sardines were next with 17 per cent, tuna followed with 6 per cent, while oysters, shrimp, clams, and miscellaneous products made up the remaining 12 per cent.

Comparative statistics of the value of canned fishery products, 1921 to 1926, inclusive

Year	Salmon	Sardine	Tuna	Oyster	Shrimp	Clam	Other	Total
1921	$28,867,169	$6,307,362	$3,074,626	$2,179,271	$3,804,781	$1,166,507	$1,234,990	$46,634,706
1922	38,420,717	9,111,589	4,511,873	2,423,616	3,064,087	1,716,365	1,216,700	60,464,947
1923	45,533,573	9,896,796	6,914,760	2,720,073	4,381,534	1,710,616	1,287,853	72,445,205
1924	42,401,602	12,636,599	5,756,586	2,478,044	4,608,950	2,161,389	2,121,419	72,164,589
1925	47,369,507	13,097,318	8,499,080	3,721,159	3,782,819	1,850,378	2,256,877	80,577,138
1926	56,219,306	14,534,792	5,282,283	2,026,569	4,122,092	2,004,650	2,003,548	86,193,240

Salmon.—In 1926 salmon were packed at 132 plants in Alaska, 31 in Washington, 18 in Oregon, and 2 in California. Compared with the previous year, there was an increase of 3 canneries in Alaska and 2 in Oregon and a decrease of 10 in Washington. The combined output of the 183 plants amounted to 7,488,620 cases, valued at $56,219,306. Of this total, 835,738 cases, valued at $10,139,302, were produced in the Pacific Coast States, and 6,652,882 cases, valued at $46,080,004, were packed in Alaska. The pack in Alaska was approximately 2,200,000 cases larger than the previous year, due principally to increased packs of red and pink salmon. The pack in the Pacific Coast States was only slightly over half that of the previous year, due almost entirely to a decreased pack of humpback or pink salmon, which is subject to alternate good and poor years, 1926 being the "off" year. The decrease in the Pacific Coast States was much more than compensated by the increase in Alaska, making the total pack 24 per cent greater in quantity and 19 per cent in value.

Pack of canned salmon, Pacific Coast States and Alaska, 1926

Products	Pacific Coast States						Southeast Alaska	
	Washington		Oregon and California		Total			
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*	*Cases*	*Value*
King, chinook, or spring:								
1-pound tall	19,381	$174,952	17,734	$106,941	37,115	$281,893	3,997	$34,405
1-pound flat	31,996	472,441	74,680	1,034,613	106,676	1,507,054	5,148	60,694
1-pound oval	1,506	33,132	3,652	80,344	5,158	113,476		
½-pound flat and oval	78,144	1,293,177	122,507	2,085,804	200,651	3,378,981	1,534	22,180
Total	131,027	1,973,702	218,573	3,307,702	349,600	5,281,404	10,679	117,279
Red or sockeye:								
1-pound tall	856	11,984			856	11,984	120,495	1,196,107
1-pound flat	8,299	132,784			8,299	132,784	19,838	247,302
½-pound flat	53,651	1,071,854	12,905	258,100	66,556	1,329,954	33,558	485,380
Total	62,806	1,216,622	12,905	258,100	75,711	1,474,722	173,891	1,928,789
Coho or silver:								
1-pound tall	72,860	591,412	9,654	73,370	82,514	664,782	86,781	724,475
1-pound flat	35,494	328,376	38,023	365,021	73,517	693,397	5,328	55,009
½-pound flat	44,247	530,964	27,863	334,356	72,110	865,320	4,280	58,905
Total	152,601	1,450,752	75,540	772,747	228,141	2,223,499	96,389	838,389
Humpback or pink:								
1-pound tall	749	4,045			749	4,045	2,115,057	11,301,223
1-pound flat	163	978			163	978	3,810	24,030
½-pound flat	1,696	14,586			1,696	14,586	39,832	345,855
Total	2,608	19,609			2,608	19,609	2,158,699	11,671,108
Chum or keta:								
1-pound tall	125,623	626,883	11,310	54,637	136,933	681,520	616,788	3,076,825
1-pound flat	78	421	1,556	7,780	1,634	8,201	551	2,755
½-pound flat	7,454	50,687	2,711	18,435	10,165	69,122	1,058	7,621
Total	133,155	677,991	15,577	80,852	148,732	758,843	618,397	3,087,201
Steelhead:								
1-pound tall	1,946	20,628	22	233	1,968	20,861		
1-pound flat	2,479	27,269	12,903	141,933	15,382	169,202		
½-pound flat and oval	2,966	41,716	10,630	149,446	13,596	191,162		
Total	7,391	89,613	23,555	291,612	30,946	381,225		
Grand total	489,588	5,428,289	346,150	4,711,013	835,738	10,139,302	3,058,056	17,642,766

Pack of canned salmon, Pacfic Coast States and Alaska, 1926—Continued

Products	Alaska						Grand total	
	Central		Western		Total			
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*	*Cases*	*Value*
King, chinook, or spring:								
1-pound tall	16,191	$158,746	17,839	$169,402	38,027	$362,553	75,142	$644,446
1-pound flat	5,702	67,665	275	2,750	11,125	131,109	117,801	1,638,163
1-pound oval							5,158	113,476
½-pound flat and oval	1,790	28,404			3,324	50,584	203,975	3,429,565
Total	23,683	254,815	18,114	172,152	52,476	544,246	402,076	5,825,650
Red or sockeye:								
1-pound tall	523,832	5,144,030	1,326,250	12,573,991	1,970,577	18,914,128	1,971,433	18,926,112
1-pound flat	76,966	832,013	7,525	85,628	104,829	1,164,943	112,628	1,297,727
½-pound flat	29,707	464,643	18,916	299,645	82,181	1,249,668	148,737	2,579,622
Total	630,505	6,440,686	1,352,691	12,959,264	2,157,087	21,328,739	2,232,798	22,803,461
Coho or silver:								
1-pound tall	86,938	688,412	1,829	14,046	175,548	1,426,933	258,062	2,091,715
1-pound flat	11,297	101,264			16,625	156,273	90,142	849,670
½-pound flat	6,074	58,452			10,364	117,357	82,464	982,677
Total	104,309	848,128	1,829	14,046	202,527	1,700,563	430,668	3,924,062
Humpback or pink:								
1-pound tall	1,045,826	5,541,094	35,470	175,056	3,196,353	17,017,373	3,197,102	17,021,418
1-pound flat	78,351	454,591			82,161	478,621	82,324	479,599
½-pound flat	20,003	145,678			59,835	491,533	61,531	506,119
Total	1,144,180	6,141,363	35,470	175,056	3,338,349	17,987,527	3,340,957	18,007,136
Chum or keta:								
1-pound tall	195,068	969,966	40,238	198,381	852,094	4,245,172	989,027	4,926,692
1-pound flat	48,431	261,527			48,982	264,282	50,616	272,483
½-pound flat	309	1,854			1,367	9,475	11,532	78,597
Total	243,808	1,233,347	40,238	198,381	902,443	4,518,929	1,051,175	5,277,772
Steelhead:								
1-pound tall							1,968	20,861
1-pound flat							15,382	169,202
½-pound flat and oval							13,596	191,162
Total							30,946	381,225
Grand total	2,146,485	14,018,339	1,448,342	13,518,899	6,652,882	46,080,004	7,488,620	56,219,306

NOTE.—The pack of salmon has been reduced to the equivalent of forty-eight 1-pound cans to the case. There were other salmon products, valued at $108,731, not shown in the above table.

Comparative statistics of the pack of salmon in the Pacific Coast States, 1921 to 1926

Year	King, chinook, or spring		Red or sockeye		Coho or silver		Humpback or pink	
	Cases	Value	*Cases*	Value	*Cases*	Value	*Cases*	Value
1921	335,854	$4,527,711	104,954	$1,905,647	111,643	$806,678	402,846	$1,732,847
1922	314,126	4,572,607	97,927	1,816,901	204,252	1,533,173	3,551	18,546
1923	384,705	5,790,419	105,336	1,955,549	245,548	1,608,627	445,175	2,211,742
1924	349,014	4,599,759	85,800	1,478,698	231,139	1,774,078	12,778	79,436
1925	432,638	5,990,019	118,387	2,065,975	307,567	3,313,060	551,375	3,152,342
1926	349,600	5,281,404	75,711	1,474,722	228,141	2,223,499	2,608	19,609

Year	Chum or keta		Steelhead		Total	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*
1921	35,132	$127,659	12,519	$133,883	1,002,948	$9,234,425
1922	87,583	365,303	25,797	326,994	733,246	8,633,524
1923	154,342	769,839	32,157	324,390	1,367,263	12,660,566
1924	247,858	1,192,156	32,073	270,340	958,662	9,394,467
1925	133,368	641,310	15,278	217,270	1,558,613	15,379,976
1926	148,732	758,843	30,946	381,225	835,738	10,139,302

Comparative statistics of the salmon pack in Alaska, 1921 to 1926

Year	King, chinook, or spring		Red or sockeye		Coho or silver	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*
1921	44, 994	$459, 807	1, 765, 798	$15, 841, 404	106, 555	$600, 140
1922	30, 660	247, 673	2, 070, 658	19, 135, 696	175, 993	962, 790
1923	38, 343	328, 270	1, 859, 496	17, 253, 792	164, 107	943, 318
1924	33, 648	299, 009	1, 447, 895	13, 803, 932	183, 601	1, 254, 551
1925	49, 978	595, 041	1, 059, 676	13, 904, 599	161, 010	1, 565, 759
1926	52, 476	544, 246	2, 157, 087	21, 328, 739	202, 527	1, 700, 563

Year	Humpback or pink		Chum or keta		Total	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*
1921	423, 984	$1, 788, 778	255, 495	$942, 525	2, 596, 826	$19, 632, 744
1922	1, 658, 423	7, 189, 494	565, 918	2, 251, 540	4, 501, 652	29, 787, 193
1923	2, 448, 129	11, 899, 956	525, 622	2, 447, 671	5, 035, 697	32, 873, 007
1924	2, 601, 283	12, 837, 346	1, 028, 488	4, 812, 297	5, 294, 915	33, 007, 135
1925	2, 110, 593	11, 137, 102	1, 078, 680	4, 787, 030	4, 459, 937	31, 989, 531
1926	3, 338, 349	17, 987, 527	902, 443	4, 518, 929	6, 652, 882	46, 080, 004

Comparative statistics of the salmon pack in the United States and Alaska, 1921 to 1926

Year	Pacific Coast States		Alaska		Total	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*
1921	1, 002, 948	$9, 234, 425	2, 596, 826	$19, 632, 744	3, 599, 774	$28, 867, 169
1922	733, 246	8, 633, 524	4, 501, 652	29, 787, 193	5, 234, 898	38, 420, 717
1923	1, 367, 263	12, 660, 566	5, 035, 697	32, 873, 007	6, 402, 960	45, 533, 573
1924	958, 662	9, 394, 467	5, 294, 915	33, 007, 135	6, 253, 577	42, 401, 602
1925	1, 558, 613	15, 379, 976	4, 459, 937	31, 989, 531	6, 018, 550	47, 369, 507
1926	835, 738	10, 139, 302	6, 652, 882	46, 080, 004	7, 488, 620	56, 219, 306

Sardines.—In 1926 packs of sardines were reported by 35 plants in Maine, 1 in Massachusetts, and 30 in California. This is an increase of 4 plants in Maine and 4 in California. The production in Maine and Massachusetts amounted to 1,717,537 standard cases of one hundred ¼-pound cans, valued at $6,727,388, which is a small decrease in quantity and a slight increase in value, compared with the previous year. In California the production amounted to 2,093,278 standard cases of forty-eight 1-pound cans, valued at $7,807,404, which is an increase of 22 per cent in quantity and value, making it the largest pack in the history of the industry.

Pack of sardines, 1926

Sardines (herring)	Maine and Massachusetts	
	Cases	*Value*
In olive oil: Quarters (100 cans)	57, 674	$394, 474
In cottonseed oil: Quarters (100 cans)	1, 282, 967	5, 042, 572
In mustard:		
Quarters (100 cans)	117, 517	537, 382
Three-quarters (48 cans)[2]	163, 595	629, 821
In other sauces: Quarters (100 cans)	[1] 23, 802	123, 139
Total	1, 645, 555	6, 727, 388
Total (standard cases)[5]	1, 717, 537	----------

Sardines (pilchard)	California	
	Cases	*Value*
½-pound oval (48 cans)[1]	32, 566	$101, 693
1-pound oval (48 cans):		
In tomato sauce	1, 915, 280	6, 902, 473
In mustard	107, 627	402, 193
Soused	5, 458	19, 417
In other sauces	17, 531	65, 991
¼-pound square (100 cans)[3]	16, 823	136, 411
½-pound square (100 cans)	[4] 21, 444	89, 226
Total	2, 116, 729	7, 807, 404
Total (standard cases)[6]	2, 093, 278	----------

[1] Largely in tomato sauce.
[2] Includes the pack of three-quarter size cans, 50 to the case, which have been converted to the basis of 48 cans to the case.
[3] Largely in olive oil.
[4] Includes the pack of 6-ounce round cans, 100 to the case, and also a few cases packed in No. 10 cans, 6 to the case, which have been converted to the basis of ½-pound cans, 100 to the case.
[5] Standard case equals one hundred ¼-pound cans.
[6] Standard case equals forty-eight 1-pound cans.

Comparative statistics of the pack of sardines, 1921 to 1926

Year	Maine and Massachusetts		California	
	Cases [1]	Value	Cases [2]	Value
1921	1,399,507	$3,960,916	398,668	$2,346,446
1922	1,809,719	5,750,109	715,364	3,361,480
1923	1,272,277	5,288,865	1,100,162	4,607,031
1924	1,899,925	7,191,026	1,367,139	5,445,573
1925	1,870,786	6,716,701	1,714,913	6,380,617
1926	1,717,537	6,727,388	2,093,278	7,807,404

[1] Standard cases of one hundred ¼-pound cans.
[2] Standard cases of forty-eight 1-pound cans.

Shad and alewives.—Shad and shad roe are packed at 6 plants in Washington and 9 in Oregon, the production amounting to 15,396 standard cases of forty-eight 1-pound cans, valued at $102,756. Of this total 14,275 cases, valued at $63,334, were shad and 1,121 cases, valued at $39,422, were shad roe. This is a substantial increase in the pack of shad but a decrease of over 50 per cent in the pack of shad roe. Alewives and alewife roe were packed at 7 plants in Maryland, 20 in Virginia, and 3 in North Carolina. The total production amounted to 114,787 standard cases of twenty-four 15-ounce cans, valued at $266,683. The pack of alewives was over four times as large as in 1925, but the pack of alewife roe was somewhat below that of the previous year.

Pack of shad and alewives, 1926

Shad	Washington and Oregon		Alewives	Maryland, Virginia, and North Carolina	
	Cases	Value		Cases	Value
½-pound flat (48 cans)	174	$905	No. 1 and No. 2 (24 cans)	[1] 42,497	$65,405
1-pound tall (48 cans)	14,188	62,429	Roe:		
Roe:			No. ½, No. 1, and No. 2 (24 cans)	[1] 72,290	201,278
½-pound flat (48 cans)	1,064	17,040			
½-pound oval (48 cans)	1,178	22,382	Total	114,787	266,683
Total	16,604	102,756	Total (standard cases)[3]	114,787	----------
Total (standard cases)[2]	15,396	----------			

[1] Reduced to standard cases.
[2] Standard case equals forty-eight 1-pound cans.
[3] Standard case equals twenty-four 15-ounce cans.

Comparative statistics of the pack of shad and shad roe, 1921 to 1926

Year	Shad		Shad roe		Total	
	Cases	Value	Cases	Value	Cases	Value
1921	641	$2,455	38	$142	679	$2,597
1922	1,781	9,961	292	8,517	2,073	18,478
1923	2,162	37,165	536	16,288	2,698	53,453
1924	6,470	20,461	1,164	72,932	7,634	93,393
1925	12,569	53,875	2,430	100,571	14,999	154,446
1926	14,275	63,334	1,121	39,422	15,396	102,756

NOTE.—Cases have been reduced to the equivalent of forty-eight 1-pound cans.

Comparative statistics of the pack of alewives and alewife roe, 1921 to 1926

Year	Alewives		Alewife roe		Total	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*
1921	333	$813	43,316	$157,841	43,649	$158,654
1922	1,043	1,994	38,612	137,514	39,665	139,508
1923	1,145	1,915	43,530	169,435	44,675	171,350
1924	3,306	5,118	88,836	332,245	92,142	337,363
1925	9,491	15,045	75,057	240,461	84,548	255,506
1926	42,497	65,405	72,290	201,278	114,787	266,683

NOTE.—Cases have been converted to the equivalent of twenty-four 15-ounce cans.

Tuna and tunalike fishes.—Nineteen plants in California reported packs of tuna and tunalike fishes in 1926. The total production was 851,199 standard cases of forty-eight ½-pound cans, valued at $5,282,283. This is a decrease of 23 per cent in quantity and 38 per cent in value as compared with the previous year. The decrease is due solely to the extremely poor pack of albacore, which was only 12 per cent as large as the pack of the previous year. All other kinds of tuna showed substantial increases.

Pack of tuna and tunalike fishes in California, 1926

Sizes	Albacore		Yellowfin		Bluefin		Tuna, bluefin, and yellowfin		Tuna, striped	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*	*Cases*	*Value*	*Cases*	*Value*
¼-pound round (48 cans)[1]	6,091	$34,363	29,864	$123,173	3,837	$13,935	1,841	$9,022	25,088	$91,928
½-pound round (48 cans)	43,765	336,849	122,014	762,068	55,346	321,016	18,685	113,148	224,568	1,186,712
1-pound round (48 cans)	6,506	94,800	17,509	195,296	7,913	81,159	3,684	38,256	23,034	218,195
Total	56,962	466,012	169,387	1,080,537	67,096	416,110	24,210	160,426	272,690	1,496,835
Total (standard cases)[2]	60,122		171,964		73,091		26,973		283,180	

Sizes	"Tonno"		Bonito		Yellowtail		Tuna flakes		Total	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*	*Cases*	*Value*	*Cases*	*Value*
¼-pound round (48 cans)[1]	238,054	$1,061,634	7,131	$26,314	374	$1,532	83	$228	312,963	$1,362,129
½-pound round (48 cans)	17,255	138,480	41,134	217,517	13,509	49,239	16,899	70,151	553,175	3,195,180
1-pound round (48 cans)	719	8,927	1,069	9,586	6,131	47,005	4,206	31,750	70,771	724,974
Total	256,028	1,209,041	49,334	253,417	20,014	97,776	21,188	102,129	936,909	5,282,283
Total (standard cases)[2]	137,720		46,838		25,958		25,353		851,199	

[1] Includes the pack of ⅛-pound round, 96 cans to the case, and ¼-pound square, 100 cans to the case which have been converted to the basis of ¼-pound cans, 48 to the case.
[2] Standard case equals forty-eight ½-pound cans.

Comparative statistics of the pack of tuna and tunalike fishes, 1921 to 1926

Year	Albacore		Bluefin and yellowfin tuna		Striped tuna		"Tonno"	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*	*Cases*	*Value*
1921	456,152	$2,657,266	64,816	$306,486	27,972	$109,929		
1922	296,210	2,304,935	168,874	1,047,621	177,995	942,356	13,714	$139,067
1923	310,037	3,106,329	261,773	1,959,812	96,452	578,254	124,416	1,136,814
1924	416,820	4,024,509	65,941	455,048	43,159	239,198	97,304	861,861
1925	[1] 518,079	4,412,655	261,482	1,745,338	168,177	997,697	131,159	1,212,024
1926 [2]	61,197	471,502	287,699	1,718,744	290,278	1,525,146	137,720	1,209,041

[1] Includes 27,489 cases of tuna flakes, valued at $120,637.
[2] Includes 25,353 cases of tuna flakes, valued at $102,129, which have been credited to the various species as packed.

NOTE.—Cases are on the standard basis of forty-eight ½-pound cans.

Comparative statistics of the pack of tuna and tunalike fishes, 1921 to 1926—Contd.

Year	Bonito		Yellowtail		Total	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*
1921			210	$945	549, 150	$3, 074, 626
1922	10, 810	$58, 900	4, 718	18, 994	672, 321	4, 511, 873
1923	15, 099	77, 906	10, 059	55, 645	817, 836	6, 914, 760
1924	12, 899	94, 806	16, 293	81, 164	652, 416	5, 756, 586
1925	10, 090	61, 207	13, 484	70, 159	1, 102, 471	8, 499, 080
1926	48, 113	259, 204	26, 192	98, 646	851, 199	5, 282, 283

NOTE.—Cases are on the standard basis of forty-eight ½-pound cans.

Shrimp.—In 1926 shrimp were canned in 1 plant in North Carolina, 2 in South Carolina, 9 in Georgia, 8 in Florida, 4 in Alabama, 18 in Mississippi, 25 in Louisiana, and 4 in Texas. The total pack amounted to 732,365 standard cases of 48 No. 1 cans, valued at $4,122,092. This is a slight decrease in quantity and 9 per cent increase in value, as compared with the previous year.

Pack of shrimp, 1926

Sizes	North Carolina, South Carolina, and Georgia		Florida		Alabama		Mississippi	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*	*Cases*	*Value*
No. 1 dry (4 dozen)	[1] 13,934	$83, 245	3, 106	$16, 345	57, 426	$299, 346	[2] 46, 494	$246, 713
No. 1 wet (4 dozen)	63, 430	353, 882	24, 437	138, 103	32, 311	166, 539	103, 286	522, 147
No. 1½ dry (2 dozen)	[3] 3, 550	20, 076	703	3, 654	[4] 9, 089	49, 347	[4] 17, 171	81, 810
No. 1½ wet (2 dozen)	100	550	1, 213	6, 542			20	100
Total	81, 014	457, 753	29, 459	164, 644	98, 826	515, 232	166, 971	850, 770
Total (standard cases)	80, 375		29, 124		97, 236		163, 962	

Sizes	Louisiana		Texas		Total	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*
No. 1 dry (4 dozen)	[2] 105, 225	$579, 034	4, 598	$23, 090	230, 783	$1, 247, 773
No. 1 wet (4 dozen)	173, 973	912, 531	31, 381	184, 705	428, 818	2, 277, 907
No. 1½ dry (2 dozen)	[4] 8, 489	49, 808			39, 002	204, 695
No. 1½ wet (2 dozen)	2, 717	15, 015			4, 050	22, 207
Total	290, 404	1, 556, 388	35, 979	207, 705	[5] 702, 653	[5] 3, 752, 582
Total (standard cases)	288, 443		35, 979		695, 119	

[1] Includes a few cases packed 4¼ ounces to the can, which have been converted to the equivalent of No. 1, 5-ounce cans.
[2] Includes a few cases packed 4 ounces to the can, which have been converted to the equivalent of No. 1, 5-ounce cans.
[3] Includes a few cases packed 8 and 8½ ounces to the can, which have been converted to the equivalent of No. 1½, 8¾-ounce cans.
[4] Includes a few cases packed 8 ounces to the can, which have been converted to the equivalent of No. 1½, 8¾-ounce cans.
[5] In addition to the above, there were packed in 4, 5, 5¼, 5½, and 6¼ ounce glass jars, 24 jars to the case, in Georgia, Florida, Mississippi, Louisiana, and Texas 77,207 cases of shrimp, or 37,246 standard cases, valued at $369,510, making a total of 732,365 cases, valued at $4,122,092.
[6] Standard case equals 48 No. 1 cans.

Comparative statistics of the pack of shrimp, 1921 to 1926

Year	Cases	Value	Year	Cases	Value
1921	655, 364	$3, 804, 781	1924	718, 517	$4, 608, 950
1922	579, 797	3, 064, 087	1925	735, 714	3, 782, 819
1923	700, 429	4, 381, 534	1926	732, 365	4, 122, 092

NOTE.—Cases have been reduced to the equivalent of 48 No. 1 cans.

Crabs.—One plant in Alaska, 2 in Washington, 2 in Virginia, and 1 in Mississippi reported packs of crabs in 1926. The total output was 1,846 cases of twenty-four 15-ounce cans, valued at $25,222. This is about half the pack of the previous year.

Pack of crabs, 1926

Sizes	Alaska, Washington, Virginia, and Mississippi	
	Cases	*Value*
6 and 7½ ounce (4 dozen)	[1] 1,304	$18,896
14, 15, and 17 ounce (2 dozen)	[1] 542	6,326
Total	1,846	25,222
Total (standard cases) [2]	1,846	

[1] Converted to standard cases. [2] Standard case equals twenty-four 15-ounce cans.

Comparative statistics of the value of the crab pack, 1921 to 1926

Year	Value	Year	Value
1921	$115,800	1924	$35,944
1922	104,171	1925	52,490
1923	47,023	1926	25,222

Clams.—In 1926 razor clams were canned at 13 plants in Washington, 5 in Oregon, and 8 in Alaska; hard clams at 2 plants in Florida, 1 in Georgia, 1 in Rhode Island, 1 in New Jersey, 1 in Oregon, and 4 in Washington; and soft clams at 12 plants in Maine and 2 in Massachusetts. The total output of all kinds, including chowders and juices, was valued at $2,004,650, an increase of 9 per cent, as compared with the previous year. In standard cases of 48 No. 1 cans, the pack was as follows: Razor clams, 94,459 cases, valued at $795,256; hard clams, 30,448 cases, valued at $191,044; soft clams, 64,083 cases, valued at $279,996; and other clam products, such as chowders, soups, bouillon, and juices, 185,007 cases, valued at $738,354.

Pack of clams, 1926

Razor clams	Washington and Oregon		Alaska		Total	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*
Whole:						
No 1 (4 dozen)	3,056	$28,556			3,056	$28,556
1-pound (4 dozen)	2,371	28,686	95	$1,040	2,466	29,726
Minced:						
½-pound flat (4 dozen)	45,546	318,845	28,240	174,376	73,786	493,221
No. 1 (4 dozen)	16,679	152,041	10,080	78,771	26,759	230,812
No. 2 (2 dozen)	[1] 1,659	12,892	[1] 11	49	1,670	12,941
Total	69,311	541,020	38,426	254,236	107,737	795,256
Total (standard cases) [2]	61,624		32,835		94,459	

Hard clams	Washington, Oregon, and Florida	
	Cases	*Value*
Whole:		
1-pound (4 dozen)	1,774	$13,118
No. 1 (4 dozen)	6,500	54,848
No. 2 (2 dozen)	10,895	65,081
No. 10 (½ dozen)	3,682	20,534
Minced:		
No. 1 (4 dozen)	[3] 2,897	20,008
No. 2 (2 dozen)	[4] 2,715	17,455
Total	28,463	191,044
Total (standard cases) [2]	30,448	

[1] Includes a few cases packed in 1-pound cans, 4 dozen to the case, which have been converted to a basis of No. 2 cans, 2 dozen to the case.
[2] Standard case equals 48 No. 1 cans.
[3] Includes a few cases packed in ½-pound cans, which have been converted to a basis of No. 1 cans.
[4] Includes the pack of No. 10 cans, ½ dozen to the case, which have been converted to a basis of No. 2 cans, 2 dozen to the case.

Pack of clams, 1926—Continued

Soft clams	Maine and Massachusetts		Other hard, soft, and razor clam products	Maine, Massachusetts, Rhode Island, New Jersey, Georgia, Florida, Washington, and Oregon	
	Cases	*Value*		*Cases*	*Value*
Whole:			Chowder and soup:		
No. 1 (4 dozen)	[4] 38, 181	$170, 773	No. 1 (2 dozen)	[6] 122, 736	$288, 228
No. 1½ (4 dozen)	9, 650	63, 104	No. 1½ and No. 2 (2 dozen)	[7] 62, 373	179, 208
No. 2 (2 dozen)	10, 462	46, 119	No. 3 (2 dozen)	38, 892	191, 619
			No. 10 (½ dozen)	4, 269	15, 044
			Bouillon and juice:		
			No. 1 (4 dozen)	[8] 13, 185	64, 255
Total	58, 293	279, 996	Total	241, 455	738, 354
Total (standard cases) [3]	64, 083		Total (standard cases) [3]	185, 007	

[3] Standard case equals 48 No. 1 cans.
[4] Includes a few cases packed in 6-ounce cans, 2 dozen to the case, which have been converted to a basis of No. 1 cans, 4 dozen to the case.
[6] Includes the pack of 8-ounce cans, 4 dozen to the case, which have been converted to a basis of No. 1 cans, 2 dozen to the case.
[7] The pack of No. 2 cans, 2 dozen to the case, has been reduced to the equivalent of No. 1½ cans, 2 dozen to the case.
[8] The pack of clam buoillon and juice was packed in various sizes, all of which have been converted to a basis of No. 1 cans, 4 dozen to the case.

Comparative statistics of the value of canned clams and clam products, 1921 to 1926, inclusive

Year	Razor clams	Hard clams	Soft clams	Clam chowders, juices, etc.	Total
1921	$506, 591	$138, 699	$338, 775	$182, 442	$1, 166, 507
1922	876, 364	201, 270	327, 287	311, 444	1, 716, 365
1923	883, 535	194, 937	308, 560	323, 584	1, 710, 616
1924	863, 126	271, 911	459, 882	566, 470	2, 161, 389
1925	860, 002	218, 601	287, 073	484, 702	1, 850, 378
1926	795, 256	191, 044	279, 996	738, 354	2, 004, 650

Oysters.—In 1926 oysters were canned at 4 plants in Maryland, 5 in North Carolina, 13 in South Carolina, 4 in Georgia, 1 in Florida, 4 in Alabama, 18 in Mississippi, 5 in Louisiana, and 1 in Texas. The total output amounted to 413,834 standard cases of forty-eight 5-ounce cans, valued at $2,026,569. This is a decrease of 37 per cent in quantity and 36 per cent in value, as compared with the previous year.

Pack of oysters, 1926

Sizes	Maryland		North Carolina		South Carolina		Georgia and Florida	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*	*Cases*	*Value*
4-ounce (4 dozen)	2, 417	$13, 142			2, 408	$10, 113		
5-ounce (4 dozen)	[1] 20, 080	127, 606	9, 343	$44, 049	[3] 65, 407	314, 652	11, 105	$56, 362
8-ounce (2 dozen)	897	4, 828			1, 554	6, 525		
10-ounce (2 dozen)	4, 259	26, 064	596	2, 779	15, 083	69, 596		
Total	27, 653	171, 640	9, 939	46, 828	84, 452	400, 886	11, 105	56, 362
Total (standard cases) [4]	26, 990		9, 939		83, 660		11, 105	

[1] Includes a few cases packed in 6-ounce cans, which have been converted to the equivalent of 5-ounce cans.
[3] Includes a few cases packed in 3-ounce cans, which have been converted to the equivalent of 5-ounce cans.
[4] Standard case equals forty-eight 5-ounce cans.

Pack of oysters, 1926—Continued

Sizes	Alabama		Mississippi		Louisiana and Texas		Total	
	Cases	*Value*	*Cases*	*Value*	*Cases*	*Value*	*Cases*	*Value*
4-ounce (4 dozen)			34,950	$150,564	5,007	$23,873	44,782	$197,692
5-ounce (4 dozen)	33,591	$154,188	123,225	566,565	[1] 32,963	162,327	295,714	1,425,749
8-ounce (2 dozen)	252	1,059	18,504	79,846	1,498	7,175	22,705	99,463
10-ounce (2 dozen)	5,395	24,726	36,680	169,546	[3] 2,117	10,954	64,130	303,665
Total	39,238	180,003	213,359	966,521	41,585	204,329	427,331	2,026,569
Total (standard cases)[4]	39,188		202,668		40,284		413,834	

[1] Includes a few cases packed in 6-ounce cans, which have been converted to the equivalent of 5-ounce cans.
[3] Includes a few cases packed in 12-ounce cans, which have been converted to the equivalent of 10-ounce cans.
[4] Standard case equals forty-eight 5-ounce cans.

Comparative statistics of the pack of oysters, 1921 to 1926

Year	Cases	Value	Year	Cases	Value
1921	442,086	$2,179,271	1924	447,481	$2,478,044
1922	505,973	2,423,616	1925	654,755	3,721,159
1923	524,544	2,720,073	1926	413,834	2,026,569

NOTE.—Cases are on the standard basis of forty-eight 5-ounce cans.

Miscellaneous canned fish.—In addition to the products shown above, miscellaneous canned goods were packed in 1926 as follows: In Maine, Massachusetts, New York, Georgia, Wisconsin, and Washington, 4,128,047 pounds of canned fish and terrapin, valued at $686,469, and 4,179,472 pounds of canned fish roe, valued at $777,551; in California, 5,215 cases of fish cakes, mackerel, and abalone, valued at $36,136, and miscellaneous salmon products valued at $108,731; making a total of $1,608,887 worth of miscellaneous canned products not mentioned elsewhere.

BY-PRODUCTS

The total value of by-products, including the products of the menhaden and whaling industries, amounted to $12,133,110 in 1926, made up of the following items: Fish and whale oils, 10,888,046 gallons, valued at $5,027,491; fish, whale, and shrimp scrap, meal, and bran to the value of $3,651,077; shell by-products, 308,670 tons, valued at $2,588,416; fish glue, 520,622 gallons, valued at $732,109; and miscellaneous by-products to the value of $134,017. The total value of by-products was 17 per cent less than in the previous year.

Production of various by-products, 1926

Products	Maine, Massachusetts, New York, and Pennsylvania		Maryland and Virginia		North Carolina and Florida		Mississippi and Louisiana	
	Quantity	*Value*	*Quantity*	*Value*	*Quantity*	*Value*	*Quantity*	*Value*
Fish scrap and meal:								
Dried...tons..	5,156	$241,757	1,808	$68,294				
Acidulated...do....	117	1,970						
Pomace...do....	3,381	5,933						
Oil:								
Herring...gallons..	117,433	48,091	33,832	13,983				
Cod liver, crude...do....	175,516	130,790						
Miscellaneous...do....	260	26	2,407	963	9,217	$5,697		
Liquid glue...do....	520,622	732,109						
Miscellaneous by-products [1] ...pounds..	601,148	75,133					2,072,880	$33,775
Total...		1,235,809		83,240		5,697		33,775

Products	Alaska, Washington, Oregon, and California		Indiana and Wisconsin		Total	
	Quantity	*Value*	*Quantity*	*Value*	*Quantity*	*Value*
Fish scrap and meal:						
Dried...tons..	30,739	$1,581,959			37,703	$1,892,010
Acidulated...do....	182	1,231			299	3,201
Pomace...do....	2,776	3,558			6,157	9,491
Oil:						
Salmon...gallons..	193,173	72,605			193,173	72,605
Sardine...do....	2,113,028	932,651			2,113,028	932,651
Tuna...do....	24,766	13,771			24,766	13,771
Herring...do....	2,965,671	1,320,689			3,116,936	1,382,763
Whale...do....	1,265,959	744,088			1,265,959	744,088
Sperm...do....	10,050	3,987			10,050	3,987
Cod liver, crude...do....					175,516	130,790
Miscellaneous...do....	30,121	8,943	3,792	$2,047	45,797	17,676
Liquid glue...do....					520,622	732,109
Miscellaneous by-products [1] ...pounds..	814,315	58,884			3,488,343	167,792
Total...		4,742,366		2,047		6,102,934

[1] Includes herring skins and scales, isinglass, agar agar, fish flour, poultry food, pickled whale meat, whale tails, and 1,036 tons of shrimp bran, valued at $33,775, which were produced in Mississippi and Louisiana.

NOTE.—The oils produced on the Pacific coast are reported in "trade" gallons (7½ pounds), and those produced on the Atlantic and Gulf coasts are reported in United States gallons (about 7.74 pounds).

Fish oils.—The production of fish and whale oils in 1926 amounted to 10,888,046 gallons, valued at $5,027,491, as follows: Menhaden, 3,942,821 gallons, valued at $1,729,160; herring, 3,116,936 gallons, valued at $1,382,763; sardine, 2,113,028 gallons, valued at $932,651; other fish oils, 439,252 gallons, valued at $234,832; and whale and sperm oil, 1,276,009 gallons, valued at $748,075. The 1926 production was below that of the previous year, due to a 35 per cent decrease in menhaden oil, a 32 per cent decrease in sardine oil, and an 8 per cent decrease in other fish oils. Herring oil increased 28 per cent and whale and sperm oil 0.5 per cent. The net decrease in all marine animal oils was 18 per cent.

Production of fish and whale oils, 1921 to 1926

Year	Menhaden		Herring		Sardine	
	Gallons	*Value*	*Gallons*	*Value*	*Gallons*	*Value*
1921	6,260,478	$1,719,892	112,838	$26,735	170,977	$35,760
1922	7,102,677	2,904,833	450,362	150,144	428,859	145,668
1923	7,461,365	3,316,277	945,424	384,053	966,247	424,103
1924	3,923,904	1,817,626	1,324,002	571,899	2,838,711	1,076,903
1925	6,023,108	3,001,106	2,442,527	1,034,071	3,120,048	1,568,753
1926	3,942,821	1,729,160	3,116,936	1,382,763	2,113,028	932,651

Production of fish and whale oils, 1921 to 1926—Continued

Year	Other fish oils		Whale and sperm		Total	
	Gallons	*Value*	*Gallons*	*Value*	*Gallons*	*Value*
1921	378,887	(1)	523,101	(1)	7,446,281	$2,078,670
1922	306,430	$145,401	2,247,145	$884,714	10,535,473	4,230,760
1923	443,935	187,877	1,556,830	791,884	11,373,801	5,104,194
1924	381,832	184,534	1,242,836	661,271	9,211,285	4,311,733
1925	480,195	211,250	1,221,198	685,011	13,287,076	6,500,191
1926	439,252	234,832	1,276,009	748,075	10,888,046	5,027,491

[1] Data not available.

Fish scrap and meal.—The total value of scrap and meal of all kinds produced in 1926 was $3,651,077, made up as follows: Dried scrap and meal, 61,929 tons, valued at $3,056,406; acidulated scrap, 23,852 tons, valued at $551,405; crude or green scrap, 6,157 tons, valued at $9,491; and 1,036 tons of shrimp bran, valued at $33,775. This is a decrease of 11 per cent in the quantity of dried scrap and meal and 43 per cent in acidulated scrap. The decreased production of these materials was due largely to the partial failure of the menhaden fishery.

Comparative statistics of the production of scrap and meal from fish (including menhaden), whale, and shrimp, 1921 to 1926

Year	Dried scrap and meal		Acidulated scrap		Crude or green scrap		Shrimp bran		Total
	Tons	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Value*
1921	60,031	$2,613,361	44,454	$895,140	2,160	$31,827	628	$16,814	$3,557,142
1922	89,459	3,755,787	25,712	555,973	433	9,519	562	15,398	4,336,677
1923	66,088	3,286,504	44,935	1,064,870	1,593	13,721	1,269	48,290	4,413,385
1924	51,855	2,370,237	24,963	504,639	3,543	6,262	936	31,580	2,912,718
1925	69,733	3,500,496	41,773	1,109,067	5,477	9,414	1,079	31,658	4,650,635
1926	61,929	3,056,406	23,852	551,405	6,157	9,491	1,036	33,775	3,651,077

Fish glue.—In 1926 the production of fish glue was 520,622 gallons, valued at $732,109. The production of this commodity has increased appreciably, as may be seen from the following figures on the production for the last six years:

Comparative statistics of the production of fish glue, 1921 to 1926

Year	Gallons	Value	Year	Gallons	Value
1921	347,048	$364,415	1924	502,940	$550,391
1922	323,003	278,424	1925	510,816	589,064
1923	465,814	680,054	1926	520,622	732,109

Shell by-products.—In 1926 there were produced 251,166 tons of crushed oyster shell for poultry grit, valued at $2,379,141; 57,232 tons of oyster-shell lime, valued at $207,019; and 272 tons of crushed marine clamshells, valued at $2,256; a total of 308,670 tons of shell products, valued at $2,588,416. This does not include crushed shell produced as a by-product of the fresh-water pearl-button industry, statistics of which are not available.

Production of shell products, 1926

Products	Connecticut and Rhode Island		New Jersey and Pennsylvania		Maryland		Virginia		North Carolina and South Carolina	
Crushed oyster shell:	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*
Poultry grit	1,383	$17,289	9,538	$108,657	68,973	$678,606	21,883	$226,552	7,100	$86,000
Lime	307	1,423	3,800	16,438	25,410	65,246	21,315	106,554	1,350	9,250
Total	1,690	18,712	13,338	125,095	94,383	743,852	43,198	333,106	8,450	95,250

Products	Florida and Alabama		Mississippi		Louisiana		Texas		Total	
Crushed oyster shell:	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*
Poultry grit	8,294	$69,127	31,922	$275,028	98,283	$886,528	3,790	$31,354	251,166	$2,379,141
Lime	1,225	1,862	800	1,100	2,675	3,746	350	1,400	57,232	207,019
Total	9,519	70,989	32,722	276,128	100,958	890,274	4,140	32,754	308,398	2,586,160

NOTE.—In addition to the above there were produced elsewhere 272 tons of crushed marine clamshells, valued at $2,256.

Comparative statistics of oyster-shell by-products, 1921 to 1926

Year	Crushed oyster shell		Oyster-shell lime		Total
	Tons	*Value*	*Tons*	*Value*	*Value*
1921	185,474	$1,759,120	73,764	$502,634	$2,261,754
1922	236,021	2,005,838	93,168	431,213	2,437,051
1923	224,983	1,986,249	83,808	372,286	2,358,535
1924	219,211	2,019,254	70,269	336,384	2,355,638
1925	226,971	2,075,057	67,818	303,261	2,378,318
1926	251,166	2,379,141	57,232	207,019	2,586,160

Menhaden industry.—This industry suffered another poor season in 1926, due to scarcity of fish, the production being well below that of 1925 and only slightly above that of 1924, which was also a very poor year. The production in 1926 was: Dried scrap and meal, 24,226 tons, valued at $1,164,396; acidulated scrap, 23,553 tons, valued at $548,204; and 3,942,821 gallons of oil, valued at $1,729,160; a total of $3,441,760 worth of products, as compared with $5,622,615 in 1925.

Products of the menhaden industry, 1926

Products	Connecticut, New York, and New Jersey		Delaware		Virginia	
Fish utilized:	*Quantity*	*Value*	*Quantity*	*Value*	*Quantity*	*Value*
Menhaden ... number	32,191,334		42,323,667		213,783,183	
Products:						
Dry scrap and meal ... tons	457	$21,403			15,356	$756,075
Acidulated scrap ... do	2,898	77,845	4,133	$100,590		
Oil ... gallons	258,318	118,182	390,687	181,934	1,835,363	814,190
Total		217,430		282,524		1,570,205

Products	North Carolina		Georgia and Florida		Total	
Fish utilized:	*Quantity*	*Value*	*Quantity*	*Value*	*Quantity*	*Value*
Menhaden ... number	168,698,900		114,318,333		[1] 571,315,417	
Products:						
Dry scrap and meal ... tons	5,100	$234,375	3,313	$152,543	[2] 24,226	$1,164,396
Acidulated scrap ... do	10,712	224,519	5,810	145,250	23,553	548,204
Oil ... gallons	1,053,606	446,868	404,847	167,986	[3] 3,942,821	1,729,160
Total		905,762		465,779		3,441,760

[1] 342,789,250 pounds.
[2] Of this quantity 5,719 tons, valued at $304,224, were reported as fish meal.
[3] Menhaden oil is reported in United States gallons, about 7.74 pounds.

Comparative statistics of the products of the menhaden industry, 1921 to 1926

Year	Dried scrap and meal		Acidulated scrap		Oil		Total
	Tons	*Value*	*Tons*	*Value*	*Gallons*	*Value*	*Value*
1921	37,858	$1,380,455	44,804	$905,640	6,260,478	$1,719,892	$4,005,987
1922	67,821	2,665,441	25,755	556,317	7,102,677	2,904,833	6,126,591
1923	43,452	2,029,406	44,935	1,064,870	7,461,365	3,316,277	6,410,553
1924	21,008	996,866	24,409	495,684	3,923,904	1,817,626	3,310,176
1925	30,167	1,519,458	41,463	1,102,051	6,023,108	3,001,106	5,622,615
1926	24,226	1,164,396	23,553	548,204	3,942,821	1,729,160	3,441,760

FOREIGN FISHERY TRADE

The foreign trade in fishery products of the United States during 1926 amounted to $70,423,793, of which $50,094,786 were the value of fishery products imported for consumption and $20,329,007 the value of exports of domestic fishery products. Compared with 1925, this is an increase of 0.2 per cent in the total trade, an increase of 2.2 per cent in the value of fishery products imported for consumption, and a decrease of 4.4 per cent in the exports of domestic fishery products.

The imports consisted of 308,677,267 pounds of edible products (including fresh, frozen, cured, and canned fish), valued at $32,517,979, and nonedible products (comprised mainly of fish and marine-animal oils, pearls and imitation pearls, and shells), valued at $17,576,807. Compared with 1925, this is an increase of 17.2 per cent in the quantity and 11.9 per cent in the value of the edible products imported and a decrease of 12 per cent in the value of nonedible products imported.

The increase in the quantity and value of the edible products imported was due largely to larger imports of fresh and frozen fish (originating chiefly in Canada and Mexico), which amounted to 138,849,434 pounds, valued at $9,770,816, an increase of 38.8 per cent in the amount and 25.9 per cent in the value, as compared with 1925; and to the imports of canned products, amounting to 34,644,050 pounds, valued at $6,142,286, an increase in this class of 26.1 per cent in the amount and 23.9 per cent in the value. The imports of other edible fishery products differed very little from the preceding year.

The decrease in the value of nonedible products imported may be attributed almost entirely to the decrease of $2,489,656, or 27.3 per cent, in the value of pearls and imitation pearls imported. Possibly the domestic factories, which began the manufacture of imitation pearls a few years ago, are now supplying the United States market with this product to a greater extent.

The exports consisted mainly of edible products, amounting to 163,507,052 pounds, valued at $19,903,837, and nonedible products, valued at $425,170, registering an increase of 1.6 per cent in the quantity and a decrease of 4 per cent in the value of the edible products exported and a decrease of 19.5 per cent in the value of nonedible products exported.

The largest individual export item in 1926, which consisted of canned-fish products, amounted to 126,789,557 pounds, valued at $15,013,052. This is an increase over 1925 of 7.2 per cent in amount and 2.4 per cent in value. The amount of canned salmon exported showed an increase of 0.4 per cent in amount, with a decrease of 5.3 per cent in the value. The exports of canned sardines, the chief competitor of canned salmon in foreign markets, amounted to 71,285,456 pounds, valued at $6,126,476, showing an increase of 13.6 per cent in amount and 15.6 per cent in value. Very slight increases or decreases in exports were made by the other classes of fishery products.

Considering only the amounts of fishery products upon which we usually have an unfavorable trade balance, the imports of fresh and frozen fish were 20.3 times the exports in 1926 and 9.5 times those in 1925. The imports of cured fish were 6 times the exports in 1926 and 5.4 times those in 1925. The imports of fresh and canned shellfish were 2.4 times the exports in 1926 and 2.1 times those in 1925. The imports of fish and marine-animal oils were 115 times the exports in 1926 and 123 times those in 1925. Contrasting the above products with the amounts of those upon which we usually have a favorable trade balance the exports of canned fish, usually the most important export fishery product, were 3.7 times the imports in 1926 and 4.3 times those in 1925. The exports of miscellaneous or other fishery products were 2.3 times the imports in 1926 and 1.3 times the 1925 export.

Following are tables showing the amount and value of the foreign trade in fishery products by the United States for 1925 and 1926 and a comparison table for 1926.

Imports for consumption and domestic exports of fishery products, 1926, and ratio comparisons

Item	Imports		Exports		Ratio of imports to exports	
	Pounds	*Value*	*Pounds*	*Value*	*Quantity*	*Value*
Edible fishery products:						
Fish, fresh, frozen, or packed in ice	138, 849, 434	$9, 770, 816	6, 828, 713	$870, 010	203 : 10	112 : 10
Fish, salted, dried, smoked, or pickled	111, 406, 751	9, 029, 419	18, 631, 684	2, 361, 320	60 : 10	38 : 10
Fish, canned or packed in oil	34, 644, 050	6, 142, 286	126, 789, 557	15, 013, 052	10 : 37	10 : 24
Shellfish, canned of fresh	23, 134, 572	7, 609, 325	9, 763, 176	1, 520, 647	24 : 10	46 : 10
Other fish products, roe caviar, etc	642, 460	566, 133	1, 493, 922	138, 808	10 : 23	41 : 10
Total	308, 677, 267	32, 517, 979	163, 507, 052	19, 903, 837	19 : 10	16 : 10
Nonedible fishery products:						
Fish and marine-animal oils [1]	93, 145, 755	6, 694, 306	808, 827	118, 086	1, 150 : 10	563 : 10
All others		10, 882, 501		306, 184		355 : 10
Total		17, 576, 807		425, 170		413 : 10
Grand total		50, 094, 786		20, 329, 007		25 : 10

[1] Gallon of fish or marine-animal oil calculated at 7.5 pounds.

Exports of domestic fishery products, 1925 and 1926

Item	1925		1926	
	Quantity	*Value*	*Quantity*	*Value*
Fish, fresh, frozen, or packed in ice:				
Salmon ... pounds	4, 233, 549	$502, 007	3, 062, 307	$487, 542
Other fresh fish ... do	6, 283, 087	662, 114	3, 766, 406	382, 468
Total ... do	10, 516, 636	1, 164, 121	6, 828, 713	870, 010
Fish, salted, dried, smoked:				
Cod ... do	4, 381, 744	537, 815	3, 954, 342	423, 937
Haddock, hake, and pollock ... do	3, 163, 658	277, 948	2, 703, 613	196, 782
Herring ... do	3, 442, 340	212, 831	2, 350, 883	155, 471
Salmon, smoked or dry-cured ... do	1, 650, 740	341, 106	2, 169, 595	455, 270
Other ... do	1, 716, 468	132, 875	1, 652, 651	190, 506
Total ... do	14, 354, 950	1, 502, 076	12, 831, 084	1, 421, 966

Exports of domestic fishery products, 1925 and 1926—Continued

Item	1925		1926	
	Quantity	*Value*	*Quantity*	*Value*
Fish, pickled:				
Salmon.....pounds..	4,748,600	$1,293,941	3,356,200	$803,051
Other.....do....	1,620,800	125,688	2,444,400	136,303
Total.....do....	6,369,400	1,419,629	5,800,600	939,354
Fish, canned:				
Salmon.....do....	53,293,716	9,061,578	53,511,098	8,578,221
Sardines.....do....	62,754,826	5,301,178	71,285,456	6,126,476
Other.....do....	2,201,176	303,788	1,993,003	308,355
Total.....do....	118,249,718	14,666,544	126,789,557	15,013,052
Shellfish:				
Canned.....do....	4,084,907	939,486	3,443,164	691,131
Not canned.....do....	6,761,681	932,286	6,320,012	829,516
Total.....do....	10,846,588	1,871,772	9,763,176	1,520,647
Other fish products.....do....	522,571	110,443	1,493,922	138,808
Total edible products.....do....	160,859,863	20,734,584	163,507,052	19,903,837
Fish oils.....do....	614,274	115,078	808,827	118,986
Buttons, pearl or shell.....gross..	408,774	193,772	350,886	141,379
Shells, unmanufactured.....pounds..	1,326,064	97,240	....	....
Sponges.....do....	98,055	122,098	105,550	164,805
Total.....	....	413,110	....	306,184
Total nonedible products.....	....	528,188	....	425,170
Grand total.....	....	21,262,772	....	20,329,007

Imports of fishery products entered for consumption, 1925 and 1926

Item	1925		1926	
	Quantity	*Value*	*Quantity*	*Value*
Edible fishery products:				
Fish, fresh, frozen, or packed in ice—				
Cod, haddock, hake, and pollock.....pounds..	1,238,452	$61,940	976,473	$48,526
Eels.....do....	798,570	113,910	901,262	125,186
Fresh-water fishes.....do....	40,358,560	3,720,236	47,985,060	4,680,585
Halibut.....do....	3,740,015	465,035	5,719,266	747,310
Herring.....do....	2,386,842	121,676	1,438,905	68,032
Herring (fresh sea).....do....	16,335,323	213,764	46,252,918	429,052
Mackerel.....do....	4,404,097	302,204	2,858,612	160,212
Salmon.....do....	6,459,167	740,433	5,348,725	636,391
Smelts.....do....	6,669,087	877,924	9,099,087	1,185,948
Swordfish.....do....	492,151	78,386	1,175,014	170,844
Tuna.....do....	10,444,220	491,318	9,898,985	525,575
Other dutiable.....do....	6,740,478	576,494	7,195,187	993,155
Total.....do....	100,066,962	7,763,320	138,849,434	9,770,816
Fish, salted, dried, smoked, or pickled—				
Cod, dried.....do....	26,862,736	2,454,238	33,196,832	2,541,117
Finnan haddie.....do....	936,353	80,820	1,637,197	141,912
Hake and pollock, dried.....do....	698,956	46,479	1,386,220	77,573
Herring—				
Dried or smoked.....do....	1,107,542	69,683	994,859	57,920
Pickled or salted.....do....	35,590,438	2,434,667	31,524,616	1,951,628
Smoked, skinned, or boned.....do....	561,877	61,928	655,014	78,451
Mackerel, pickled or salted.....do....	13,494,366	1,044,118	10,721,327	652,617
Salmon, dried.....do....	6,661	1,267	130,568	13,330
Salmon, kippered, smoked, salted, pickled, or otherwise prepared.....pounds..	1,137,151	166,407	1,066,653	183,045
Other kippered, smoked, salted, pickled or otherwise prepared, not elsewhere specified.....pounds..	3,376,852	396,809	19,769,295	2,003,369
Other dried fish.....do....	6,049,707	816,728	5,621,252	765,498
Others, in bulk or packages.....do....	22,721,130	2,207,655	4,702,918	562,959
Total.....do....	112,543,769	9,780,799	111,406,751	9,029,419
Fish packed in oil or other substances—				
Sardines.....do....	20,180,843	3,590,012	25,529,032	4,358,219
All others.....do....	7,291,419	1,368,751	9,115,018	1,784,067
Total.....do....	27,472,262	4,958,763	34,644,050	6,142,286

Imports of fishery products entered for consumption, 1925 and 1926—Continued

Item	1925		1926	
	Quantity	*Value*	*Quantity*	*Value*
Edible fishery products—Continued.				
Fish roe, frozen, prepared, or preserved—				
Caviar .... pounds	158,734	$322,428	358,903	$505,765
Other fish roe, preserved .... do	253,550	62,238	283,557	60,368
Total .... do	412,284	384,666	642,460	566,133
Shellfish—				
Crabs .... do	34,601	3,105	102,644	8,609
Crab meat packed in ice, frozen, or otherwise prepared or preserved .... pounds	8,332,099	2,818,299	7,243,455	3,188,154
Lobsters, canned .... do	1,382,513	819,048	1,792,038	1,135,921
Lobsters, fresh, frozen, packed in ice, or prepared or preserved in any manner (not specially provided for) .... pounds	6,998,997	1,585,843	6,537,088	1,555,875
Turtles .... do	643,315	40,391	465,000	25,746
Other shellfish and shrimp .... do	5,442,633	904,991	6,994,338	1,095,020
Total .... do	22,834,758	6,171,677	23,134,572	7,009,325
Total edible fishery products .... do	263,330,035	29,059,225	308,677,267	32,517,979
Nonedible fishery products:				
Fish and marine-animal oils—				
Cod oil .... gallons	1,755,070	864,131	2,425,599	1,250,836
Cod-liver oil .... do	1,220,440	1,055,914	1,921,422	1,615,967
Herring, menhaden, and sod oil .... do	567,236	238,468	1,942,846	755,316
Other fish oils .... do	125,798	41,578	108,263	41,565
Seal oil .... do	364,893	187,718	650,775	315,203
Whale oil, sperm .... do	258,261	103,863	137,309	51,272
Whale oil, other .... do	7,141,111	4,224,551	5,233,220	2,664,147
Total .... do	11,432,809	6,716,223	12,419,434	6,694,306
Pearls and imitation pearl—				
Pearls and parts, not strung or set .... number	2,052,518	6,734,149	....	5,322,140
Imitation half pearls and hollow or filled pearls without holes or with holes partly through .... number	9,139,307	198,107	17,755,752	93,654
Imitation solid pearls, wholly or partly pierced, mounted or unmounted .... number	1,408,156	24,541	1,061,040	40,528
Imitation-pearl beads .... pounds	1,613,044	2,169,251	....	1,180,070
Total	....	9,126,048	....	6,636,392
Shells and buttons of pearl or shell—				
Shells, not manufactured—				
Green snail shell .... pounds	260,588	26,688	182,509	24,409
Mother-of-pearl .... do	5,484,394	1,707,817	7,049,902	2,040,517
All others .... do	1,116,934	194,186	4,329,950	133,440
Shells, manufactured .... do	118,268	119,505	....	100,112
Shell pearl buttons—				
Fresh-water .... gross	20,600	7,057	7,864	2,600
Ocean or trochus .... do	242,623	83,670	103,900	41,735
Button blanks, not turned, faced or drilled .... gross	1,934	1,135	638	735
Buttons (from Philippine Islands) .... do	722,223	316,460	992,109	455,619
Total	....	2,456,524	....	2,799,167
Sponges .... pounds	232,969	241,213	244,540	243,437
From Cuba .... do	663,302	644,671	700,831	604,804
From Philippine Islands .... do	2,586	5,628	1,130	3,514
Manufactures of, not specially provided for .... pounds	471	1,818	704	645
From Cuba .... do	694	1,178	2,631	3,904
From Philippine Islands .... do	....	....	53	138
Total .... do	900,022	894,508	949,889	916,442
Agar agar .... do	501,226	461,947	465,832	320,559
Ambergris .... do	223	80,365	134	14,551
Cuttlefish bone .... do	308,441	46,663	264,471	31,250
Fish for purposes other than human consumption .... pounds	2,491,645	80,490	3,851,060	72,967
Fish skins, raw or salted .... do	226,892	7,378	367,643	11,715
Fish sounds, crude, dried, or salted for preservation only .... do	151,854	42,263	116,654	31,218
Sea grass, eelgrass, and sea-weed, dyed or manufactured .... do	191,227	41,169	....	43,891
Sealskins .... number	289	7,253	....	....
Whalebone, unmanufactured .... pounds	18,945	10,037	5,148	3,878
Whalebone, manufactures of .... do	220	489	173	471
Total	....	778,063	....	530,500
Total nonedible fishery products	....	19,971,366	....	17,576,807
Grand total	....	49,030,591	....	50,094,786

COLD-STORAGE HOLDINGS OF FROZEN FISH IN 1926

The statistics of the cold-storage holdings of frozen fish and the quantities of fish frozen are collected by the Bureau of Agricultural Economics, Department of Agriculture, and in 1926, as in previous years, were published monthly and distributed by the Bureau of Fisheries. The regular monthly cold-storage bulletin usually is in the hands of the trade by the 20th of each month. Due to the complexities of fishing operations, it is patent that the information contained in this bulletin should reach the trade at the earliest possible date. To this end, a comprehensive first release is issued on the 1st of each month, which, while not in such detail as the regular bulletin, shows the holdings of fish for the current month, the holdings for the corresponding month a year previous, and the amount frozen during the current month for 14 of the most important commercial species. Both of these bulletins will be sent to interested parties, free of charge, upon application to the Bureau of Fisheries.

During 1926 there were 177 freezers and cold-storage establishments devoted wholly or in part to the storage of frozen fish. The holdings were somewhat less during the first seven months and considerably more during the last five months of the year than in the previous year, varying between 16,154,002 pounds, in the month of April, to 75,034,255 pounds, in the month of November. The average monthly holdings during the year amounted to 45,906,276 pounds, as compared with 44,084,251 pounds in 1925, an increase of 4.13 per cent. Compared with the 5-year average, the monthly holdings in 1926 were somewhat larger, being 11.71 per cent above the 5-year average. The holdings during the first seven months of 1926 were 1.98 to 28.02 per cent smaller than in the same months of the previous year, and during the last five months they were 16.61 to 21.39 per cent larger. Compared with the 5-year average, they were 2.35 to 19.59 per cent smaller during the first four months and less than 1 to 33.85 per cent larger during the last eight months of 1926.

Comparative statement of cold-storage holdings of frozen fish for 1926 and 1925, and the 5-year average

Month	1926	1925	Five-year average	Increase (+) or decrease (−)	
				Compared with 1925	Compared with 5-year average
	Pounds	*Pounds*	*Pounds*	*Per cent*	*Per cent*
January	48,180,927	55,307,587	50,026,000	−12.89	−3.69
February	37,378,116	44,034,613	38,278,000	−15.12	−2.35
March	24,893,707	29,864,613	27,007,000	−16.65	−7.82
April	16,154,002	22,441,873	20,089,000	−28.02	−19.59
May	21,540,012	23,749,277	20,268,000	−9.31	+6.28
June	31,345,473	31,979,574	26,001,000	−1.98	+20.55
July	33,901,690	40,458,169	33,901,000	−16.21	+.002
August	57,626,753	47,473,515	43,052,000	+21.39	+33.85
September	64,656,804	55,446,548	52,178,000	+16.61	+23.92
October	70,309,906	58,357,764	60,328,000	+20.48	+16.55
November	75,034,255	61,849,359	62,288,000	+21.32	+20.46
December	69,853,669	58,048,280	59,694,000	+20.34	+17.02
Average for year	45,906,276	44,084,251	41,092,500	+4.13	+11.71

Holdings of frozen fish in the United States in 1926, by species, and a 5-year average, 1921 to 1925 [1]

Species	Month ended—					
	Jan. 15	Feb. 15	Mar. 15	Apr. 15	May 15	June 15
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Bluefish (all trade sizes)	445, 718	342, 679	290, 567	206, 176	231, 655	320, 871
Butterfish (all trade sizes)	845, 568	611, 333	293, 825	159, 848	227, 486	276, 655
Catfish	111, 382	82, 784	37, 606	41, 975	127, 020	158, 619
Ciscoes (including bluefin, blackfin, chub, lake herring, etc.)	2, 305, 327	1, 376, 924	668, 938	360, 868	324, 283	519, 128
Ciscoes (tullibees)	1, 062, 725	1, 412, 594	1, 257, 336	829, 212	667, 620	597, 686
Cod, haddock, hake, pollock	883, 933	636, 144	495, 504	553, 529	703, 128	1, 045, 593
Croaker	342, 371	178, 790	69, 196	2, 285	1, 572, 358	1, 712, 547
Flounders	627, 801	424, 832	341, 022	158, 483	346, 400	622, 718
Halibut (all trade sizes)	4, 907, 844	2, 504, 272	1, 584, 131	1, 473, 747	3, 047, 381	5, 366, 294
Herring, sea (including alewives and bluebacks)	2, 851, 964	2, 362, 962	2, 367, 792	2, 164, 260	2, 647, 074	2, 476, 106
Lake trout	2, 093, 198	1, 703, 539	886, 958	227, 040	214, 730	529, 802
Mackerel (except Spanish)	4, 311, 884	3, 158, 859	1, 639, 170	747, 455	1, 962, 009	2, 404, 645
Pike perches and pike or pickerel	3, 695, 913	3, 390, 366	2, 199, 018	1, 164, 051	1, 426, 211	2, 235, 296
Sablefish (black cod)	1, 821, 194	1, 144, 991	967, 089	837, 229	730, 536	642, 016
Salmon, silver and fall	2, 732, 494	1, 865, 869	1, 031, 104	332, 137	200, 614	173, 192
Salmon, steelhead trout	431, 588	275, 550	52, 655	26, 805	20, 810	44, 494
Salmon, all other	2, 412, 673	1, 926, 443	1, 408, 211	946, 895	798, 594	888, 113
Scup (porgies)	318, 035	192, 368	61, 726	14, 906	63, 862	209, 334
Shad and shad roe	576, 913	399, 073	196, 543	150, 748	234, 529	496, 712
Shellfish	900, 000	847, 960	633, 348	359, 090	417, 966	574, 338
Smelts, eulachon, etc	1, 035, 946	1, 416, 159	1, 329, 662	655, 477	556, 632	532, 011
Squeteagues or "sea trout"	1, 129, 495	673, 440	269, 947	83, 068	306, 778	445, 472
Squid	1, 190, 883	871, 578	751, 118	390, 189	394, 976	1, 309, 658
Sturgeon and spoonbill cat	195, 705	145, 574	132, 557	56, 922	106, 349	293, 926
Suckers	72, 210	47, 994	28, 409	31, 118	49, 120	62, 717
Whitefish	2, 308, 708	2, 201, 183	1, 554, 089	610, 889	432, 528	510, 636
Whiting	4, 901, 429	3, 803, 529	1, 827, 068	1, 216, 222	904, 961	3, 331, 875
Miscellaneous frozen fish	3, 668, 036	3, 380, 827	2, 519, 058	2, 353, 378	2, 823, 802	3, 565, 019
Total frozen fish	48, 180, 927	37, 378, 116	24, 893, 707	16, 164, 002	21, 540, 012	31, 345, 473
Five-year average, 1921–1925	50, 026, 000	38, 278, 000	27, 007, 000	20, 089, 000	20, 268, 000	26, 001, 000

Species	Month ended—					
	July 15	Aug. 15	Sept. 15	Oct. 15	Nov. 15	Dec. 15
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Bluefish (all trade sizes)	334, 823	277, 952	334, 813	409, 841	498, 909	559, 021
Butterfish (all trade sizes)	490, 020	658, 629	1, 180, 787	1, 433, 005	1, 618, 329	1, 361, 269
Catfish	158, 206	171, 155	193, 921	217, 795	213, 440	238, 968
Cisco (Lake Erie)	61, 850	280, 414	400, 806	588, 273	531, 773	638, 968
Cisco (lake herring), including bluefin, blackfin, and chub	669, 297	1, 198, 422	1, 569, 295	1, 705, 492	2, 321, 208	3, 419, 619
Cisco (tullibees, Canadian lakes)	590, 946	594, 333	659, 240	581, 454	1, 083, 907	1, 321, 792
Cod, haddock, hake, pollock	1, 319, 861	2, 048, 874	2, 466, 600	2, 798, 065	3, 017, 477	2, 534, 705
Croaker	2, 005, 068	2, 767, 786	2, 422, 491	1, 938, 832	1, 744, 454	1, 581, 488
Flounders	789, 390	818, 798	794, 769	780, 015	885, 590	802, 994
Halibut (all trade sizes)	8, 018, 732	10, 769, 155	12, 312, 485	12, 078, 605	11, 431, 849	9, 368, 933
Herring, sea (including alewives and bluebacks)	2, 567, 666	2, 515, 497	2, 370, 729	2, 409, 106	2, 627, 105	2, 325, 225
Lake trout	672, 915	740, 261	755, 354	1, 094, 541	2, 026, 143	2, 019, 089
Mackerel (except Spanish)	6, 352, 132	9, 510, 431	11, 510, 394	11, 322, 610	10, 533, 613	9, 063, 993
Pike, blue and sauger	993, 640	607, 981	441, 140	535, 570	1, 263, 096	1, 117, 219
Pike, yellow or wall-eyed	279, 612	194, 923	204, 235	244, 168	294, 463	221, 548
Pike (including pickerel, jacks, and yellow jack)	714, 016	738, 740	869, 600	1, 354, 757	1, 528, 656	1, 497, 892
Sablefish (black cod)	754, 016	940, 396	1, 108, 591	1, 551, 825	1, 951, 222	1, 732, 324
Salmon, chinook	789, 597	1, 398, 178	1, 685, 145	1, 942, 840	1, 705, 416	1, 361, 277
Salmon, silver	377, 706	1, 336, 802	2, 008, 421	3, 538, 461	3, 424, 282	3, 738, 254
Salmon, fall and pink	71, 349	176, 488	202, 060	961, 300	1, 404, 737	1, 281, 194
Salmon, steelhead trout	440, 077	863, 327	1, 064, 738	1, 109, 401	994, 107	712, 874
Salmon, all other	1, 378, 768	1, 535, 118	1, 949, 944	2, 045, 996	2, 008, 669	2, 313, 964
Scup (porgies)	230, 678	248, 070	234, 978	211, 168	186, 655	145, 485

[1] Beginning with July 15, 1926, the following groups or classifications were changed: "Ciscoes (including bluefin, blackfin, chub, lake herring, etc.)" to "Cisco (Lake Erie)" and "Cisco (lake herring), including bluefin, balckfin, and chub"; "Ciscoes (tullibees)" to "Cisco (tullibees, Canadian lakes)"; "Pike perches and pike or pickerel" subdivided to "Pike, blue and sauger", "Piko, yellow or wall-eyed", and "Pike (including pickerel, jacks, and yellow jacks)"; "Salmon, silver and fall" discontinued and salmon classified as "Salmon, chinook", "Salmon, silver", "Salmon, fall and pink", "Salmon, steelhead trout", and "Salmon, all other"; and "Squeteagues or 'sea trout' " to "Weakfish (including southern 'sea trout')".

Holdings of frozen fish in the United States in 1926, by species, and a 5-year average, 1921 to 1925—Continued

Species	Month ended—					
	July 15	Aug. 15	Sept. 15	Oct. 15	Nov. 15	Dec. 15
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Shad and shad roe	521, 920	507, 793	493, 089	463, 308	433, 885	347, 378
Shellfish	625, 166	487, 332	508, 320	985, 248	1, 375, 848	1, 548, 401
Smelts, eulachon, etc	520, 545	516, 022	520, 852	530, 102	574, 760	518, 920
Squid	1, 615, 412	1, 586, 189	1, 573, 194	2, 079, 983	2, 229, 339	2, 044, 650
Sturgeon and spoonbill cat	530, 140	617, 007	745, 713	1, 255, 385	1, 230, 711	1, 136, 955
Suckers	63, 261	60, 831	58, 812	58, 165	92, 705	87, 329
Weakfish (including southern "sea trout")	390, 678	498, 244	581, 093	1, 111, 981	1, 363, 422	1, 278, 683
Whitefish	696, 969	969, 881	985, 660	952, 574	1, 324, 421	1, 297, 356
Whiting	6, 696, 870	7, 752, 541	8, 067, 142	7, 431, 789	7, 623, 602	7, 069, 007
Miscellaneous frozen fish	3, 884, 364	4, 149, 233	4, 382, 443	4, 588, 253	5, 490, 462	5, 177, 001
Total frozen fish	45, 605, 690	57, 626, 753	64, 656, 804	70, 309, 906	75, 034, 255	69, 853, 669
Five-year average, 1921–1925	33, 901, 000	43, 052, 000	52, 178, 000	60, 328, 000	62, 288, 000	59, 604, 000

NEW ENGLAND VESSEL FISHERIES

GENERAL STATISTICS

The vessel fisheries centering at Boston and Gloucester, Mass., and Portland, Me., experienced a record year in 1926 in the quantity of products, which was greater than for any previous year for which statistics are available; the value of the products was greater than for any year since 1918. There was an increase over 1925 at the three ports of 3.46 per cent in the number of trips and of 9.94 per cent in the quantity and 11.74 per cent in the value of the products. The increases were at Boston and Gloucester, but there was a decrease at Portland. The increase at Boston was 3.75 per cent in the number of trips and 12.26 per cent in the quantity and 14.72 per cent in the value of the products. The increase at Gloucester was 6.99 per cent in the number of trips and 10.97 per cent in the quantity and 7.16 per cent in the value of the products. At Portland the decrease was 3.18 per cent in the number of trips and 11.72 per cent in the quantity and 7.24 per cent in the value of the products. Statistics of the fisheries have been collected by the local agents and published in monthly bulletins, showing, by species and fishing grounds, the quantity and value of fishery products landed by American fishing vessels during the year at these ports. Two annual bulletins were issued, one showing the catch by months and the other by fishing grounds.

During the calendar year 1926 the fishing fleet at these ports numbered 350 sail, steam, and gasoline vessels, including 30 steam trawlers. These vessels landed 4,569 trips at Boston, aggregating 167,317,826 pounds of fish, valued at $7,002,602; 2,665 trips at Gloucester, aggregating 54,900,824 pounds, valued at $1,490,211; and 1,461 trips at Portland aggregating 16,207,573 pounds, valued at $575,760. The total for the three ports amounted to 8,695 trips, aggregating 238,426,223 pounds of fresh and salted fish, having a value to the fishermen of $9,068,573. In making these trips, including the date of departure and date of arrival, the vessels were absent from port 44,236 days. At Boston the trips landed occupied 29,996 days; at Gloucester, 10,882 days; and at Portland, 3,358 days.

Compared with the previous year, there was an increase of 291 trips, or 3.46 per cent, in the total number landed at Boston, Gloucester, and Portland, and an increase of 21,556,958 pounds, or 9.94 per cent, in the quantity and $953,003, or 11.74 per cent, in the value of the products landed. There was considerable increase in both the quantity and value of cod and haddock and a large increase in the quantity and value of the catch of mackerel and swordfish. There was also a large increase in the catch of pollock, with a small increase in the value. The catch of hake, cusk, and herring declined in both quantity and value. The catch of halibut also declined to some extent in quantity, with a small increase in value. The catch of cod increased 10,968,573 pounds, or 16.31 per cent, in quantity and $326,241, or 14.05 per cent, in value; haddock increased 2,174,474 pounds, or 2.37 per cent, in quantity and $335,183, or 12.2 per cent, in value; and mackerel increased 10,022,795 pounds, or 38.24 per cent, in quantity and $215,333, or 18.08 per cent, in value. The catch of hake decreased 301,101 pounds, or 5.19 per cent, in quantity and $27,424, or 15.79 per cent, in value; pollock increased 1,449,641 pounds, or 27.4 per cent, in quantity and $6,103, or 4.14 per cent, in value; and cusk decreased 984,903 pounds, or 26.53 per cent, in quantity and $15,014, or 17.75 per cent, in value. The catch of halibut decreased 130,145 pounds, or 3.65 per cent, in quantity and increased $15,978, or 2.44 per cent, in value. The catch of swordfish increased 964,499 pounds, or 63.16 per cent, in quantity and $106,700, or 27.65 per cent, in value. The herring catch decreased 2,361,951 pounds, or 59.91 per cent, in quantity and $63,418, or 61.68 per cent, in value. The Newfoundland herring catch decreased from 2,400,336 pounds, valued at $84,265, in 1925, to 555,280 pounds, valued at $26,510, in 1926. In the various other species, combined, there was a decrease of 244,924 pounds, or 3.19 per cent, in quantity and an increase of $53,321, or 17.44 per cent, in value.

The catch of scrod cod landed at these ports decreased from 227,698 pounds, valued at $3,539, in 1925, to 185,594 pounds, valued at $2,897, in 1926; and the catch of scrod haddock decreased from 14,571,900 pounds, valued at $299,393, in 1925, to 11,251,594 pounds, valued at $244,143, in 1926. The small quantity of these grades landed each year, as compared with other grades of these species, is said to be due to the fact that the price was so low that the fishermen did not save all that were 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 1926. These include only the vessels of 5 net tons and upward, as measured by the United States Customs Service. 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.

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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, 1926

Fishing grounds	Number of trips	Cod							
		Large (10 pounds and over)				Market (under 10 and over 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	71	1,535,440	$66,722			434,380	$11,913		
Western Bank	90	2,093,410	66,294	8,000	$333	186,965	3,735		
Quereau Bank	14	14,000	495			12,000	330		
Green Bank	4								
Grand Bank	4	3,500	105						
St. Peters Bank	10								
Burgeo Bank	1								
Cape Shore	72	244,300	10,864			177,200	4,204		
Labrador Coast	1								
West of 66° W. longitude:									
Browns Bank	223	3,582,013	164,909			1,976,345	59,308		
Georges Bank	701	16,818,898	674,574			2,535,190	71,373		
Cashes Bank	12	98,000	4,288			40,720	1,305		
Clark Bank	3	33,640	1,353			8,260	209		
Fippenies Bank	4	3,299	321			2,580	170		
Middle Bank	224	96,339	5,497			67,630	2,753		
Jeffreys Ledge	167	120,302	7,100			59,776	2,558		
South Channel	1,095	5,839,660	276,822	5,980	274	2,813,451	86,123	3,290	$132
Nantucket Shoals	212	571,533	27,776			499,478	12,881		
Off Highland Light	62	11,200	632			5,900	193		
Off Chatham	317	186,773	9,403			115,045	4,613		
Seal Island	1	10,420	625			5,500	156		
South	3								
Shore, general	1,278	825,622	24,537			294,261	9,906		
Total	4,569	31,788,349	1,342,317	13,980	607	9,234,681	271,730	3,290	132
LANDED AT GLOUCESTER									
East of 66° W. longitude:									
La Have Bank	33	621,100	13,712	223,855	10,450	185,000	3,170	29,485	1,100
Western Bank	146	17,946,615	394,401	2,530,194	113,563	1,983,185	32,877	395,420	13,274
Quereau Bank	11	58,100	1,312	127,995	5,947	17,540	301	16,930	648
Green Bank	2	10,510	236	977	49	105	2	2,420	97
Grand Bank	7	16,270	366	89,005	4,144	6,395	96	47,240	1,760
St. Peters Bank	11	75,890	1,188	78,075	3,771	8,230	110	12,990	490
Burgeo Bank	2	2,320	52	17,071	822	370	6	1,744	68
Off Newfoundland	2								
Cape Shore	16	56,970	1,317			38,460	701		
West of 66° W. longitude:									
Browns Bank	31	804,792	17,243	108,490	5,311	246,600	4,390	6,938	261
Georges Bank	103	2,648,760	64,349	603,250	30,165	228,690	4,291	121,385	4,716
South Channel	22	34,375	819			41,690	800		
Nantucket Shoals	16	2,800	69			1,525	31		
Off Chatham	40								
Shore, general	2,223	3,322,440	155,314			65,120	3,075	10,340	362
Total	2,665	25,600,942	650,378	3,778,912	174,222	2,823,000	49,850	644,892	22,776
LANDED AT PORTLAND									
East of 66° W. longitude:									
La Have Bank	2	23,370	548			4,780	96		
Western Bank	18	1,610,740	32,600	9,820	372	28,802	957	8,828	295
Quereau Bank	6	27,375	925	69,040	3,452	5,650	181	4,135	165
Grand Bank	3								
Cape Shore	6								
Gulf of St. Lawrence	2								
The Gully	3	2,600	59	1,320	59	100	2	90	3
Labrador Coast	1								
West of 66° W. longitude:									
Browns Bank	3	31,450	1,488			26,730	703		
Georges Bank	20	28,000	560						
Cashes Bank	70	173,503	5,455	13,035	612	76,371	2,263	1,515	56
Fippenies Bank	5	2,690	114			1,965	65		
Middle Bank	5	2,220	67			2,775	69		
Platts Bank	98	71,181	3,659			42,476	1,682		
Jeffreys Ledge	368	521,658	26,480			69,880	2,345		
South Channel	13	90,500	1,905	270	14			60	2
Nantucket Shoals	1								
Off Highland Light	4								
Shore, general	833	1,037,632	40,449	2,841	164	150,115	4,616	1,540	88
Total	1,461	3,622,919	114,309	96,326	4,673	409,650	12,979	16,168	609
Grand total	8,695	61,012,210	2,107,004	3,889,218	179,502	12,467,331	334,559	664,350	23,517

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, 1926—Continued

Fishing grounds	Cod—Continued				Haddock			
	Scrod (1 to 2½ pounds)				Large (over 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	2,800	$28			899,500	$28,344		
Western Bank					655,615	18,003		
Cape Shore	1,000	15			216,435	6,690		
West of 66° W. longitude:								
Browns Bank	8,275	110			4,029,675	159,283		
Georges Bank	1,345	18			7,401,670	306,852		
Cashes Bank	500	5			65,555	2,068		
Clark Bank					44,700	2,026		
Fippenies Bank	1,075	27			30,600	2,180		
Middle Bank	5,520	103			861,028	45,713		
Jeffreys Ledge	4,555	93			874,000	49,784		
South Channel	13,825	367			42,084,463	1,465,919		
Nantucket Shoals	6,300	91			7,134,975	201,865		
Off Highland Light					114,450	4,249		
Off Chatham	2,215	67			2,718,495	127,960		
Seal Island					42,800	1,098		
Shore, general	13,765	226			4,281,022	169,846		
Total	61,175	1,150			71,454,983	2,591,880		
LANDED AT GLOUCESTER								
East of 66° W. longitude:								
La Have Bank	460	5	30	$1	173,915	1,911		
Western Bank	6,200	62	4,950	134	591,213	6,281	2,210	$48
Quereau Bank			85	3				
Grand Bank			2,930	81				
Cape Shore					13,955	220		
West of 66° W. longitude:								
Browns Bank	110	1			411,785	5,761		
Georges Bank	265	3	60	2	1,096,417	14,602	185	4
South Channel					1,220,425	12,742		
Nantucket Shoals					1,324,965	13,607		
Shore, general					604,115	22,129		
Total	7,035	71	8,055	221	5,436,790	77,253	2,395	52
LANDED AT PORTLAND								
East of 66° W. longitude:								
La Have Bank	485	2			32,200	582		
Western Bank	5,150	52	19,655	346	823,515	14,787	74,085	1,473
Quereau Bank			200	4				
West of 66° W. longitude:								
Browns Bank	70	2			48,750	2,021		
Georges Bank					459,800	8,424		
Cashes Bank	14,260	165			149,533	8,074		
Fippenies Bank	423	7			8,805	560		
Middle Bank	600	3			33,890	750		
Platts Bank	19,898	286			379,532	20,630		
Jeffreys Ledge	20,311	256			666,826	30,791		
South Channel					2,028,000	39,360		
Nantucket Shoals					189,500	2,843		
Shore, general	27,981	320	296	12	1,020,491	39,273	45	1
Total	89,178	1,093	20,151	362	5,840,842	168,122	74,130	1,474
Grand total	157,388	2,314	28,206	583	82,732,615	2,837,255	76,525	1,526

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, 1926—Continued

Fishing grounds	Haddock—Continued				Hake			
	Scrod (1 to 2½ pounds)				Large (6 pounds and over)			
	Fresh		Salted		Fresh		Salted	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
LANDED AT BOSTON								
East of 66° W. longitude:								
La Have Bank	20,575	$502			30,050	$972		
Western Bank	1,100	33			5,150	140		
Quereau Bank					1,000	10		
Cape Shore					1,260	15		
West of 66° W. longitude:								
Browns Bank	86,020	2,601			31,385	877		
Georges Bank	570,660	14,599			39,660	950		
Cashes Bank	500	5			44,665	2,082		
Clark Bank	7,000	265			400	8		
Fippenies Bank	1,870	48			16,930	738		
Middle Bank	22,465	672			245,905	8,393		
Jeffreys Ledge	33,615	969			208,275	6,167		
South Channel	7,461,230	167,434			3,208,477	71,595	3,420	$71
Nantucket Shoals	1,143,135	20,877			111,550	3,471		
Off Highland Light	9,885	151			7,100	526		
Off Chatham	392,315	11,399			69,790	3,146		
Seal Island					2,775	42		
Shore, general	657,523	16,854			141,975	3,312		
Total	10,407,893	236,409			4,256,347	102,444	3,420	71
LANDED AT GLOUCESTER								
East of 66° W. longitude:								
La Have Bank	270	5			68,470	973	4,465	90
Western Bank	18,080	128			570	7	1,085	22
Quereau Bank					1,860	23	5,360	120
Grand Bank					840	8	4,070	81
St. Peters Bank					1,080	12		
Burgeo Bank					260	3		
Cape Shore					600	6		
West of 66° W. longitude:								
Browns Bank	2,900	23			8,170	98	1,480	26
Georges Bank	67,380	1,274			26,600	320	605	12
South Channel	426,760	3,253			10,195	115		
Nantucket Shoals	194,520	1,511			4,645	52		
Shore, general					51,515	865		
Total	710,510	6,194			174,805	2,482	17,065	351
LANDED AT PORTLAND								
East of 66° W. longitude:								
La Have Bank	1,350	7						
Western Bank			800	$16				
Quereau Bank							1,500	45
West of 66° W. longitude:								
Browns Bank	3,670	58						
Cashes Bank	11,285	182			5,920	174		
Fippenies Bank	790	11						
Middle Bank	210	1						
Platts Bank	17,976	293			3,656	87		
Jeffreys Ledge	33,645	414			3,875	144		
Shore, general	63,465	558			1,445	37		
Total	132,391	1,524	800	16	14,895	442	1,500	45
Grand total	11,250,794	244,127	800	16	4,446,047	105,368	21,985	467

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, 1926—Continued

Fishing grounds	Hake—Continued: Small (under 6 pounds): Fresh		Hake—Continued: Small (under 6 pounds): Salted		Pollock: Fresh		Pollock: Salted	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
LANDED AT BOSTON								
East of 66° W. longitude:								
La Havre Bank					62,260	$1,282		
Western Bank					27,685	775		
Cape Shore					5,560	93		
West of 66° W. longitude:								
Browns Bank	3,905	$263			213,231	6,217		
Georges Bank	9,030	676			696,928	17,334		
Cashes Bank	13,650	408			12,260	337		
Clark Bank					675	23		
Fippenies Bank					2,780	76		
Middle Bank	30,310	1,795			85,040	1,694		
Jeffreys Ledge	38,675	1,840			102,060	2,191		
South Channel	271,427	15,502			1,033,791	47,011		
Nantucket Shoals	11,540	398			85,300	2,099		
Off Highland Light					4,025	109		
Off Chatham	18,120	1,360			35,640	1,794		
Seal Island					100	1		
Shore, general	17,270	700			136,388	4,737		
Total	413,927	22,942			3,103,723	85,773		
LANDED AT GLOUCESTER								
East of 66° W. longitude:								
La Have Bank					26,030	268	1,030	$21
Western Bank					127,770	1,322	13,950	287
Quereau Bank					800	8	970	19
Grand Bank					170	3		
St. Peters Bank					1,485	15	80	2
Cape Shore					420	4		
West of 66° W. longitude:								
Browns Bank					19,810	384	3,025	61
Georges Bank					32,480	325	4,580	93
South Channel					2,010	20		
Shore, general					2,624,440	51,461		
Total					2,835,415	53,810	23,635	483
LANDED AT PORTLAND								
East of 66° W. longitude:								
La Have Bank	1,015	28			225	4		
Western Bank	4,935	98			5,175	54	9,670	238
Quereau Bank			470	$9	930	14	500	13
West of 66° W. longitude:								
Browns Bank	200	2			1,400	28		
Cashes Bank	55,985	2,000			28,955	696	75	2
Fippenies Bank	3,563	79			338	10		
Platts Bank	163,317	4,533			33,967	651		
Jeffreys Ledge	254,869	7,167			422,278	6,944		
South Channel	3,300	102			16,742	285		
Shore, general	135,006	3,447			255,937	4,670	459	10
Total	622,190	17,456	470	9	766,037	13,356	10,704	263
Grand total	1,036,117	40,398	470	9	6,705,175	152,939	34,339	746

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, 1926—Continued

Fishing grounds	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	62,865	$1,294			228,393	$45,818		
Western Bank	23,860	429			207,405	36,067		
Quereau Bank	500	5			443,917	83,535		
Green Bank					143,145	23,117		
Grand Bank					129,097	22,231		
St. Peters Bank					282,196	53,952		
Burgeo Bank					14,278	2,368		
Cape Shore	19,565	249			1,684	419		
Labrador Coast					21,511	3,667		
West of 66° W. longitude:								
Browns Bank	446,910	11,145			225,445	52,756		
Georges Bank	142,330	2,970			972,204	201,089		
Cashes Bank	108,180	2,419			1,757	482		
Clark Bank					336	96		
Fippenies Bank	2,350	94			400	200		
Middle Bank	144,130	4,577			2,581	965		
Jeffreys Ledge	93,370	2,971			1,175	389		
South Channel	250,505	8,057			218,542	44,797		
Nantucket Shoals	535	12			44,005	7,560		
Off Highland Light	2,140	107			1,718	204		
Off Chatham	40,570	2,035			13,686	2,482		
Seal Island	1,950	20			430	65		
Shore, general	92,650	2,273			13,497	2,443		
Total	1,432,410	38,657			2,967,402	584,702		
LANDED AT GLOUCESTER								
East of 66° W. longitude:								
La Have Bank	139,505	1,875	9,780	$262				
Western Bank	5,285	87	2,005	48	9,860	2,958	335	$32
Quereau Bank	54,820	314	4,090	86			2,695	358
Grand Bank	550	6	1,700	49				
St. Peters Bank	540	8	280	7			1,700	190
Burgeo Bank			25	1				
West of 66° W. longitude:								
Browns Bank	47,570	619	4,310	126				
Georges Bank	183,280	2,669	12,065	327				
Shore, general	560	6						
Total	432,110	5,584	34,255	906	9,860	2,958	4,730	580
LANDED AT PORTLAND								
East of 66° W. longitude:								
La Have Bank	4,425	77			577	94		
Western Bank	7,000	140			53,236	9,623		
Quereau Bank	920	28	100	3	127,382	25,838		
Grand Bank					77,554	12,033		
Gulf of St. Lawrence					59,622	11,084		
The Gully					77,131	13,930		
Labrador Coast					21,113	4,549		
West of 66° W. longitude:								
Browns Bank	4,710	64			345	65		
Cashes Bank	397,280	10,655			16,086	2,925		
Fippenies Bank	20,890	674			154	25		
Middle Bank	50	1						
Platts Bank	125,174	4,400			1,284	286		
Jeffreys Ledge	80,048	2,836			2,315	435		
South Channel	770	15	30	1	1,105	149		
Shore, general	187,735	5,541	40	1	11,061	1,874		
Total	829,002	24,431	170	5	448,965	82,910		
Grand total	2,693,522	68,672	34,425	911	3,426,227	670,570	4,730	580

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, 1926—Continued

Fishing grounds	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					17,275	$2,809		
Western Bank					8,707	865		
Quereau Bank					4,432	643		
Green Bank					485	101		
Grand Bank					243	75		
St. Peters Bank					248	77		
Cape Shore	1,950,769	$87,808	106,600	$3,200	102,067	25,085		
West of 66° W. longitude:								
Browns Bank					346,020	60,253		
Georges Bank					1,885,905	353,940		
Cashes Bank					180	2		
Clark Bank	95	14			3,025	254		
Fippenies Bank					100	10		
Middle Bank	2,610,165	104,654			19,720	1,406		
Jeffreys Ledge	1,202,816	57,170	7,600	696	15,437	1,011		
South Channel	2,330,086	70,137	16,000	640	1,678,570	114,236		
Nantucket Shoals	8,230	823			525,138	26,969		
Off Highland Light	1,566,460	73,382	28,800	1,778	2,500	99		
Off Chatham	3,991,263	171,000	19,400	1,124	283,956	11,442		
Seal Island					75	2		
South	111,850	7,255						
Shore, general	9,480,991	390,361	57,000	3,003	3,793,438	151,404		
Total	23,252,725	962,604	236,000	10,501	8,687,521	750,683		
LANDED AT GLOUCESTER								
East of 66° W. longitude:								
Off Newfoundland					240,000	14,400	315,280	$12,110
Cape Shore	19,820	595	109,400	5,470				
West of 66° W. longitude:								
Georges Bank					6,530	1,175		
Off Chatham	669,030	30,082	6,200	417				
Shore, general	9,251,928	299,168	734,460	38,536	1,003,770	40,087		
Total	9,940,778	329,845	850,060	44,423	1,250,300	55,662	315,280	12,110
LANDED AT PORTLAND								
East of 66° W. longitude:								
Western Bank					8,290	80		
Quereau Bank					1,040	21		
Cape Shore					39,087	9,409		
West of 66° W. longitude:								
Browns Bank					6,820	1,149		
Georges Bank					249,544	48,304		
Cashes Bank					12,229	275		
Fippenies Bank					2,897	82		
Middle Bank	81,947	2,204						
Platts Bank					8,506	265		
Jeffreys Ledge	241,870	8,998	11,800	236	142,335	2,884		
South Channel					20,817	292		
Off Highland Light	128,400	4,518						
Shore, general	1,477,635	42,662	11,440	494	765,828	9,749		
Total	1,929,852	58,382	23,240	730	1,257,993	72,570		
Grand total	35,123,355	1,350,831	1,109,300	55,654	11,195,814	878,915	315,280	12,110

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, 1926—Continued

Fishing grounds	Total				Grand total	
	Fresh		Salted			
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
LANDED AT BOSTON						
East of 66° W. longitude:						
La Have Bank	3, 293, 538	$159, 684			3, 293, 538	$159, 684
Western Bank	3, 209, 897	126, 341	8, 000	$333	3, 217, 897	126, 674
Quereau Bank	475, 849	85, 018			475, 849	85, 018
Green Bank	143, 630	23, 218			143, 630	23, 218
Grand Bank	132, 840	22, 411			132, 840	22, 411
St. Peters Bank	282, 444	54, 029			282, 444	54, 029
Burgeo Bank	14, 278	2, 368			14, 278	2, 368
Cape Shore	2, 719, 840	135, 442	106, 600	3, 200	2, 826, 440	138, 642
Labrador Coast	21, 511	3, 667			21, 511	3, 667
West of 66° W. longitude:						
Browns Bank	10, 949, 224	517, 722			10, 940, 224	517, 722
Georges Bank	31, 073, 820	1, 644, 375			31, 073, 820	1, 644, 375
Cashes Bank	385, 967	13, 401			385, 967	13, 401
Clark Bank	98, 131	4, 248			98, 131	4, 248
Fippenies Bank	61, 984	3, 864			61, 984	3, 864
Middle Bank	4, 190, 833	178, 222			4, 190, 833	178, 222
Jeffreys Ledge	2, 754, 056	132, 243	7, 600	696	2, 761, 656	132, 939
South Channel	67, 894, 027	2, 368, 000	28, 690	1, 117	67, 922, 717	2, 369, 117
Nantucket Shoals	10, 141, 719	304, 822			10, 141, 719	304, 822
Off Highland Light	1, 725, 378	79, 652	28, 800	1, 778	1, 754, 178	81, 430
Off Chatham	7, 867, 868	346, 701	19, 400	1, 124	7, 887, 268	347, 825
Seal Island	64, 050	2, 009			64, 050	2, 009
South	111, 850	7, 255			111, 850	7, 255
Shore, general	19, 448, 402	776, 599	57, 600	3, 063	19, 506, 002	779, 662
Total	167, 061, 136	6, 991, 291	256, 690	11, 311	167, 317, 826	7, 002, 602
LANDED AT GLOUCESTER						
East of 66° W. longitude:						
La Have Bank	1, 214, 840	21, 919	268, 645	11, 924	1, 483, 485	33, 843
Western Bank	20, 689, 378	438, 123	2, 950, 149	127, 408	23, 639, 527	565, 531
Quereau Bank	133, 120	1, 958	158, 125	7, 181	291, 245	9, 139
Green Bank	10, 615	238	3, 397	146	14, 012	384
Grand Bank	24, 225	479	144, 945	6, 115	169, 170	6, 594
St. Peters Bank	87, 225	1, 333	93, 125	4, 460	180, 350	5, 793
Burgeo Bank	2, 950	61	18, 840	891	21, 790	952
Off Newfoundland	240, 000	14, 400	315, 280	12, 110	555, 280	26, 510
Cape Shore	130, 225	2, 843	109, 400	5, 470	239, 625	8, 313
West of 66° W. longitude:						
Browns Bank	1, 541, 737	28, 519	124, 243	5, 785	1, 665, 980	34, 304
Georges Bank	4, 290, 402	89, 008	742, 130	35, 319	5, 032, 532	124, 327
South Channel	1, 735, 455	17, 749			1, 735, 455	17, 749
Nantucket Shoals	1, 528, 455	15, 270			1, 528, 455	15, 270
Off Chatham	669, 030	30, 082	6, 200	417	675, 230	30, 499
Shore, general	16, 923, 888	572, 105	744, 800	38, 898	17, 668, 688	611, 003
Total	49, 221, 545	1, 234, 087	5, 679, 279	256, 124	54, 900, 824	1, 490, 211
LANDED AT PORTLAND						
East of 66° W. longitude:						
La Have Bank	68, 427	1, 438			68, 427	1, 438
Western Bank	2, 546, 843	58, 391	122, 858	2, 740	2, 669, 701	61, 131
Quereau Bank	163, 297	27, 007	75, 945	3, 691	239, 242	30, 698
Grand Bank	77, 554	12, 033			77, 554	12, 033
Cape Shore	39, 687	9, 469			39, 687	9, 469
Gulf of St. Lawrence	59, 622	11, 084			59, 622	11, 084
The Gully	79, 831	13, 991	1, 410	62	81, 241	14, 053
Labrador Coast	21, 113	4, 549			21, 113	4, 549
West of 66° W. longitude:						
Browns Bank	124, 235	5, 580			124, 235	5, 580
Georges Bank	737, 344	57, 288			737, 344	57, 288
Cashes Bank	941, 407	32, 864	14, 625	670	956, 032	33, 534
Fippenies Bank	42, 515	1, 636			42, 515	1, 636
Middle Bank	121, 692	3, 095			121, 692	3, 095
Platts Bank	866, 966	36, 781			866, 966	36, 781
Jeffreys Ledge	2, 459, 916	89, 694	11, 800	236	2, 471, 716	89, 930
South Channel	2, 161, 234	42, 117	360	17	2, 161, 594	42, 134
Nantucket Shoals	189, 500	2, 843			189, 500	2, 843
Off Highland Light	128, 400	4, 518			128, 400	4, 518
Shore, general	5, 134, 331	153, 196	16, 661	770	5, 150, 992	153, 966
Total	15, 963, 914	567, 574	243, 659	8, 186	16, 207, 573	575, 760
Grand total	232, 246, 595	8, 792, 952	6, 179, 628	275, 621	238, 426, 223	9, 068, 573

NOTE.—The items under "Miscellaneous" include bluebacks, 7,300 pounds, value $144; butterfish, 33,499 pounds, value $4,537; flounders, 6,778,965 pounds, value $324,398; herring, fresh, 1,265,570 pounds, value $27,290; herring, salted, 315,280 pounds, value $12,110; "perch" or cunner, 35 pounds, value $1; rosefish, 65,620 pounds, value $985; salmon, 156 pounds, value $24; shad, 1,233 pounds, value $93; sharks, 23,057 pounds, value $671; skates, 20,425 pounds, value $522; sturgeon, 1,161 pounds, value $294; swordfish, 2,441,679 pounds, value $492,629; whiting, 26,280 pounds, value $774; wolf fish, 885,674 pounds, value $12,385; lobster, 8 pounds, value $2; squid, 6,295 pounds, value $80; scallops, 40 pounds, value $16; livers, 3,080 pounds, value $67; and spawn, 135,737 pounds, value $14,003.

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels, 1926

Months	Number of trips	Cod							
		Large (10 pounds and over)				Market (under 10 and over 2½ pounds)			
		Fresh		Salted		Fresh		Salted	
		Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
LANDED AT BOSTON									
January	308	2,979,695	$127,549			979,366	$33,655		
February	331	4,560,200	197,891			380,753	19,872		
March	361	5,585,665	194,058			430,322	18,258		
April	316	2,169,153	79,394			630,640	17,589		
May	303	1,960,779	61,134			639,070	14,018		
June	497	2,445,333	100,153	4,710	$122	888,944	23,933	2,020	$61
July	501	1,607,215	67,118			895,950	20,556		
August	473	2,455,607	99,981			1,012,280	22,614		
September	411	2,391,531	102,285	6,200	279	869,503	22,399		
October	405	2,511,608	107,648	1,800	54	882,688	23,676	140	3
November	375	1,922,472	114,419			998,985	27,631		
December	288	1,199,091	90,687	1,270	152	626,180	27,530	1,130	68
Total	4,569	31,788,349	1,342,317	13,980	607	9,234,681	271,730	3,290	132
LANDED AT GLOUCESTER									
January	164	161,770	9,521			12,950	807		
February	97	119,350	6,829			19,080	1,128		
March	315	2,373,755	78,605	20,995	1,089	60,180	1,584	12,215	439
April	281	1,779,925	62,114	54,255	2,737	175,170	3,327	13,100	539
May	252	5,145,685	121,846	333,277	16,386	736,850	13,002	59,940	2,345
June	186	3,717,715	87,640	480,256	22,686	877,760	14,363	149,734	5,565
July	182	4,489,710	100,922	1,437,745	66,319	279,535	4,773	253,095	8,741
August	256	4,947,525	106,546	1,089,714	49,104	254,940	4,150	123,395	4,016
September	271	2,004,502	43,254	280,270	12,072	189,015	2,880	27,803	924
October	199	618,305	17,524	76,540	3,536	146,825	2,542	5,025	184
November	228	111,330	6,008	5,860	293	48,560	932	585	23
December	234	131,370	9,569			22,135	362		
Total	2,665	25,600,942	650,378	3,778,912	174,222	2,823,000	40,850	644,892	22,776
LANDED AT PORTLAND									
January	95	40,052	2,320			34,677	1,339		
February	86	66,685	3,790			60,663	2,645		
March	94	1,072,667	22,869	1,400	71	65,288	2,228	828	33
April	159	623,330	15,370	10,195	390	58,807	1,526	5,230	167
May	137	590,986	14,672	12,680	599	35,915	710	4,515	161
June	129	328,024	14,360	2,050	91	12,630	333	335	12
July	161	323,939	14,096			15,490	324		
August	214	136,445	7,061			10,426	258		
September	84	60,859	2,487			6,585	177		
October	83	164,969	5,395	70,001	3,522	25,668	732	5,260	236
November	104	101,521	5,026			37,581	1,119		
December	125	101,442	6,863			45,920	1,589		
Total	1,401	3,622,919	114,309	96,326	4,673	409,650	12,979	16,168	609
Grand total	8,695	61,012,210	2,107,004	3,889,218	179,502	12,467,331	334,559	664,350	23,517
Grounds east of 66° West long	538	24,342,510	591,196	3,155,352	142,962	3,089,252	58,681	519,282	17,900
Grounds west of 66° West long	8,157	36,669,700	1,515,808	733,866	36,540	9,378,079	275,878	145,068	5,617
Landed at Boston in 1925	4,404	26,578,740	1,141,069	16,250	721	9,535,417	293,541		
Landed at Gloucester in 1925	2,491	19,798,595	536,900	2,262,544	108,046	3,858,685	74,093	686,548	28,265
Landed at Portland in 1925	1,509	3,602,737	112,596	126,948	5,849	523,818	15,372	32,150	1,247

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels, 1926—Continued

Months	Cod—Continued				Haddock			
	Scrod (1 to 2½ pounds)				Large (over 2½ pounds)			
	Fresh		Salted		Fresh		Salted	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
LANDED AT BOSTON								
January	12, 260	$229			5, 623, 418	$298, 289		
February	2, 970	105			6, 860, 457	427, 854		
March	8, 220	292			8, 771, 485	390, 271		
April	3, 190	41			6, 894, 610	204, 985		
May	420	4			4, 473, 825	110, 156		
June					5, 127, 070	106, 635		
July	800	10			3, 464, 438	82, 205		
August	750	8			4, 740, 695	92, 977		
September	6, 790	83			5, 361, 335	129, 151		
October	4, 840	60			6, 616, 235	190, 491		
November	6, 850	75			7, 229, 305	212, 931		
December	14, 085	243			6, 292, 110	345, 935		
Total	61, 175	1, 150			71, 464, 983	2, 591, 880		
LANDED AT GLOUCESTER								
February					5, 340	376		
March					448, 595	7, 688		
April	260	3			806, 365	17, 800		
May	6, 200	62			1, 362, 782	21, 120	835	$21
June			2, 155	$53	1, 092, 143	11, 152	360	7
July			5, 645	162	33, 250	336		
August			255	6	493, 680	4, 925	1, 200	24
September	265	3			561, 230	5, 809		
October					443, 685	5, 079		
November	310	3			161, 830	2, 519		
December					27, 890	449		
Total	7, 035	71	8, 055	221	5, 436, 790	77, 253	2, 395	52
LANDED AT PORTLAND								
January	8, 835	177			224, 152	14, 174		
February	11, 985	187			175, 013	12, 864		
March	11, 013	145			880, 777	20, 972	74, 085	1, 473
April	8, 248	90	11, 890	191	1, 187, 812	24, 156		
May	3, 530	26	7, 765	155	1, 705, 211	29, 313		
June	1, 480	9			83, 076	2, 580		
July	1, 160	7			121, 733	4, 159		
August	1, 825	12			174, 150	5, 823		
September	3, 115	18			141, 627	5, 665		
October	8, 241	48	496	16	395, 915	12, 562	45	1
November	13, 905	89			395, 534	13, 869		
December	15, 841	285			355, 842	21, 985		
Total	89, 178	1, 093	20, 151	362	5, 840, 842	168, 122	74, 130	1, 474
Grand total	157, 388	2, 314	28, 206	583	82, 732, 615	2, 837, 255	76, 525	1, 526
Grounds east of 66° West long	16, 095	164	27, 850	569	3, 406, 348	76, 818	76, 295	1, 521
Grounds west of 66° West long	141, 293	2, 150	356	14	79, 326, 267	2, 760, 437	230	5
Landed at Boston in 1925	84, 620	1, 443			61, 388, 177	2, 098, 724		
Landed at Gloucester in 1925	13, 210	142	9, 179	296	8, 522, 510	136, 652	24, 090	601
Landed at Portland in 1925	101, 195	1, 163	19, 494	495	7, 379, 198	212, 361	385	10

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels, 1926—Continued

Months	Haddock—Continued				Hake			
	Scrod (1 to 1½ pounds)				Large (6 pounds and over)			
	Fresh		Salted		Fresh		Salted	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
LANDED AT BOSTON								
January	983,678	$35,672			83,165	$5,559		
February	568,030	28,017			68,720	4,971		
March	854,245	32,705			32,660	2,947		
April	901,280	17,303			30,900	2,080		
May	664,825	8,546			41,065	2,125		
June	524,820	5,860			142,490	5,270	3,120	$65
July	811,615	7,947			519,555	8,167		
August	779,800	6,535			383,540	7,378		
September	864,510	13,923			691,375	13,733		
October	1,320,915	21,293			930,145	15,498	300	6
November	1,330,590	25,932			810,024	13,911		
December	803,585	32,676			522,708	20,805		
Total	10,407,893	236,409			4,256,347	102,444	3,420	71
LANDED AT GLOUCESTER								
March	66,895	1,209						
April	25,700	320			435	4		
May	94,305	759			3,660	37	2,190	44
June	218,045	1,636			5,340	54	1,340	27
July	9,400	71			4,635	47	2,065	41
August	88,775	667			60,730	677	6,960	140
September	66,435	413			61,880	1,101	4,510	99
October	140,470	1,054			17,745	233		
November	485	5			19,780	323		
December					600	6		
Total	710,510	6,194			174,805	2,482	17,065	351
LANDED AT PORTLAND								
January	9,998	201						
February	11,885	257			1,410	85		
March	6,112	126	800	$16	160	11		
April	5,482	57						
May	4,420	37			5,405	121		
June	5,910	42			1,125	32		
July	8,036	45						
August	12,615	89						
September	12,540	92			1,900	57	1,500	45
October	20,821	127			3,840	85		
November	17,307	162			1,055	51		
December	17,265	289						
Total	132,391	1,524	800	16	14,895	442	1,500	45
Grand total	11,250,794	244,127	800	16	4,446,047	105,368	21,985	467
Grounds east of 66° West long	41,975	875	800	16	111,140	2,169	16,480	358
Grounds west of 66° West long	11,208,819	243,452			4,334,907	103,199	5,505	109
Landed at Boston in 1925	12,893,075	279,686			1,702,913	70,252		
Landed at Gloucester in 1925	1,034,835	10,506			303,815	4,832	15,880	366
Landed at Portland in 1925	643,220	9,180	770	21	16,650	518		

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels, 1926—Continued

Months	Hake—Continued				Pollock			
	Small (under 6 pounds)							
	Fresh		Salted		Fresh		Salted	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
LANDED AT BOSTON								
January	79,770	$5,689			350,905	$11,946		
February	106,275	7,591			158,060	8,863		
March	48,677	4,551			117,629	5,905		
April	17,945	1,135			104,290	6,039		
May	22,935	925			73,450	2,354		
June	27,150	945			158,072	4,061		
July	69,950	1,529			133,940	3,184		
August					293,268	7,220		
September					285,796	7,284		
October					418,755	7,737		
November	35,865	385			520,338	8,290		
December	5,360	192			489,220	12,890		
Total	413,927	22,942			3,103,723	85,773		
LANDED AT GLOUCESTER								
January					170,630	6,725		
February					5,905	473		
March					6,355	64		
April					13,860	138	185	$4
May					39,535	395	875	18
June					29,225	319	3,705	74
July					21,425	289	5,575	104
August					22,795	237	5,565	111
September					99,440	1,946	6,900	155
October					405,320	5,094	830	17
November					943,020	11,397		
December					1,077,905	26,733		
Total					2,835,415	63,810	23,635	483
LANDED AT PORTLAND								
January	36,700	1,891			13,782	376		
February	23,653	1,147			18,307	618		
March	17,392	677			24,770	515	1,859	46
April	13,069	386			9,574	288	4,570	115
May	49,803	1,354			32,307	786	3,775	89
June	14,743	334			117,624	2,157		
July	31,385	529			169,500	2,491		
August	30,650	518			85,755	1,327		
September	50,700	1,131			45,195	684		
October	68,270	1,714	470	$9	54,543	836	500	18
November	186,738	3,941			125,775	1,764		
December	99,087	3,834			68,905	1,514		
Total	622,190	17,456	470	9	766,037	13,356	10,704	263
Grand total	1,036,117	40,398	470	9	6,705,175	152,939	34,339	746
Grounds east of 66° West long	5,950	126	470	9	258,510	3,842	26,200	580
Grounds west of 66° West long	1,030,167	40,272			6,446,665	149,097	8,139	166
Landed at Boston in 1925	2,943,428	75,633			2,759,539	91,363		
Landed at Gloucester in 1925					1,790,499	42,115	32,292	809
Landed at Portland in 1925	822,069	22,043	965	22	692,523	12,951	15,020	344

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels, 1926—Continued

Months	Cusk				Halibut			
	Fresh		Salted		Fresh		Salted	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
LANDED AT BOSTON								
January	177,040	$5,804			19,362	$8,052		
February	131,995	6,412			47,148	14,151		
March	147,105	5,354			129,140	27,794		
April	134,060	3,320			178,715	41,943		
May	81,930	1,582			542,669	92,945		
June	50,040	1,225			568,600	113,473		
July	19,330	433			271,951	51,792		
August	94,155	1,599			533,059	93,811		
September	58,935	1,253			359,819	72,477		
October	77,925	1,612			237,874	46,275		
November	269,865	4,632			68,506	17,270		
December	190,030	5,425			10,559	4,719		
Total	1,432,410	38,667			2,967,402	584,702		
LANDED AT GLOUCESTER								
February					9,860	2,958		
April	19,450	220						
May	23,795	286	50	$1				
June	1,255	19	5,710	123			2,695	$368
July	116,330	1,676	6,715	199			1,700	100
August	126,085	1,813	19,525	526			335	32
September	40,010	551	2,055	52				
October	91,780	840	200	5				
November	13,405	170						
Total	432,110	5,584	34,255	906	9,860	2,958	4,730	580
LANDED AT PORTLAND								
January	62,717	2,338			753	160		
February	136,825	5,350			1,357	355		
March	243,640	7,089	30	$1	4,320	649		
April	129,683	3,928			28,136	5,499		
May	143,959	2,287			84,786	14,400		
June	13,941	314			41,389	7,282		
July	2,322	59			84,063	15,724		
August	818	23			81,247	13,455		
September	7,539	192			44,892	9,375		
October	15,254	387	140	4	56,620	11,427		
November	24,779	595			20,513	4,337		
December	47,525	1,809			889	187		
Total	829,002	24,431	170	5	448,965	82,910		
Grand total	2,693,522	68,672	34,425	911	3,426,227	670,570	4,730	580
Grounds east of 66° West long	319,835	4,512	17,980	456	1,898,101	351,283	4,730	580
Grounds west of 66° West long	2,373,687	64,160	16,445	455	1,528,126	319,287		
Land at Boston in 1925	1,899,147	47,184			2,837,875	535,435		
Landed at Gloucester in 1925	646,485	9,098	82,830	1,714	103,428	10,897	7,580	434
Landed at Portland in 1925	1,060,388	26,301	24,000	300	612,159	108,404	60	2

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels, 1926—Continued

Months	Mackerel				Miscellaneous[1]			
	Fresh		Salted		Fresh		Salted	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
LANDED AT BOSTON								
January					704,052	$38,026		
February					560,277	35,064		
March					850,908	48,023		
April	12,350	$2,118			710,147	27,023		
May	1,109,775	65,443			650,655	14,103		
June	4,711,618	216,766	107,400	$3,248	851,350	68,470		
July	6,196,953	189,413	42,600	2,049	1,417,683	220,860		
August	4,874,776	130,132	38,800	2,502	876,519	149,757		
September	3,302,820	164,542	45,800	2,613	459,068	46,239		
October	1,745,138	107,995	1,400	89	342,510	22,479		
November	1,293,545	85,234			601,130	37,078		
December	5,750	961			663,222	43,562		
Total	23,252,725	962,604	236,000	10,501	8,687,521	750,683		
LANDED AT GLOUCESTER								
January					480,710	27,692		
February					176,560	9,682		
March					110,840	4,499		
April					2,560	86		
May	19,460	1,260			3,230	65		
June	442,290	18,917	109,400	5,470	27,600	414		
July	2,451,740	53,861	330,800	16,382				
August	3,454,040	76,704	323,380	17,424	41,730	1,593		
September	1,776,320	53,291	80,280	4,730	105,200	1,315		
October	855,073	49,250	6,200	417	25,190	830		
November	926,815	73,593			58,830	1,239		
December	15,040	2,969			217,850	8,247	315,280	$12,110
Total	9,940,778	329,845	850,060	44,423	1,250,300	55,662	315,280	12,110
LANDED AT PORTLAND								
January					7,897	268		
February					18,972	579		
March					34,320	601		
April					15,426	219		
May	2,625	197			9,597	111		
June	37,686	3,407	310	25	97,560	1,536		
July	235,347	7,920			237,608	29,881		
August	1,385,307	33,599	11,130	469	245,397	23,111		
September	244,580	10,923	11,800	236	131,451	10,920		
October	24,307	2,336			343,473	3,817		
November					83,138	570		
December					33,154	957		
Total	1,929,852	58,382	23,240	730	1,257,993	72,570		
Grand total	35,123,355	1,350,831	1,109,300	55,654	11,195,814	878,915	315,280	12,110
Grounds east of 66° West long.	1,970,589	88,403	216,000	8,670	422,474	53,625	315,280	12,110
Grounds west of 66° West long.	33,152,766	1,262,428	893,300	46,984	10,773,340	825,290		
Landed at Boston in 1925	18,087,423	836,833	299,200	22,139	8,012,694	610,256		
Landed at Gloucester in 1925	5,236,537	172,822	1,789,943	132,373	852,122	35,354	2,400,336	84,265
Landed at Portland in 1925	790,757	26,516	6,000	469	1,888,318	64,548		

[1] Includes herring from Newfoundland, 240,000 pounds fresh, value $14,400, and 315,280 pounds salted, value $12,110.

Statement, by months, of quantities and values of certain fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by American fishing vessels, 1926—Continued

Months	Total				Grand total	
	Fresh		Salted			
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
LANDED AT BOSTON						
January	11,992,711	$570,469			11,992,711	$570,469
February	13,444,885	750,791			13,444,885	750,791
March	16,976,056	730,158			16,976,056	730,158
April	11,787,280	402,976			11,787,280	402,976
May	10,261,398	373,335			10,261,398	373,335
June	15,495,487	646,791	117,250	$3,496	15,612,737	650,287
July	15,409,380	653,213	42,600	2,049	15,451,980	655,262
August	16,044,449	612,012	38,800	2,502	16,083,249	614,514
September	14,651,482	573,369	52,000	2,892	14,703,482	576,261
October	15,088,633	544,764	3,640	152	15,092,273	544,916
November	15,087,475	547,788			15,087,475	547,788
December	10,821,900	585,625	2,400	220	10,824,300	585,845
Total	167,061,136	6,991,291	256,690	11,311	167,317,826	7,002,602
LANDED AT GLOUCESTER						
January	826,060	44,745			826,060	44,745
February	336,095	21,446			336,095	21,446
March	3,066,620	93,709	33,210	1,528	3,099,830	95,237
April	2,823,725	84,012	67,540	3,280	2,891,265	87,292
May	7,435,502	158,832	397,167	18,815	7,832,669	177,647
June	6,411,373	134,514	755,355	34,363	7,166,728	168,877
July	7,406,025	161,975	2,043,340	92,138	9,449,365	254,113
August	9,490,300	197,312	1,570,329	71,383	11,060,629	268,695
September	4,904,297	110,563	401,818	18,032	5,306,115	128,595
October	2,744,393	82,455	88,795	4,159	2,833,188	86,614
November	2,284,365	96,189	6,445	316	2,290,810	96,505
December	1,492,790	48,335	315,280	12,110	1,808,070	60,445
Total	49,221,545	1,234,087	5,679,279	256,124	54,900,824	1,490,211
LANDED AT PORTLAND						
January	445,563	23,244			445,503	23,244
February	526,755	27,877			526,755	27,877
March	2,360,459	55,882	79,002	1,640	2,439,461	57,522
April	2,079,567	51,518	31,885	863	2,111,452	52,381
May	2,674,544	64,074	28,735	1,004	2,703,279	65,078
June	755,188	32,386	2,695	128	757,883	32,514
July	1,230,583	75,235			1,230,583	75,235
August	2,164,635	85,276	11,130	469	2,175,765	85,745
September	749,083	41,664	11,800	236	760,883	41,900
October	1,179,981	39,438	78,412	3,846	1,258,393	43,284
November	1,010,631	31,557			1,010,631	31,557
December	786,925	39,423			786,925	39,423
Total	15,963,914	567,574	243,659	8,186	16,207,573	575,760
Grand total	232,246,595	8,792,952	6,179,628	275,621	238,426,223	9,068,573
Grounds east of 66° West long	35,882,779	1,231,404	4,376,719	185,731	40,259,498	1,417,225
Grounds west of 66° West long	196,363,816	7,561,458	1,802,909	89,890	198,166,725	7,651,348
Landed at Boston in 1925	148,723,048	6,081,418	315,450	22,860	149,038,498	6,104,278
Landed at Gloucester in 1925	42,160,721	1,033,411	7,311,222	357,169	49,471,943	1,390,580
Landed at Portland in 1925	18,133,032	611,953	225,792	8,759	18,358,824	620,712

The fishery products landed at Boston and Gloucester, Mass., and Portland, Me., by fishing vessels each year are taken chiefly from fishing grounds off the coast of the United States. In the calendar year 1926, 83.09 per cent of the quantity and 84.35 per cent of the value were from these grounds; 0.69 per cent of the quantity and 1.79 per cent of the value, consisting principally of cod, halibut, and herring, were from fishing banks off the coast of Newfoundland; and 16.23 per cent of the quantity and 13.86 per cent of the value were from fishing grounds off the Canadian Provinces. Compared with the previous year there was a small decrease in the percentage of products from grounds off the coast of the United States, but a slight increase in the percentage of value; a decrease in the percentage of both quantity and value from grounds off Newfoundland; and an increase in the percentage of quantity, with a decrease in the percentage of value, from grounds off the Canadian Provinces. Newfoundland herring constituted less than 0.5 per cent of the quantity and value of the fishery products landed at these ports by fishing vessels during the year. The herring were taken from the treaty coast of Newfoundland, and the cod, 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 coasts of the Canadian Provinces were from offshore fishing grounds. The catch from each of these regions is shown in the following table:

Quantity and value of fish landed by American fishing vessels at Boston and Gloucester, Mass., and Portland, Me., in 1926, from fishing grounds off the coasts specified

Species	United States		Newfoundland		Canadian Provinces		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Cod:								
Fresh	46, 173, 152	$1, 793, 055	123, 590	$2, 161	27, 340, 187	$648, 661	73, 636, 929	$2, 443, 877
Salted	879, 290	42, 171	252, 452	11, 282	3, 450, 032	150, 149	4, 581, 774	203, 602
Haddock:								
Fresh	90, 492, 286	3, 002, 791			3, 491, 123	78, 591	93, 983, 409	3, 081, 382
Salted	230	5			77, 095	1, 537	77, 325	1, 542
Hake:								
Fresh	5, 362, 299	143, 429	2, 180	23	117, 685	2, 314	5, 482, 164	145, 766
Salted	5, 505	109	4, 070	81	12, 880	286	22, 455	476
Pollock:								
Fresh	6, 446, 565	149, 096	1, 655	18	256, 955	3, 825	6, 705, 175	152, 939
Salted	8, 139	166	80	2	26, 120	578	34, 339	746
Cusk:								
Fresh	2, 371, 737	64, 140	1, 090	14	320, 695	4, 518	2, 693, 522	68, 672
Salted	16, 445	455	2, 005	57	15, 975	399	34, 425	911
Halibut:								
Fresh	1, 527, 696	319, 222	688, 894	121, 017	1, 209, 637	229, 431	3, 426, 227	670, 570
Salted			1, 700	190	3, 030	390	4, 730	580
Mackerel:								
Fresh	33, 152, 766	1, 262, 428			1, 970, 589	88, 403	35, 123, 355	1, 350, 831
Salted	893, 300	46, 984			216, 000	8, 670	1, 109, 300	55, 654
Herring:								
Fresh	1, 025, 570	12, 890	240, 000	14, 400			1, 265, 570	27, 290
Salted			315, 280	12, 110			315, 280	12, 110
Swordfish, fresh	2, 280, 604	453, 850	976	253	160, 099	38, 526	2, 441, 679	492, 629
Miscellaneous, fresh	7, 467, 091	358, 548			21, 474	448	7, 488, 565	358, 996
Total	198, 102, 675	7, 649, 339	1, 633, 972	162, 508	38, 689, 576	1, 256, 726	238, 426, 223	9, 068, 573

SPECIES

Cod.—In 1926 there were 6 vessels in the salt-bank fishery, or 3 more than in the previous year, and 105 in the market fishery, or 5 more than in the previous year. These vessels landed their fares of cod, haddock, and other ground fish at these ports during the year, and large quantities were landed by vessels fishing on the shore grounds. The catch of cod landed at these ports during the year was 78,218,703 pounds, valued at $2,647,479, of which 73,636,929 pounds, valued at $2,443,877, were fresh and 4,581,774 pounds, valued at $203,602, were salted. Cod ranked second in both quantity and value among the various species.

Haddock. Haddock ranked first in both quantity and value, the catch exceeding that of cod by 15,842,031 pounds and $435,445 in value. The quantity of haddock landed at these ports by fishing vessels during the year amounted to 94,060,734 pounds, valued at $3,082,924, all fresh except 77,325 pounds, valued at $1,542, salted. These fish were taken chiefly from Browns Bank, Georges Bank, South Channel, Nantucket Shoals, and the shore grounds, and about 56 per cent of the quantity and 53 per cent of the value were taken in the otter-trawl fishery. South Channel, from which the largest quantity of haddock was taken, produced 53,220,878 pounds, valued at $1,688,717. The greater part of the catch, or 81,862,876 pounds, valued at $2,828,289, was landed at Boston.

Hake.—The catch of hake amounted to 5,504,619 pounds, valued at $146,242, all landed fresh except 22,455 pounds, valued at $476, salted. Of this catch, 4;673,694 pounds, valued at $125,457, were landed at Boston; 191,870 pounds, valued at $2,833, at Gloucester; and 639,055 pounds, valued at $17,952, at Portland. More than half the catch, or 3,586,819 pounds, valued at $87,385, was taken in South Channel.

Pollock.—The catch of pollock amounted to 6,739,514 pounds, valued at $153,685, all landed fresh except 34,339 pounds, valued at $476, salted. The greater part of the catch was taken from Georges Bank, South Channel, and shore grounds and was landed chiefly at Boston and Gloucester.

Cusk.—The catch of cusk was 2,727,947 pounds, valued at $69,583, all landed fresh except 34,425 pounds, valued at $911, salted. The greater part of the catch was landed at Boston. Compared with the previous year there was a decrease in the catch of this species of 984,903 pounds and of $15,014 in the value.

Halibut.—The catch of halibut amounted to 3,430,957 pounds, valued at $671,150, all landed fresh except 4,730 pounds, valued at $580, salted. Compared with the previous year there was a decrease in the catch landed of 3.65 per cent in quantity and an increase of 2.44 per cent in value. The quantity landed at Boston was 2,967,402 pounds, valued at $584,702; at Gloucester, 14,590 pounds, valued at $3,538; and at Portland, 448,965 pounds, valued at $82,910.

Mackerel.—The total catch of fresh mackerel taken by the American fishing fleet in 1926 was 304,490 barrels, or 45,673,500 pounds, compared with 203,961 barrels, or 30,594,150 pounds, in 1925, an increase of 100,529 barrels, or 15,079,350 pounds. The total catch of salted mackerel landed by the fishing fleet was 5,380 barrels, or 1,076,000 pounds; compared with 12,442 barrels, or 2,488,400 pounds, in 1925, this is a decrease of 7,062 barrels, or 1,412,400 pounds. In 1926 about 16,000 barrels of salted mackerel were prepared from mackerel landed fresh, as compared with about 20,000 barrels in 1925. The quantity of mackerel landed at Boston, Gloucester, and Portland by fishing vessels during the year was 36,232,655 pounds, valued at $1,406,485, of which 35,123,355 pounds, valued at $1,350,831, were fresh and 1,109,300 pounds, valued at $55,654, were salted. There was an increase in the total catch of mackerel landed by fishing vessels at these ports of 10,022,795 pounds and of $215,333 in value, as compared with 1925.

In 1926 the catch of mackerel up to July 1 was 93,798 barrels fresh and 1,352 barrels salted, compared with 46,934 barrels fresh and 1,075 barrels salted for the same period in 1925. The southern mackerel seiners had a very successful season, but the netters had very poor success, which was largely due to the fact that the prices were low most of the time. The seining fleet numbered about 50 vessels, compared with 33 vessels the previous year. The increase consisted largely of small vessels. The netting fleet also numbered about 50 vessels. The first seiners arrived at Cape May on April 11, which was Sunday. The next day (Monday) there were 11 vessels having 142,000 pounds of fresh mackerel. These fish weighed from 1 to 2¼ pounds each, but mostly from 1¼ to 1½ pounds each. They were caught 85 miles southeast of Cape May and were shipped to New York and Boston, where they were sold at 22 to 25 cents per pound.

The first netters arrived at Cape May and New York on April 28. stormy weather prevailed soon after the first catches were made, and a large number of vessels lost seines and seine boats and had to take time to replace them. The first arrivals last year were at Cape May on April 13, when five vessels arrived with a total of 87,000 pounds of mackerel, weighing about 1 pound each, which were sold at 23 to 25 cents per pound. This year the first arrival at Boston, direct from the south, was on May 10, consisting of 70,000 pounds of large and medium fresh mackerel caught off Barnegat, N. J., which were sold at 5½ cents per pound. The first arrival in the previous season was on May 6, consisting of 3,000 pounds of large and medium-sized fresh mackerel caught 60 miles southeast of Atlantic City, which sold at 19 cents per pound.

The first mackerel taken in New England waters this year were three fish caught in a trap net at Seaconnet, in the vicinity of Newport, R. I., on April 28, two days earlier than the first taken the previous year. The traps at Rockport, Mass., contained eight mackerel on May 20—the first of the season in that locality. Nine mackerel were taken in a trap net at Yarmouth, Nova Scotia, on May 19, the first of the season on that shore. The first taken last year in that locality consisted of 53 fish on May 20.

The Cape Shore fleet numbered about 48 vessels. The first arrival was on June 2, five days later than the first arrival last year, and consisted of 25,000 pounds of large and medium mackerel caught off Halifax, Nova Scotia, which were sold at 13 cents per pound. It was reported that the weather had been bad and that the mackerel were in small schools.

The Cape Shore catch of mackerel for the past five years, shown in pounds, was as follows:

Year	Trips	Fresh	Salted
1926	54	2,397,700	270,400
1925	84	1,545,000	215,000
1924	24	996,000	170,800
1923	31	1,240,680	42,200
1922	37	1,353,900	468,800

Swordfish.—The catch of swordfish amounted to 2,441,679 pounds, valued at $492,629, all sold fresh. There were 40 vessels engaged in this fishery, or 1 less than in the previous year. There was an increase in the catch, as compared with the previous year, of 63.16 per cent in quantity and 27.65 per cent in value.

Flounders.—The catch of flounders taken in the vessel fisheries amounted to 6,778,965 pounds, valued at $324,398, an increase over the previous year of 140,993 pounds, or 2.12 per cent, in quantity and of $48,611, or 17.63 per cent, in value. The catch taken by boats under 5 tons net tonnage is not included in these statistics.

Herring.—The catch of herring amounted to 1,580,850 pounds, valued at $39,400. Of this quantity 1,025,570 pounds, valued at $12,890, were taken off the coast of the United States and were landed fresh. The remainder, consisting of 240,000 pounds fresh, valued at $14,400, and 315,280 pounds salted, valued at $12,110, were Newfoundland herring.

OTTER-TRAWL FISHERY

In 1926 there were 667 trips landed at Boston, Gloucester, and Portland by 30 otter-trawl vessels, amounting to 61,175,851 pounds of fish having a value, as landed, of $2,004,333, or 25.66 per cent of the quantity and 22.13 per cent of the value of the total catch landed by fishing vessels at these ports during the year. In making these trips, including the date of departure and date of arrival, the vessels were absent from port 5,336 days. The catch included cod, 5,203,911 pounds, valued at $190,296; haddock, 52,405,653 pounds, valued at $1,619,326; hake, 894,885 pounds, valued at $34,607; pollock, 1,099,741 pounds, valued at $37,572; cusk, 23,997 pounds, valued at $1,685; halibut, 68,144 pounds, valued at $17,953; and other species 1,479,520 pounds, valued at $102,894. In these statistics the small quantities of salted fish landed (such as cod, haddock, hake, pollock, and cusk) have been reduced to the basis of weights of fresh fish. Otter trawls catch chiefly haddock, and in 1926 their catch amounted to 55.71 per cent of the quantity and 52.53 per cent of the value of the entire catch of this species landed by fishing vessels at these ports. The otter-trawl catch was taken from Western Bank, Georges Bank, South Channel, Nantucket Shoals, off Highland Light, and off Chatham. Over 73 per cent of the quantity and nearly 79 per cent of the value were from South Channel. Compared with 1925, there was an increase of one vessel and 60 trips in the otter-trawl fishery. There was also an increase of 6,569,933 pounds, or 12.03 per cent, in the quantity and $321,565, or 19.11 per cent, in the value of the fish landed.

The following tables give the catch landed by steam otter trawlers at these ports in 1926, by fishing grounds and by months, 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 1926

[Salt fish have been reduced to the basis of weights of fresh fish]

Item	Trips	Days absent	Cod		Haddock		Hake		Pollock	
BY FISHING GROUNDS										
East of 66° W. longitude:			*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Western Bank	23	279	1,974,635	$40,694	1,479,010	$30,226	880	$49	42,214	$840
West of 66° W. longitude:										
Georges Bank	28	242	330,040	13,367	2,281,010	57,755	7,735	382	15,395	712
South Channel	515	4,034	2,691,321	126,511	39,257,448	1,286,866	770,980	30,039	983,247	33,603
Nantucket Shoals	86	663	132,150	5,204	8,323,200	189,532	104,210	3,285	39,285	1,086
Off Highland Light	1	6	1,600	55	96,400	2,757	1,300	62	500	16
Off Chatham	14	112	74,165	4,465	968,585	52,190	9,780	790	19,100	1,315
Total	667	5,336	5,203,911	190,296	52,405,653	1,619,326	894,885	34,607	1,099,741	37,572
BY MONTHS										
January	61	544	505,295	23,810	3,828,015	176,580	90,735	7,103	224,815	7,811
February	59	493	400,920	21,237	4,186,560	247,131	42,665	3,554	94,565	6,188
March	83	687	1,567,365	44,553	6,630,705	267,151	37,177	3,522	91,504	4,588
April	56	418	690,072	19,389	5,074,020	124,998	19,575	1,447	51,778	3,636
May	52	495	691,874	14,610	5,385,175	92,598	11,045	492	42,209	1,104
June	51	374	119,048	4,214	4,000,920	60,851	65,223	2,576	6,580	237
July	29	195	109,815	3,077	2,401,188	43,071	102,650	1,637	8,820	269
August	37	252	43,630	1,159	3,180,690	43,289	55,115	993	1,195	33
September	33	227	98,645	4,611	2,915,230	61,030	36,655	770	11,575	401
October	56	446	288,837	11,302	4,774,395	111,000	51,800	768	20,800	422
November	71	559	370,345	17,732	5,297,415	139,839	126,080	2,431	170,275	2,762
December	79	646	318,065	24,602	4,731,340	251,788	256,165	9,314	375,625	10,121
Total	667	5,336	5,203,911	190,296	52,405,653	1,619,326	894,885	34,607	1,099,741	37,572

Item	Cusk		Halibut		Miscellaneous		Total	
BY FISHING GROUNDS								
East of 66° W. latitude:	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Western Bnak	-------	------	9,811	$1,397	13,030	$132	3,519,580	$73,338
West of 66° W. longitude:								
Georges Bank	775	$178	3,023	805	41,520	3,580	2,679,498	76,779
South Channel	22,532	1,469	51,275	14,614	1,233,149	88,303	45,009,952	1,581,405
Nantucket Shoals	265	7	2,906	809	145,540	7,841	8,747,556	207,764
Off Highland Light	-------	------	172	14	2,300	69	102,272	2,973
Off Chatham	425	31	957	314	43,981	2,969	1,116,993	62,074
Total	23,997	1,685	68,144	17,953	1,479,520	102,894	61,175,851	2,004,333
BY MONTHS								
January	6,175	828	4,233	1,577	193,213	16,949	4,852,481	234,658
February	6,600	467	6,633	2,032	154,997	11,056	4,892,940	291,665
March	6,657	249	9,915	2,129	180,883	12,043	8,524,206	334,235
April	1,655	52	7,801	1,566	81,188	4,875	5,926,089	155,963
May	90	2	10,069	1,722	88,010	1,816	6,228,472	112,344
June	-------	------	2,805	493	114,739	3,368	4,309,315	71,739
July	-------	------	3,425	723	88,721	3,406	2,714,619	52,183
August	-------	------	1,003	230	35,400	2,296	3,317,033	48,000
September	-------	------	3,030	788	21,835	1,839	3,080,970	69,430
October	-------	------	3,398	967	68,090	6,352	5,207,320	130,811
November	720	16	12,697	4,279	227,787	18,020	6,205,319	185,085
December	2,100	71	3,135	1,447	224,657	20,868	5,911,087	318,211
Total	23,997	1,685	68,144	17,953	1,479,520	102,894	61,175,851	2,004,333

Cod, haddock, and hake landed at Boston and Glouchester, Mass., and Portland, Me., by otter trawlers in various years

Year	Trips	Cod	Haddock	Hake	Year	Trips	Cod	Haddock	Hake
		Pounds	*Pounds*	*Pounds*			*Pounds*	*Pounds*	*Pounds*
1908	44	209,800	1,542,000	46,600	1920	646	6,311,389	51,962,457	--------
1909	47	159,800	1,719,000	74,400	1921	346	2,482,833	26,734,803	241,650
1910	59	125,850	2,775,000	46,600	1922	578	11,161,947	35,878,524	576,370
1911	178	564,500	7,367,100	151,700	1923	665	14,961,590	35,527,297	471,600
1912	295	1,952,950	12,966,700	105,500	1924	543	8,231,430	35,197,940	616,853
1913	326	1,667,806	12,488,992	209,485	1925	607	7,309,930	44,034,281	711,212
1914	387	1,149,595	15,383,550	259,913	1926	667	5,203,911	52,405,653	894,885

DAYS' ABSENCE

Statistics of the number of days' absence of vessels on fishing trips from Boston and Gloucester, Mass., and Portland, Me., have been collected for 1926. The days absent on each trip were reckoned to include the date of departure and date of arrival. The number of days occupied in fishing by all vessels was 44,236, or an average of 5.09 days per trip. The number of days occupied in fishing by otter trawlers was 5,336, or an average of 8 days per trip. The number of days occupied in fishing and the average number of days per trip by all vessels and also by otter trawlers, separately, differ but little from the previous year. Statistics of the number of days absent from port during the year are presented by months, fishing grounds, and ports for all vessels, including otter trawlers, and for otter trawlers separately, in the following tables:

Days' absence from port of fishing vessels landing fish at Boston and Gloucester, Mass., and Portland, Me., 1926

Fishing grounds	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
BOSTON													
East of 66° W. longitude:													
La Have Bank	147		8	67	87	16	19	123	117	91	173	116	964
Western Bank	34		14	28	377	308	118	280	95	46	21		1,321
Quereau Bank		20	22	28	24	61	25	71	38	43			332
Green Bank					16		23	6	23				68
Grand Bank					29	22	31		16				98
St. Peters Bank			75	27	15	38	11		22	19			207
Burgeo Bank						32							32
Cape Shore	28					843		57	147	20	61	52	1,208
Labrador coast								23					23
West of 66° W. longitude:													
Browns Bank	358	28	52	347	124		90	504	262	111	104	559	2,539
Georges Bank	408	740	1,285	530	457	763	1,306	881	338	298	282	52	7,370
Cashes Bank	8			14	30	15			9		8		84
Clark Bank	8										12		20
Fippenies Bank												19	19
Middle Bank	54	66	63	35			44	135	73	64	51	80	665
Jeffreys Ledge	148	49		7			2	69	18	72	78	90	533
South Channel	453	577	581	380	228	431	704	528	600	1,094	881	659	7,116
Nantucket Shoals	16				163	200	82	222	90	151	275	238	1,437
Off Highland Light						11		11	45	7	83	13	170
Off Chatham	50	105	63	200	70	23	185	23	145	163	66	39	1,131
South				5	10								15
Seal Island											8		8
Shore, general	369	395	564	449	573	827	404	251	258	175	197	174	4,636
Total	2,073	1,980	2,727	2,155	2,203	3,590	3,044	3,184	2,296	2,354	2,299	2,001	29,996
GLOUCESTER													
East of 66° W. longitude:													
La Have Bank				76	74		19	195	108	88	45		605
Western Bank		24		36	566	496	724	605	205	42	23		2,721
Quereau Bank				60	27	99			46	76			308
Green Bank					37								37
Grand Bank					32	28	131	60	32				283
St. Peters Bank			52	26	33		29		23	20			183
Burgeo Bank						60							60
Off Newfoundland	26											75	101
Cape Shore					14	301						26	341
West of 66° W. longitude:													
Browns Bank				141	81			39	138	76	14	11	500
Georges Bank			240	273	254	281	148	140	73	84	8		1,501
South Channel				15	10	76		16	35	37			189
Nantucket Shoals					53	46	8	31					138
Off Chatham						23			4	119			146
Shore, general	227	159	335	250	206	221	420	576	487	195	366	327	3,769
Total	253	183	627	877	1,387	1,631	1,479	1,662	1,151	737	456	439	10,882

Days' absence from port of fishing vessels landing fish at Boston and Gloucester, Mass., and Portland, Me., 1926—Continued

Fishing grounds	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
PORTLAND													
East of 66° W. longitude:													
La Have Bank				9	8								17
Western Bank			61	37	67	26	21	22		12			246
Quereau Bank				28				22	27	25	22		124
Green Bank								43					43
Grand Bank							30						30
Cape Shore									127				127
Gulf of St. Lawrence						28	24						52
The Gully				30	32								62
Labrador coast									23				23
West of 66° W. longitude:													
Browns Bank		6						15				16	37
Georges Bank				9	16		152	145					322
Cashes Bank	12	43	48	42	60	6	4		7	9	2		233
Fippenies Bank		5		4									9
Middle Bank				7			4	2					13
Platts Bank	18	17	20	12					4		56	76	203
Jeffreys Ledge	37	25	9	8	12	4	62	44	82	66	70	83	502
South Channel			50	38	22								110
Nantucket Shoals					8								8
Off Highland Light							14						14
Shore, general	71	41	69	136	140	154	107	216	47	105	67	30	1,183
Total	138	137	257	360	365	218	418	509	317	217	217	205	3,358
Grand total	2,464	2,300	3,611	3,392	3,955	5,439	4,941	5,355	3,764	3,308	2,972	2,735	44,236

Days' absence from port of otter trawlers landing fish at Boston and Gloucester, Mass., and Portland, Me., 1926

Fishing grounds	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
BOSTON													
East of 66° W. longitude:													
Western Bank	34		14	12	45								105
West of 66° W. longitude:													
Georges Bank	67	16	8	5	10				8	27	30		171
South Channel	423	427	502	287	136	125	179	116	191	382	449	533	3,750
Nantucket Shoals	11				110	114	8	89			72	113	517
Off Highland Light						6							6
Off Chatham	9	50	23	15		15							112
Total	544	493	547	319	301	260	187	205	199	409	551	646	4,661
GLOUCESTER													
East of 66° W. longitude:													
Western Bank					24								24
West of 66° W. longitude:													
Georges Bank			29		9						8		46
South Channel				15	10	68		16	28	37			174
Nantucket Shoals					53	46	8	31					138
Total			29	15	96	114	8	47	28	37	8		382
PORTLAND													
East of 66° W. longitude:													
Western Bank			61	37	52								150
West of 66° W. longitude:													
Georges Bank				9	16								25
South Channel			50	38	22								110
Nantucket Shoals					8								8
Total			111	84	98								293
Grand total	544	493	687	418	495	374	195	252	227	446	559	646	5,336

VESSEL FISHERIES AT SEATTLE, WASH.

The vessel fisheries at Seattle, Wash., had a more prosperous year in 1926 than in the previous year. There was an increase in the quantity and value of the products landed by the fishing fleet and also by the collecting vessels. The products landed by fishing vessels showed an increase in the catch of halibut, "lingcod," and rockfishes, but some decrease in the catch of sablefish. In the products landed by collecting vessels there was an increase in the quantity and value of salmon, sturgeon, herring, and steelhead trout, while flounders increased in quantity but decreased in value. There was a decrease in both the quantity and value of all other species. Statistics of the vessel fisheries at Seattle were 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 1926 the fishing fleet at Seattle landed 1,068 trips, amounting to 13,371,610 pounds of fish, having a value to the fishermen of $1,896,677. The catch was taken chiefly from fishing grounds along the coast from Oregon to Portlock Bank, Alaska. Hecate Strait was the most productive of these grounds, the catch amounting to 7,087,930 pounds, valued at $1,128,447. Flattery Banks produced 4,509,580 pounds, valued at $557,411, and the Oregon coast 1,006,400 pounds, valued at $86,397. Smaller quantities were taken from the west coast of Vancouver Island, Yakutat grounds, and Portlock Bank. The products included halibut, 10,050,610 pounds, valued at $1,738,015; sablefish, 2,082,800 pounds, valued at $107,673; "lingcod," 821,250 pounds, valued at $33,356; rockfishes, 398,950 pounds, valued at $16,720; and sturgeon, 18,000 pounds, valued at $913. Compared with 1925, there was an increase of 230 trips and of 375,060 pounds, or 2.89 per cent, in the quantity and $302,379, or 18.97 per cent, in the value of the products landed by fishing vessels.

The fishery products taken in Puget Sound and landed at Seattle by collecting vessels during the year amounted to 19,046,820 pounds, valued at $1,702,064. These products included salmon, 16,979,700 pounds, valued at $1,613,598; herring, 761,000 pounds, valued at $4,585; sturgeon, 10,150 pounds, valued at $1,852; steelhead trout, 110,400 pounds, valued at $11,040; smelt, 160,000 pounds, valued at $16,870; perch, 79,600 pounds, valued at $5,046; rockfishes, 88,250 pounds, valued at $5,010; "lingcod," 48,000 pounds, valued at $1,840; flounders, 81,600 pounds, valued at $1,632; sole, 281,300 pounds, valued at $11,346; and crabs, 446,820 pounds, or 18,510 dozen, valued at $29,245. Compared with 1925, there was an increase in the products landed by collecting vessels of 1,648,910 pounds, or 9.48 per cent, in quantity and $340,545, or 25.01 per cent, in value. The quantity and value of fishery products landed at Seattle by fishing and collecting vessels in 1926 are given in detail in the following tables:

Statement, by fishing grounds and months, of quantities and values of certain fresh fishery products landed at Seattle, Wash., by American fishing vessels during the calendar year 1926

	Number of trips	Halibut		Sablefish		"Lingcod"	
		Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
FISHING GROUNDS							
Oregon coast	53	268, 100	$49, 879	681, 100	$34, 003	28, 700	$1, 165
Flattery Banks	510	2, 652, 530	467, 133	1, 050, 600	54, 802	527, 350	23, 072
West coast Vancouver Island	2	6, 100	2, 222			3, 100	210
Hecate Strait	483	6, 369, 380	1, 097, 041	349, 600	18, 703	262, 100	8, 909
Yakutat grounds	6	211, 000	35, 480				
Portlock Bank	14	543, 500	86, 260	1, 500	75		
Total	1, 068	10, 050, 610	1, 738, 015	2, 082, 800	107, 673	821, 250	33, 356
MONTHS							
January	4					21, 500	1, 895
February	8	20, 000	6, 322			23, 900	1, 996
March	131	980, 800	173, 408	65, 450	2, 936	86, 750	4, 036
April	145	1, 453, 500	234, 190	98, 150	5, 358	113, 700	4, 000
May	143	1, 676, 800	282, 667	29, 400	1, 764	130, 600	3, 405
June	145	1, 571, 250	271, 097	223, 200	12, 426	108, 200	2, 408
July	104	1, 311, 100	229, 594	213, 000	10, 633	41, 000	1, 230
August	118	1, 223, 080	204, 269	281, 300	14, 285	62, 500	2, 220
September	112	886, 350	162, 265	345, 200	17, 923	86, 800	2, 699
October	94	443, 780	86, 399	557, 600	29, 317	43, 500	1, 970
November	57	483, 050	87, 804	269, 500	13, 031	52, 800	3, 055
December	7					50, 000	4, 444
Total	1, 068	10, 050, 610	1, 738, 015	2, 082, 800	107, 673	821, 250	33, 356

	Rockfishes		Sturgeon		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
FISHING GROUNDS						
Oregon coast	28, 500	$1, 350			1, 006, 400	$86, 397
Flattery Banks	268, 600	11, 776	10, 500	$538	4, 509, 580	557, 411
West coast Vancouver Island	2, 500	175			11, 700	2, 607
Hecate Strait	99, 350	3, 419	7, 500	375	7, 087, 930	1, 128, 447
Yakutat grounds					211, 000	35, 480
Portlock Bank					545, 000	86, 335
Total	398, 950	16, 720	18, 000	913	13, 371, 610	1, 896, 677
MONTHS						
January	19, 500	1, 475			41, 000	3, 370
February	10, 000	775			53, 900	9, 093
March	40, 700	1, 716			1, 173, 700	182, 096
April	64, 550	2, 355			1, 729, 900	245, 903
May	49, 000	1, 120			1, 885, 800	288, 956
June	39, 500	870			1, 942, 150	286, 799
July	10, 500	315			1, 575, 600	241, 772
August	44, 000	1, 780			1, 610, 880	222, 554
September	62, 700	2, 419	18, 000	913	1, 399, 050	186, 219
October	16, 000	725			1, 060, 880	118, 411
November	19, 500	1, 185			825, 750	105, 075
December	23, 000	1, 985			73, 000	6, 429
Total	398, 950	16, 720	18, 000	913	13, 371, 610	1, 896, 677

Fishery products, by months, taken in Puget Sound and landed at Seattle, Wash., by collecting vessels during the year 1926

Species	January		February		March		April		May	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Herring	195,000	$975	260,000	$1,300	60,000	$300	60,000	$300	30,000	$150
Salmon:										
King or spring									420,000	42,000
Coho or silver									60,000	4,800
Trout: Steelhead									40,000	4,000
Smelt	5,000	700	3,000	500	2,000	340	4,000	600	4,000	280
Perch	8,500	585	9,600	576	14,000	840	10,500	630	12,000	600
Rockfishes	7,000	490	4,350	304	11,500	920	2,300	138	8,500	490
"Lingcod"					4,000	120	12,000	600		
Flounders	6,400	128	8,000	160	4,000	80	7,400	148	4,000	80
Sole	38,000	1,720	34,000	1,300	16,000	640	10,600	318	20,000	800
Crabs	79,200	4,200	75,900	5,175	62,260	4,225	12,100	825	44,000	3,000
Total	339,100	8,798	394,850	9,375	173,760	7,465	118,900	3,559	642,500	56,200

Species	June		July		August		September	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Sturgeon	2,000	$200	550	$52	2,500	$600	1,600	$300
Salmon:								
Humpback or pink			8,300	252	22,000	440	16,500	330
Chum or keta			14,400	576	14,000	270	18,000	360
King or spring	2,800,000	420,000	3,600,000	360,000	2,100,000	210,000	1,600,000	160,000
Coho or silver	450,000	31,600	246,000	12,300	470,000	18,800	980,000	98,000
Sockeye or red	22,000	2,200	12,500	1,250	50,000	5,000	12,000	1,200
Trout: Steelhead	18,400	1,840	22,000	2,200	12,000	1,200	18,000	1,800
Smelt					11,000	1,200	15,000	1,650
Perch					3,000	180	9,000	720
Rockfishes	4,000	160			18,000	720	8,600	688
"Lingcod"	8,000	160	12,000	480			4,000	160
Flounders	8,400	168	16,400	328	8,000	100	11,000	220
Sole	12,300	492	10,000	400	22,000	880	16,400	656
Total	3,325,100	456,820	3,942,150	377,838	2,732,500	239,450	2,710,100	266,084

Species	October		November		December		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Sturgeon	3,500	$700					10,150	$1,852
Herring			76,000	$760	80,000	$800	761,000	4,585
Salmon:								
Humpback or pink							46,800	1,022
Chum or keta	1,700,000	68,000	353,000	13,120			2,099,400	82,326
King or spring	111,000	11,100					10,631,000	1,203,100
Coho or silver	1,750,000	140,000	150,000	12,000			4,106,000	317,500
Sockeye or red							96,500	9,650
Trout: Steelhead							110,400	11,040
Smelt	28,000	2,800	30,000	3,600	52,000	5,200	160,000	16,870
Perch			6,500	455	6,500	460	79,600	5,046
Rockfishes	6,000	180	8,000	320	10,000	600	88,250	5,010
"Lingcod"					8,000	320	48,000	1,840
Flounders	4,000	80	4,000	80			81,600	1,632
Sole	15,000	600	32,000	1,280	55,000	2,200	281,300	11,346
Crabs	70,400	4,800	50,160	3,420	52,800	3,600	[1] 446,820	29,245
Total	3,687,900	228,260	715,660	35,036	264,300	13,180	19,046,820	1,702,064

[1] 18,510 dozen.

FISHERY PRODUCTS RECEIVED AT MUNICIPAL FISH WHARF AND MARKET, WASHINGTON, D. C.[2]

The receipts of fishery products at the municipal fish wharf and market, Washington, D. C., in 1926 amounted to 7,511,427 pounds, an increase of 470,369 pounds, or 6.68 per cent, as compared with 1925. The most important products, in quantity, were squeteagues

[2] Daily reports of the quantity of fishery products received at this market are furnished to the bureau for publication through the courtesy of the health department of the District of Columbia.

or "sea trout", 1,326,250 pounds; croaker, 1,177,400 pounds; river herring, including 1,270 pounds of roe, 592,470 pounds; oysters, in the shell and opened, 538,294 pounds; shad, 437,850 pounds; striped bass, 413,250 pounds; butterfish, 388,000 pounds; haddock, 339,590 pounds; mackerel, 330,400 pounds; spot, 233,700 pounds; flounders, 213,250 pounds; and crabs, 206,310 pounds. The species ranking next in importance include catfish, perch, halibut, whiting, and hake.

Fishery products, in pounds, received at municipal fish wharf and market, Washington, D. C., 1926

Species	January	February	March	April	May	June	July
Bass, black or sea	1, 350	1, 900	1, 600		8, 300	7, 400	5, 300
Bluefish					600	10, 600	11, 500
Blue runner or hardtail							
Butterfish	4, 500	6, 000	4, 600	1, 500	47, 900	72, 400	101, 500
Carp	4, 400	4, 800	14, 300	11. 400	13, 600	6, 400	3, 900
Catfish	1, 650	6, 100	35, 100	21, 900	9, 100	19, 500	5, 300
Cod	4, 000	5, 000	5, 400	10, 100	3, 700	4, 600	4, 400
Croaker	20, 800	7, 200	13, 300	195, 600	257, 600	164, 200	228, 300
Eels			500	900		900	500
Flounders	18, 300	21, 200	44, 900	23, 800	21, 000	13, 800	10, 200
Gizzard shad		3, 400	9, 600				
Haddock	26, 100	38, 900	55, 830	29, 300	12, 350	29, 520	35, 900
Hake							
Halibut	7, 700	10, 200	22, 600	21, 400	10, 200	14, 500	7, 300
Herring, river	19, 550	36, 700	134, 300	318, 250	82, 000	400	
Herring roe, river			250	1, 020			
Hickory shad or "jacks"	5, 950	4, 000	5, 800	3, 300	1, 100		
Kingfish				900	1, 600		
Mackerel	36, 800	8, 400	7, 200	7, 100	35, 000	51, 200	43, 700
Menhaden							
Mullet		100	600	200			
Perch	5, 100	8, 200	51, 700	27, 400	10, 000	8, 500	1, 700
Pigfish							
Pike or pickerel	500	2, 100	3, 050	200			
Pollock	4, 200		200			2, 200	2, 400
Pompano					200		
Redfish or red drum	2, 900				30		
Red snapper					200		600
Salmon	1, 600	1, 300	1, 600		700	1, 700	2, 200
Scup or porgy					800	2, 000	600
Shad	53, 300	25, 900	99, 500	197, 100	55, 550	2, 300	
Sheepshead		2, 600		1, 000			
Smelt	4, 200	200	2, 805				
Spot	800	1, 000	7, 000	100	9, 400	32, 800	43, 200
Squeteagues or "sea trout"	78, 000	15, 800	19, 800	6, 800	281, 600	163, 500	121, 100
Squid							
Striped bass	9. 200	8, 900	36, 700	76, 900	32, 400	30, 900	26, 500
Sturgeon				120	145	64	100
Swordfish						480	2, 000
Tilefish		400	900	400			
Whitefish							
Whiting	4, 800	4, 500	4, 400				
Clams, hard	2, 208	1, 920	3, 120	3, 936	8. 192	11, 040	8, 736
Oysters:							
In the shell	16, 975	20, 545	19, 985	3, 654	336	392	196
Opened	49, 368	38, 511	30, 772	7, 013	280		
Scallops		240	80	720		840	960
Crabs		150		615	5, 670	45, 420	61, 305
Crabmeat	285	875	1, 430	3, 320	9, 985	26, 035	20, 155
Lobster		50	300	160	850	500	350
Shrimp	3, 855	550	2, 275	775	5, 575	10, 900	5, 400
Turtles			80	50	754	354	48
Frogs			12	24	24	93	
Total	388, 391	288, 241	641, 589	975, 957	926, 741	736, 038	755, 350

Fishery products, in pounds, received at municipal fish wharf and market, Washington, D. C., 1926—Continued

Species	August	September	October	November	December	Total
Bass, black or sea	1,200	600	700	2,800	8,300	39,450
Bluefish	11,400	6,900	22,100	4,400		67,500
Blue runner or hardtail		300				300
Butterfish	64,200	27,500	35,200	20,400	2,300	388,000
Carp	2,900	7,300	5,600	6,100	14,975	95,675
Catfish	1,200	10,000	23,700	19,700	11,250	164,500
Cod	2,300	2,300	2,300	4,200	400	48,700
Croaker	155,900	25,500	21,900	54,000	33,100	1,177,400
Eels		200	1,800	2,800	310	7,910
Flounders	4,300	6,000	13,900	23,100	12,750	213,250
Gizzard shad	200	600	1,900	8,000	6,400	30,100
Haddock	19,600	35,300	16,630	24,440	15,720	339,590
Hake		400	12,600	60,000	32,838	106,438
Halibut	6,400	10,100	8,800	8,500	6,950	134,650
Herring, river						591,200
Herring roe, river						1,270
Hickory shad or "jacks"					500	21,250
Kingfish			200	3,000	1,850	7,550
Mackerel	39,000	28,000	19,000	47,700	7,300	330,400
Menhaden				200		200
Mullet			600	4,700	600	6,800
Perch	1,600	2,000	7,000	16,600	12,150	150,950
Pigfish			400			400
Pike or pickerel		200	1,400	1,400	543	9,393
Pollock	1,400	1,000	2,300	6,000	1,000	20,700
Pompano						200
Redfish or red drum			1,300	800		5,030
Red snapper	1,500			1,400		3,700
Salmon	1,800	4,800	3,800	1,000	400	20,900
Scup or porgy	500	600	1,500	200		6,800
Shad					4,200	437,850
Sheepshead			100		200	3,900
Smelt				300	600	8,105
Spot	19,700	40,100	67,200	9,900	2,500	233,700
Squeteagues or "sea trout"	140,900	27,000	241,800	173,100	56,850	1,326,250
Squid			400			400
Striped bass	43,200	35,100	49,100	39,900	24,450	413,250
Sturgeon						429
Swordfish	900	200				3,580
Tilefish			600	1,000	800	4,100
Whitefish			500			500
Whiting			1,400	63,400	55,800	124,300
Clams, hard	6,336	5,600	4,928	5,056	2,240	[1] 63,312
Oysters:						
In the shell	224	3,829	52,654	86,093	34,398	[2] 239,281
Opened		9,306	36,036	69,350	58,377	[3] 299,013
Scallops		1,440	320	320		4,920
Crabs	44,610	36,030	12,360	150		206,310
Crabmeat	20,770	9,915	3,525	2,370	375	99,040
Lobster	350	650	450	150	50	3,860
Shrimps	4,300	6,800	5,600	700	500	47,230
Turtles	200	44	4		204	1,738
Frogs						153
Total	596,890	345,614	681,607	763,829	411,180	7,511,427

[1] 7,914 bushels. [2] 34,183 bushels. [3] 36,244 gallons.

NOTE.—The clams have been reduced to pounds on the basis of 8 pounds of meat to a bushel, the oysters on the basis of 7 pounds of meat to a bushel and 8¼ pounds to a gallon.

SHAD AND ALEWIFE FISHERIES OF THE POTOMAC RIVER

The regular annual statistics of the shad and alewife fisheries of the Potomac River were taken for the season 1926. They show that the shad fishery yielded 336,662 shad that weighed 1,034,206 pounds, valued at $217,461 to the fishermen. This is an increase over 1925 of 65 per cent in number, 48 per cent in weight, and 33 per cent in value. While the catch is not large, compared with many of the former years upon which statistics are available, the fishery nevertheless has registered substantial increases since the exceptionally poor year 1924.

The catch of alewives amounted to 13,795,848 fish, with a weight of 5,518,930 pounds, valued at $55,366 to the fishermen. The catch shows an increase over 1925 of 76 per cent in number, 76 per cent in weight, and 48 per cent in value, and with the exception of 1924 is the largest catch on record since 1909.

The following tables give detailed statistics for 1926 and comparative statistics on the shad and alewife catches in the Potomac River for the years for which statistics are available.

Shad and alewife fisheries of the Potomac River, 1926

Item	Maryland			Virginia			Total		
	Number	*Pounds*	*Value*	*Number*	*Pounds*	*Value*	*Number*	*Pounds*	*Value*
Fishermen	256			493			749		
Rowboats and scows	96		$3,870	197		$7,365	293		$11,235
Gasoline boats	56		15,575	188		66,205	244		81,780
Pound nets	98		15,625	311		107,460	409		123,085
Gill nets	82		8,255	219		8,664	301		16,919
Haul seines	5		1,900				5		1,900
Shore and accessory property			1,000						1,000
Total			46,225			189,694			235,919
Shad caught:									
With pound nets	11,177	34,775	7,353	252,435	760,967	157,519	263,612	795,742	164,872
With gill nets	35,874	115,791	25,091	32,626	110,378	25,134	68,500	226,169	50,225
With haul seines	4,550	12,295	2,364				4,550	12,295	2,364
Total	51,601	162,861	34,808	285,061	871,345	182,653	336,662	1,034,206	217,461
Alewives caught:									
With pound nets	1,163,020	465,800	5,818	12,280,828	4,912,330	45,548	13,443,848	5,378,130	51,366
With gill nets				220,000	88,000	3,300	220,000	88,000	3,300
With haul seines	132,000	52,800	700				132,000	52,800	700
Total	1,295,020	518,600	6,518	12,500,828	5,000,330	48,848	13,795,848	5,518,930	55,366

Production of shad in the Potomac River in various years, 1896 to 1926

Year	Maryland			Virginia			Total		
	Number	*Pounds*	*Value*	*Number*	*Pounds*	*Value*	*Number*	*Pounds*	*Value*
1926	51,601	162,861	$34,808	285,061	871,345	$182,653	336,662	1,034,206	$217,461
1925	46,008	157,786	35,310	158,574	538,846	128,088	204,582	696,632	163,398
1924	37,505	127,285	20,469	134,805	450,925	67,981	172,310	578,210	88,450
1923	93,619	308,729	52,917	257,927	878,653	145,702	351,546	1,187,382	198,619
1922	203,682	706,501	95,140	680,494	2,409,070	324,882	884,176	3,115,571	420,022
1921	49,681	138,207	25,191	356,191	1,022,231	182,179	405,872	1,160,438	207,370
1920	80,944	302,237	55,963	448,414	1,677,543	278,501	529,358	1,979,780	334,464
1919	94,512	354,420	56,833	449,957	1,687,339	275,564	544,469	2,041,759	332,397
1915	17,196	64,485	6,827	165,206	619,523	65,300	182,402	684,008	72,127
1909	31,158	116,843	9,232	172,813	648,049	44,500	203,971	764,892	53,732
1904	83,147	311,801	16,343	289,500	1,085,625	51,709	372,647	1,397,426	68,052
1901	146,000	547,500	14,800	648,462	2,431,733	104,566	794,462	2,979,233	119,366
1896	233,238	874,643	20,524	450,825	1,690,594	43,084	684,063	2,565,237	63,608

Production of alewives in the Potomac River in various years, 1909 to 1926

Year	Maryland			Virginia			Total		
	Number	*Pounds*	*Value*	*Number*	*Pounds*	*Value*	*Number*	*Pounds*	*Value*
1926	1,295,020	518,600	$6,518	12,500,828	5,000,330	$48,848	13,795,848	5,518,930	$55,366
1925	415,000	166,000	2,070	7,420,380	2,968,152	35,271	7,835,380	3,134,152	37,341
1924	1,834,000	733,600	6,855	13,299,388	5,319,156	49,667	15,133,388	6,052,756	56,552
1923	2,119,787	847,916	8,764	9,308,782	3,722,912	40,657	11,428,569	4,570,828	49,421
1922	1,292,500	517,000	3,700	10,074,500	4,029,800	34,642	11,367,000	4,546,800	38,342
1921	1,395,000	558,000	9,010	8,908,510	3,563,404	35,031	10,303,510	4,121,404	44,041
1920	1,077,775	538,888	13,940	7,681,561	3,813,780	41,197	8,759,336	4,352,668	55,137
1919	1,488,583	772,867	15,508	7,379,319	2,904,054	45,508	8,867,902	3,676,921	61,016
1915	335,000		1,420	7,276,428		30,741	7,611,428		32,161
1909	4,883,000		10,369	24,601,040		42,854	29,484,040		53,223

SHAD FISHERY OF THE HUDSON RIVER

In 1925 there were 221 persons engaged in the shad fishery of the Hudson River in New York and New Jersey. The investment amounted to $26,265, and 38,868 shad, or 124,334 pounds, were caught, valued at $26,430. Of this quantity, 34,568 shad, or 110,359 pounds, valued at $24,030, were taken in New York, and 4,300 shad, or 13,975 pounds, valued at $2,400, in New Jersey.

In 1926 there were 240 persons engaged in this fishery. The investment amounted to $27,370, and 84,462 shad, or 265,420 pounds, valued at $53,475, were caught. The catch in New York amounted to 73,312 shad, or 219,183 pounds, valued at $47,175, and in New Jersey to 11,150 shad, or 46,237 pounds, valued at $6,300.

Compared with 1924, there was an increase in 1925 of 37 in the number of persons engaged, $3,427 in the investment, 10,074 in number of shad taken (or 29,972 pounds), and of $3,326 in the value. In 1926, as compared with 1924, there was an increase of 56 persons, $4,532 in the investment, and 55,668 in the number of shad taken (or 171,051 pounds), and of $30,371 in the value. As compared with the previous year, the number of persons engaged and the investment in 1926 were only slightly greater, while the catch of shad and the value were more than double. The statistics for 1925 and 1926 and comparative statistics of the catch from 1915 to 1926, inclusive, are given in the following table:

Shad fishery of the Hudson River, 1925

Items	New York			New Jersey			Total		
	Number	*Pounds*	*Value*	*Number*	*Pounds*	*Value*	*Number*	*Pounds*	*Value*
Fishermen	205			16			221		
Rowboats and scows	89		$4,920	6		$1,240	95		$6,160
Gasoline boats	20		2,805	3		2,000	23		4,805
Gill nets, drift	90		11,165				90		11,165
Gill nets, stake	13		920	4		400	17		1,320
Haul seines	4		415				4		415
Shore and accessory property			1,100			1,300			2,400
Total			21,325			4,940			26,265
Shad caught:									
With drift gill nets	32,509	104,063	22,902				32,509	104,063	22,902
With stake gill nets	1,144	3,644	729	4,300	13,975	2,400	5,444	17,619	3,129
With haul seines	825	2,375	344				825	2,375	344
With other apparatus, incidentally	90	277	55				90	277	55
Total	34,568	110,359	24,030	4,300	13,975	2,400	38,868	124,334	26,430

Shad fishery of the Hudson River, 1926

Items	New York			New Jersey			Total		
	Number	*Pounds*	*Value*	*Number*	*Pounds*	*Value*	*Number*	*Pounds*	*Value*
Fishermen	224			16			240		
Rowboats and scows	95		$5,140	6		$1,240	101		$6,380
Gasoline boats	18		2,655	3		2,000	21		4,655
Gill nets, drift	96		11,825				96		11,825
Gill nets, stake	11		775	4		400	15		1,175
Haul seines	8		935				8		935
Shore and accessory property			1,100			1,300			2,400
Total			22,430			4,940			27,370
Shad caught:									
With drift gill nets	61,625	184,059	39,356				61,625	184,059	39,356
With stake gill nets	4,544	14,443	3,708	11,150	46,237	6,300	15,694	60,680	10,008
With haul seines	6,963	20,102	3,986				6,963	20,102	3,986
With other apparatus, incidentally	180	579	125				180	579	125
Total	73,312	219,183	47,175	11,150	46,237	6,300	84,462	265,420	53,475

Comparative statistics of the shad fishery of the Hudson River, 1915 to 1926

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	43,882	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
1923	28,636	97,863	22,644	6,450	23,865	6,000	35,086	121,728	28,644
1924	22,814	72,519	17,619	5,980	21,850	5,485	28,794	94,369	23,104
1925	34,568	110,359	24,030	4,300	13,975	2,400	38,868	124,334	26,430
1926	73,312	219,183	47,175	11,150	46,237	6,300	84,462	265,420	53,475

FLORIDA SPONGE FISHERY

In 1926 the quantity of sponges sold at the Sponge Exchange, Tarpon Springs, Fla., was 367,745 pounds, valued at $666,093, of which 235,143 pounds, valued at $592,637, were large wool; 26,073 pounds, valued at $36,502, were small wool; 55,205 pounds, valued at $22,682, yellow; 49,233 pounds, valued at $13,441, grass; and 2,091 pounds, valued at $1,101, wire. It is estimated that sponges to the value of $50,000 were sold outside of the exchange at Tarpon Springs.

Compared with the production of 1925, this is a decrease of 66,927 pounds, or 15.4 per cent, in quantity and $49,004, or 6.9 per cent, in value. The production of grass sponges is the only one showing an increase over 1925. The total production is less than for any of the past eight years. This decrease is believed due, at least in part, to the generally unfavorable weather conditions that existed and to a shortage of divers. The increase in the production of grass sponges is attributed to the demand for this kind of sponges and to the fact that the unfavorable weather did not affect their being gathered in the shallow waters.

Sponges sold at the exchange, Tarpon Springs, Fla., 1919 to 1926

Year	Total		Large wool	Small wool	Yellow	Grass	Wire
	Pounds	*Value*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1926	367,745	$666,093	235,143	26,073	55,205	49,233	2,091
1925	434,672	715,097	242,020	29,968	120,748	28,622	13,314
1924	425,305	714,760	265,392	58,021	81,420	14,898	5,574
1923	490,200	734,391	243,230	54,292	87,878	88,772	16,028
1922	526,885	699,089	248,475	70,478	115,455	84,892	7,585
1921	386,390	540,093	173,723	63,786	70,218	65,745	12,918
1920	409,746	678,209	176,722	60,902	72,648	92,880	6,594
1919	424,075	707,964	205,462	76,309	73,051	62,547	6,706

FISHERIES OF CONNECTICUT

Through the courtesy and cooperation of the State board of fisheries and game in detailing one of its officers (Capt. Christopher Culver) to act as agent of the Bureau of Fisheries in collecting the statistics of the fisheries of Connecticut, it has been possible to secure the statistics for the years 1925 and 1926, which are presented in detail in this section. For purposes of comparison the data for 1919 and 1924 also have been included in the summary tables.

In 1925 the fisheries of Connecticut gave employment to 1,451 fishermen and transporters; the value of vessels, boats, and gear employed in the fisheries amounted to $1,559,274; and the yield of the fisheries was 31,865,966 pounds, valued at $2,236,550. Though the number of persons engaged has increased from about 1,300 to 1,450 during the last three years, it is still below the number in 1919, which was 1,666. The value of the vessels, boats, and gear increased with each successive canvass and is now nearly 50 per cent above the investment in 1919. The substantial increases during this period in the number of motor vessels and otter trawls are the outstanding changes to be noted.

The total yield of the fisheries increased from 23,652,647 pounds, valued at $1,700,638, in 1919 to 38,265,091 pounds, valued at $2,592,327 in 1925, and then decreased to 31,865,966 pounds, valued at $2,236,550 in 1926. These changes may be understood by examining the components of the yield. These are summarized in the accompanying table, from which it may be seen that food fishes in 1926 constituted about 29 per cent, food shellfish about 18 per cent, and nonfood items about 53 per cent of the total quantity. Of the total value food fishes accounted for about 21 per cent, food shellfish 50 per cent, and nonfood items 29 per cent.

Summary of the yield of the fisheries of Connecticut in 1919 and 1924 to 1926, inclusive

Year	Food fish		Food shellfish		Nonfood items		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
1919	3,656,394	$266,196	6,025,308	$747,780	13,970,945	$686,662	23,652,647	$1,700,638
1924	6,280,075	351,782	4,957,955	952,081	14,531,486	702,795	25,769,516	2,006,658
1925	7,625,523	377,469	6,751,044	1,434,559	23,888,524	780,299	38,265,091	2,592,327
1926	9,401,692	465,897	5,671,478	1,125,269	16,792,796	645,384	31,865,966	2,236,550

The yield of the food fishes has increased steadily with the successive canvasses, more than doubling in quantity and nearly doubling in value since 1919. The yield of flounders dominates the catch of food fishes. Four-fifths of the total poundage and nearly two-thirds of the total value of the food fishes taken in 1926 were flounders, and the increased catch of this variety accounts for the increase in the total. The shad is next to flounders in importance. In 1919 the value of the shad yield was nearly as large as the value of flounders, but with the marked increase in the flounder yield and a decreased yield of shad the latter was a poor second in 1926, with a value less than one-tenth that of flounders. Other important items were haddock, cod, and swordfish.

The food shellfish constitute the most valuable fishery resource of Connecticut, and of these the oyster is by far the most important. The yield of oysters in 1926, mostly from private beds, approached 5,000,000 pounds of meat, valued at more than $880,000. This is somewhat less than the yield in 1925 but above the yields of 1919 and 1924. The lobster is the other important shellfish, with a yield in 1926 of 645,454 pounds, valued at $227,003. The quantities taken were less in each successive canvass.

Of the nonfood items seed oysters, taken mostly from private beds, are the most important. In 1926 their value was nearly $600,000. Menhaden and oyster shells are the other items in this category; together they had a value of slightly over $50,000 in 1926.

Comparative statistics of the persons engaged in the fisheries of Connecticut, 1919 and 1924 to 1926

Items	1919	1924	1925	1926
	Number	*Number*	*Number*	*Number*
On vessels fishing	566	574	619	629
On vessels transporting	81	17	15	17
In shore fisheries	1,019	707	765	805
Total	1,666	1,298	1,399	1,451

Comparative statistics on the vessels, boats, and apparatus used in the fisheries of Connecticut, 1919 and 1924 to 1926

Items	1919		1924		1925		1926	
	Number	*Value*	*Number*	*Value*	*Number*	*Value*	*Number*	*Value*
Vessels fishing, steam	24	$328,243	25	$480,200	27	$481,400	27	$489,350
Tonnage	2,240		2,250		2,243		2,653	
Outfit		135,346		149,225		112,302		98,723
Vessels fishing, motor	67	180,425	83	301,590	73	351,295	81	426,710
Tonnage	924		1,103		1,121		1,090	
Outfit		94,690		40,842		143,507		139,347
Vessels fishing, sail	24	12,495	10	7,300	9	7,900	4	2,800
Tonnage	183		67		64		28	
Outfit		7,955		415				1,058
Vessels transporting, steam	2	13,200	1	4,000	1	7,500	1	10,000
Tonnage	111		18		18		18	
Outfit		9,627		1,250				1,000
Vessels transporting, motor	4	7,800	8	12,350	5	9,500	9	15,500
Tonnage	95		86		38		79	
Outfit		4,370		1,295				500
Vessels transporting, sail			1	7,000	1	1,000	1	1,000
Tonnage			55		5		5	
Outfit				200				100
Vessels transporting, unrigged	2	4,000	2	5,000	1	2,500		
Tonnage	316		316		6			
Outfit		1,900						
Boats, motor	364	136,881	385	263,075	349	216,895	345	235,150
Boats, sail, row, etc	399	9,670	511	25,605	330	10,393	306	9,850
Apparatus, vessel fisheries:								
Seines	4	7,800	4	3,850	5	3,850	7	4,450
Gill nets	115	2,680						
Otter trawls	14	680	25	1,220	28	2,448	34	3,400
Lines, hand and trawl		555		406		176		975
Harpoons		600		265		535		675
Lobster pots	480	745	545	695	494	1,225	180	800
Eel pots			12	10				
Dredges	372	8,437	246	7,114	191	11,884	183	11,799
Tongs			6	30	4	45	12	125
Apparatus, shore fisheries:								
Seines	54	4,893	24	2,697	48	4,172	59	3,107
Gill nets	204	13,910	95	5,650	89	6,479	95	6,755
Pound nets, trap nets, and weirs	42	9,112	38	9,785	45	8,650	36	5,675
Fyke nets	439	3,985	315	3,043	269	3,315	256	2,863
Dip nets	7	35	59	71	15	54	21	72
Otter trawls	53	2,394	62	2,610	114	7,227	116	8,123
Lines, hand and trawl		58		427		1,795		693
Harpoons		80		280		633		315
Spears	30	39	25	49	65	180	53	165
Eel pots and traps	801	617	1,270	1,146	1,594	2,398	1,532	1,917
Lobster pots	16,173	42,534	16,223	20,515	22,070	77,634	21,445	75,642
Crab pots			75	75				
Dredges	55	395	98	627	27	346	12	160
Tongs and rakes	305	2,361	187	699	145	862	76	475
Minor apparatus		82		40		105		
Total		1,048,594		1,360,651		1,478,205		1,559,274

Comparative statistics of the yield of the fisheries of Connecticut, 1919 and 1924 to 1926, inclusive

Products	1919		1924		1925		1926	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Food fishes:								
Alewives—								
Fresh	177,150	$6,637	98,813	$2,234	114,962	$1,387	40,350	$442
Salted			11,662	275	19,000	650		
Bluefish	3,710	386	17,241	4,514	7,490	2,442	1,926	596
Bonito	6,120	912						
Butterfish	18,810	2,607	5,650	442	7,000	815	23,295	2,255
Carp	40,141	4,922	39,333	5,258	14,264	1,932	5,408	638
Catfish	1,492	100	800	49	590	47	375	16
Cod	96,136	9,603	538,887	30,972	564,995	26,794	507,230	23,885
Cusk	6,767	73						
Eels—								
Common	63,046	9,839	112,458	12,406	108,274	17,051	90,710	13,992
Lamprey					4,890	1,550	1,886	941
Flounders	2,349,181	91,962	4,415,927	197,507	5,905,477	218,362	7,360,346	295,482
Haddock	350	38	48,950	2,440	111,800	6,950	592,347	25,027
Hake	10,100	102	3,000	108	14,900	279	850	20
Halibut	25,000	5,000			75,000	11,075	106,717	12,806
Herring	3,000	71	100	2	400	6	1,000	19
Hickory shad			1,900	83	1,150	63		
Mackerel	91,389	10,990	303,860	20,067	144,575	10,349	177,960	18,801
Mummichog			2,700	720	8,700	1,260	11,050	2,060
Perch—								
White			50	6	45	5		
Yellow	6,108	595	3,396	337	1,326	134	1,656	162
Pickerel	1,079	143	555	62	520	78	50	2
Pollock	10,135	717	48,200	1,941	8,800	466	18,475	919
Scup	1,980	202	1,750	176	1,025	122	640	90
Sea bass	3,555	528	3,150	409	1,400	252	6,406	1,422
Sea robin			25	1	11,200	410		
Shad	463,203	86,637	88,808	20,855	145,790	31,628	111,115	25,291
Sharks					3,150	51	3,375	90
Skates	400	10	200	4	2,400	83	2,600	59
Smelt	25,217	4,466	11,300	2,410	9,515	2,364	10,515	2,701
Spot							1,820	83
Squeteagues	23,076	3,257	40,835	5,302	36,925	5,738	21,233	5,057
Striped bass	4,810	1,059	1,545	396	5,227	1,149	4,629	1,002
Sturgeon	25	5	290	79	220	73	236	70
Suckers	99,053	7,488	119,674	8,024	108,281	8,468	102,352	7,376
Sunfish	105	11						
Swordfish	88,428	15,006	80,145	13,896	78,401	14,908	81,600	13,832
Tautog	21,942	2,068	72,636	6,234	100,139	10,007	100,300	9,815
Tilefish			200,130	14,170			13,000	917
Tomcod	455	37	190	7	400	4		
Tuna	5,114	550					240	20
Whiting	9,317	175	2,000	40	5,600	206		
Other fish			3,915	296	1,692	311		
Total	3,656,394	266,196	6,280,075	351,782	7,625,523	377,469	9,401,692	465,897
Food shellfish:								
Lobster	740,848	189,157	701,647	240,809	686,875	236,729	645,454	227,003
Crabs—								
Hard			440	28	950	44	1,047	110
Sand			10,000	250			14,000	403
Squid	3,012	258	16,630	484	17,100	614	13,950	951
Clams, hard—								
Public	49,976	18,912	22,096	10,005	24,080	12,498	18,256	6,718
Private			1,536	768			5,952	3,098
Clams, soft, public	229,150	32,070	44,350	12,155	30,080	11,436	15,330	5,971
Scallops	38,400	13,717	2,430	683	58,752	10,487		
Oysters, market—								
Public	136,654	21,900	18,410	3,865	116,410	20,680	131,733	21,808
Private	4,826,668	471,766	4,140,416	683,034	5,816,797	1,142,071	4,830,756	859,207
Total	6,025,308	747,780	4,957,955	952,081	6,751,044	1,434,559	5,671,478	1,125,269
Nonfood items:								
Menhaden	6,736,564	93,312	5,270,020	56,438	13,503,058	124,466	4,347,425	36,269
Oysters, seed—								
Public	740,516	68,349	383,950	55,933	73,500	9,550	176,358	23,670
Private	6,493,865	525,001	3,477,516	583,224	3,801,966	635,433	4,409,013	571,645
Oyster shells			5,400,000	7,200	6,510,000	10,850	7,860,000	13,800
Total	13,970,945	686,662	14,531,486	702,795	23,888,524	780,299	16,792,796	645,384
Grand total	23,652,647	1,700,638	25,769,516	2,006,658	38,265,091	2,592,327	31,865,966	2,236,550

Yield of the vessel fisheries of Connecticut in 1925, by apparatus and species

Species	Purse seines		Lines, hand and trawl		Otter trawls		Harpoons	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Cod			353,600	$16,144	47,400	$2,272		
Flounders			1,400	112	2,862,825	103,146		
Haddock			31,200	1,760	61,000	4,116		
Hake					13,300	199		
Halibut			75,000	11,075				
Mackerel	98,750	$7,109	1,800	180				
Menhaden	13,328,658	121,958						
Pollock			400	16	2,000	100		
Sea robin					1,200	60		
Sharks					1,425	16		
Swordfish							48,246	$8,531
Tautog					100	10		
Lobsters					625	202		
Scallops					31,182	5,472		
Total	13,427,408	129,067	463,400	29,287	3,021,057	115,593	48,246	8,531

Species	Lobster pots		Dredges		Tongs	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Lobsters	26,612	$9,475				
Oysters, market:						
Public			43,400	$7,700	17,500	$3,750
Private			5,789,392	1,133,476		
Oysters, seed:						
Public			58,800	6,975		
Private			3,778,866	630,483		
Clams, hard, public					80	40
Oyster shells			2,010,000	3,350		
Total	26,612	9,475	11,680,458	1,781,984	17,580	3,790

Yield of the shore and boat fisheries of Connecticut in 1925, by apparatus and species

Species	Lines, hand and trawl		Haul seines		Pound nets, traps, and weirs		Fyke nets	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Alewives:								
Fresh			16,400	$820	94,562	$497	4,000	$70
Salted					13,000	450	6,000	200
Bluefish	7,180	$2,395			310	47		
Bullheads							590	47
Butterfish					7,000	815		
Carp			9,464	1,392	1,300	150	3,500	390
Cod	131,495	6,752						
Dace							10	1
Eels	300	60			3,100	490	7,540	1,888
Eels, lamprey							4,890	1,550
Flounders	25,300	1,480	200	20	31,807	2,622	4,800	185
Groupers					7	2		
Haddock	3,600	280						
Hake	1,200	64						
Herring					400	6		
Hickory shad					1,150	63		
Mackerel	22,250	1,609			7,775	751		
Menhaden					73,800	928		
Mummichog			7,700	1,175				
Perch:								
White							45	5
Yellow							1,326	134
Pickerel							520	78
Pollock	6,400	350						
Scup	1,000	120			25	2		
Sea bass	1,350	238						
Shad			58,648	9,874	118	28		
Shiners			1,675	308				
Skates	400	24						
Smelt	200	50	8,560	2,132				
Squeteagues	130	26			36,425	5,637		
Striped bass	150	37	600	150	4,474	961		
Sturgeon					20	3		
Suckers			72,201	5,679	11,700	1,050	24,380	1,739
Tautog	91,027	9,096	60	6	8,552	855		
Tomcod			400	4				
Whiting			600	6				
Crabs, hard					150	6		
Lobsters					40	12		
Squid					17,100	614		
Total	291,982	22,581	176,608	21,566	312,815	15,989	57,601	6,287

Yield of the shore and boat fisheries of Connecticut in 1925, by apparatus and species—Continued

Species	Purse seines		Gill nets		Dip nets		Otter trawls	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Cod							32,500	$1,626
Flounders							2,979,145	110,797
Haddock							16,000	794
Hake							400	16
Mackerel	14,000	$700						
Menhaden			100,600	$1,580				
Sea bass							50	14
Sea robin							10,000	350
Shad			85,489	21,343	1,535	$383		
Sharks							1,725	35
Skates							2,000	59
Smelt					655	157	100	25
Squeteagues			370	75				
Striped bass			3	1				
Sturgeon							200	70
Tautog							400	40
Whiting							5,000	200
Crabs, hard					800	38		
Lobsters							815	255
Scallops							27,570	5,015
Total	14,000	700	186,462	22,999	2,990	578	3,075,905	119,296

Species	Drag nets		Harpoons		Lobster pots		Eel pots	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Eels							76,724	$11,445
Mummichog	1,000	$85						
Swordfish			30,155	$6,377				
Lobsters					658,783	$226,785		
Total	1,000	85	30,155	6,377	658,783	226,785	76,724	11,445

Species	Dredges		Tongs and rakes		Spears	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Eels					20,610	$3,168
Oysters, market:						
Public	24,150	$2,650	31,360	$6,580		
Private	7,070	1,470	20,335	7,125		
Oysters, seed:						
Public	14,700	2,575				
Private	21,000	4,500	2,100	450		
Clams:						
Hard, public			24,000	12,458		
Soft, public			30,080	11,436		
Oyster shells			4,500,000	7,500		
Total	66,920	11,195	4,607,875	45,549	20,610	3,168

Summary of the yield of 1925

Species	Shore fisheries		Vessel fisheries		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Alewives:						
Fresh	114,962	$1,387			114,962	$1,387
Salted	19,000	650			19,000	650
Bluefish	7,490	2,442			7,490	2,442
Bullheads	590	47			590	47
Butterfish	7,000	815			7,000	815
Carp	14,264	1,932			14,264	1,932
Cod	163,995	8,378	401,000	$18,416	564,995	26,794
Dace	10	1			10	1
Eels	108,274	17,051			108,274	17,051
Eels, lamprey	4,890	1,550			4,890	1,550
Flounders	3,041,252	115,104	2,864,225	103,258	5,905,477	218,362
Groupers	7	2			7	2
Haddock	19,600	1,074	92,200	5,876	111,800	6,950
Hake	1,600	80	13,300	199	14,900	279
Halibut			75,000	11,075	75,000	11,075
Herring	400	6			400	6
Hickory shad	1,150	63			1,150	63
Mackerel	44,025	3,060	100,550	7,289	144,575	10,349
Menhaden	174,400	2,508	13,328,658	121,958	13,503,058	124,466
Mummichog	8,700	1,260			8,700	1,260
Perch:						
White	45	5			45	5
Yellow	1,326	134			1,326	134
Pickerel	520	78			520	78
Pollock	6,400	350	2,400	116	8,800	466
Scup	1,025	122			1,025	122
Sea bass	1,400	252			1,400	252
Sea robin	10,000	350	1,200	60	11,200	410
Shad	145,790	31,628			145,790	31,628
Sharks	1,725	35	1,425	16	3,150	51
Shiners	1,675	308			1,675	308
Skates	2,400	83			2,400	83
Smelt	9,515	2,364			9,515	2,364
Squeteagues	36,925	5,738			36,925	5,738
Striped bass	5,227	1,149			5,227	1,149
Sturgeon	220	73			220	73
Suckers	108,281	8,468			108,281	8,468
Swordfish	30,155	6,377	48,246	8,531	78,401	14,908
Tautog	100,039	9,997	100	10	100,139	10,007
Tomcod	400	4			400	4
Whiting	5,600	206			5,600	206
Crabs, hard	950	44			950	44
Lobsters	659,638	227,052	27,237	9,677	686,875	236,729
Squid	17,100	614			17,100	614
Clams:						
Hard, public	24,000	12,458	80	40	24,080	12,498
Soft, public	30,080	11,436			30,080	11,436
Scallops	27,570	5,015	31,182	5,472	58,752	10,487
Oysters, market:						
Public	55,510	9,230	60,900	11,450	116,410	20,680
Private	27,405	8,595	5,789,392	1,133,476	5,816,797	1,142,071
Oysters, seed:						
Public	14,700	2,575	58,800	6,975	73,500	9,550
Private	23,100	4,950	3,778,866	630,483	3,801,966	635,433
Oyster shells	4,500,000	7,500	2,010,000	3,350	6,510,000	10,850
Total	9,580,330	514,600	28,684,761	2,077,727	38,265,091	2,592,327

Yield of the vessel fisheries of Connecticut in 1926, by apparatus and species

Species	Purse seines		Haul seines		Lines, hand and trawl		Otter trawls	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Cod					217,740	$9,654	94,100	$4,466
Flounders							4,419,386	176,554
Haddock					17,947	1,056	414,800	17,405
Halibut					106,717	12,806		
Mackerel	114,550	$11,803			15,250	1,062		
Menhaden	4,202,800	34,463						
Pollock					400	20		
Sharks							1,850	53
Smelt			1,000	$400				
Tilefish					13,000	917		
Tuna					240	20		
Lobsters							2,515	813
Total	4,317,350	46,266	1,000	400	371,294	26,135	4,932,651	199,291

Yield of the vessel fisheries of Connecticut in 1926, by apparatus and species—Continued

Species	Harpoons		Lobster pots	
	Pounds	*Value*	*Pounds*	*Value*
Swordfish	71,200	$12,126		
Lobsters			4,000	$2,400

Species	Dredges		Tongs	
	Pounds	*Value*	*Pounds*	*Value*
Oysters, market:				
Public	97,608	$16,036	28,000	$4,000
Private	4,820,466	855,347		
Oysters, seed:				
Public	144,200	19,480		
Private	4,409,013	571,645		
Clams, hard, private			4,000	2,000
Oyster shells			4,080,000	7,500
Total	9,471,287	1,462,508	4,112,000	13,500

Yield of the shore and boat fisheries of Connecticut in 1926, by apparatus and species

Species	Haul seines		Pound nets, traps, and weirs		Fyke nets		Lines, hand and trawl	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Alewives	7,800	$96	31,750	$338	800	$8		
Bluefish			76	20			1,850	$576
Bullheads					375	16		
Butterfish			23,295	2,255				
Carp	2,710	347	373	52	2,025	209		
Cod							86,540	4,332
Eels			750	160	6,693	1,603	2,650	420
Eels, lamprey					1,886	941		
Flounders			28,310	2,090	2,431	123	9,480	627
Haddock							6,500	346
Hake							600	12
Herring			1,000	19				
Mackerel			3,200	320			40,960	4,416
Menhaden			74,500	1,087	3,000	27		
Mummichog	4,750	710	6,000	1,200				
Perch, yellow					1,656	162		
Pickerel					50	2		
Pollock							18,075	899
Scup			440	79			200	20
Sea bass							3,006	742
Shad	45,382	9,338						
Smelt	5,181	1,416	4,000	800			100	25
Spot			1,820	83				
Squeteagues			20,283	4,847	300	70	350	80
Striped bass			3,419	755			610	127
Sturgeon			50	5				
Suckers	51,212	3,892	4,600	295	46,540	3,189		
Tautog			10,423	1,040	100	10	89,777	8,765
Squid			13,950	951				
Total	117,035	15,799	228,239	16,396	65,856	6,360	260,698	21,387

Species	Gill nets		Dip nets		Otter trawls		Harpoons	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Carp	300	$30						
Cod					108,850	$5,433		
Flounders					2,900,739	116,088		
Haddock					153,100	6,220		
Hake					250	8		
Mackerel	4,000	600						
Menhaden	67,125	692						
Mummichog			300	$150				
Sea bass					3,400	680		
Shad	64,133	15,609	1,600	344				
Sharks					1,525	37		
Skates					2,600	59		
Smelt			234	60				
Squeteagues	300	60						
Striped bass	600	120						
Sturgeon					186	65		
Swordfish							10,400	$1,706
Crabs, hard			1,047	110				
Lobsters					950	304		
Total	136,458	17,111	3,181	664	3,171,600	128,894	10,400	1,706

Yield of the shore and boat fisheries of Connecticut in 1926, by apparatus and species—Continued

Species	Lobster pots		Eel pots		Spears	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Eels			67,393	$9,603	13,224	$2,206
Crabs, sand	14,000	$403				
Lobsters	637,989	223,486				
Total	651,989	223,889	67,393	9,603	13,224	2,206

Species	Dredges		Tongs and rakes	
	Pounds	*Value*	*Pounds*	*Value*
Clams, hard:				
Public	200	$100	13,056	$6,618
Private			1,952	1,098
Clams, soft, public			15,330	5,971
Oysters, market:				
Public			6,125	1,772
Private	2,030	380	8,260	3,480
Oysters, seed, public	29,358	3,990	2,800	200
Oyster shells			3,780,000	6,300
Total	31,588	4,470	3,827,523	25,439

Summary of the yield in 1926

Species	Shore fisheries		Vessel fisheries		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Alewives	40,350	$442			40,350	$442
Bluefish	1,926	596			1,926	596
Bullheads	375	16			375	16
Butterfish	23,295	2,255			23,295	2,255
Carp	5,408	638			5,408	638
Cod	195,390	9,765	311,840	$14,120	507,230	23,885
Eels	90,710	13,992			90,710	13,992
Eels, lamprey	1,886	941			1,886	941
Flounders	2,940,960	118,928	4,419,386	176,554	7,360,346	295,482
Haddock	159,600	6,566	432,747	18,461	592,347	25,027
Hake	850	20			850	20
Halibut			106,717	12,806	106,717	12,806
Herring	1,000	19			1,000	19
Mackerel	48,160	5,336	129,800	13,465	177,960	18,801
Menhaden	144,625	1,806	4,202,800	34,463	4,347,425	36,269
Mummichog	11,050	2,060			11,050	2,060
Perch, yellow	1,656	162			1,656	162
Pickerel	50	2			50	2
Pollock	18,075	899	400	20	18,475	919
Scup	640	99			640	99
Sea bass	6,406	1,422			6,406	1,422
Shad	111,115	25,291			111,115	25,291
Sharks	1,525	37	1,850	53	3,375	90
Skates	2,600	59			2,600	59
Smelt	9,515	2,301	1,000	400	10,515	2,701
Spot	1,820	83			1,820	83
Squeteagues	21,233	5,057			21,233	5,057
Striped bass	4,629	1,002			4,629	1,002
Sturgeon	236	70			236	70
Suckers	102,352	7,376			102,352	7,376
Swordfish	10,400	1,706	71,200	12,126	81,600	13,832
Tautog	100,300	9,815			100,300	9,815
Tilefish			13,000	917	13,000	917
Tuna			240	20	240	20
Crabs, hard	1,047	110			1,047	110
Crabs, sand	14,000	403			14,000	403
Lobsters	638,939	223,790	6,515	3,213	645,454	227,003
Squid	13,950	951			13,950	951
Clams, hard:						
Public	13,256	6,718			13,250	6,718
Private	1,952	1,098	4,000	2,000	5,952	3,098
Clams, soft, public	15,330	5,971			15,330	5,971
Oysters, market:						
Public	6,125	1,772	125,608	20,036	131,733	21,808
Private	10,290	3,860	4,820,466	855,347	4,830,756	859,207
Oysters, seed:						
Public	32,158	4,190	144,200	19,480	176,358	23,670
Private			4,409,013	571,645	4,409,013	571,645
Oyster shells	3,780,000	6,300	4,080,000	7,500	7,860,000	13,800
Total	8,585,184	473,924	23,280,782	1,762,626	31,865,966	2,236,550

FISHERIES OF THE GREAT LAKES, 1913 TO 1925

For many years some of the border States on the Great Lakes have been collecting annual statistics of the yield of their respective lake fisheries.[3] However, until recently no attempt was made to unify and publish these statistics so that the data would be in comparable form. Inasmuch as the fisheries of the Great Lakes are of great commercial importance, and as unusual interest has been shown lately concerning the diminished catches of several important species, it has seemed desirable that these State statistics should be brought together and published. Figures from the State sources for the years 1913 to 1924 are already available, having been obtained in a tariff survey of the lake fisheries. To bring these up to date, the bureau obtained figures for 1925 from the State records. Statistics for the Canadian Great Lakes fishery for 1913 to 1925, obtained from official reports, also are included to complete the picture.

SCIENTIFIC AND COMMON NAMES

Confusion always has existed in the common names of the fishes of the Great Lakes. In many cases a certain species, when taken in two or more lakes, or even in several localities of the same lake, is called by a different name. On some occasions this name may be the same as that applied to a different species in another lake. Moreover, some groups of species are known by a single common name. Inasmuch as this condition exists, it is impossible to adopt a natural system of nomenclature, for the itemization of trade statistics is limited to trade names or categories. The names used in this report are those most commonly used by the trade; and where the trade groups various species under one name, the same grouping is followed in this report. Also, where the trade divides one species into two categories, the same division has been followed. Thus, the cisco of Lake Erie, differing in economic importance from the herring of the other lakes, has been listed separately, although they have been considered as one species in scientific literature. In the table of names that follows it will be noted that certain species appear as "not specified" in certain States. This means that the species may not be taken commercially in the waters of that State, or it may have occurred only in small quantities and may have been included with similar varieties or with the item "miscellaneous." The detailed classification of all fishes in the various States may be found in the table.

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[3] Each of the eight border States of the Great Lakes has an agency with legislative authority to collect or receive certain fisheries statistics, but only six of them regularly collect data. These are New York, Pennsylvania, Ohio, Michigan, Wisconsin, and Minnesota. The fisheries of the other two (Indiana and Illinois) are relatively unimportant. In 1922 the combined catch of Indiana and Illinois approximated 1,137,000 pounds, or only about 1 per cent of the total Great Lakes catch.

In New York, Pennsylvania, Michigan, and Wisconsin statistics on the fisheries are returned at the close of the year in which the fisheries were prosecuted. In Minnesota statistics for Lake Superior are for the calendar year, but for the Lake of the Woods they are for the season beginning Dec. 1 and ending Apr. 1. In Ohio separate reports are made for the two fishing seasons—Mar. 15 to Aug. 31 and Sept. 1 to Dec. 15.

It is the law in some States and the custom in others for the State to furnish printed statistical schedules to fishermen. These usually are mailed to the licensees, filled in by them, and returned to the State agency. There is considerable difference in the diligence with which the several agencies enforce their statistical powers. Some of them remind delinquents by correspondence of their failure to report, and others invoke the authority of the law-enforcing officers. Only one State fails to make a bookkeeping comparison between the license records and the statistical report.

Scientific and common names of certain lake fishes

Scientific name	Common names		
	Used in this report	Previously used in Bureau of Fisheries reports	Canadian Fisheries Department
Stizostedion vitreum [1]	Blue pike	Pike perch, blue pike.	Blue pickerel.
All Leucichthys except artedi (in Great Lakes).	Chubs	Ciscoes	Tullibee.
Leucichthys artedi (Lake Erie only)	Cisco	do	Herring.
Esox lucius	Jacks	Pike	Pike
Leucichthys artedi (Great Lakes, except Lake Erie).	Lake herring	Ciscoes	Herring.
Cristivomer namaycush	Lake trout	Lake trout	Trout.
Catostomus commersonii and C. catostomus (commonest species).	Suckers or "mullet".	Suckers	Mullets.
Stizostedion canadense griseum	Sauger	Sauger	(Not specified).
Aplodinotus grunniens	Sheepshead	Sheepshead or drum	Do.
Leucichthys (species) (in Lake of the Woods).	Tullibees	Ciscoes ("tullibees").	Tullibee
Coregonus clupeiformis	Whitefish	Whitefish	Whitefish.
Perca flavescens	Yellow perch	Yellow perch	Perch.
Stizostedion vitreum	Yellow pike	Pike perch, wall-eyed or yellow pike.	Pickerel or dore.

Scientific name	Common names			
	New York	Pennsylvania	Ohio	Michigan
Stizostedion vitreum [1]	Blue pike	Blue pike	Blue pike	(Not specified).
All Leucichthys except artedi (in Great Lakes).	(Not specified)	(Not specified)	(Not specified)	Chubs, longjaws, blackfins, and bluefins.
Leucichthys artedi (Lake Erie only).	Cisco	Cisco	Herring	Herring.
Esox lucius	(Not specified)	(Not specified)	(Not specified)	Jacks and grass pike.
Leucichthys artedi (Great Lakes, except Lake Erie).	Cisco	do	do	Herring.
Cristivomer namaycush	Lake trout	Lake trout	do	Lake trout.
Catostomus commersonii and C. catostomus (commonest species).	Sucker and mullet.	(Not specified)	Sucker—mullet.	Suckers and mullets.
Stizostedion canadense griseum.	(Not specified)	do	Sauger	Sauger.
Aplodinotus grunniens	do	do	Sheepshead	Sheepshead.
Leucichthys (species) (in Lake of the Woods).	do	do	(Not specified)	(Not specified).
Coregonus clupeiformis	Whitefish	Whitefish	Whitefish	Whitefish.
Perca flavescens	Yellow perch	Yellow perch	Yellow perch	Perch.
Stizostedion vitreum	Wall-eyed pike, pike perch, and pickerel.	Pike perch	Pickerel	Pickerel.

Scientific name	Common names		
	Wisconsin	Minnesota	Indiana
Stizostedion vitreum [1]	(Not shown separately).	(Not specified)	(Not specified).
All Leucichthys except artedi (in Great Lakes).	Chubs and bluefins	Bluefins, ciscoes, and ciscoetts.	Chubs and bluefins.
Leucichthys artedi (Lake Erie only).	(Not taken)	(Not taken)	(Not taken).
Esox lucius	Pickerel	Pickerel	(Not specified).
Leucichthys artedi (Great Lakes, except Lake Erie).	Herring	Herring	Herring.
Cristivomer namaycush	Lake trout	Trout	Trout.
Catostomus commersonii and C. catostomus (commonest species).	(Not specified)	Suckers and mullets	Suckers.
Stizostedion canadense griseum	Sauger	Sauger and sand pike	(Not specified).
Aplodinotus grunniens	(Not specified)	(Not specified)	Do.
Leucichthys (species) (in Lake of the Woods).	do	Tullibees	Do.
Coregonus clupeiformis	Whitefish	Whitefish	Whitefish.
Perca flavescens	Perch	Perch	Perch.
Stizostedion vitreum	Pike	Yellow pike	(Not specified).

[1] Described by Mr. Hubbs as a distinct species, which he has named Stizostedion glaucum.

COMPARISON WITH STATISTICS PREVIOUSLY PUBLISHED FOR 1917 AND 1922

The statistics for the States herein presented differ from those already gathered and published by the Bureau of Fisheries for the years 1917 and 1922 (those being the only years during the period 1913 to 1925 when a canvass was made in the regular manner by the Bureau of Fisheries). This difference is to be expected for various reasons. First, in the canvass made by the Bureau of Fisheries' representatives the figures for the catch are obtained directly from the fishermen or fish dealers, rather than from State records, and it is believed that these representatives exert a greater effort than do the State authorities to secure the record of the catch from every source, with the result that the total catch probably is more nearly approximated. Second, the State agency receives its reports shortly after the close of each fishing season, at a time when the fisherman or fish dealer has a written record of his catch or has the figures fresh in his memory. On the other hand, the canvass by representatives of the Bureau of Fisheries, while begun shortly after the beginning of the calendar year, is not completed for four or five months. During the interval, it is likely that a new fishing season may begin and it is decidedly improbable that a written record, or even an estimate will be obtained, and the figures given the representatives may be greater or less than the actual catch. Thus, the Bureau of Fisheries' canvass is likely to obtain more complete returns, but, on the other hand, the individual returns may be less accurate than those of the States. Third, due to the lack of uniform common names for certain fishes throughout the Great Lakes region, there may be considerable difference in the size of the catch credited to each species by the various agencies collecting the statistics. The following tables, giving a comparison between State and bureau statistics by species and by Lakes, clearly show this difference. However, the State statistics are available for consecutive years and probably are collected in a sufficiently comparable manner to be of considerable value in showing the trend in the yield of the fisheries of the Great Lakes.

Comparison by species of the statistics of the Great Lakes, including Lake of the Woods, as obtained from State reports and a canvas by the Bureau of Fisheries for the years 1917 and 1922 (expressed in thousands of pounds; that is, 000 omitted)

Species	1917		1922	
	From State reports	From Bureau of Fisheries reports	From State reports	From Bureau of Fisheries reports
Lake trout	10,733	13,344	11,101	13,727
Whitefish	5,773	6,238	4,325	4,296
Lake herring, Chubs, Cisco	44,803	53,529	28,117	36,010
Sturgeon	49	108	33	103
Yellow pike	3,457	2,770	2,907	4,076
Blue pike	1,655	2,103	10,361	14,590
Sauger	4,336	3,929	4,623	6,002
Sucker, "mullet"	5,699	5,571	3,788	5,492
Sheepshead	3,013	2,902	1,415	2,414
Yellow perch	4,086	4,209	3,555	4,903
Pike (jacks)	461	352	402	402
Carp	4,602	7,563	5,094	7,869
White bass	333	287	831	1,031
Catfish and bullheads	2,296	883	805	1,758
Burbot	69	936	323	400
Miscellaneous	4,438	430	1,756	395
Total	95,893	105,154	79,436	103,528

Comparison by lakes of the statistics of the Great Lakes, including Lake of the Woods, as obtained from State reports and as canvassed by the Bureau of Fisheries for the years 1917 and 1922 (expressed in thousands of pounds; that is, 000 omitted)

Lakes	1917		1922	
	States	U. S. Bureau of Fisheries	States	U. S. Bureau of Fisheries
Ontario	656	1,054	889	1,026
Erie	41,416	38,710	40,912	55,078
Huron	12,512	13,363	13,481	13,942
Michigan	29,317	35,381	16,605	21,056
Superior	9,889	15,547	6,569	10,988
Woods	2,103	1,099	978	1,438
Total	95,893	105,154	79,434	103,528

GENERAL STATISTICS

The Great Lakes, with their cisco, trout, whitefish, herring, and pike fisheries, constitute one of our important fishery sections. While the total yield is considerably less than in some other fishery sections, the value is unusually high in proportion. The total yield of this fishery in the United States and Canada in 1913 was 102,826,000 pounds. The high peak was reached in 1918, with a production of 149,523,000 pounds, and then followed a decline to 100,289,000 pounds in 1925. Considered alone, the yield in the United States was 68,309,000 pounds in 1913, reached the high peak of 108,948,000 pounds in 1915, and then declined to 69,132,000 pounds in 1925. The Canadian catch, which was only about one-half as large as the United States catch, followed a similar course, but which was less pronounced.

Yield by lakes.—Considered separately, the total yield by lakes shows varying tendencies during the period 1913 to 1925. The Lake Erie yield, which always has ranked first in amount, shows a downward tendency since 1913. This condition is reflected especially in the American catch, while that for Canada has remained fairly stable. The catch in Lake Michigan, which is taken entirely in American waters and which usually ranks second in amount, also shows a downward trend. The yield of Lake Huron, which usually ranks third in amount, also shows a tendency downward. As the Canadian catch in this lake has been fairly uniform, the decrease is due to the smaller catch in American waters.

The yield of Lake Superior (fourth in importance as to amount, and which reached its peak in 1918) suffered a decline until 1922 but now seems to be growing. This condition is due largely to the gradually increasing catch in American waters in the face of the somewhat diminishing catch in Canadian waters. The yield of Lake Ontario (fifth in importance in amount) increased until 1921 and since that year has shown a decline, which is reflected in the fisheries of both American and Canadian waters. The yield of Lake of the Woods, which usually is of least importance, as to amount, in the international Lakes, registered a decline from 1917 to 1921. From that year until 1925 the yield increased markedly, with that of 1925 being nearly as great as that of 1915 and greater than that for Lake

Ontario for 1925. The increased catch in the Canadian waters of this lake is responsible for this condition, inasmuch as the catch in the United States has not been decidedly upward.

Yield by species.—The yields of individual species have registered varying trends. The most remarkable of these is shown in the record for cisco of Lake Erie. Beginning with a catch in the United States and Canada of 24,121,000 pounds in 1913, it increased to 48,823,000 in 1918, remained between about 20,000,000 and 32,000,000 pounds until 1924, and then decreased to 5,657,000 pounds in 1925. The United States catch in this lake has been two to three times as large as that of Canada during the years 1913 to 1924. In 1925 the catch was about equally divided between the two countries. The trends of catch have been similar in each country, though the decline in 1925 was more severe in the United States than in Canada. The yield of lake herring was 15,301,000 pounds in 1913, reached a high peak of 26,536,000 pounds in 1918, and declined to 16,232,000 pounds in 1925. The vast majority of the lake herring were produced in the United States. The yield of chubs (a fish sometimes classed with the cisco or lake herring) registered 5,492,000 pounds in 1913, a high peak of 8,094,000 pounds in 1918, and a decline to 6,445,000 pounds in 1925. Only about 6 per cent of each year's catch was contributed by the Canadian chub fisheries.

The yield of lake trout has remained fairly constant over this period, with a yield of 16,238,000 pounds in 1913, increasing to 18,206,000 pounds in 1919, and then decreasing to 17,985,000 pounds in 1925. This is true in both the United States and Canada, although the production in the United States was always about twice that for Canada. The yield of whitefish also has remained almost unchanged, with a reported production of 8,797,000 pounds in 1913, rising to 11,405,000 pounds in 1918, and then slightly declining to 9,328,000 pounds in 1925. In each year of this period the production in Canada exceeded the catch in United States waters by several hundred thousand pounds to over 2,000,000 pounds.

The total yield of blue pike has shown successive periods of very high and very low production. In 1913 the total yield amounted to 2,370,000 pounds, then increased to 23,693,000 pounds in 1915, decreased to 2,130,000 pounds in 1918, increased again to 16,703,000 in 1922, and decreased again to 13,958,000 pounds in 1925. The catch in the United States usually has been much larger than in Canada—in some years nearly four times as large. The only exception is found in 1919, when the Canadian catch was considerably larger than the United States catch. In general, the fluctuations in the two countries have been very similar. The total yield of yellow pike was about 4,077,000 pounds in 1913, increased to 6,795,000 in 1914, and then declined to 4,663,000 pounds in 1925. Since 1916 the United States catch has tended to decrease and the Canadian catch to increase. In 1916 the United States catch was about 70 per cent larger than the Canadian catch, but since 1923 the catches of the two countries have been about equal.

The total yield of yellow perch, varying between 5,443,000 and 7,966,000 pounds, was relatively constant during the period 1913 to 1925, although the United States catch has declined while the Canadian catch has increased. In the early part of this period the United States catch was about five times the Canadian catch, but since 1922 it has been less than twice the Canadian catch.

The following table shows the yield of these and the remaining species, as recorded by the States bordering the Great Lakes and as published by the Canadian Government.

Yield of the fisheries of the Great Lakes and Lake of the Woods, 1913 to 1925 (expressed in thousands of pounds; that is, 000 omitted)

LAKE TROUT

Year	Lake Ontario			Lake Erie			Lake Huron		
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total
1913	27	548	575	2	2	4	2,163	3,324	5,487
1914	[1] 29	600	629	9	2	11	1,357	3,009	4,366
1915	31	551	582	17	2	19	1,774	3,901	5,675
1916	14	348	362	21	4	25	1,734	3,729	5,463
1917	24	464	488	5	2	7	2,111	3,490	5,601
1918	22	386	408	33	2	35	2,601	3,478	6,079
1919	26	553	579	12	2	14	2,316	3,322	5,638
1920	28	459	487	2	1	3	1,210	2,870	4,080
1921	[1] 25	529	554	46	1	47	1,358	3,176	4,534
1922	[1] 34	721	755	2	1	3	1,827	3,769	5,596
1923	[1] 36	749	785	1	([2])	1	1,827	3,397	5,224
1924	45	939	984	1	1	2	1,421	3,790	5,211
1925	70	1,063	1,133	4	1	5	1,502	3,798	5,300

Year	Lake Michigan, United States	Lake Superior			Lake of the Woods, Canada	Total		
		United States	Canada	Total		United States	Canada	Total
1913	6,307	[3] 2,373	1,402	3,775	90	10,872	5,366	16,238
1914	6,837	[3] 1,667	1,439	3,106	162	9,899	5,212	15,111
1915	7,704	[3] 1,366	1,645	3,011	93	10,892	6,192	17,084
1916	5,999	[3] 2,166	1,502	3,668	75	9,934	5,658	15,592
1917	6,612	1,981	1,661	3,642	112	10,733	5,729	16,462
1918	4,810	2,318	2,659	4,977	94	9,784	6,619	16,403
1919	6,482	3,442	1,960	5,402	91	12,278	5,928	18,206
1920	[3] 6,782	[3] 2,044	1,332	3,376	123	10,066	4,785	14,851
1921	6,689	2,121	1,513	3,634	80	10,239	5,299	15,538
1922	7,065	2,173	1,872	4,045	88	11,101	6,451	17,552
1923	6,177	1,900	1,956	3,856	73	9,941	6,175	16,116
1924	6,628	2,049	1,711	3,760	86	10,144	6,527	16,671
1925	6,894	2,655	1,868	4,523	130	11,125	6,860	17,985

WHITEFISH

Year	Lake Ontario			Lake Erie			Lake Huron			Lake Michigan
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total	United States
1913	16	473	489	1,509	1,939	3,448	745	1,010	1,755	1,355
1914	[1] 21	516	537	2,083	1,993	4,076	1,444	1,194	2,638	1,439
1915	27	810	837	1,145	1,832	2,977	871	1,101	1,972	1,613
1916	38	1,131	1,169	930	1,086	2,016	1,996	1,240	3,236	1,693
1917	116	1,140	1,256	1,777	1,240	3,017	889	1,069	1,958	2,663
1918	101	1,274	1,375	1,600	1,128	2,728	1,170	1,113	2,283	2,427
1919	76	1,586	1,662	1,723	1,094	2,817	785	1,281	2,066	1,548
1920	44	2,024	2,068	1,426	818	2,244	692	1,430	2,122	[4] 1,151
1921	[1] 109	2,157	2,266	922	965	1,887	815	1,286	2,101	1,397
1922	[1] 106	2,097	2,203	791	751	1,542	1,635	1,389	3,024	1,435
1923	[1] 130	2,564	2,694	489	536	1,025	1,231	1,517	2,748	1,634
1924	137	2,654	2,791	331	580	911	1,427	1,476	2,903	1,601
1925	111	1,926	2,037	583	1,033	1,616	1,049	1,617	2,666	1,652

[1] New York yield estimated.
[2] Yield less than 500 pounds.
[3] Minnesota yield estimated.
[4] Wisconsin yield estimated.

Yield of the fisheries of the Great Lakes and Lake of the Woods, 1913 to 1925 (expressed in thousands of pounds; that is, 000 omitted)—Continued

WHITEFISH—Continued

Year	Lake Superior			Lake of the Woods			Total		
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total
1913	[3] 67	373	440	[3] 111	1,199	1,310	3,803	4,994	8,797
1914	[3] 372	338	710	92	995	1,087	5,451	5,036	10,487
1915	[3] 600	842	1,442	125	1,350	1,475	4,381	5,935	10,316
1916	[3] 231	465	696	64	685	749	4,952	4,607	9,559
1917	265	446	711	63	681	744	5,773	4,576	10,349
1918	334	1,517	1,851	63	678	741	5,695	5,710	11,405
1919	266	2,030	2,296	46	496	542	4,444	6,487	10,931
1920	[4] 282	1,705	1,987	39	398	437	3,634	6,375	10,009
1921	259	1,497	1,756	30	385	415	3,532	6,290	9,822
1922	330	1,198	1,528	28	590	618	4,325	6,025	10,350
1923	154	1,267	1,421	39	604	643	3,677	6,488	10,165
1924	269	283	552	29	735	764	3,794	5,728	9,522
1925	247	347	594	26	737	763	3,668	5,660	9,328

LAKE HERRING

Year	Lake Ontario			Lake Huron			Lake Michigan
	United States	Canada	Total	United States	Canada	Total	United States
1913	85	686	771	2,399	217	2,616	8,452
1914	[1] 159	991	1,150	2,357	211	2,568	7,476
1915	232	1,706	1,938	1,491	360	1,851	10,071
1916	188	1,610	1,798	7,674	291	7,965	6,781
1917	381	1,930	2,311	4,411	506	4,917	8,540
1918	206	1,795	2,001	5,044	332	5,376	7,335
1919	181	1,709	1,890	4,836	232	5,068	10,932
1920	144	1,288	1,432	3,387	246	3,633	[4] 6,710
1921	1,521	1,014	2,535	2,164	189	2,353	2,472
1922	514	243	857	4,396	269	4,665	3,248
1923	59	250	309	3,039	229	3,268	2,930
1924	394	263	657	3,090	255	3,345	3,223
1925	47	294	341	1,412	242	1,654	4,143

Year	Lake Superior			Total		
	United States	Canada	Total	United States	Canada	Total
1913	[3] 3,163	299	3,462	14,099	1,202	15,301
1914	[3] 4,420	782	5,202	14,412	1,984	16,396
1915	[3] 3,130	2,777	5,907	14,924	4,843	19,767
1916	[3] 2,338	3,127	5,465	16,981	5,028	22,005
1917	7,009	2,443	9,452	20,341	4,879	25,220
1918	8,142	3,682	11,824	20,727	5,809	26,536
1919	6,344	1,508	7,852	22,293	3,449	25,742
1920	[4] 6,562	1,287	7,849	16,803	2,821	19,624
1921	4,728	425	5,153	10,885	1,628	12,513
1922	3,573	577	4,150	11,731	1,189	12,920
1923	5,132	1,079	6,211	11,160	1,558	12,718
1924	6,108	1,050	7,158	12,815	1,568	14,383
1925	8,947	1,147	10,094	14,549	1,683	16,232

[1] New York yield estimated. [3] Minnesota yield estimated. [4] Wisconsin yield estimated

Yield of the fisheries of the Great Lakes and Lake of the Woods, 1913 to 1925 (expressed in thousands of pounds; that is, 000 omitted)—Continued

CHUBS

Year	Lake Huron			Lake Michigan	Lake Superior			Total		
	United States	Canada	Total	United States	United	Canada	Total	United States	Canada	Total
1913	919	329	1,248	4,210	33	1	34	5,162	330	5,492
1914	52	479	531	3,863	23	7	30	3,938	486	4,424
1915	513	365	878	3,297	55	9	64	3,865	374	4,239
1916	23	649	672	3,142	82	2	84	3,247	651	3,898
1917	214	819	1,033	4,697	188	-------	188	5,099	819	5,918
1918	742	375	1,117	6,758	210	9	219	7,710	384	8,094
1919	498	250	748	5,772	80	1	81	6,350	251	6,601
1920	243	303	546	3,545	59	(2)	59	3,847	303	4,150
1921	494	254	748	1,850	94	(2)	94	2,438	254	2,692
1922	341	207	548	1,860	163	(2)	163	2,364	207	2,571
1923	369	203	572	1,488	98	1	99	1,955	204	2,159
1924	255	241	496	2,703	[3] 83	1	84	3,041	242	3,283
1925	1,480	429	1,909	4,481	55	(2)	55	6,016	429	6,445

CISCO

Year	Lake Erie			Year	Lake Erie		
	United States	Canada	Total		United States	Canada	Total
1913	12,513	11,608	24,121	1920	12,893	9,651	22,544
1914	14,108	5,982	20,090	1921	14,964	5,225	20,189
1915	15,978	5,574	21,552	1922	14,022	6,306	20,328
1916	8,337	5,211	13,548	1923	20,930	9,241	30,171
1917	19,453	14,158	33,611	1924	21,293	10,908	32,201
1918	35,291	13,532	48,823	1925	2,817	2,840	5,657
1919	17,846	7,426	25,272				

STURGEON

Year	Lake Ontario			Lake Erie			Lake Huron			Lake Michigan
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total	United States
1913	4	(2)	4	6	48	54	8	51	59	12
1914	[1] 7	(2)	7	12	56	68	7	52	59	11
1915	10	2	12	20	56	76	28	46	74	13
1916	5	3	8	38	68	106	7	29	36	7
1917	3	2	5	28	47	75	4	33	37	6
1918	12	2	14	16	52	68	4	34	38	26
1919	4	-------	4	19	43	62	57	26	83	7
1920	2	1	3	9	(2)	9	12	26	38	13
1921	[1] 3	2	5	8	-------	8	4	24	28	7
1922	[1] 3	2	5	15	36	51	3	27	30	8
1923	[1] 5	3	8	1	41	42	2	25	27	7
1924	12	7	19	7	44	51	2	22	24	5
1925	4	6	10	7	42	49	1	22	23	9

[1] New York yield estimated. [2] Yield less than 500 pounds. [3] Minnesota yield estimated.

Yield of the fisheries of the Great Lakes and Lake of the Woods, 1913 to 1925 (expressed in thousands of pounds; that is, 000 omitted)—Continued

STURGEON—Continued

Year	Lake Superior			Lake of the Woods			Total		
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total
1913	1	3	4	[3] 36	90	126	67	192	259
1914	1	9	10	[3] 38	96	134	76	213	289
1915	4	16	20	[3] 34	86	120	109	206	315
1916	(2)	3	3	[3] 3	9	12	60	112	172
1917	------	5	5	[3] 8	20	28	49	107	156
1918	(2)	6	6	[3] 10	24	34	68	118	186
1919	3	22	25	6	14	20	96	105	201
1920	(2)	31	31	4	9	13	40	67	107
1921	(2)	26	26	3	2	5	25	54	79
1922	1	23	24	3	4	7	33	92	125
1923	1	27	28	4	14	18	20	110	130
1924	1	4	5	3	43	46	30	120	150
1925	(2)	3	3	3	17	20	24	90	114

YELLOW PIKE

Year	Lake Ontario			Lake Erie			Lake Huron			Lake Michigan, United States
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total	
1913	4	27	31	422	964	1,386	416	604	1,020	165
1914	------	64	64	1,850	2,086	3,936	340	667	1,007	225
1915	5	86	91	1,824	608	2,432	1,067	586	1,653	216
1916	5	40	45	2,025	599	2,624	846	539	1,385	275
1917	5	54	59	1,617	227	1,844	1,147	501	1,648	194
1918	12	15	27	814	184	998	1,904	466	2,370	121
1919	8	40	48	597	144	741	1,388	485	1,873	122
1920	9	37	46	884	166	1,050	844	449	1,293	[4] 113
1921	[1] 23	73	96	1,032	311	1,343	724	324	1,048	141
1922	[1] 36	116	152	1,051	505	1,556	1,284	446	1,730	64
1923	[1] 52	168	220	1,127	603	1,730	809	483	1,292	99
1924	38	122	160	1,002	615	1,617	729	502	1,231	111
1925	29	71	100	1,431	224	1,655	122	500	622	93

Year	Lake Superior			Lake of the Woods			Total		
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total
1913	62	104	166	[3] 429	880	1,309	1,498	2,579	4,077
1914	61	129	190	[3] 450	923	1,373	2,926	3,869	6,795
1915	71	180	251	[3] 567	1,164	1,731	3,750	2,624	6,374
1916	30	90	120	[3] 313	641	954	3,494	1,909	5,403
1917	25	70	95	[3] 469	962	1,431	3,457	1,814	5,271
1918	45	107	152	[3] 367	753	1,120	3,263	1,525	4,788
1919	17	141	158	408	837	1,245	2,540	1,647	4,187
1920	[4] 18	119	137	389	649	1,038	2,257	1,420	3,677
1921	[5] 22	199	221	352	972	1,324	2,294	1,879	4,173
1922	28	164	192	444	1,042	1,486	2,907	2,273	5,180
1923	22	159	181	652	1,152	1,804	2,761	2,565	5,326
1924	23	81	104	659	1,398	2,057	2,562	2,718	5,279
1925	19	94	113	626	1,454	2,080	2,320	2,343	4,663

[1] New York yield estimated.
[2] Yield less than 500 pounds.
[3] Minnesota yield estimated.
[4] Wisconsin yield estimated.
[5] Michigan yield estimated.

Yield of the fisheries of the Great Lakes and Lake of the Woods, 1913 to 1925 (expressed in thousands of pounds; that is, 000 omitted)—Continued

BLUE PIKE

Year	Lake Ontario			Lake Erie			Total		
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total
1913	39	--------	39	1,843	[6] 488	2,331	1,882	488	2,370
1914	[1] 39	--------	39	11,396	[6] 2,968	14,364	11,435	2,968	14,403
1915	50	--------	50	18,761	4,882	23,643	18,811	4,882	23,693
1916	22	--------	22	9,381	2,539	11,920	9,403	2,539	11,942
1917	50	--------	50	1,605	565	2,170	1,655	565	2,220
1918	108	15	123	1,222	785	2,007	1,330	800	2,130
1919	35	3	38	1,675	2,388	4,063	1,710	2,391	4,101
1920	[1] 18	10	28	3,965	3,355	7,320	3,983	3,365	7,348
1921	[1] 2	23	25	8,944	6,367	15,311	8,946	6,390	15,336
1922	[1] 2	29	31	10,359	6,313	16,672	10,361	6,342	16,703
1923	[1] 3	50	53	9,683	3,194	12,877	9,686	3,244	12,930
1924	3	48	51	8,967	2,988	11,955	8,970	3,036	12,006
1925	35	15	50	10,478	3,430	13,908	10,513	3,445	13,958

SAUGER

Year	Lake Erie, United States	Year	Lake Erie, United States	Year	Lake Erie, United States
1913	1,248	1918	2,101	1922	4,623
1914	4,569	1919	2,655	1923	3,321
1915	4,533	1920	2,932	1924	1,847
1916	6,187	1921	5,010	1925	2,119
1917	4,336				

SUCKERS OR "MULLET" [7]

Year	United States					
	Lake Ontario	Lake Erie	Lake Huron	Lake Michigan	Lake Superior	Total
1913	9	466	1,580	700	[3] 240	2,995
1914	[1] 16	1,316	1,501	3,093	[3] 259	6,185
1915	23	1,124	2,306	824	[3] 240	4,517
1916	17	1,321	2,266	963	[3] 234	4,801
1917	13	1,058	1,465	2,955	208	5,699
1918	20	911	1,779	663	176	3,549
1919	40	953	2,714	1,097	204	5,008
1920	17	1,061	1,900	919	181	4,078
1921	[1] 20	[1] 1,420	1,803	639	159	4,041
1922	[1] 20	[1] 991	1,986	626	165	3,788
1923	24	1,038	1,445	570	110	3,187
1924	92	684	1,182	619	146	2,723
1925	40	905	772	905	140	2,762

SHEEPSHEAD

Year	United States				Year	United States			
	Lake Erie	Lake Huron	Lake Michigan	Total		Lake Erie	Lake Huron	Lake Michigan	Total
1913	596	--------	--------	596	1920	1,926	42	16	1,984
1914	2,282	--------	--------	2,282	1921	2,842	47	16	2,905
1915	2,212	--------	--------	2,212	1922	1,370	42	3	1,415
1916	2,384	--------	--------	2,384	1923	1,456	58	7	1,521
1917	3,013	--------	--------	3,013	1924	2,288	41	5	2,334
1918	2,982	--------	--------	2,982	1925	2,365	18	12	2,395
1919	2,119	13	18	2,150					

[1] New York yield estimated.
[3] Minnesota yield estimated.
[6] Estimated.
[7] Mullet in Lake of the Woods are included with miscellaneous fish.

Yield of the fisheries of the Great Lakes and Lake of the Woods, 1913 to 1925 (expressed in thousands of pounds; that is, 000 omitted)—Continued

YELLOW PERCH

Year	Lake Ontario			Lake Erie			Lake Huron			Lake Michigan, United States
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total	
1913	4	125	129	756	955	1,711	2,323	61	2,384	2,935
1914	------	105	105	2,026	1,408	3,434	997	137	1,134	2,731
1915	7	119	126	1,933	1,042	2,975	1,371	189	1,560	2,790
1916	4	167	171	1,637	769	2,406	1,795	170	1,965	2,263
1917	5	214	219	1,259	995	2,254	891	147	1,038	1,927
1918	3	108	111	1,088	2,056	3,144	934	78	1,012	1,928
1919	3	159	162	2,775	1,097	3,872	1,337	85	1,422	2,490
1920	4	107	111	1,259	1,272	2,531	1,051	142	1,193	[4] 2,257
1921	[1] 10	87	97	2,192	1,965	4,157	945	143	1,088	2,105
1922	[1] 8	74	82	1,926	2,109	4,035	674	148	822	924
1923	[1] 9	83	92	1,870	2,397	4,267	759	142	901	873
1924	9	80	89	1,940	2,192	4,132	330	108	438	1,044
1925	9	90	99	2,458	2,060	4,518	114	74	188	1,512

Year	Lake Superior			Lake of the Woods			Total		
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total
1913	7	--------	7	--------	--------	--------	6,025	1,141	7,166
1914	17	(2)	17	(2 3)	1	1	5,771	1,651	7,422
1915	17	(2)	17	[3] 6	8	14	6,124	1,358	7,482
1916	3	(2)	3	[3] 6	8	14	5,708	1,114	6,822
1917	3	--------	3	[3] 1	1	2	4,086	1,357	5,443
1918	19	--------	19	[3] 6	7	13	3,978	2,249	6,227
1919	3	--------	3	7	10	17	6,615	1,351	7,966
1920	[4] 13	--------	13	7	12	19	4,591	1,533	6,124
1921	10	--------	10	6	8	14	5,268	2,203	7,471
1922	17	(2)	17	6	15	21	3,555	2,346	5,901
1923	6	--------	6	8	5	13	3,525	2,627	6,152
1924	9	(2)	9	13	10	23	3,345	2,390	5,735
1925	2	--------	2	15	9	24	4,116	2,233	6,343

PIKE (JACKS)

Year	Lake Ontario	Lake Erie			Lake Huron			Lake Michigan
	Canada	United States	Canada	Total	United States	Canada	Total	United States
1913	221	[5] 55	2,288	2,343	[5] 40	126	166	[6] 28
1914	248	[5] 71	2,927	2,998	[5] 27	201	228	40
1915	337	[5] 15	630	645	[5] 5	180	185	[6] 51
1916	283	[5] 11	437	448	[5] 27	125	152	[6] 63
1917	280	[5] 3	142	145	[5] 43	196	239	[6] 74
1918	213	[5] 6	229	235	[5] 36	100	136	[6] 85
1919	246	18	727	745	83	192	275	97
1920	311	29	115	144	69	118	187	[6] 79
1921	233	30	97	127	82	229	311	93
1922	250	6	144	150	53	217	270	94
1923	281	5	130	135	54	197	251	38
1924	256	6	72	78	38	195	233	35
1925	192	7	29	36	18	197	215	26

[1] New York yield estimated.
[2] Yield less than 500 pounds.
[3] Minnesota yield estimated.
[4] Wisconsin yield estimated.
[5] Michigan yield estimated.
[6] Michigan and Wisconsin yields estimated.

Yield of the fisheries of the Great Lakes and Lake of the Woods, 1913 to 1925 (expressed in thousands of pounds; that is, 000 omitted)—Continued

PIKE (JACKS)—Continued

Year	Lake Superior			Lake of the Woods			Total		
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total
1913	[4] 6	38	44	[3] 298	693	991	427	3,366	3,793
1914	[4] 29	201	230	[3] 327	761	1,088	494	4,338	4,832
1915	[4] 10	71	81	[3] 525	1,222	1,747	606	2,440	3,046
1916	[4] 4	25	29	[3] 218	508	726	323	1,378	1,701
1917	[4] 3	18	21	[3] 338	787	1,125	461	1,423	1,884
1918	([2])	18	18	[3] 290	674	964	417	1,234	1,651
1919	3	19	22	273	635	908	474	1,819	2,293
1920	4	15	19	425	449	874	606	1,008	1,614
1921	10	54	64	251	451	702	466	1,064	1,530
1922	13	30	43	236	488	724	402	1,129	1,531
1923	10	23	33	237	455	692	344	1,086	1,430
1924	84	19	103	237	603	840	400	1,145	1,545
1925	7	12	19	211	730	941	269	1,160	1,429

CARP

Year	Lake Ontario			Lake Erie			Lake Huron		
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total
1913	1	48	49	1,690	374	2,064	375	2	377
1914	[1] 1	81	82	[1] 12,024	1,395	13,419	14	14	28
1915	1	113	114	9,615	905	10,520	516	27	543
1916	1	268	269	5,859	782	6,641	-------	35	35
1917	7	391	398	4,569	667	5,236	26	16	42
1918	([2])	142	142	4,172	711	4,883	643	14	657
1919	3	169	172	2,961	378	3,339	1,109	62	1,171
1920	([2])	66	66	4,102	432	4,534	1,721	76	1,797
1921	[1] 17	63	80	[1] 6,542	345	6,887	857	83	940
1922	[1] 32	121	153	[1] 3,887	234	4,121	1,169	70	1,239
1923	261	103	364	3,215	286	3,501	297	59	356
1924	21	78	99	1,256	289	1,545	496	50	546
1925	1	30	31	2,339	244	2,583	57	46	103

Year	Lake Michigan	Lake Superior			Lake of the Woods	Total		
	United States	United States	Canada	Total	Canada	United States	Canada	Total
1913	6	-------	-------	-------	-------	2,072	424	2,496
1914	-------	-------	-------	-------	125	12,039	1,615	13,654
1915	9	-------	1	1	190	10,141	1,236	11,377
1916	1	-------	-------	-------	12	5,861	1,097	6,958
1917	-------	-------	1	1	([2])	4,602	1,075	5,677
1918	5	-------	1	1	12	4,820	880	5,700
1919	7	-------	-------	-------	53	4,080	662	4,742
1920	5	([2])	-------	-------	9	5,828	583	6,411
1921	4	-------	5	5	8	7,420	504	7,924
1922	6	-------	7	7	3	5,094	435	5,529
1923	7	-------	5	5	14	3,780	467	4,247
1924	7	-------	2	2	14	1,780	433	2,213
1925	12	-------	-------	-------	7	2,409	327	2,736

[1] New York yield estimated.
[2] Yield less than 500 pounds.
[3] Minnesota yield estimated.
[4] Wisconsin yield estimated.

Yield of the fisheries of the Great Lakes and Lake of the Woods, 1913 to 1925 (expressed in thousands of pounds; that is, 000 omitted)—Continued

WHITE BASS

Year	United States			
	Lake Erie	Lake Michigan	Lake Superior	Total
1913	512	14	....	526
1914	478	(2)	....	478
1915	694	1	....	695
1916	343	....	(2)	343
1917	333	....	....	333
1918	129	(2)	....	129
1919	193	10	2	205
1920	504	[4] 10	....	514
1921	841	12	....	853
1922	821	[4] 10	....	831
1923	300	[4] 10	....	310
1924	182	[4] 10	....	192
1925	232	....	....	232

CATFISH

Year	Lake Ontario			Lake Erie			Lake Huron		
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total
1913	2	279	281	160	27	187	[8] 34	9	43
1914	[1] 1	269	270	771	49	820	[8] 29	5	34
1915	1	268	269	592	38	630	[8] 3	10	13
1916	15	302	317	1,247	23	1,270	[8] 19	6	25
1917	3	225	228	2,191	37	2,228	[8] 102	8	110
1918	2	236	238	420	47	467	[8] 92	5	97
1919	1	248	249	1,091	34	1,125	70	6	76
1920	1	170	171	730	42	772	43	4	47
1921	[1] 49	184	233	1,422	46	1,468	28	18	46
1922	[1] 47	178	225	705	58	763	49	7	56
1923	[1] 48	181	229	642	58	700	22	8	30
1924	43	162	205	275	57	332	48	7	55
1925	3	122	125	685	37	722	22	8	30

Year	Lake Michigan	Lake Superior	Lake of the Woods	Total		
	United States	Canada	Canada	United States	Canada	Total
1913	....	....	17	196	332	528
1914	....	3	66	801	392	1,193
1915	....	....	119	596	435	1,031
1916	....	(2)	....	1,281	331	1,612
1917	....	(2)	8	2,296	278	2,574
1918	....	....	208	514	496	1,010
1919	2	....	77	1,164	365	1,529
1920	2	....	53	776	269	1,045
1921	3	....	51	1,502	299	1,801
1922	4	....	....	805	243	1,048
1923	4	....	....	716	247	963
1924	(2)	....	....	366	226	592
1925	125	....	66	835	233	1,068

TULLIBEES

Year	Lake of the Woods		
	United States	Canada	Total
1913	(9)	177	177
1914	(9)	127	127
1915	(9)	262	262
1916	(9)	139	139
1917	(9)	174	174
1918	(9)	240	240
1919	(9)	241	241
1920	(9)	129	129
1921	(9)	117	117
1922	(9)	131	131
1923	(9)	112	112
1924	(9)	255	255
1925	301	461	762

[1] New York yield estimated.
[2] Yield less than 500 pounds.
[4] Wisconsin yield estimated.
[8] Michigan yield estimated.
[9] Included with miscellaneous fish prior to 1925.

Yield of the fisheries of the Great Lakes and Lake of the Woods, 1913 to 1925 (expressed in thousands of pounds; that is, 000 omitted)—Continued

BURBOT

Year	United States					
	Lake Ontario	Lake Erie	Lake Huron	Lake Michigan	Lake Superior	Total
1913		42	(10)			42
1914		108	(10)			108
1915		45	(10)			45
1916		247	(10)			247
1917	46	23	(10)			69
1918	34	346	(10)			380
1919	94	407	18	22	1	542
1920	43	371	25	60	(2)	499
1921	[6] 40	441	1	7	1	490
1922	[6] 40	262	4	16	1	323
1923	[6] 40	255	8	7	(2)	310
1924	40	142	15	12	1	210
1925	84	130	(2)	55	(2)	269

MISCELLANEOUS FISH

Year	Lake Ontario			Lake Erie			Lake Huron			Lake Michigan
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total	United States
1913	19	550	569	300	860	1,160	182	550	732	2,810
1914	[1] 4	651	655	468	1,116	1,584	123	647	770	2,480
1915	8	658	666	1,001	970	1,971	300	552	852	5,091
1916	8	775	783	1,255	1,105	2,360	758	476	1,234	1,836
1917	3	844	847	146	700	846	1,209	518	1,727	1,649
1918	4	847	851	348	767	1,115	17	502	519	2,517
1919	1	770	771	110	795	905	16	538	554	1,214
1920	4	506	510	99	939	1,038	11	565	576	[4] 1,391
1921	36	529	565	75	1,087	1,162	8	652	660	1,583
1922	47	595	642	83	1,227	1,310	18	613	631	1,242
1923	43	502	545	45	1,287	1,332		551	551	1,507
1924	215	575	790	43	1,231	1,274		614	614	1,691
1925	13	542	555	79	1,140	1,219	(2)	815	815	1,791

Year	Lake Superior			Lake of the Woods			Total		
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total
1913	465	111	576	[3] 510	247	757	4,286	2,318	6,604
1914	239	26	265	[3] 339	164	503	3,663	2,604	6,257
1915	201	157	358	[3] 168	141	309	6,769	2,478	9,247
1916	349	250	599	[3] 683	366	1,049	4,889	2,972	7,861
1917	207	333	540	[3] 1,224	593	1,817	4,438	2,988	7,426
1918	302	755	1,057	[3] 753	377	1,130	3,941	3,248	7,189
1919	135	290	425	537	260	797	2,013	2,653	4,666
1920	104	143	247	435	197	632	2,044	2,350	4,394
1921	72	88	160	406	166	572	2,180	2,522	4,702
1922	105	114	219	261	152	413	1,756	2,701	4,457
1923	151	50	201	219	135	354	1,965	2,525	4,490
1924	171	65	236	315	212	527	2,435	2,697	5,132
1925	235	96	331	281	800	1,081	2,399	3,393	5,792

[1] New York yield estimated.
[2] Yield less than 500 pounds.
[3] Minnesota yield estimated.
[4] Wisconsin yield estimated.
[6] Estimated.
[10] Included with miscellaneous fish prior to 1919.

Yield of the fisheries of the Great Lakes and Lake of the Woods, 1913 to 1925 (expressed in thousands of pounds; that is, 000 omitted)—Continued

SUMMARY OF THE YIELD BY LAKES AND YEARS

Year	Lake Ontario			Lake Erie			Lake Huron			Lake Michigan
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total	United States
1913	210	2,957	3,167	22,120	19,553	41,673	11,184	6,283	17,467	26,994
1914	277	3,525	3,802	53,571	19,982	73,553	8,248	6,616	14,864	28,195
1915	395	4,650	5,045	59,509	16,539	76,048	10,245	7,317	17,562	31,680
1916	317	4,927	5,244	41,223	12,623	53,846	17,145	7,289	24,434	23,023
1917	656	5,544	6,200	41,416	18,780	60,196	12,512	7,303	19,815	29,317
1918	524	5,033	5,557	51,479	19,493	70,972	14,966	6,497	21,463	26,675
1919	472	5,483	5,955	35,154	14,128	49,282	15,240	6,479	21,719	29,820
1920	314	4,979	5,293	32,192	16,791	47,983	11,250	6,229	17,479	23,053
1921	1,855	4,894	6,749	46,731	16,409	63,140	9,330	6,378	15,708	17,018
1922	889	4,526	5,415	40,912	17,684	58,596	13,481	7,162	20,643	16,605
1923	710	4,934	5,644	44,878	17,773	62,151	9,920	6,811	16,731	15,358
1924	1,049	5,184	6,233	40,264	18,977	59,241	9,074	7,260	16,334	17,694
1925	446	4,351	4,797	26,639	11,080	37,719	6,567	7,748	14,315	21,710

Year	Lake Superior			Lake of the Woods			Total		
	United States	Canada	Total	United States	Canada	Total	United States	Canada	Total
1913	6,417	2,331	8,748	1,384	3,393	4,777	68,309	34,517	102,826
1914	7,088	2,934	10,022	1,246	3,420	4,666	98,625	36,477	135,102
1915	5,694	5,698	11,392	1,425	4,635	6,060	108,948	38,839	147,787
1916	5,437	5,464	10,901	1,287	2,443	3,730	88,432	32,746	121,178
1917	9,889	4,977	14,866	2,103	3,338	5,441	95,893	39,942	135,835
1918	11,546	8,754	20,300	1,489	3,067	4,556	106,679	42,844	149,523
1919	10,500	5,971	16,471	1,277	2,714	3,991	92,463	34,775	127,238
1920	9,267	4,632	13,899	1,299	2,028	3,327	77,375	34,659	112,034
1921	7,476	3,807	11,283	1,048	2,240	3,288	83,458	33,728	117,186
1922	6,569	3,985	10,554	978	2,513	3,491	79,434	35,870	115,304
1923	7,584	4,567	12,151	1,159	2,544	3,703	79,109	36,629	115,738
1924	8,944	3,216	12,160	1,256	3,356	4,612	78,281	37,993	116,274
1925	12,307	3,567	15,874	1,463	4,411	5,874	69,132	31,157	100,289

FISHERIES OF THE PACIFIC COAST STATES, 1924

The plan adopted for obtaining annual statistics on the fisheries of the Pacific Coast States in 1923 was used again in the canvass of these States for 1924. The statistics given herein are the available State statistics, supplemented and made uniform in character and scope by canvassing the industry for the necessary additional information.[4]

The Pacific Coast States, with their valuable salmon, halibut, tuna, and sardine fisheries, constitute one of our most important fishery sections. In 1924 there were 15,359 persons, 560 vessels

[4] The State of Washington requires reports from fishermen and fish dealers on the quantity of each species caught within the territorial limits of the State. Oregon requires periodical reports from fish dealers on the quantities of certain species (salmon, shad, sturgeon, clams, and crabs). Values of these were calculated from estimates of average prices secured from fish dealers. Quantities and values of the remaining species and all fish caught in the high seas and Indian reservations were secured by canvassing. Statistics on persons, vessels, boats, and gear were obtained from the State license lists and supplemented by canvass, as in the case of quantities and values.

The State of California requires a carbon copy of the receipt for all fish landed in California by fishing vessels and boats, regardless of source. Fish caught in waters off the Mexican coast are designated separately. The statistics on quantities, by species, were taken from the State tabulations, and values were secured by calculating from price estimates of representative wholesalers. Statistics of the Alaska cod caught by California vessels, and of the California whaling operations, were secured direct from the companies concerned. Statistics on persons, boats, and gear were taken from the State's registration lists.

In Washington and Oregon the statistics were credited to the district in which the fishing was done, except the ocean fisheries, which were credited to the district in which the fish were landed. In California the statistics on the catch were credited to the district where landed, and the men, vessels, boats, gear, etc., to the home port of the fishermen.

fishing and transporting fish, 5,727 power boats, and 676 rowboats in these States engaged in producing 473,697,017 pounds of fish, shellfish, and whale products, valued at $20,052,214 to the fishermen.

Judging from first values, the salmon fishery was the most important of the Pacific coast fisheries, producing 101,960,651 pounds, valued at $7,825,101 to the fishermen. Next in importance was the tuna fishery, prosecuted in the waters of California, which produced 29,365,748 pounds of albacore, tuna, bonito, and skipjack, valued at $2,621,424. Of third importance was the halibut fishery, which centers at Seattle. The total catch credited to the Pacific Coast States was 15,973,183 pounds, valued at $2,138,170. In addition to this, vessels of the Pacific Coast States landed 3,798,508 pounds, valued at $363,881, in ports of Alaska. The sardine fishery of southern California ranked fourth, with 242,685,958 pounds, valued at $2,079,727.

Personnel and fishing craft employed in the fisheries of the Pacific Coast States, 1924

Items	Washington	Oregon	California	Total
	Number	*Number*	*Number*	*Number*
Vessel fishery:				
Fishermen	1,639	25	1,933	3,597
Vessels	217	6	337	560
Tonnage	6,175	68	5,821	12,064
Shore fishery:				
Fishermen	4,551	4,335	2,876	11,762
Power boats	2,036	2,178	1,513	5,727
Rowboats	261	283	132	676

Yield of the fisheries of the Pacific Coast States in 1924

Species	Washington		Oregon		California		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
FISH								
Albacore					17,695,362	$1,828,812	17,695,362	$1,828,812
Anchovies					346,951	1,984	346,951	1,984
Barracuda					7,128,523	257,022	7,128,523	257,022
Bonito					1,038,369	29,130	1,038,369	29,130
Carp	379,258	$11,376			75,965	1,554	455,223	12,930
Catfish					351,960	51,977	351,960	51,977
Cod, dry salted	3,700,791	176,815			2,884,028	190,041	6,584,819	366,856
Flounders	188,273	3,778			2,081,470	59,290	2,269,743	63,068
Grayfish	97,005	247			392,634	11,982	489,639	12,229
Hake					60,780	1,519	60,780	1,519
Halibut	15,329,569	2,040,881	510,977	$81,373	132,637	15,916	15,973,183	2,138,170
Halibut, "California"					2,576,261	348,759	2,576,261	348,759
Hardhead					19,023	761	19,023	761
Herring	183,444	1,836			435,620	8,602	619,064	10,438
Kingfish					384,317	8,892	384,317	8,892
"Lingcod"	476,926	15,025	51,630	1,549	400,432	24,026	928,988	40,600
Mackerel					3,240,534	86,834	3,240,534	86,834
Mullet					61,971	3,343	61,971	3,343
Pilchard or sardine					242,685,958	2,079,727	242,685,958	2,079,727
Pompano					17,579	7,855	17,579	7,855
Rock bass					466,208	38,876	466,208	38,876
Rockfishes	295,187	10,715	39,223	1,172	4,716,790	211,344	5,051,200	223,231
Sablefish	1,894,527	103,394	161,348	8,067	933,310	34,540	2,989,185	146,001
Salmon	58,625,990	3,953,098	33,319,392	2,846,165	10,015,269	1,025,838	101,960,651	7,825,101
Sculpin					109,070	10,213	109,070	10,213
Sea bass:								
Black					231,404	4,163	231,404	4,163
White, or squeteague					1,515,584	185,086	1,515,584	185,086
Shad	193,442	1,940	983,422	10,561	1,539,217	74,553	2,716,081	87,054
Sheepshead					24,267	493	24,267	493
Skates	10,179	103			131,137	1,967	141,316	2,070
Skipjack or striped tuna					3,780,971	179,210	3,780,971	179,210
Smelt:								
Silver	457,506	45,750			721,912	40,651	1,179,418	86,401
Eulachon	983,353	9,835	226,800	2,268			1,210,153	12,103
"Sole"	266,377	7,986			8,835,351	307,809	9,101,728	315,795
Steelhead trout	1,143,453	66,439	3,604,558	197,053	87,088	7,402	4,835,099	270,894
Striped bass					661,777	87,493	661,777	87,493
Sturgeon	86,205	6,109	175,507	10,821			261,712	16,930

Yield of the fisheries of the Pacific Coast States in 1924—Continued

Species	Washington		Oregon		California		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
FISH—continued								
Surf fishes	43,896	$2,194			288,969	$13,767	332,865	$15,961
Swordfish					31,833	3,610	81,833	3,610
Tomcod	424	4			42,524	978	42,948	982
Tuna:								
Bluefin					3,241,110	291,306	3,241,110	291.306
Yellowfin					3,063,398	244,389	3,063,398	244,389
Mixed					546,538	48,577	546,538	48,577
Whitebait					122,483	2,449	122,483	2,449
Whitefish					273,077	14,391	273,077	14,391
Yellowtail					4,714,149	375,156	4,714,149	375,156
Other fish					376,640	18,658	376,640	18,658
Total	84,355,805	6,457,525	39,072,857	$3,159,029	328,480,450	8,240,945	451.909,112	17,857,499
SHELLFISH								
Crabs	1,145,587	66,578	433,411	31,474	1,506,816	126,616	3,085,814	224,668
Crawfish			12,200	966			12,200	966
Sea crawfish or spiny lobster					1,027,312	199,650	1,027,312	199,650
Shrimp	38,012	5,702			1,551,086	155,109	1,589,098	160,811
Clams:								
Cockle					845	571	845	571
Hard	203,412	26,479	800	180			204,212	26,659
Mixed					7,407	3,333	7,407	3,333
Pismo					73,287	35,178	73,287	35,178
Razor	524,205	72,842	32,879	5,032			557,084	77,874
Soft			14,621	2,631	40,554	15,816	55,175	18,447
Mussels					8,204	1,119	8,204	1,119
Oysters:								
Eastern, market	36,022	23,362			52,678	22,576	88,700	45,938
Native, market	650,700	342,447	11,070	4,305			661,770	346,752
Japanese, market	15,680	9,997					15,680	9,997
Scallops	4,200	1,155					4,200	1,155
Abalone					449,362	249,646	449,362	249,646
Octopus	104,534	3,137			166,291	6,570	270,825	9,707
Squid					6,831,029	409,350	6,831,029	409,350
Terrapin and turtles					363	28	363	28
Total	2,722,352	551,699	504,981	44,588	11,715,234	1,225,562	14,942,567	1,821,849
WHALE PRODUCTS								
Sperm oil	67,875	3,620					67,875	3,620
Whale oil	1,471,875	98,125			2,932,088	216,350	4,403,963	314,475
Other whale products	606,000	12,488			1,767,500	42,283	2,373,500	54,771
Total	2,145,750	114,233			4,699,588	258,633	6,845,338	372,866
Grand total	89,223,907	7,123,457	39,577,838	3,203,617	344,895 272	9,725,140	473,697,017	20,052,214

WASHINGTON

In 1924 the fisheries of Washington employed 6,190 persons, 217 vessels, 2,036 motor boats, and 261 rowboats. The production of the fisheries amounted to 89,223,907 pounds, valued at $7,123,457. Of this value, 90.7 per cent consisted of fish, 7.7 per cent of shellfish, and 1.6 per cent of whale products.

The various species of salmon were the most important of Washington's fishes, yielding 58,625,990 pounds, valued at $3,953,098. Chinook salmon ranked highest in value, yielding 24,697,911 pounds, valued at $2,086,769. Next, in both quantity and value, was silver salmon, with a yield of 16,158,108 pounds, valued at $930,501.

Of second importance was the halibut, the total credited to this State, being 15,329,569 pounds, valued at $2,040,881. In addition to this, the vessels of Washington landed 3,798,508 pounds, valued at $363,881, at ports in Alaska.

Of third importance among the fishes was the cod. The cod fishery, for the most part, is carried on by a few large vessels sailing from ports in the State of Washington to the cod banks in Alaskan waters, where the fishing is done during the summer months, and bringing back their cargoes of salted cod at the end of the season. In 1924, 3,700,791 pounds of salt cod, valued at $176,815, were reported for Washington ports, which is estimated to be the equivalent of 9,250,000 pounds of fresh cod.

The production of all other fish in 1924 was 6,699,455 pounds, valued at $286,731, of which sablefish, steelhead trout, smelts, and carp were the most important.

The production of shellfish amounted to 2,722,352 pounds, valued at $551,699. In value, the most important shellfish produced in this State was the oyster, with a production of 702,402 pounds of meats, valued at $375,806. The production of razor clams (used largely in canning) amounted to 524,205 pounds, valued at $72,842. Next in importance were crabs, with a yield of 1,145,587 pounds, valued at $66,578. The catch of all other shellfish, including hard clams, shrimp, scallops, and octopus, amounted to 350,158 pounds, valued at $36,473.

The products of the whale fishery, which is prosecuted by vessels operating from shore stations, amounted to 2,145,750 pounds, valued at $114,233, and consisted of 1,471,875 pounds of whale oil, valued at $98,125; 67,875 pounds of sperm oil, valued at $3,620; and other products amounting to 606,000 pounds, valued at $12,488.

Yield of the fisheries of Washington in 1924, by districts and species

Species	Puget Sound		Washington coast		Columbia River		Total	
FISH	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Carp					379,258	$11,376	379,258	$11,376
Cod, dry-salted	3,700,791	$176,815					3,700,791	176,815
Flounders	188,273	3,778					188,273	3,778
Grayfish	97,005	247					97,005	247
Halibut	15,329,560	2,040,881					15,329,569	2,040,881
Herring	183,444	1,836					183,444	1,836
"Lingcod"	476,926	15,025					476,926	15,025
Rockfishes	295,187	10,715					295,187	10,715
Sablefish	1,894,527	103,394					1,894,527	103,394
Salmon:								
Blueback or sockeye	4,673,641	613,449	230,000	$27,600	148,935	17,874	5,052,576	658,923
Chinook	16,082,053	1,209,725	1,717,614	115,490	6,898,244	761,554	24,697,911	2,086,769
Chum	8,902,233	208,911	2,693,660	38,824	623,252	6,238	12,219,145	253,973
Humpback	498,250	22,932					498,250	22,932
Silver	12,438,989	748,190	1,790,925	93,880	1,928,194	88,431	16,158,108	930,501
Shad	36	1	91	1	193,315	1,938	193,442	1,940
Skates	10,179	103					10,179	103
Smelt:								
Silver	457,506	45,750					457,506	45,750
Eulachon					983,353	9,835	983,353	9,835
"Sole"	266,149	7,979			228	7	266,377	7,986
Steelhead trout	100,433	8,027	34,156	3,750	1,008,864	54,662	1,143,453	66,439
Sturgeon	1,832	169	8,339	627	76,034	5,313	86,205	6,109
Surf fishes	36,574	1,828	7,322	366			43,896	2,194
Tomcod	424	4					424	4
Total	65,634,021	5,219,759	6,482,107	280,538	12,239,677	957,228	84,355,805	6,457,525
SHELLFISH								
Octopus	104,534	3,137					104,534	3,137
Crabs	729,057	43,083	416,530	23,495			1,145,587	66,578
Shrimp	38,012	5,702					38,012	5,702
Clams:								
Hard	203,412	26,479					203,412	26,479
Razor			524,205	72,842			524,205	72,842
Oysters, market:								
Native	625,164	329,487	25,536	12,960			650,700	342,447
Eastern			36,022	23,362			36,022	23,362
Japanese	15,680	9,997					15,680	9,997
Scallops	4,200	1,155					4,200	1,155
Total	1,720,059	419,040	1,002,293	132,659			2,722,352	551,699
WHALE PRODUCTS								
Sperm oil			67,875	3,620			67,875	3,620
Whale oil			1,471,875	98,125			1,471,875	98,125
Other whale products			606,000	12,488			606,000	12,488
Total			2,145,750	114,233			2,145,750	114,233
Grand total	67,354,080	5,638,799	9,630,150	527,430	12,239,677	957,228	89,223,907	7,123,457

Vessel fisheries.—In 1924 the fisheries of Washington employed 217 fishing craft of 5 net tons and over, as measured by the United States Customs Service. This included 4 steamers, totaling 382 net tons; 208 motor vessels, totaling 4,345 net tons; and 5 sailing vessels, totaling 1,448 net tons, engaged in the fisheries of Washington, but does not include transporting vessels engaged principally in the carrying of fish. The total yield of fishing vessels was 34,628,428 pounds, valued at $2,888,327, of which 25,649,628 pounds, valued at $1,810,259, were landed at Washington ports, and 8,978,800 pounds, valued at $1,078,068, at ports in Canada. In addition to this, Washington vessels landed 3,818,439 pounds, valued at $364,256, at ports in Alaska.

Lines, catching virtually all the halibut and cod and quantities of salmon, were the most important apparatus employed by fishing vessels, taking 21,977,482 pounds of fish, valued at $2,369,467. Purse seines follow in importance, yielding 10,438,610 pounds, valued at $402,209, which consisted entirely of salmon and steelhead trout. The whale fishery, located at Grays Harbor, yielded 2,145,750 pounds of products, valued at $114,233. Haul seines, drag bag nets, and beam trawls, which constitute the remainder of the apparatus used on vessels, yielded 66,586 pounds, valued at $2,418.

Vessels engaged in the fisheries of Washington in 1924, by apparatus and rig

Apparatus	Motor vessels			Sailing vessels			Steam vessels			Total		
	Number	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*
Lines:												
Trawl (ocean)	122	2,749	848	5	1,448	176	1	187	39	128	4,384	1,063
Troll (Cape Flattery)	9	118	57							9	118	57
Purse seines (Puget Sound)	88	1,788	616							88	1,788	616
Haul seines (Puget Sound)	2	22	6							2	22	6
Drag bag nets (Puget Sound)	2	38	6							2	38	6
Beam trawls (Puget Sound)	1	11	5							1	11	5
Whaling apparatus (ocean)							3	195	30	3	195	30
Total [1]	208	4,345	1,394	5	1,448	176	4	382	69	217	6,175	1,639

[1] Exclusive of duplication.

Yield of the vessel fisheries of Washington in 1924, by apparatus and species

Species	Purse seines (Puget Sound)		Haul seines (Puget Sound)		Lines [1] (ocean)	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Cod, dry salted					[2] 3,700,791	$176,815
Halibut					15,320,660	2,039,773
"Lingcod"			267	$8	467,975	14,753
Rockfishes			487	23	208,855	7,716
Sablefish					1,894,000	103,362
Salmon:						
Blueback or sockeye	614,054	$82,808			[3] 265,640	19,850
Chinook	49,700	3,634				
Chum	7,344,446	172,417				
Humpback	62,170	2,746				
Silver	2,347,386	138,936			[3] 118,246	7,095
"Sole"			3,583	108	550	11
Steelhead trout	20,864	1,668				
Sturgeon					765	92
Surf fishes			557	27		
Total	10,438,610	402,209	4,894	166	21,977,482	2,369,467

[1] The line fishery was prosecuted by vessels sailing from Puget Sound ports, and virtually all of the catch was taken in ocean waters. This includes 8,912,300 pounds of halibut, valued at $1,074,978, and 66,500 pounds of sablefish, valued at $3,090, taken by Washington vessels and landed in Canada. In addition to this, Washington vessels caught 3,798,508 pounds of halibut, valued at $363,881; 16,792 pounds of sablefish, valued at $297; and 3,139 pounds of rockfishes, valued at $78, which were landed in Alaska.

[2] Taken in waters off Alaska.

[3] Taken off Cape Flattery.

Yield of the vessel fisheries of Washington in 1924, by apparatus and species—Con.

Species	Drag bag nets (Puget Sound)		Beam trawls (Puget Sound)		Whaling apparatus (ocean)		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Cod, dry salted							3,700,791	$176,815
Halibut							15,320,660	2,039,773
Herring	42,490	$425					42,490	425
"Lingcod"							468,242	14,761
Rockfishes	8,145	244					217,487	7,983
Sablefish							1,894,000	103,362
Salmon:								
Blueback or sockeye							614,054	82,808
Chinook							315,340	23,484
Chum							7,344,446	172,417
Humpback							62,170	2,746
Silver							2,465,632	146,031
Smelt, silver	1,510	151					1,510	151
"Sole"							4,133	119
Steelhead trout							20,854	1,668
Sturgeon							765	92
Surf fishes							557	27
Shrimp			9,547	$1,432			9,547	1,432
Whale oil					1,471,875	$98,125	1,471,875	98,125
Sperm oil					67,875	3,620	67,875	3,620
Other whale products					606,000	12,488	606,000	12,488
Total	52,145	820	9,547	1,432	2,145,750	114,233	34,628,428	2,888,327

Men and boats engaged in the shore fisheries of Washington in 1924, by apparatus and districts

Apparatus	Puget Sound			Washington coast			Columbia River			Total		
	Men	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*
Haul seines	160	79					57	20	9	217	99	9
Gill nets:												
Drift	173	171		98	85		539	390		810	646	
Set	6	6		167	81	65	39	32	6	212	119	71
Pound nets	146	71		99	58	10	188	100		433	229	10
Lines	1,279	850		133	82		170	111		1,582	1,043	
Drag bag nets	10	7		2	1					12	8	
Beam trawls	43	22								43	22	
Fish wheels							7			7		
Dip nets	33	33					40	40		73	73	
Reef nets	8	4								8	4	
Brush weir	2	2								2	2	
Crab traps	85	85		36	36					121	121	
Clam hoes, shovels, and forks	370			988						1,358		
Oyster tongs and forks	111	13	162	13	3	19				124	16	181
Total [1]	2,157	1,129	162	1,418	282	84	976	625	15	4,551	2,036	261

[1] Exclusive of duplication.

Shore and boat fisheries.—The statistics on the shore fisheries include the catch by all fishing craft of less than 5 net tons, as measured by the United States Customs Service, as well as all fish caught without the use of boats. In 1924 there were 2,036 motor boats and 261 rowboats employed in the fisheries of Washington. The yield of the shore and boat fisheries amounted to 54,595,479 pounds, valued at $4,235,130, which was considerably greater than the yield of the vessel fisheries.

The catch by pound nets ranked first in importance, both as to amount and value, with the yield of lines being almost identical. In 1924 pound nets yielded 20,113,737 pounds, valued at $1,527,382, and lines, 20,111,519 pounds, valued at $1,400,363. The catch by pound nets consisted almost entirely of salmon and steelhead trout, with much smaller quantities of flounders, halibut, "lingcod," surf fishes, rockfishes, shad, skate, sole, sturgeon, and octopus. The catch by lines consisted mainly of salmon, with smaller quantities of varieties similar to those taken by the pound nets.

Next in amount and yield were drift and set gill nets, with a total catch amounting to 8,522,857 pounds, valued at $613,208, which consisted almost entirely of salmon and steelhead trout, with much lesser quantities of surf fishes, rockfishes, shad, silver smelt, sturgeon, and octopus.

Haul seines yielded 1,581,022 pounds, valued at $99,240, of which salmon, carp, and silver smelts formed the greater part. The remainder consisted of flounders, herring, surf fishes, sablefish, shad, and sole. The yield of dip nets amounted to 1,168,330 pounds, valued at $28,237, consisting almost entirely of smelts. Other apparatus, including beam trawls, reef nets, fish wheels, drag bag nets, and brush weirs, contributed 522,408 pounds of fish, valued at $24,995.

Of the shellfish appliances, tongs yielded 702,402 pounds of oyster meats, valued at $375,806; hoes, shovels, and forks yielded 727,617 pounds of clam meats, valued at $99,321; and crab traps caught 1,145,587 pounds of crabs, valued at $66,578.

Yield of the shore fisheries of Washington in 1924, by districts and species

Species	Puget Sound		Washington coast		Columbia River		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Carp					379,258	$11,376	379,258	$11,376
Flounders	188,273	$3,778					188,273	3,778
Grayfish	97,005	247					97,005	247
Halibut	8,909	1,108					8,909	1,108
Herring	140,954	1,411					140,954	1,411
"Lingcod"	8,684	264					8,684	264
Rockfishes	77,700	2,732					77,700	2,732
Sablefish	527	32					527	32
Salmon:								
Blueback or sockeye	4,059,587	530,641	230,000	$27,600	148,935	17,874	4,438,522	576,115
Chinook	15,766,718	1,186,241	1,717,614	115,490	6,898,244	761,554	24,382,571	2,063,285
Chum	1,557,787	36,494	2,693,660	38,824	623,252	6,238	4,874,699	81,556
Humpback	436,080	20,186					436,080	20,186
Silver	9,973,857	602,159	1,790,925	93,880	1,928,194	88,431	13,692,476	784,470
Shad	36	1	91	1	193,315	1,938	193,442	1,940
Skates	10,179	103					10,179	103
Smelt:								
Silver	455,996	45,599					455,996	45,599
Eulachon					983,353	9,835	983,353	9,835
"Sole"	262,016	7,860			228	7	262,244	7,867
Steelhead trout	79,579	6,359	34,156	3,750	1,008,864	54,662	1,122,599	64,771
Sturgeon	1,067	77	8,339	627	76,034	5,313	85,440	6,017
Surf fishes	36,017	1,801	7,322	366			43,339	2,167
Tomcod	424	4					424	4
Octopus	104,534	3,137					104,534	3,137
Crabs	729,057	43,083	416,530	23,495			1,145,587	66,578
Shrimp	28,465	4,270					28,465	4,270
Clams:								
Hard	203,412	26,479					203,412	26,479
Razor			524,205	72,842			524,205	72,842
Oysters, market:								
Native	625,164	329,487	25,536	12,960			650,700	342,447
Eastern			36,022	23,362			36,022	23,362
Japanese	15,680	9,997					15,680	9,997
Scallops	4,200	1,155					4,200	1,155
Total	34,871,402	2,864,705	7,484,400	413,197	12,230,677	957,228	54,595,479	4,235,130

Yield of the shore fisheries of Washington in 1924, by districts, apparatus, and species

Apparatus and species	Puget Sound		Washington coast		Columbia River		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Haul seines:								
Carp					379,258	$11,376	379,258	$11,376
Flounders	76,922	$1,551					76,922	1,551
Halibut	770	96					770	96
Herring	72,814	729					72,814	729
"Lingcod"	370	11					370	11
Rockfishes	15,824	654					15,824	654
Sablefish	50	3					50	3
Salmon—								
Blueback or sockeye	22,473	2,940			3,476	418	25,949	3,358
Chinook	31,520	2,365			307,522	36,902	339,042	39,267
Chum	9,029	216			1,000	10	10,029	226
Humpback	2,760	121					2,760	121
Silver	105,840	6,350			8,139	325	113,979	6,675
Shad					75,941	760	75,941	760
Skates	27	1					27	1
Smelt, silver	251,308	25,133					251,308	25,133
"Sole"	94,115	2,824					94,115	2,824
Steelhead trout	90	7			86,808	4,754	86,898	4,761
Sturgeon					366	26	366	26
Surf fishes	31,767	1,587					31,767	1,587
Tomcod	224	2					224	2
Octopus	2,609	79					2,609	79
Total	718,512	44,669			862,510	54,571	1,581,022	99,240
Drift gill nets:								
Salmon—								
Blueback or sockeye	47,051	5,914			42,472	5,097	89,523	11,011
Chinook	637,027	52,710	339,939	$21,660	2,953,923	352,169	3,930,889	426,539
Chum	622,600	14,229	603,986	8,629	320,625	3,208	1,547,211	26,066
Humpback	12,830	565					12,830	565
Silver	736,557	46,053	412,926	22,935	201,275	8,051	1,350,758	77,039
Shad	36	1	91	1	77,241	774	77,368	776
Smelt, silver	6,485	649					6,485	649
Steelhead trout	361	22	9,935	1,159	276,730	15,563	287,026	16,744
Sturgeon	257	20	8,339	627	45,350	3,179	53,946	3,826
Surf fishes	600	30					600	30
Octopus	400	12					400	12
Total	2,064,204	120,205	1,375,216	55,011	3,917,616	388,041	7,357,036	563,257
Set gill nets:								
Rockfishes	120	4					120	4
Salmon—								
Blueback or sockeye			119,735	14,368	13,735	1,648	133,470	16,016
Chinook	520	39	52,675	2,046	52,089	6,285	105,284	8,370
Chum	32,077	764	540,185	7,575	4,060	45	576,322	8,384
Silver	2,656	159	304,347	13,502	3,510	141	310,513	13,802
Shad					1,038	12	1,038	12
Steelhead trout			22,437	2,424	12,853	697	35,290	3,121
Sturgeon					2,621	184	2,621	184
Surf fishes	1,163	58					1,163	58
Total	36,536	1,024	1,039,379	39,915	89,906	9,012	1,165,821	49,951
Pound nets:								
Flounders	2,696	54					2,696	54
Halibut	169	21					169	21
"Lingcod"	535	16					535	16
Rockfishes	5,595	205					5,595	205
Salmon—								
Blueback or sockeye	3,968,542	518,963	110,265	13,232	84,269	10,113	4,163,076	542,308
Chinook	4,182,840	312,466	187,440	7,332	2,141,219	256,034	6,511,499	575,832
Chum	884,452	21,056	1,546,959	22,584	297,567	2,975	2,728,978	46,615
Humpback	419,365	19,451					419,365	19,451
Silver	3,792,856	227,573	600,630	29,117	1,114,670	44,585	5,508,156	301,275
Shad					37,372	374	37,372	374
Skates	9,087	91					9,087	91
"Sole"	200	6					200	6
Steelhead trout	79,128	6,330	1,784	167	628,597	33,433	709,509	39,930
Sturgeon	810	57			16,335	1,133	17,145	1,190
Surf fishes	135	7					135	7
Octopus	220	7					220	7
Total	13,346,630	1,106,303	2,447,078	72,432	4,320,029	348,647	20,113,737	1,527,382
Lines:								
Flounders	10	1					10	1
Grayfish	97,005	247					97,005	247
Halibut	7,970	991					7,970	991
"Lingcod"	5,558	170					5,558	170

Yield of the shore fisheries of Washington in 1924, by districts, apparatus, and species—Continued

Apparatus and species	Puget Sound		Washington coast		Columbia River		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Lines—Continued.								
Rockfishes	47,332	$1,516					47,332	$1,516
Salmon—								
Chinook	[1] 10,914,460	818,635	[2] 1,137,240	$84,439	[3] 1,418,274	$107,138	13,469,974	1,010,212
Silver	[1] 5,297,408	319,752	[2] 471,204	28,226	[3] 600,600	35,329	6,369,212	383,307
Skates	1,000	10					1,000	10
"Sole"	399	12			228	7	627	19
Steelhead trout					2,366	133	2,366	133
Sturgeon					11,123	775	11,123	775
Surf fishes	7	1					7	1
Octopus	99,335	2,981					99,335	2,981
Total	16,470,484	1,144,316	1,608,444	112,665	2,032,591	143,382	20,111,519	1,400,363
Drag bag nets:								
Flounders	240	4					240	4
Herring	30,200	302					30,200	302
Salmon—								
Chinook			320	13			320	13
Chum			2,530	36			2,530	36
Silver			1,818	100			1,818	100
Smelt, silver	12,021	1,202					12,021	1,202
Skates	65	1					65	1
"Sole"	100	3					100	3
Surf fishes	965	48	7,322	366			8,287	414
Octopus	1,580	47					1,580	47
Total	45,171	1,607	11,990	515			57,161	2,122
Beam trawls:								
Flounders	108,405	2,168					108,405	2,168
Herring	30	1					30	1
"Lingcod"	2,221	67					2,221	67
Rockfishes	8,829	353					8,829	353
Sablefish	477	29					477	29
Smelt, silver	2,820	282					2,820	282
"Sole"	167,202	5,015					167,202	5,015
Surf fishes	75	4					75	4
Tomcod	200	2					200	2
Octopus	390	11					390	11
Shrimp	28,465	4,270					28,465	4,270
Scallops	4,200	1,155					4,200	1,155
Total	323,314	13,357					323,314	13,357
Fish wheels:								
Salmon—								
Blueback or sockeye					4,983	598	4,983	598
Chinook					25,217	3,026	25,217	3,026
Shad					1,723	18	1,723	18
Steelhead trout					1,510	82	1,510	82
Sturgeon					239	16	239	16
Total					33,672	3,740	33,672	3,740
Dip nets:								
Herring	310	3					310	3
Smelt—								
Silver	183,362	18,333					183,362	18,333
Eulachon					[4] 983,353	9,835	983,353	9,835
Surf fishes	1,305	66					1,305	66
Total	184,977	18,402			983,353	9,835	1,168,330	28,237
Reef nets:								
Salmon—								
Blueback or sockeye	21,521	2,824					21,521	2,824
Chinook	346	26					346	26
Chum	9,629	229					9,629	229
Humpback	1,125	49					1,125	49
Silver	38,040	2,272					38,040	2,272
Total	70,661	5,400					70,661	5,400
Brush weir: Herring	37,600	376					37,600	376
Crab traps: Crabs	729,057	43,083	416,530	23,495			1,145,587	66,578

[1] Caught largely by trollers off Cape Flattery.
[2] Caught largely by trollers off Grays Harbor and Willapa Harbor, though a small portion of this catch may have been taken off the mouth of the Columbia River.
[3] All taken by trollers off the mouth of the Columbia River.
[4] Caught in tributaries of the Columbia River.

Yield of the shore fisheries of Washington in 1924, by districts, apparatus, and species—Continued

Apparatus and species	Puget Sound		Washington coast		Columbia River		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Hoes, shovels, and forks:								
Clams—								
Hard	203, 412	$26, 479					203, 412	$26, 479
Razor			524, 205	$72, 842			524, 205	72, 842
Total	203, 412	26, 479	524, 205	72, 842			727, 617	99, 321
Tongs:								
Oysters, market—								
Native	625, 164	329, 487	25, 536	12, 960			650, 700	342, 447
Eastern			36, 022	23, 362			36, 022	23, 362
Japanese	15, 680	9, 997					15, 680	9, 997
Total	640, 844	339, 484	61, 558	36, 322			702, 402	375, 806

OREGON

The fisheries of Oregon employed 4,360 persons, 6 vessels, 2,178 motor boats, and 283 rowboats in 1924. The products of the fisheries amounted to 39,577,838 pounds, valued at $3,203,617, ranking third in importance among the Pacific Coast States in 1924.

The various species of salmon were by far the most important of Oregon's commercial fishes, yielding 33,319,392 pounds, valued at $2,846,165. Steelhead trout contributed 3,604,558 pounds, valued at $197,053; and seven varieties of much less importance made up the remainder, aggregating 2,148,907 pounds, valued at $115,811. The yield of the various kinds of shellfish, including crabs, crawfish, clams, oysters, and octopus, amounted to 504,981 pounds, valued at $44,588.

Vessel fisheries.—In the vessel fishery of Oregon only 6 vessels, having a net tonnage of 68 and carrying 25 fishermen, were actually engaged in fishing. The catch was made up entirely of halibut, "lingcod," rockfishes, and sablefish, amounting to 763,178 pounds, valued at $92,161. The fares of these vessels were landed at Portland and Astoria, Oreg.

Shore and boat fisheries.—The shore and boat fisheries of Oregon greatly exceeded the vessel fishery in importance, employing 4,335 fishermen, 2,178 motor boats under 5 tons net, and 283 rowboats, and yielded products amounting to 38,814,660 pounds, valued at $3,111,456.

Men and boats engaged in the shore fisheries of Oregon in 1924, by apparatus and districts

Apparatus	Columbia River			Oregon coast			Total		
	Men	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*
Gill nets, drift	1, 672	1, 061		955	601		2, 627	1, 662	
Gill nets, set	125	96	29	549	292	196	674	388	225
Haul seines	448	35	23	154	15	15	602	50	38
Pound nets	138	69					138	69	
Lines	361	199		70	40		431	239	
Dip nets	128		12				128		12
Wheels	48						48		
Crab traps				106	106		106	106	
Crawfish traps	43	27	16				43	27	16
Clam shovels and forks				74			74		
Oyster tongs				2	1	2	2	1	2
Total[1]	2, 743	1, 337	77	1, 592	841	206	4, 335	2, 178	283

[1] Exclusive of duplication.

Yield of the fisheries of Oregon in 1924, by districts and species [1]

Species	Columbia River		Oregon coast		Total	
FISH	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Halibut	510,977	$81,373			510,977	$81,373
"Lingcod"	51,630	1,549			51,630	1,549
Rockfishes	39,223	1,172			39,223	1,172
Sablefish	161,348	8,067			161,348	8,067
Salmon:						
Blueback or sockeye	434,038	52,085	2,302	$271	436,340	52,356
Chinook	15,742,530	1,889,103	3,863,231	463,566	19,605,761	2,352,669
Chum	2,067,158	20,672	931,298	9,314	2,998,456	29,986
Silver	3,636,996	145,480	6,641,839	265,674	10,278,835	411,154
Shad	533,732	5,337	449,690	5,224	983,422	10,561
Smelt, eulachon	226,800	2,268			226,800	2,268
Steelhead trout	2,981,677	163,993	622,881	33,060	3,604,558	197,053
Sturgeon	158,081	10,224	17,426	597	175,507	10,821
Total	26,544,190	2,381,323	12,528,667	777,706	39,072,857	3,159,029
SHELLFISH						
Crabs			433,411	31,474	433,411	31,474
Crawfish	12,200	966			12,200	966
Clams:						
Hard			800	180	800	180
Razor			32,879	5,032	32,879	5,032
Soft			14,621	2,631	14,621	2,631
Oysters, native, market			11,070	4,305	11,070	4,305
Total	12,200	966	492,781	43,622	504,981	44,588
Grand total	26,556,390	2,382,289	13,021,448	821,328	39,577,838	3,203,617

[1] All taken by shore fisheries except the halibut, "lingcod," rockfishes, and sablefish, totaling 763,178 pounds and valued at $92,161, which were taken by 6 vessels operating trawl lines and landing their fares at Portland and Astoria, Oreg. These vessels had a total net tonnage of 68 and carried 25 fishermen.

CALIFORNIA

In 1924 California was the leading fish-producing State on the Pacific coast. There were 4,809 persons, 337 vessels, 1,513 motor boats, and 132 rowboats engaged in fishing. The production amounted to 344,895,272 pounds of fishery products, valued at $9,725,140 to the fishermen. Of this production, 328,480,450 pounds, valued at $8,240,945, were fish; 11,715,234 pounds, valued at $1,225,562, were shellfish; and the remaining 4,699,588 pounds, valued at $258,633, were whale products. Of the total production, 329,565,939 pounds, valued at $8,633,484, were from waters off California; 12,445,305 pounds, valued at $901,615, were from waters off Mexico; and 2,884,028 pounds, valued at $190,041, were from waters off Alaska.

Species of fish used largely for canning are the most important taken by California fishermen. Leading all others in amount and value was the pilchard or sardine, producing 242,685,958 pounds, valued at $2,079,727. Albacore was next, with a production of 17,695,362 pounds, valued at $1,828,812. Third was salmon, with a production of 10,015,269 pounds, valued at $1,025,838. Fourth in value were the bluefin and yellowfin tunas, with a production of 6,851,046 pounds, valued at $584,272. Other species used largely for canning are the skipjack, with a production of 3,780,971 pounds, valued at $179,210, and bonito, with a production of 1,038,369 pounds, valued at $29,130.

Of first importance among the market fishes is the flounder group, with a production of 13,493,082 pounds, valued at $715,858. Of this amount, 2,576,261 pounds, valued at $348,759, were reported as

"California halibut," and 8,835,351 pounds, valued at $307,809, were reported as "sole." Next was yellowtail, with 4,714,149 pounds, valued at $375,156; barracuda followed, with 7,128,523 pounds, valued at $257,022; rockfishes, with 4,716,790 pounds, valued at $211,344; and white sea bass, with 1,515,584 pounds, valued at $185,086. More than 30 additional varieties of fresh market fishes made up 11,961,319 pounds, valued at $579,449.

The production of shellfish amounted to 11,715,234 pounds, valued at $1,225,562. Squid was most important, yielding 6,831,029 pounds, valued at $409,350. Next in value was abalone, with a yield of 449,362 pounds, valued at $249,646. Sea crawfish or spiny lobster followed with a production of 1,027,312 pounds, valued at $199,650. Shrimp yielded 1,551,086 pounds, valued at $155,109, and crabs, 1,506,816 pounds, valued at $126,616. The remainder of the shellfish catch amounted to 349,629 pounds, valued at $85,191, and consisted of oysters, clams, mussels, octopus, terrapin, and turtles.

In addition to the fish and shellfish products, there were 4,699,588 pounds of whale products, valued at $258,633, made up of 2,932,088 pounds of whale oil, valued at $216,350, and 1,767,500 pounds of other products, valued at $42,283.

Vessels engaged in the fisheries of California in 1924, by apparatus and district

Apparatus	Northern district			San Francisco district			Monterey district		
	Number	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*
Lines	2	11	2	8	1,719	149	3	18	6
Lampara and bait nets							1	11	9
Purse seines									
Trammel nets							1	5	6
Paranzella nets	2	14	7	12	178	90			
Gill nets				2	15	4			
Bag nets				1	6	2			
Lobster traps									
Crab traps	1	6	1						
Abalone outfits							1	5	6
Whaling apparatus				4	147	44			
Dip nets									
Total [1]	4	25	9	26	2,059	287	5	34	21

Apparatus	Los Angeles district			San Diego district			Total		
	Number	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*
Lines	141	1,301	760	69	689	256	223	3,738	1,173
Lampara and bait nets	126	1,187	819	71	716	318	198	1,914	1,146
Purse seines	32	763	268	6	159	42	38	922	310
Trammel nets	7	54	23				8	59	29
Paranzella nets	3	17	16				17	209	113
Gill nets	16	156	73	11	77	37	29	248	114
Bag nets							1	6	2
Lobster traps				4	37	11	4	37	11
Crab traps							1	6	1
Abalone outfits							1	5	6
Whaling apparatus							4	147	44
Dip nets	2	18	4				2	18	4
Total [1]	199	2,601	1,185	103	1,102	431	337	5,821	1,933

[1] Exclusive of duplication.

NOTE.—All of the above were motor vessels, excepting 11 vessels sailing from the San Francisco district, as follows: 4 steamers in the whale fishery, 2 steamers in the paranzella fishery, and 5 schooners in the line fishery.

Men and boats engaged in the shore fisheries of California in 1924, by apparatus and districts

Apparatus	Northern district			San Francisco district			Monterey district		
	Men	*Gas boats*	*Row-boats*	*Men*	*Gas boats*	*Row-boats*	*Men*	*Gas boats*	*Row-boats*
Lines	138	123	2	287	237	6	233	139	1
Gill nets	175	2	106	430	232	6.	3	2	
Lampara and bait nets	3	3	1	38	10	1	324	40	
Haul seines	1	1		18	6				
Bag nets				21	10	1			
Fyke nets				27	15	8			
Dip nets	2		2	2	2				
Crab traps	23	22		163	157		2	1	
Lobster traps				1	1				
Abalone outfits							19	4	
Clam shovels	5			15					
Oyster tongs				2	1				
Total[1]	319	123	107	787	486	19	485	172	1
Apparatus	**Los Angeles district**			**San Diego district**			**Total**		
	Men	*Gas boats*	*Row-boats*	*Men*	*Gas boats*	*Row-boats*	*Men*	*Gas boats*	*Row-boats*
Lines	612	412	1	233	126		1,493	1,027	10
Gill nets	129	45	4	40	16		777	297	116
Lampara and bait nets	187	51		74	25		026	129	2
Haul seines	14	5					33	12	
Bag nets							21	10	1
Fyke nets	2	2					29	17	8
Dip nets	1	1					5	3	2
Crab traps							188	180	
Lobster traps	41	24		24	17		66	42	
Abalone outfits				4	1		23	5	
Clam shovels	55						75		
Oyster tongs							2	1	
Total[1]	943	549	5	342	183		2,876	1,513	132

[1] Exclusive of duplication.

Summary of the yield of the California fisheries in 1924, by species

Species	From waters off California		From waters off Mexico		Total	
FISH	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Albacore	17,280,346	$1,790,373	415,016	$38,439	17,695,362	$1,828,812
Anchovies	346,951	1,984			346,951	1,984
Barracuda	4,733,779	186,599	2,394,744	70,423	7,128,523	257,022
Bonito	836,182	25,087	202,187	4,043	1,038,369	29,130
Carp	75,965	1,554			75,965	1,554
Catfish	351,960	51,977			351,960	51,977
Cod, dry salted	2,884,028	190,041			2,884,028	190,041
Eels	56	3			56	3
Flounders	2,081,196	59,285	274	5	2,081,470	59,290
Grayfish	392,634	11,982			392,634	11,982
Hake	60,780	1,519			60,780	1,519
Halibut	132,637	15,916			132,637	15,916
Halibut, "California"	1,527,778	211,519	1,048,483	137,240	2,576,261	348,759
Hardhead	19,023	761			19,023	761
Herring	435,620	8,602			435,620	8,602
Kingfish	383,927	8,884	390	8	384,317	8,892
"Lingcod"	400,432	24,026			400,432	24,026
Mackerel	3,227,300	86,523	13,234	311	3,240,534	86,834
Mullet	24,496	,469	37,475	1,874	61,971	3,343
Pike, Sacramento	4,953	220			4,953	220
Pilchard or sardine	242,685,958	2,079,727			242,685,958	2,079,727
Pompano	13,059	5,866	4,520	1,989	17,579	7,855
Rockbass	380,620	32,676	85,588	6,200	466,208	38,876
Rockfishes	4,684,065	210,154	32,725	1,190	4,716,790	211,344
Sablefish	933,310	34,540			933,310	34,540
Salmon	10,015,269	1,025,838			10,015,269	1,025,838
Sculpin	100,070	10,213			100,070	10,213
Sea bass:						
Black	88,677	1,962	142,727	2,201	231,404	4,163
White, or squeteague	964,755	121,125	550,829	63,961	1,515,584	185,086

Summary of the yield of the California fisheries in 1924, by species—Continued

Species	From waters off California		From waters off Mexico		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
FISH—continued						
Shad	1,539,217	$74,553			1,539,217	$74,553
Sheepshead	23,427	480	840	$13	24,267	493
Skates	131,137	1,967			131,137	1,967
Skipjack or striped tuna	1,356,426	74,083	2,424,545	105,127	3,780,971	179,210
Smelt, silver	715,280	40,533	6,632	118	721,912	40,651
"Sole"	8,828,380	307,598	6,971	211	8,835,351	307,809
Splittail	3,671	73			3,671	73
Steelhead trout	87,088	7,402			87,088	7,402
Striped bass	661,777	87,493			661,777	87,493
Suckers	2,085	48			2,085	48
Surf fishes	288,969	13,767			288,969	13,767
Swordfish	31,833	3,610			31,833	3,610
Tomcod	42,524	978			42,524	978
Tuna:						
Bluefin	3,241,110	291,306			3,241,110	291,306
Yellowfin	680,759	59,833	2,382,639	184,556	3,063,398	244,389
Mixed	485,401	43,686	61,137	4,891	546,538	48,577
Whitebait	122,483	2,449			122,483	2,449
Whitefish	250,663	13,480	22,414	911	273,077	14,391
Yellowtail	2,863,012	238,446	1,851,137	136,710	4,714,149	375,156
Other fish	339,033	16,951	26,842	1,363	365,875	18,314
Total	316,769,101	7,479,161	11,711,349	761,784	328,480,450	8,240,945
SHELLFISH						
Crabs	1,506,816	126,616			1,506,816	126,616
Shrimp	1,551,086	155,109			1,551,086	155,109
Sea crawfish or spiny lobster	294,356	60,375	732,956	139,275	1,027,312	199,650
Oysters, eastern, market	52,678	22,576			52,678	22,576
Clams:						
Cockle	845	571			845	571
Mixed	7,407	3,333			7,407	3,333
Pismo	73,287	35,178			73,287	35,178
Soft	40,554	15,816			40,554	15,816
Mussels	8,204	1,119			8,204	1,119
Abalone	448,362	249,090	1,000	556	449,362	249,646
Octopus	166,291	6,570			166,291	6,570
Squid	6,831,029	409,350			6,831,029	409,350
Terrapin	312	25			312	25
Turtles	51	3			51	3
Total	10,981,278	1,085,731	733,956	139,831	11,715,234	1,225,562
WHALE PRODUCTS						
Whale oil	2,932,088	216,350			2,932,088	216,350
Other whale products	1,767,500	42,283			1,767,500	42,283
Total	4,699,588	258,633			4,699,588	258,633
Grand total	332,449,967	8,823,525	12,445,305	901,615	344,895,272	9,725,140

Yield of the fisheries off the California coast in 1924, by districts and species

Species	Northern district		San Francisco district		Monterey district	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
FISH						
Albacore					420	$27
Anchovies			10,718	$107	297,000	1,485
Barracuda			487	18	138	6
Bonito					166	7
Carp	4,366	$122	71,597	1,432		
Catfish	62,096	9,004	289,864	42,973		
Cod, dry salted			[1] 2,884,028	190,041		
Flounders	25,690	646	1,969,132	56,094	77,011	2,177
Grayfish			93,606	2,995	7,724	247
Hake			58,405	1,460	2,376	59
Halibut	126,400	15,168	6,237	748		
Halibut, "California"					10,569	1,268
Hardhead			19,023	761		
Herring	2,593	52	420,226	8,405	1,430	29
Kingfish			2,513	80	78,410	2,744
"Lingcod"	29,803	1,788	233,866	14,032	136,763	8,206

[1] Taken in Bering Sea.

Yield of the fisheries off the California coast in 1924, by districts and species—Con.

Species	Northern district		San Francisco district		Monterey district	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
FISH—continued						
Mackerel			22	$1	715,770	$21,473
Pike, Sacramento			4,953	220		
Pilchard or sardine	125	$2	1,090,727	16,361	117,528,884	822,702
Pompano					72	22
Rockfishes	20,477	1,125	551,448	27,559	1,000,622	33,286
Sablefish	21,100	844	353,446	14,138	558,657	19,553
Salmon	2,880,928	187,260	6,257,165	750,859	877,180	87,719
Sea bass, white, or squetague	1,117	145	34,507	4,486	43,263	2,763
Shad			1,538,735	74,524	482	29
Skates			121,627	1,824	2,075	31
Skipjack or striped tuna					6,913	346
Smelt, silver	36,052	2,163	156,355	9,381	168,028	15,122
"Sole"	141,226	4,943	8,279,043	289,767	265,598	7,968
Splittail			3,671	73		
Steelhead trout	87,088	7,402				
Striped bass	33	4	660,401	87,314	1,343	175
Suckers	1,788	41	297	7		
Surf fishes	43,775	1,642	117,200	4,395	25,377	1,015
Tomcod			34,037	783	8,487	195
Whitebait	56,257	1,125	65,811	1,316	415	8
Other fish	39,584	1,979	62,569	3,128	62,118	3,106
Total	3,580,500	235,455	25,391,706	1,605,282	121,877,296	1,031,768
SHELLFISH						
Crabs	170,976	14,248	1,285,536	107,128	50,304	5,240
Shrimp			1,551,086	155,109		
Oysters, eastern			52,678	22,576		
Clams:						
Cockle	123	83	577	390		
Mixed	2,227	1,002	5,036	2,266	23	10
Pismo					9	4
Soft	429	167	40,125	15,649		
Mussels			1,230	185	1,424	171
Abalone					446,733	248,185
Octopus	31	1	7,800	234	158,311	6,332
Squid					6,779,857	406,791
Terrapin			312	26		
Total	173,786	15,501	2,944,380	303,562	7,436,061	666,733
WHALE PRODUCTS						
Whale oil			2,932,088	216,350		
Other whale products			1,767,500	42,283		
Total			4,699,588	258,633		
Grand total	3,754,286	250,956	33,035,674	2,167,477	129,313,957	1,698,501

Species	Los Angeles district		San Diego district		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
FISH						
Albacore	12,470,635	$1,309,417	4,809,291	$480,929	17,280,346	$1,790,373
Anchovies	39,233	392			346,951	1,984
Barracuda	3,692,837	147,563	1,040,317	39,012	4,733,779	186,599
Bonito	724,881	21,746	111,135	3,334	836,182	25,087
Carp					75,965	1,554
Catfish					351,960	51,977
Cod, dry salted					2,884,028	190,041
Eels			56	3	56	3
Flounders	9,313	367	50	1	2,081,196	59,285
Grayfish	705	22	290,599	8,718	392,634	11,982
Hake					60,780	1,519
Halibut					132,637	15,916
Halibut, "California"	1,264,357	174,852	252,852	35,399	1,527,778	211,519
Hardhead					19,023	761
Herring	202	4	11,169	112	435,620	8,602
Kingfish	294,550	5,891	8,454	169	383,927	8,884
"Lingcod"					400,432	24,026
Mackerel	2,180,115	56,704	331,393	8,285	3,227,300	86,523
Mullet	240	14	24,256	1,455	24,496	1,469
Pike, Sacramento					4,953	220
Pilchard or sardine	116,957,409	1,169,574	7,108,813	71,088	242,685,958	2,079,727
Pompano	12,650	5,692	337	152	13,059	5,866

Yield of the fisheries off the California coast in 1924, by districts and species—Cor

Species	Los Angeles district		San Diego district		Total	
FISH—continued	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Rockbass	222,653	$20,039	157,967	$12,637	380,620	$32,6
Rockfishes	1,677,145	83,637	1,434,373	64,547	4,684,065	210,1
Sablefish	107	5			933,310	34,5
Salmon					10,015,269	1.025,8
Sculpin	79,334	7,537	29,736	2,676	109,070	10,2
Sea bass:						
Black	37,582	940	51,095	1,022	88,677	1,9
White, or squeteague	743,418	96,054	142,450	17,677	964,755	121,1
Shad					1,539,217	74,5
Sheepshead	12,412	260	11,015	220	23,427	4
Skates	7,435	112			131,137	1,9
Skipjack or striped tuna	1,252,318	68,877	97,195	4,860	1,356,426	74,0
Smelt, silver	335,373	13,283	19,472	584	715,280	40,5
"Sole"	120,366	4,394	13,147	526	8,828,380	307,5
Splittail					3,671	
Steelhead trout					87,088	7,4
Striped bass					661,777	87,4
Suckers					2,085	
Surf fishes	90,473	5,865	12,144	850	288,969	13,7
Swordfish	17,808	2,137	14,025	1,473	31,833	3,6
Tomcod					42,524	[illegible]
Tuna:						
Bluefin	3,201,703	288,153	39,407	3,153	3,241,110	291,3
Yellowfin	537,221	48,350	143,538	11,483	680,759	59,8
Mixed	485,401	43,686			485,401	43,6
Whitebait					122,483	2,4
Whitefish	189,346	10,414	61,317	3,066	250,663	13,4
Yellowtail	1,226,362	104,241	1,636,650	134,205	2,863,012	238,4
Other fish	154,554	7,728	20,208	1,010	339,033	16,9
Total	148,047,138	3,698,010	17,872,461	908,646	316,769,101	7,479,
SHELLFISH						
Crabs					1,506,816	126,
Shrimp					1,551,086	155,
Sea crawfish or spiny lobster	187,941	39,092	106,415	21,283	294,356	60,
Oysters, eastern					52,678	22,
Clams:						
Cockle	145	98			845	
Mixed	111	50	10	5	7,407	3,
Pismo	73,278	35,174			73,287	35,
Soft					40,554	15,
Mussels	5,550	763			8,204	1,
Abalone	1,629	905			448,362	249,
Octopus	124	2	25	1	166,291	6,
Squid	51,172	2,559			6,831,029	409,
Terrapin					312	
Turtles	51	3			51	
Total	320,001	78,646	106,450	21,289	10,981,278	1,085,
WHALE PRODUCTS						
Whale oil					2,932,088	216,
Other whale products					1,767,500	42,
Total					4,699,588	258,
Grand total	148,367,139	3,776,656	17,978,911	929,935	332,449,967	8,828,

Yield of the fisheries prosecuted by California fishermen in waters off the coast of Mexico, 1924

Species	Landed at San Pedro		Landed at San Diego		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
FISH						
Albacore	217,537	$20,666	197,479	$17,773	415,016	$38,439
Barracuda	1,899,139	56,794	495,605	13,629	2,394,744	70,423
Bonito	133,671	2,673	68,516	1,370	202,187	4,043
Flounders			274	5	274	5
Halibut, "California"	187,440	25,304	861,043	111,936	1,048,483	137,240
Kingfish	215	4	175	4	390	8
Mackerel	5,074	127	8,160	184	13,234	311
Mullet	3,590	180	33,885	1,694	37,475	1,874
Pompano	770	339	3,750	1,650	4,520	1,989
Rock bass	20,862	1,669	64,726	4,531	85,588	6,200
Rockfishes	8,892	356	23,833	834	32,725	1,190
Sea bass:						
Black	12,221	244	130,506	1,957	142,727	2,201
White, or squeteague	123,245	14,789	427,584	49,172	550,829	63,961
Sheepshead			840	13	840	13
Skipjack or striped tuna	1,628,932	73,302	795,613	31,825	2,424,545	105,127
Smelt, silver	2,818	42	3,814	76	6,632	118
"Sole"	1,910	59	5,061	152	6,971	211
Tuna:						
Yellowfin	1,777,167	142,173	605,472	42,383	2,382,639	184,556
Mixed	61,137	4,891			61,137	4,891
Whitefish	2,882	130	19,532	781	22,414	911
Yellowtail	1,142,992	85,724	708,145	50,986	1,851,137	136,710
Other fish	14,276	708	12,566	655	26,842	1,363
Total	7,244,770	430,174	4,466,579	331,610	11,711,349	761,784
SHELLFISH						
Sea crawfish or spiny lobster	1,381	276	731,575	138,999	732,956	139,275
Abalone	1,000	556			1,000	556
Total	2,381	832	731,575	138,999	733,956	139,831
Grand total	7,247,151	431,006	5,198,154	470,609	12,445,305	901,615

FISHERIES OF THE PACIFIC COAST STATES, 1925[5]

In 1925 there were 16,856 persons, 673 vessels, 5,424 motor boats, and 1,019 rowboats engaged in the commercial fisheries of these States, producing 610,993,424 pounds of fish, shellfish, and whale products, with a first value of $24,580,524. This is the largest production on record.

The salmon fishery (by far the most important) yielded 139,848,020 pounds, valued at $10,149,961. Next in importance was the tuna fishery, which produced 54,776,970 pounds of albacore, tuna, skipjack, and bonito, valued at $4,558,183. Of third importance was the halibut fishery, centered at Seattle but operating along the coast from California northward; the total catch credited to the Pacific Coast States was 19,256,185 pounds, valued at $2,177,125; in addition to this, vessels of the Pacific Coast States landed 2,680,687 pounds, valued at $187,698, in Alaska. The sardine fishery ranked fourth, with 315,294,986 pounds, valued at $2,087,756.

[5] For an explanation of the sources of the statistics given herewith, see footnote 4, p. 419.

Fisheries of the Pacific Coast States, 1925

Items	Washington		Oregon		California		Total	
Vessel fishery:	*Number*	*Value*	*Number*	*Value*	*Number*	*Value*	*Number*	*Value*
Fishermen	2, 338		36		2, 044		4, 418	
Vessels	303		8		362		673	
Tonnage	7, 931		80		5, 350		13, 361	
Shore fishery:								
Fishermen	5, 055		4, 909		2, 474		12, 438	
Power boats	1, 945		2, 224		1, 255		5, 424	
Row boats	330		539		150		1, 019	
PRODUCTS	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Albacore					22, 206, 923	$2, 333, 600	22, 206, 923	$2, 333, 600
Anchovies					123, 919	1, 232	123, 919	1, 232
Barracuda					8, 005, 601	340, 341	8, 005, 601	340, 341
Bonito					866, 530	25, 983	866, 530	25, 983
Carp	286, 137	$8, 584	62, 700	$1, 881	94, 935	1, 928	443, 772	12, 393
Catfish					366, 279	54, 942	366, 279	54, 942
Cod:								
Fresh	1, 027	58					1, 027	58
Dry salted	4, 125, 538	183, 456			3, 415, 608	237, 724	7, 541, 146	421, 180
Flounders	260, 665	6, 678			2, 551, 193	71, 469	2, 811, 858	78, 147
Grayfish	41, 549	86			372, 332	3, 723	413, 881	3, 809
Hake					22, 017	441	22, 017	441
Halibut	18, 516, 341	2, 079, 833	577, 742	75, 713	162, 102	21, 579	19, 256, 185	2, 177, 125
Halibut, "California"					2, 451, 759	334, 136	2, 451, 759	334, 136
Hardhead					24, 028	961	24, 028	961
Herring	669, 843	4, 495			865, 774	17, 315	1, 535, 617	21, 810
Kingfish					536, 654	12, 868	536, 654	12, 868
"Lingcod"	695, 494	21, 413	58, 592	1, 617	683, 130	40, 975	1, 437, 216	64, 005
Mackerel					3, 522, 419	97, 754	3, 522, 419	97, 754
Mullet					36, 807	2, 619	36, 807	2, 619
Pilchard or sardine					315, 294, 986	2, 087, 756	315, 294, 986	2, 087, 756
Pompano					10, 536	4, 808	10, 536	4, 808
Rock bass					330, 285	28, 543	330, 285	28, 543
Rockfishes	442, 500	17, 321	31, 296	858	5, 453, 510	266, 069	5, 927, 306	284, 248
Sablefish	2, 442, 400	167, 123	347, 592	17, 271	722, 472	26, 118	3, 512, 464	210, 512
Salmon	95, 964, 331	6, 170, 768	34, 357, 936	3, 059, 473	9, 525, 753	919, 720	139, 848, 020	10, 149, 961
Sculpin					226, 456	22, 419	226, 456	22, 419
Sea bass:								
Black					189, 072	3, 602	189, 072	3, 602
White or squeteague					1, 920, 295	252, 144	1, 920, 295	252, 144
Shad	254, 610	5, 086	1, 016, 776	31, 381	2, 439, 726	105, 118	3, 711, 112	141, 585
Sheepshead					48, 811	1, 058	48, 811	1, 058
Skates	1, 287	26			183, 484	3, 625	184, 771	3, 651
Skipjack or striped tuna					14, 235, 089	751, 609	14, 235, 089	751, 609
Smelt:								
Silver	225, 664	20, 317			751, 669	40, 953	977, 333	61, 270
Eulachon	1, 249, 264	18, 841	308, 676	4, 352			1, 557, 940	23, 193
"Sole"	231, 191	10, 229	2, 243	112	8, 762, 535	331, 391	8, 995, 969	341, 732
Steelhead trout	1, 718, 786	113, 399	2, 307, 062	169, 410	222	31	4, 026, 070	282, 840
Striped bass			6, 000	600	837, 773	116, 028	843, 773	116, 628
Sturgeon	119, 799	7, 709	161, 330	10, 177			281, 129	17, 976
Surf fishes	80, 456	5, 755			268, 473	13, 126	348, 929	18, 881
Swordfish					27, 045	3, 851	27, 045	3, 851
Tomcod					14, 508	363	14, 508	363
Tuna:								
Bluefin					3, 803, 677	342, 140	3, 803, 677	342, 140
Yellowfin					13, 237, 898	1, 066, 421	13, 237, 898	1, 066, 421
Mixed					426, 853	38, 430	426, 853	38, 430
Whitebait					70, 968	3, 903	70, 968	3, 903
Whitefish					222, 112	12, 034	222, 112	12, 034
Yellowtail					3, 179, 891	272, 717	3, 179, 891	272, 717
Other fish					252, 852	11, 495	252, 852	11, 495
Total	127, 326, 882	8, 841, 267	39, 237, 945	3, 372, 845	428, 744, 961	10, 325, 062	595, 309, 788	22, 539, 174
SHELLFISH								
Crabs	952, 345	65, 080	522, 201	35, 402	3, 234, 312	269, 526	4, 708, 858	370, 008
Crawfish			128, 250	12, 255			128, 250	12, 255
Sea crawfish or spiny lobster					1, 486, 406	289, 785	1, 486, 406	289, 785
Shrimp	35, 761	5, 363			1, 460, 234	146, 023	1, 495, 995	151, 386
Clams:								
Cockle					399	299	399	299
Hard	221, 585	36, 299					221, 585	36, 299
Mixed					9, 276	6, 182	9, 276	6, 182
Pismo					80, 811	40, 406	80, 811	40, 406
Razor	892, 887	123, 992	89, 132	13, 845			982, 019	137, 837
Soft			20, 128	3, 719	44, 009	27, 856	64, 137	31, 575
Mussels					4, 324	631	4, 324	631

Fisheries of the Pacific Coast States, 1925—Continued

Items	Washington		Oregon		California		Total	
SHELLFISH—contd.	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Oysters:								
Eastern, market	10,332	$9,608			56,900	$24,386	67,232	$33,994
Native, market	663,348	350,042	9,693	$4,300	25	8	673,066	354,350
Japanese, market	28,000	16,000					28,000	16,000
Scallops	6,000	1,650					6,000	1,650
Abalone					470,732	261,507	470,732	261,507
Octopus	105,570	6,423			133,449	12,027	239,019	18,450
Squid					1,891,220	119,167	1,891,220	119,167
Trepang or sea cucumber	4,100	185					4,100	185
Turtles					21	1	21	1
Total	2,919,928	614.642	769.404	69,521	8,872,118	1,197,804	12,561,450	1,881,967
WHALE PRODUCTS								
Sperm oil	86,625	4,620			48,870	2,281	135,495	6,901
Whale oil	142,125	11,370			1,525,733	111,887	1,667,858	123,257
Other whale products	210,000	4,550			1,108,833	24,675	1,318,833	29,225
Total	438,750	20,540			2,683,436	138,843	3,122,186	159,383
Grand total	130,685,560	9,476,449	40,007,349	3,442,360	440,300,515	11,661,709	610,993,424	24,580,524

WASHINGTON

In 1925 the fisheries of Washington employed 7,393 fishermen, 303 fishing vessels, 1,945 motor boats, 330 rowboats, and yielded 130,685,560 pounds of fishery products, valued at $9,476,449.

The five species of salmon were the most important of Washington's commercial fishes, yielding 95,964,331 pounds, valued at $6,170,768. Chinook salmon ranked highest in value, yielding 23,756,404 pounds, valued at $2,291,041. Next was sockeye salmon, yielding 10,211,758 pounds, valued at $1,296,596. Third in value but first in amount was humpback salmon, yielding 35,308,770 pounds, valued at $1,290,550.

Second to the salmons, according to value, was the halibut. The total credited to this State was 18,516,341 pounds, valued at $2,079,833. Of this amount, 9,430,641 pounds, valued at $1,157,132, were landed at ports in Washington, and 9,085,700 pounds, valued at $922,701, were landed in Canada. In addition to this, vessels of Washington landed 2,680,687 pounds, valued at $187,698, in Alaska.

The cod was of third importance among the fishes. It is taken in Alaskan waters during the summer months, salted there, and landed at ports in Washington at the end of the season. In 1925, 4,125,538 pounds, valued at $183,456, were so landed, which is estimated to be the equivalent of 10,300,000 pounds of fresh cod. An additional 1,027 pounds of cod, valued at $58, were landed fresh. Sablefish was of fourth importance, with 2,442,400 pounds, valued at $167,123, and steelhead was fifth, with 1,718,786 pounds, valued at $113,399.

The production of all other fish in Washington in 1925 was 4,558,459 pounds, valued at $126,630, and consisted of carp, flounders, grayfish, herring, "lingcod," perch, rockfishes, shad, skates, smelts, sole, and sturgeon.

The production of shellfish amounted to 2,919,928 pounds, valued at $614,642. Oysters ranked first, according to value, with a yield (native, eastern, and Japanese oysters) of 701,680 pounds, valued at $375,650. Of next importance was the razor clam, used mainly in canning, the yield of which amounted to 892,887 pounds, valued at $123,992. The catch of all other shellfish, including crabs, shrimp, hard clams, scallops, octopus, and sea cucumbers, amounted to 1,325,361 pounds, valued at $115,000.

The products of the whale fishery, which is prosecuted by vessels operating from shore stations, amounted to 438,750 pounds, valued at $20,540, and consisted of sperm oil, whale oil, and other whale products.

Yield of the fisheries of Washington in 1925, by districts and species

Species	Puget Sound		Washington coast		Columbia River		Total	
FISH	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Carp					286, 137	$8, 584	286, 137	$8, 584
Cod:								
Fresh	1, 027	$58					1, 027	58
Dry salted	4, 125, 538	183, 456					4, 125, 538	183, 456
Flounders	260, 665	6, 678					260, 665	6, 678
Grayfish	41, 549	86					41, 549	86
Halibut	18, 516, 341	2, 079, 833					18, 516, 341	2, 079, 833
Herring	663, 893	4, 435	5, 950	$60			669, 843	4, 495
"Lingcod"	695, 494	21, 413					695, 494	21, 413
Rockfishes	442, 500	17, 321					442, 500	17, 321
Sablefish	2, 442, 400	167, 123					2, 442, 400	167, 123
Salmon:								
Blueback or sockeye	9, 694, 346	1, 246, 548	328, 440	27, 370	188, 972	22, 678	10, 211, 758	1, 296, 596
Chinook	12, 831, 100	1, 115, 097	1, 399, 969	82, 430	9, 525, 335	1, 093, 514	23, 756, 404	2, 291, 041
Chum	6, 064, 550	189, 096	4, 333, 464	52, 957	1, 094, 488	19, 266	11, 492, 502	261, 319
Humpback	35, 308, 770	1, 290, 554					35, 308, 770	1, 290, 554
Silver	10, 561, 744	739, 323	1, 643, 842	79, 696	2, 989, 311	212, 239	15, 194, 897	1, 031, 258
Shad					254, 610	5, 086	254, 610	5, 086
Skates	1, 287	26					1, 287	26
Smelt:								
Silver	225, 664	20, 317					225, 664	20, 317
Eulachon					1, 249, 264	18, 841	1, 249, 264	18, 841
"Sole"	231, 191	10, 229					231, 191	10, 229
Steelhead trout	77, 346	7, 735	56, 058	4, 425	1, 585, 382	101, 239	1, 718, 786	113, 399
Sturgeon	616	74	26, 130	1, 829	93, 053	5, 896	119, 799	7, 799
Surf fishes	79, 748	5, 707	708	48			80, 456	5, 755
Total	102, 265, 769	7, 105, 109	7, 794, 561	248, 815	17, 266, 552	1, 487, 343	127, 326, 852	8, 841, 267
SHELLFISH								
Crabs	685, 199	46, 866	267, 146	18, 214			952, 345	65, 080
Shrimp	35, 761	5, 363					35, 761	5, 363
Clams:								
Hard	221, 585	36, 299					221, 585	36, 299
Razor			892, 887	123, 992			892, 887	123, 992
Oysters, market:								
Native	656, 268	348, 004	7, 080	2, 038			663, 348	350, 042
Eastern			10, 332	9, 608			10, 332	9, 608
Japanese	28, 000	16, 000					28, 000	16, 000
Scallops	6, 000	1, 650					6, 000	1, 650
Octopus	105, 570	6, 423					105, 570	6, 423
Trepang or sea cucumber	4, 100	185					4, 100	185
Total	1, 742, 483	460, 790	1, 177, 445	153, 852			2, 919, 928	614, 642
WHALE PRODUCTS								
Sperm oil			86, 625	4, 620			86, 625	4, 620
Whale oil			142, 125	11, 370			142, 125	11, 370
Other whale products			210, 000	4, 550			210, 000	4, 550
Total			438, 750	20, 540			438, 750	20, 540
Grand total	104, 008, 252	7, 565, 899	9, 410, 756	423, 207	17, 266, 552	1, 487, 343	130, 685, 560	9, 476, 449

Vessel fisheries.—In 1925 the fisheries of Washington employed 303 fishing crafts of 5 tons net or over, as measured by the United States Customs Service. This included 6 steamers, totaling 220 net tons; 291 motor vessels, totaling 5,873 net tons; and 6 sailing vessels, totaling 1,838 net tons, engaged in the fisheries of Washington, but does not include transporting vessels engaged principally in carrying fish. The yield of the vessel fisheries was 62,081,687 pounds, valued at $4,119,254. This includes all products caught by Washington vessels, except 2,680,687 pounds of halibut, valued at $187,698; 155,263 pounds of sablefish, valued at $6,389; and 1,167 pounds of rockfishes, valued at $32, which were landed in Alaska.

Lines, catching all the halibut and cod and quantities of salmon, were, according to value of products, the most important form of apparatus, yielding 25,798,895 pounds, valued at $2,433,832. Purse seines follow in importance, yielding 34,907,693 pounds, valued at $1,620,043, consisting almost entirely of salmon.

The whale fishery, having its center of operations at Grays Harbor, yielded 438,750 pounds of products, valued at $20,540. Haul seines, drift gill nets, drag bag nets, beam trawls, and crab traps, which constitute the remainder of the vessel apparatus, yielded 936,349 pounds, valued at $44,839.

Vessels engaged in the fisheries of Washington in 1925, by apparatus and rig

Apparatus	Motor vessels			Sailing vessels			Steam vessels			Total		
	Number	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*
Lines (ocean)	140	2,904	988	6	1,838	221				146	4,742	1,209
Purse seines (Puget Sound)	152	3,091	1,177							152	3,091	1,177
Haul seines (Puget Sound)	14	156	42							14	156	42
Gill nets (Puget Sound)	4	26	8							4	26	8
Drag bag nets (Puget Sound)	7	111	21							7	111	21
Beam trawls (Puget Sound)	17	188	46				3	25	8	20	213	54
Crab traps (Puget Sound)	5	68	10							5	68	10
Whaling apparatus (ocean)							3	195	31	3	195	31
Total [1]	291	5,873	2,078	6	1,838	221	6	220	39	303	7,931	2,338

[1] Exclusive of duplication.

Yield of the vessel fisheries of Washington in 1925, by apparatus and species

Species	Purse seines (Puget Sound)		Haul seines (Puget Sound)		Lines [1] (ocean)		Drift gill nets (Puget Sound)	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Cod:								
Fresh								
Dry salted					[2] 4,125,538	$183,456		
Flounders	85	$3	1,522	$30				
Halibut					18,178,882	2,046,007		
Herring			114,765	708				
"Lingcod"					681,650	20,772		
Rockfishes	1,037	52	10,761	545	279,088	9,067		
Sablefish					2,442,400	167,123		
Salmon:								
Blueback or sockeye	3,006,871	386,005	46,613	5,093			6,440	$828
Chinook	203,236	18,476	41,492	4,161	[3] 48,415	4,855	638	65
Chum	5,130,760	159,054	9,350	560			18,630	1,117
Humpback	23,993,505	875,769	24,695	902	[3] 6,500	247	13,325	486
Silver	2,571,024	179,971	4,136	289	[3] 29,272	2,049	13,224	926
Smelt, silver	219	20	5,366	480				
"Sole"	47	2	202	9	7,150	256		
Steelhead trout	909	91						
Surf fishes			11,032	786				
Crabs								
Shrimp								
Scallops								
Octopus			18	1				
Whale oil								
Sperm oil								
Other whale products								
Total	34,907,693	1,620,043	269,952	14,533	25,798,895	2,433,832	52,257	3,422

[1] The line fishery was prosecuted by vessels sailing from Puget Sound ports, and virtually all of the catch was taken in ocean waters. This includes 9,085,700 pounds of halibut, valued at $922,701, and 55,000 pounds of sablefish, valued at $2,300, taken by Washington vessels and landed in Canada. In addition to this, Washington vessels caught 2,680,687 pounds of halibut, valued at $187,698; 155,263 pounds of sablefish, valued at $6,389; and 1,167 pounds of rockfishes, valued at $32, which were landed in Alaska.

[2] Taken in waters off Alaska.

[3] Taken off Cape Flattery

Yield of the vessel fisheries of Washington in 1925, by apparatus and species—Con.

Species	Drag bag nets (Puget Sound)		Beam trawls (Puget Sound)		Crab trap (Puget Sound)		paratus (ocean)		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Cod:										
Fresh			1,027	$58					1,027	$58
Dry salted									4,125,538	183,456
Flounders			172,894	4,425					174,501	4,467
Halibut									18,178,882	2,046,007
Herring	111,693	$749							226,458	1,517
"Lingcod"			104	9					681,844	20,781
Rockfishes			20,493	1,042					311,379	10,706
Sablefish									2,442,400	167,123
Salmon:										
Blueback or sockeye									3,059,924	393,426
Chinook									293,781	27,557
Chum									5,158,740	160,731
Humpback									24,038,025	877,404
Silver									2,617,656	183,235
Smelt, silver	240	22							5,825	522
"Sole"	300	14	168,336	7,496					176,035	7,777
Steelhead trout									909	91
Surf fishes	3,010	215	197	14					14,239	1,015
Crabs					102,489	$7,133			102,489	7,133
Shrimp			26,886	4,032					26,886	4,032
Scallops			6,000	1,650					6,000	1,650
Octopus			381	25					399	26
Whale oil							142,125	$11,370	142,125	11,370
Sperm oil							86,625	4,620	86,625	4,620
Other whale products							210,000	4,550	210,000	4,550
Total	115,243	1,000	396,408	18,751	102,489	7,133	438,750	20,540	62,081,687	4,119,254

Shore and boat fisheries.—The statistics of the shore fisheries include the catch by all fishing craft of less than 5 tons net, as measured by the United States Customs Service, as well as all fish caught without the use of boats. In 1925 there were 5,055 persons, 1,945 motor boats, and 330 rowboats employed in the shore and boat fisheries of Washington, with a yield amounting to 68,603,873 pounds, valued at $5,357,195.

The catch by pound nets ranked of first importance, both as to amount and value, with a yield of 34,451,197 pounds, valued at $2,351,413, consisting almost entirely of salmon and steelhead trout. The catch by lines ranked second, with a yield of 15,403,607 pounds, valued at $1,283,725, consisting almost entirely of salmon, some halibut, and smaller quantities of other fish. Third in both amount and value were drift and set gill nets with a total catch amounting to 11,455,401 pounds, valued at $877,577, which consisted of salmon and steelhead trout, with much smaller quantities of shad, sturgeon, and other fishes.

Next were haul seines, with a yield of 1,580,499 pounds, valued at $117,997, of which salmon, carp, silver smelt, and steelhead trout made up the greater part. The yield of dip nets amounted to 1,287,291 pounds, valued at $21,648, consisting almost entirely of eulachons or smelts. The yield of fish wheels amounted to 873,347 pounds, valued at $82,477, and consisted of salmon, shad, steelhead trout, and sturgeon. Other apparatus, including drag bag nets, beam trawls, reef nets, and brush weirs, contributed 886,523 pounds, valued at $28,470.

Among the shellfish appliances, tongs were most productive, with a yield of 701,680 pounds of oysters, valued at $375,650. Shovels were next, with 1,114,472 pounds of clams, valued at $160,291. Crab traps took 849,856 pounds of crabs, valued at $57,947.

Men and boats engaged in the shore fisheries of Washington in 1925, by apparatus and districts

Apparatus	Puget Sound			Washington coast			Columbia River			Total		
	Men	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*
Haul seines	152	65		2	1		207	15	17	361	81	17
Gill nets:												
Drift	551	310		175	101		861	520		1,587	931	
Set	8	4	4	168	45	121	63	44	19	239	93	144
Pound nets	322	118		109	65		131	131		562	314	
Lines	842	466		93	56		138	102	6	1,073	624	6
Drag bag nets	90	45		3	1					93	46	
Beam trawls	14	7								14	7	
Fish wheels							29			29		
Dip nets	2	1					84	52		86	53	
Reef nets	12	6								12	6	
Brush weirs	6	4								6	4	
Crab traps	101	73		43	27					144	100	
Clam hoes, shovels, and forks	318			1,026						1,344		
Oyster tongs	98	14	151	7	2	12				105	16	163
Total [1]	2,206	958	155	1,449	226	133	1,400	761	42	5,055	1,945	330

[1] Exclusive of duplication.

Yield of the shore fisheries of Washington in 1925, by districts and species

Species	Puget Sound		Washington coast		Columbia River		Total	
FISH	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Carp					286,137	$8,584	286,137	$8,584
Flounders	86,164	$2,211					86,164	2,211
Grayfish	41,549	86					41,549	86
Halibut	337,459	33,826					337,459	33,826
Herring	437,435	2,918	5,950	$60			443,385	2,978
"Lingcod"	13,650	632					13,650	632
Rockfishes	131,121	6,615					131,121	6,615
Salmon:								
Blueback or sockeye	6,634,422	853,122	328,440	27,370	188,972	22,678	7,151,834	903,170
Chinook	12,537,319	1,087,540	1,399,969	82,430	9,525,335	1,093,514	23,462,623	2,263,484
Chum	905,810	28,365	4,333,464	52,957	1,094,488	19,266	6,333,762	100,588
Humpback	11,270,745	413,150					11,270,745	413,150
Silver	7,944,088	556,088	1,643,842	79,696	2,989,311	212,236	12,577,241	848,023
Shad					254,610	5,086	254,610	5,086
Skates	1,287	26					1,287	26
Smelt:								
Silver	219,839	19,795					219,839	19,795
Eulachon					1,249,264	18,841	1,249,264	18,841
"Sole"	55,156	2,452					55,156	2,452
Steelhead trout	76,437	7,644	56,058	4,425	1,585,382	101,239	1,717,877	113,308
Sturgeon	616	74	26,130	1,829	93,053	5,896	119,799	7,799
Surf fishes	65,509	4,692	708	48			66,217	4,740
Total	40,758,606	3,019,236	7,794,561	248,815	17,266,552	1,487,343	65,819,719	4,755,394
SHELLFISH								
Crabs	582,710	39,733	267,146	18,214			849,856	57,947
Shrimp	8,875	1,331					8,875	1,331
Clams:								
Hard	221,585	36,299					221,585	36,299
Razor			892,887	123,992			892,887	123,992
Oysters, market:								
Native	656,268	348,004	7,080	2,038			663,348	350,042
Eastern			10,332	9,608			10,332	9,608
Japanese	28,000	16,000					28,000	16,000
Octopus	105,171	6,397					105,171	6,397
Trepang or sea cucumber	4,100	185					4,100	185
Total	1,606,709	447,949	1,177,445	153,852			2,784,154	601,801
Grand total	42,365,315	3,467,185	8,972,006	402,667	17,266,552	1,487,343	68,603,873	5,357,195

Yield of the shore fisheries of Washington in 1925, by districts, apparatus, and species

Apparatus and species	Puget Sound		Washington coast		Columbia River		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Haul seines:								
Carp					286,137	$8,584	286,137	$8,584
Flounders	8,158	$209					8,158	20[illegible]
Grayfish	2,096	5					2,096	5
Herring	66,135	441					66,135	441
"Lincod"	514	24					514	24
Rockfishes	9,378	478					9,378	478
Salmon—								
Blueback or sockeye	36,904	4,745			11,500	1,380	48,404	6,125
Chinook	50,138	5,038			563,868	64,744	614,006	69,782
Chum	330	19			16,839	299	17,169	318
Humpback	93,330	3,408					93,330	3,408
Silver	26,184	1,833			13,770	1,055	39,954	2,888
Shad					73,671	1,474	73,671	1,474
Skates	116	3					116	3
Smelt, silver	140,738	12,666					140,738	12,666
"Sole"	17,737	788					17,737	788
Steelhead trout	180	18			108,560	6,924	108,740	6,942
Sturgeon					84	5	84	5
Surf fishes	53,937	3,845	195	$12			54,132	3,857
Total	505,875	33,520	195	12	1,074,429	84,465	1,580,499	117,997
Drift gill nets:								
Herring			5,950	60			5,950	60
"Lingcod"	950	57					950	57
Salmon—								
Blueback or sockeye	69,755	8,969			30,625	3,677	100,380	12,646
Chinook	765,182	69,862	362,411	18,119	5,003,926	574,449	6,131,519	662,430
Chum	273,830	8,666	885,624	10,821	522,900	9,202	1,682,354	28,689
Humpback	173,890	6,347					173,890	6,347
Silver	670,880	46,964	207,170	10,359	281,540	19,991	1,159,590	77,314
Shad					133,196	2,662	133,196	2,662
Smelt, silver	2,900	290					2,900	290
Steelhead trout	18,765	1,877	2,820	226	497,700	31,118	519,285	33,221
Sturgeon			25,470	1,783	46,920	2,972	72,390	4,755
Surf fishes	1,225	92					1,225	92
Octopus	470	33					470	33
Total	1,977,847	143,157	1,489,445	41,368	6,516,807	644,071	9,984,099	828,596
Set gill nets:								
Grayfish	36,673	74					36,673	74
"Lingcod"	2,222	101					2,222	101
Rockfishes	2,979	161					2,979	161
Salmon—								
Blueback or sockeye			155,412	12,951	5,855	703	161,267	13,654
Chinook			175,036	5,311	42,435	4,867	217,471	10,178
Chum	2,420	145	624,612	7,336	11,790	207	638,822	7,688
Humpback	20	1					20	1
Silver	19,712	1,380	312,650	10,251	8,570	610	340,932	12,241
Shad					784	9	784	9
"Sole"	392	19					392	19
Steelhead trout			27,738	2,159	27,430	1,717	55,168	3,876
Sturgeon					9,880	625	9,880	625
Surf fishes	3,467	268					3,467	268
Octopus	1,225	86					1,225	86
Total	69,110	2,235	1,295,448	38,008	106,744	8,738	1,471,302	48,981
Pound nets:								
Flounders	5,796	148					5,796	148
Grayfish	40	1					40	1
Halibut	242	30					242	30
Herring	140	1					140	1
Rockfishes	8,782	418					8,782	418
Salmon—								
Blueback or sockeye	6,502,762	836,070	173,028	14,419	25,115	3,013	6,700,905	853,502
Chinook	5,162,212	356,662	344,494	15,602	2,808,369	322,399	8,315,075	694,663
Chum	621,790	19,275	2,810,808	34,645	542,331	9,545	3,974,929	63,465
Humpback	9,656,315	352,555					9,656,315	352,555
Silver	3,348,472	234,393	673,700	32,081	1,002,200	71,155	5,024,372	337,629
Shad					30,984	621	30,984	621
Skates	1,051	21					1,051	21
Steelhead trout	55,368	5,537	25,500	2,040	638,960	39,934	719,828	47,511
Sturgeon	616	74	660	46	11,360	721	12,636	841
Octopus	102	7					102	7
Total	25,363,688	1,805,192	4,028,190	98,833	5,059,319	447,388	34,451,197	2,351,413

Yield of the shore fisheries of Washington in 1925, by districts, apparatus, and species—Continued

Apparatus and species	Puget Sound		Washington coast		Columbia River		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Lines:								
Flounders	166	$10					166	$10
Grayfish	2,740	6					2,740	6
Halibut	337,217	33,796					337,217	33,796
Herring	20	1					20	1
"Lingcod"	9,944	449					9,944	449
Rockfishes	99,881	5,048					99,881	5,048
Salmon—								
Blueback or sockeye	5,772	866					5,772	866
Chinook	[1] 6,559,369	655,936	[2] 517,269	$43,360	[3] 728,249	$83,604	7,804,887	782,900
Chum					286	5	286	5
Humpback	[1] 1,111,010	42,218					1,111,010	42,218
Silver	[1] 3,856,424	269,949	445,872	26,782	1,611,633	114,425	5,913,929	411,156
Skates	120	2					120	2
"Sole"	100	5					100	5
Steelhead trout	2,124	212			938	59	3,062	271
Sturgeon					8,609	546	8,609	546
Surf fishes	2,490	175					2,490	175
Octopus	103,374	6,271					103,374	6,271
Total	12,090,751	1,014,944	963,141	70,142	2,349,715	198,639	15,403,607	1,283,725
Drag bag nets:								
Herring	11,740	78					11,740	78
Rockfishes	22	1					22	1
Salmon—								
Chinook			759	38			759	38
Chum			12,420	155			12,420	155
Silver			4,450	223			4,450	223
Smelt, silver	75,301	6,758					75,301	6,758
Surf fishes	4,150	295	513	36			4,663	331
Total	91,213	7,132	18,142	452			109,355	7,584
Beam trawls:								
Flounders	72,044	1,844					72,044	1,844
"Lingcod"	20	1					20	1
Rockfishes	10,079	509					10,079	509
"Sole"	36,927	1,640					36,927	1,640
Surf fishes	240	17					240	17
Trepang or sea cucumber	4,100	185					4,100	185
Shrimp	8,875	1,331					8,875	1,331
Total	132,285	5,527					132,285	5,527
Fish wheels:								
Salmon—								
Blueback or sockeye					110,570	13,268	110,570	13,268
Chinook					376,602	43,234	376,602	43,234
Silver					68,680	4,796	68,680	4,796
Shad					15,975	320	15,975	320
Steelhead trout					285,320	19,832	285,320	19,832
Sturgeon					16,200	1,027	16,200	1,027
Total					873,347	82,477	873,347	82,477
Dip nets:								
Herring	200	2					200	2
Salmon—								
Blueback or sockeye					5,307	637	5,307	637
Chinook					1,886	217	1,886	217
Chum					342	8	342	8
Silver					2,918	207	2,918	207
Smelt—								
Silver	900	81					900	81
Eulachon					[4] 1,249,264	18,841	1,249,264	18,841
Steelhead trout					26,474	1,655	26,474	1,655
Total	1,100	83			1,286,191	21,565	1,287,291	21,648
Reef nets:								
Salmon—								
Blueback or sockeye	19,229	2,472					19,229	2,472
Chinook	418	42					418	42
Chum	7,440	260					7,440	260
Humpback	236,180	8,621					236,180	8,621
Silver	22,416	1,569					22,416	1,569
Total	285,683	12,964					285,683	12,964

[1] Caught largely by trollers off Neah Bay.
[2] Caught largely by trollers off Grays Harbor and Willipa Harbor, though a small portion of this catch may have been taken off the mouth of the Columbia River.
[3] All taken by trollers off the mouth of the Columbia River.
[4] Caught in tributaries of the Columbia River.

Yield of the shore fisheries of Washington in 1925, by districts, apparatus, and species—Continued

Apparatus and species	Puget Sound		Washington coast		Columbia River		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Brush weirs: Herring	359,200	$2,395					359,200	$2,395
Crab traps: Crabs	582,710	39,733	267,146	$18,214			849,856	57,947
Shovels:								
Clams, hard	221,585	36,299					221,585	36,299
Clams, razor			892,887	123,992			892,887	123,992
Total	221,585	36,299	892,887	123,992			1,114,472	160,291
Tongs:								
Oysters, market, private—								
Native	656,268	348,004	7,080	2,038			663,348	350,042
Eastern			10,332	9,608			10,332	9,608
Japanese	28,000	16,000					28,000	16,000
Total	684,268	364,004	17,412	11,646			701,680	375,650

OREGON

The fisheries of Oregon employed 4,945 persons, 8 vessels, 2,224 motor boats, and 539 rowboats in 1925. The products of the fisheries amounted to 40,007,349 pounds, valued at $3,442,366.

The various species of salmon were by far the most important of Oregon's commercial fishes, yielding 34,357,936 pounds, valued at $3,059,473. Steelhead trout contributed 2,307,062 pounds, valued at $169,410; shad, 1,016,776 pounds, valued at $31,381; halibut, 577,742 pounds, valued at $75,713; sablefish, 347,592 pounds, valued at $17,271; and eulachon or smelt, 308,676 pounds, valued at $4,352. The remaining portion of the catch amounted to 322,161 pounds, valued at $15,245, and consisted of carp, "lingcod," rockfishes, sole, striped bass, and sturgeon. The yield of the various kinds of shellfish, consisting of crabs, crawfish, clams, and oysters, amounted to 769,404 pounds, valued at $69,521.

Vessel fisheries.—In the vessel fishery only 8 vessels, having a net tonnage of 80 and carrying 36 fishermen, were actually engaged in fishing. The catch was made up entirely of halibut, "lingcod," rockfishes, and sablefish, amounting to 1,015,222 pounds, valued at $95,459. The fares of these vessels were landed at Portland and Astoria, Oreg.

Shore and boat fisheries.—The shore and boat fisheries greatly exceeded the vessel fisheries in importance, employing 4,909 fishermen, 2,224 motor boats of under 5 tons net, and 539 rowboats, and yielded products amounting to 38,992,127 pounds, valued at $3,346,907.

Men and boats engaged in the shore fisheries of Oregon in 1925, by apparatus and districts

Apparatus	Columbia River			Oregon coast			Total		
	Men	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*
Gill nets:									
Drift	1,634	979		1,026	677		2,660	1,656	
Set	138	62	76	577	206	371	715	268	447
Haul seines	592	40	24	121	14	14	713	54	38
Pound nets	64	32					64	32	
Lines	409	257		90	53		499	310	
Dip nets	238		37				238		37
Wheels	33						33		
Crab traps				259	259		259	259	
Crawfish traps	44	24	20				44	24	20
Clam shovels and forks				236			236		
Oyster tongs				5	1	3	5	1	3
Total [1]	3,013	1,303	157	1,896	921	382	4,909	2,224	539

[1] Exclusive of duplication.

Yield of the fisheries of Oregon in 1925, by districts and species [1]

Species	Columbia River		Oregon coast		Total	
FISH	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Carp	62,700	$1,881			62,700	$1,881
Halibut	577,742	75,713			577,742	75,713
"Lingcod"	58,592	1,617			58,592	1,617
Rockfishes	31,296	858			31,296	858
Sablefish	347,592	17,271			347,592	17,271
Salmon:						
Blueback or sockeye	352,726	42,327	73	$9	352,799	42,336
Chinook	17,211,872	1,975,923	4,208,395	381,772	21,420,267	2,357,695
Chum	1,108,849	19,516	1,229,496	14,566	2,338,345	34,082
Silver	4,703,124	333,922	5,543,401	201,438	10,246,525	625,360
Shad	410,527	8,211	606,249	23,170	1,016,776	31,381
Smelt, eulachon	308,676	4,352			308,676	4,352
"Sole"	2,243	112			2,243	112
Steelhead trout	1,770,839	110,677	536,223	58,733	2,307,062	169,410
Striped bass			6,000	600	6,000	600
Sturgeon	138,309	8,989	23,021	1,188	161,330	10,177
Total	27,085,087	2,601,369	12,152,858	771,476	39,237,945	3,372,845
SHELLFISH						
Crabs			522,201	35,402	522,201	35,402
Crawfish	128,250	12,255			128,250	12,255
Clams:						
Razor			89,132	13,845	89,132	13,845
Soft			20,128	3,719	20,128	3,719
Oysters, native, market			9,693	4,300	9,693	4,300
Total	128,250	12,255	641,154	57,266	769,404	69,521
Grand total	27,213,337	2,613,624	12,794,012	828,742	40,007,349	3,442,366

[1] All taken by shore fisheries except the halibut, "lingcod," rockfishes, and sablefish, totaling 1,015,222 pounds and valued at $95,459, which were taken by 8 vessels operating trawl lines and landing their fares principally at Portland and Astoria, Oreg. These vessels had a total net tonnage of 80 and carried 36 fishermen.

CALIFORNIA

In 1925 the fisheries of California were prosecuted by 4,518 fishermen, who used 362 vessels with a tonnage of 5,350 net tons, as well as 1,255 motor boats and 150 rowboats. The greater part of their catch was made in waters off California, where 414,503,026 pounds, valued at $9,716,492, were taken. From waters off Mexico, 22,381,881 pounds, valued at $1,707,493, were landed, and 3,415,608 pounds of dried cod, valued at $237,724, were caught by California fishermen in the waters off Alaska. The total yield amounted to 440,300,515 pounds, valued at $11,661,709.

The various species used for canning loom largest in the California catch. The pilchard or sardine, with a yield of 315,294,986 pounds, valued at $2,087,756, accounted for three-fourths of the total quantity and one-fifth of the value. Next was the albacore, with 22,206,923 pounds, valued at $2,333,600. The two tunas—bluefin and yellowfin—accounted for 17,468,428 pounds, valued at $1,446,991. Salmon yielded 9,525,753 pounds, valued at $919,720; skipjack, 14,235,089 pounds, valued at $751,609; and bonita, 866,530 pounds, valued at $25,983.

Of the market species, the flounder group was most important, yielding 13,765,487 pounds, valued at $736,996, of which 2,451,759 pounds, valued at $334,136, were reported as "California halibut," and 8,762,535 pounds, valued at $331,391, as soles. Barracuda was next, with 8,005,601 pounds, valued at $340,341; yellowtail, 3,179,891 pounds, valued at $272,717; the rockfishes, 5,453,510 pounds, valued at $266,069; and white sea bass, 1,920,295 pounds, valued at $252,144. The salt-cod production was 3,415,608 pounds, valued at $237,724. The remaining 13,406,860 pounds, valued at $653,412, were made up of smaller quantities of over 30 varieties of fish.

The production of shellfish amounted to 8,872,118 pounds, valued at $1,197,804. Spiny lobsters, crabs, and abalone, each with more than $250,000 worth of products, were the most important items in the catch. In addition to the fish and shellfish products, there were whale products to the value of $138,843, consisting of 1,525,733 pounds of whale oil, valued at $111,887; 48,870 pounds of sperm oil, valued at $2,281, and 1,108,833 pounds of other whale products, valued at $24,675.

Vessels engaged in the fisheries of California in 1925, by apparatus and districts

Apparatus	Northern district			San Francisco district			Monterey district		
	Number	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*
Lines	7	41	11	7	1,408	114	3	26	17
Lampara nets							4	34	46
Paranzella nets	2	14	10	12	211	59			
Gill nets	1	5	2	1	5	1			
Bag nets				1	6	2			
Crab traps							1	5	1
Abalone outfit				1	7	5	3	27	15
Whaling apparatus				4	147	44			
Total [1]	9	55	21	25	1,761	223	8	66	62

Apparatus	Los Angeles district			San Diego district			Total		
	Number	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*	*Number*	*Tonnage*	*Crew*
Lines	164	1,403	984	101	935	432	282	3,813	1,558
Lampara nets	119	1,103	815	85	822	388	207	1,959	1,249
Purse seines	43	1,022	367	3	75	25	46	1,097	392
Trammel nets	13	115	38	9	64	33	22	179	71
Paranzella nets	2	10	4				16	235	73
Gill nets	23	152	83	11	74	38	36	236	124
Bag nets							1	6	2
Lobster traps	4	23	10	5	63	14	9	86	24
Crab traps							1	5	1
Abalone outfit							4	34	20
Whaling apparatus							4	147	44
Dip nets	1	8	2				1	8	2
Total [1]	212	2,434	1,274	106	1,034	464	362	5,350	2,044

[1] Exclusive of duplication.

NOTE.—All of the above were motor vessels, except 10 vessels sailing from the San Francisco district, as follows: 4 schooners in the line fishery, 4 steamers in the whale fishery, and 2 steamers in the paranzella fishery.

Men and boats engaged in the shore fisheries of California in 1925, by apparatus and districts

Apparatus	Northern district			San Francisco district			Monterey district		
	Men	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*
Lines	166	133	4	356	274	5	208	146	
Gill nets	190	3	123	225	132	10	8	4	
Lampara nets	2	1		47	11		286	26	
Haul seines	15		1	8	5	1			
Bag nets				26	13	1			
Fyke nets	2	2		9	7	1			
Crab traps	29	26		178	173	1	2	2	
Lobster traps				1	1				
Clam shovels	6			16	1				
Oyster tongs				2	1				
Total [1]	375	135	126	618	414	20	417	165	

Apparatus	Los Angeles district			San Diego district			Total		
	Men	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*	*Men*	*Motor boats*	*Row-boats*
Lines	601	346	3	266	157		1, 597	1, 056	12
Gill nets	105	32	1	56	30		584	201	134
Lampara nets	218	53		63	23		616	114	
Haul seines	3	1					26	6	2
Trammel nets	67	21		32	12		99	33	
Paranzella nets	15	5					15	5	
Bag nets							26	13	1
Fyke nets							11	9	1
Crab traps				1	1		210	192	1
Lobster traps	42	25		31	24		74	50	
Clam shovels	62			2			86	1	
Oyster tongs							2	1	
Total [1]	788	382	4	276	159		2, 474	1, 255	150

[1] Exclusive of duplication.

Summary of the yield of the California fisheries in 1925, by species

Species	From waters off California		From waters off Mexico		Total	
FISH	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Albacore	21, 684, 942	$2,282,776	521, 981	$50, 824	22, 206, 923	$2, 333, 600
Anchovies	123, 919	1, 232			123, 919	1, 232
Barracuda	5, 945, 605	268, 753	2, 059, 996	71, 588	8, 005, 601	340, 341
Bonito	770, 232	23, 980	96, 298	2, 003	866, 530	25, 983
Carp	94, 935	1, 928			94, 935	1, 928
Catfish	366, 279	54, 942			366, 279	54, 942
Cod, dry salted	[1] 3, 415, 608	237, 724			[1] 3, 415, 608	237, 724
Eels	246	13			246	13
Flounders	2, 551, 193	71, 469			2, 551, 193	71, 469
Grayfish	372, 332	3, 723			372, 332	3, 723
Hake	22, 017	441			22, 017	441
Halibut	162, 102	21, 579			162, 102	21, 579
Halibut, "California"	1, 351, 456	189, 407	1, 100, 303	144, 729	2, 451, 759	334, 136
Hardhead	24, 028	961			24, 028	961
Herring	862, 974	17, 259	2, 800	56	865, 774	17, 315
Kingfish	536, 604	12, 867	50	1	536, 654	12, 868
"Lingcod"	683, 130	40, 975			683, 130	40, 975
Mackerel	3, 506, 103	97, 408	16, 316	346	3, 522, 419	97, 754
Mullet	21, 651	1, 861	15, 156	758	36, 807	2, 619
Pike, Sacramento	5, 764	231			5, 764	231
Pilchard or sardine	315, 294, 986	2, 087, 756			315, 294, 986	2, 087, 756
Pompano	9, 111	4, 181	1, 425	627	10, 536	4, 808
Rock bass	310, 061	27, 004	20, 224	1, 539	330, 285	28, 543
Rockfishes	5, 449, 694	265, 914	3, 816	155	5, 453, 510	266, 069
Sablefish	722, 472	26, 118			722, 472	26, 118
Salmon	9, 525, 753	919, 720			9, 525, 753	919, 720
Sculpin	226, 456	22, 419			226, 456	22, 419

[1] From waters off Alaska.

Summary of the yield of the California fisheries in 1925, by species—Continued

Species	From waters off California		From waters off Mexico		Total	
	Pounds	Value	Pounds	Value	Pounds	Value
FISH—continued						
Sea bass:						
Black	102,904	$2,286	86,168	$1,316	189,072	$3,602
White or squeteague	925,623	120,986	994,672	131,158	1,920,295	252,144
Shad	2,439,726	105,118			2,439,726	105,118
Sheepshead	47,748	1,042	1,063	16	48,811	1,058
Skates	183,484	3,625			183,484	3,625
Skipjack or striped tuna	8,768,114	501,101	5,466,975	250,508	14,235,089	751,609
Smelt, silver	749,798	40,911	1,871	42	751,669	40,953
"Sole"	8,756,338	331,196	6,197	195	8,762,535	331,391
Splittail	6,557	131			6,557	131
Steelhead trout	222	31			222	31
Striped bass	837,773	116,028			837,773	116,028
Suckers	5,709	114			5,709	114
Surf fishes	268,473	13,126			268,473	13,126
Swordfish	25,612	3,665	1,433	186	27,045	3,851
Tomcod	14,508	363			14,508	363
Tuna:						
Bluefin	3,803,677	342,140			3,803,677	342,140
Yellowfin	2,963,620	266,114	10,274,278	800,307	13,237,898	1,066,421
Mixed	385,463	35,077	41,390	3,353	426,853	38,430
Whitebait	70,968	3,903			70,968	3,903
Whitefish	219,430	11,925	2,682	109	222,112	12,034
Yellowtail	2,586,621	226,628	593,270	46,089	3,179,891	272,717
Other fish	215,653	10,089	18,923	917	234,576	11,006
Total	407,417,674	8,818,240	21,327,287	1,506,822	428,744,961	10,325,062
SHELLFISH						
Crabs	3,234,312	269,526			3,234,312	269,526
Shrimp	1,460,234	146,023			1,460,234	146,023
Sea crawfish or spiny lobster	432,059	89,207	1,054,347	200,578	1,486,406	289,785
Oysters, eastern, market	56,900	24,386			56,900	24,386
Oysters, native, market	25	8			25	8
Clams:						
Cockle	399	299			399	299
Mixed	9,265	6,176	11	6	9,276	6,182
Pismo	80,811	40,406			80,811	40,406
Soft	44,009	27,856			44,009	27,856
Mussels	4,324	631			4,324	631
Abalone	470,572	261,429	160	78	470,732	261,507
Octopus	133,394	12,019	55	8	133,449	12,027
Squid	1,891,220	119,167			1,891,220	119,167
Turtles			21	1	21	1
Total	7,817,524	997,133	1,054,594	200,671	8,872,118	1,197,804
WHALE PRODUCTS						
Sperm oil	48,870	2,281			48,870	2,281
Whale oil	1,525,733	111,887			1,525,733	111,887
Other whale products	1,108,833	24,675			1,108,833	24,675
Total	2,683,436	138,843			2,683,436	138,843
Grand total	417,918,634	9,954,216	22,381,881	1,707,493	440,300,515	11,661,709

Yield of the fisheries off the California coast in 1925, by districts and species

Species	Northern district		San Francisco District		Monterey district	
	Pounds	Value	Pounds	Value	Pounds	Value
FISH						
Albacore			20,525	$2,258	439,304	$32,296
Anchovies			26,012	260	1,400	7
Bonito			13	1	6,025	301
Carp	29,652	$593	65,028	1,327		
Catfish	163,239	24,486	203,040	30,456		
Cod, dry salted			[1] 3,416,608	237,724		
Eels			130	7		
Flounders	73,418	1,736	2,085,734	58,843	379,889	10,329
Grayfish			196,131	1,961	870	9
Hake			16,892	338	5,125	103

[1] Taken in Bering Sea.

Yield of the fisheries off the California coast in 1925, by districts and species—Contd.

Species	Northern district		San Francisco district		Monterey district	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
FISH—continued						
Halibut	151,262	$20,278	10,840	$1,301		
Halibut, "California"					8,761	$1,051
Hardhead	431	17	23,597	944		
Herring	3,222	64	847,071	16,941	2,136	43
Kingfish			3,888	136	103,832	4,153
"Lingcod"	49,165	2,950	426,571	25,594	204,862	12,292
Mackerel	100	3	446	13	845,764	25,373
Pike, Sacramento			5,764	231		
Pilchard or sardine			464,182	9,284	124,756,314	785,965
Pompano					60	18
Rockfishes	66,414	3,319	747,191	42,324	1,190,918	39,388
Sablefish	11,275	564	418,442	16,738	291,929	8,758
Salmon	4,377,256	323,874	4,049,782	485,974	1,098,715	109,872
Sculpin			125	13	3,227	323
Sea bass: White or squeteague	20	3	56,131	5,231	41,686	1,294
Shad			2,439,726	105,118		
Skates	650	13	156,328	3,127	17,452	349
Skipjack or striped tuna			1,344	81	11,292	565
Smelt, silver	39,473	2,763	110,247	7,717	142,606	12,319
"Sole"	257,797	10,312	6,845,793	239,604	1,462,006	73,100
Splittail			6,557	131		
Steelhead trout	222	31				
Striped bass			837,716	116,021	57	7
Suckers	4,972	99	737	15		
Surf fishes	41,013	1,230	89,209	2,676	32,255	1,290
Tom cod			12,633	316	1,875	47
Whitebait	38,017	2,091	32,951	1,812		
Other fish	15,640	782	10,226	511	24,350	487
Total	5,323,247	305,208	23,626,610	1,415,028	131,072,710	1,119,739
SHELLFISH						
Crabs	196,944	16,412	2,962,800	246,900	74,568	6,214
Shrimp			1,460,234	146,023		
Oysters:						
Eastern, market			56,900	24,386		
Native, market			25	8		
Clams:						
Cockle	64	48	335	251		
Mixed	3,656	2,437	5,385	3,590	18	12
Pismo					15	8
Soft	137	82	43,872	27,774		
Mussels			3,561	534	540	66
Abalone					497,352	259,640
Octopus	81	7	15,667	1,410	117,450	10,571
Squid			492	25	1,827,416	109,645
Total	200,882	18,986	4,549,271	450,901	2,487,368	386,156
WHALE PRODUCTS						
Sperm oil			48,870	2,281		
Whale oil			1,525,733	111,887		
Other whale products			1,108,833	24,675		
Total			2,683,436	138,843		
Grand total	5,524,129	414,194	30,859,317	2,004,772	133,560,078	1,505,895

Species	Los Angeles district		San Diego district		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
FISH						
Albacore	16,760,017	$1,801,712	4,465,096	$446,510	21,684,942	$2,282,776
Anchovies	96,507	965			123,919	1,232
Barracuda	5,154,707	237,117	790,898	31,636	5,945,605	268,753
Bonito	629,065	19,624	135,129	4,054	770,232	23,980
Carp			255	8	94,935	1,928
Catfish					366,279	54,942
Cod, dry salted					3,415,608	237,724
Eels	116	6			246	13
Flounders	12,112	560	40	1	2,551,193	71,469
Grayfish	8,992	90	166,339	1,663	372,332	3,723
Hake					22,017	441
Halibut					162,102	21,579
Halibut, "California"	1,087,508	152,630	255,187	35,726	1,351,456	180,407

Yield of the fisheries off the California coast in 1925, by districts and species—Contd.

Species	Los Angeles district		San Diego district		Total	
FISH—continued	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Hardhead					24,028	$961
Herring	1,480	$30	9,065	$181	862,974	17,259
Kingfish	419,378	8,388	9,506	190	536,604	12,867
"Lingcod"	2,532	139			683,130	40,975
Mackerel	2,074,768	57,393	585,025	14,626	3,506,103	97,408
Mullet	6,419	642	15,232	1,219	21,651	1,861
Pike, Sacramento					5,764	231
Pilchard or sardine	174,405,326	1,185,957	15,669,164	106,550	315,204,986	2,087,756
Pompano	8,974	4,128	77	35	9,111	4,181
Rockbass	122,076	11,025	187,985	15,979	310,061	27,004
Rockfishes	1,880,387	103,094	1,555,784	77,789	5,449,694	265,914
Sablefish	826	58			722,472	26,118
Salmon					9,525,753	919,720
Sculpin	200,395	20,039	22,709	2,044	226,456	22,419
Sea bass:						
Black	42,488	1,078	60,416	1,208	102,904	2,286
White or squeteague	662,748	91,481	165,029	22,077	925,623	120,986
Shad					2,439,726	105,118
Sheepshead	28,850	664	18,898	378	47,748	1,042
Skates	8,984	135	70	1	183,484	3,625
Skipjack or striped tuna	6,268,079	376,085	2,487,399	124,370	8,768,114	501,101
Smelt, silver	438,714	17,549	18,758	563	749,798	40,911
"Sole"	183,394	7,886	7,348	294	8,756,338	331,196
Splittail					6,557	131
Steelhead trout					222	31
Striped bass					837,773	116,028
Suckers					5,709	114
Surf fishes	100,286	7,530	5,710	400	268,473	13,126
Swordfish	8,023	1,203	17,589	2,462	25,612	3,665
Tom cod					14,508	363
Tuna:						
Bluefin	3,765,496	338,895	38,181	3,245	3,803,677	342,140
Yellowfin	2,841,212	255,709	122,408	10,405	2,963,620	266,114
Mixed	385,463	35,077			385,463	35,077
Whitebait					70,968	3,903
Whitefish	136,235	7,765	83,195	4,160	219,430	11,925
Yellowtail	1,353,045	121,774	1,233,576	104,854	2,586,621	226,628
Other fish	165,437	8,309			215,653	10,089
Total	219,269,039	4,874,737	28,126,068	1,013,528	407,417,674	8,818,240
SHELLFISH						
Crabs					3,234,312	269,526
Shrimp					1,460,234	146,023
Sea crawfish or spiny lobster	293,401	61,475	138,658	27,732	432,059	89,207
Oysters:						
Eastern, market					56,900	24,386
Native, market					25	8
Clams:						
Cockle					399	299
Mixed	74	49	132	88	9,265	6,176
Pismo	80,796	40,398			80,811	40,406
Soft					44,009	27,856
Mussels	214	31			4,324	631
Abalone	3,220	1,789			470,572	261,429
Octopus	196	31			133,394	12,019
Squid	44,867	6,730	18,445	2,767	1,891,220	119,167
Total	422,768	110,503	157,235	30,587	7,817,524	997,133
WHALE PRODUCTS						
Sperm oil					48,870	2,281
Whale oil					1,525,733	111,887
Other whale products					1,108,833	24,675
Total					2,683,436	138,843
Grand total	219,691,807	4,985,240	28,283,303	1,044,115	417,918,634	9,954,216

Yield of the fisheries by California fishermen in waters off the coast of Mexico, 1925

Species	Landed at San Pedro		Landed at San Diego		Total	
	Pounds	Value	Pounds	Value	Pounds	Value
FISH						
Albacore	512,748	$49,993	9,233	$831	521,981	$50,824
Barracuda	1,631,427	58,731	428,569	12,857	2,059,996	71,588
Bonito	77,675	1,631	18,623	372	96,298	2,003
Halibut, "California"	168,972	23,656	931,331	121,073	1,100,303	144,729
Herring			2,800	56	2,800	56
Kingfish			50	1	50	1
Mackerel	3,869	97	12,447	249	16,316	346
Mullet			15,156	758	15,156	758
Pompano			1,425	627	1,425	627
Rock bass	3,676	298	16,548	1,241	20,224	1,539
Rockfishes	326	15	3,490	140	3,816	155
Sea bass:						
Black	4,696	94	81,472	1,222	86,168	1,316
White or squeteague	370,254	49,984	624,418	81,174	994,672	131,158
Sheepshead	70	1	993	15	1,063	16
Skipjack or striped tuna	3,182,899	159,145	2,284,076	91,363	5,466,975	250,508
Smelt, silver	472	14	1,399	28	1,871	42
"Sole"	3,190	105	3,007	90	6,197	195
Swordfish			1,433	186	1,433	186
Tuna:						
Yellowfin	5,947,255	475,780	4,327,023	324,527	10,274,278	800,307
Mixed	41,390	3,353			41,390	3,353
Whitefish	222	11	2,460	98	2,682	109
Yellowtail	318,767	25,501	274,503	20,588	593,270	46,089
Other fish	16,288	764	2,635	153	18,923	917
Total	12,284,196	849,173	9,043,091	657,649	21,327,287	1,506,822
SHELLFISH						
Sea crawfish or spiny lobster	19,363	3,931	1,034,984	196,647	1,054,347	200,578
Clams, mixed	11	6			11	6
Abalone	160	78			160	78
Octopus	55	8			55	8
Turtles	21	1			21	1
Total	19,610	4,024	1,034,984	196,647	1,054,594	200,671
Grand total	12,303,806	853,197	10,078,075	854,296	22,381,881	1,707,493

COMPARATIVE STATISTICS OF THE FISHERIES OF THE PACIFIC COAST STATES

With the presentation in this report of the 1924 and 1925 statistics, there are available four successive sets of annual data on the fisheries of the Pacific Coast States. It seems desirable to bring together these four years' statistics for ready reference purposes. This is especially desirable because some revisions have been necessary in the data for 1922 and 1923, particularly as regards the oysters, clams, scallops, and mussels. In the first presentation of the statistics there was some confusion in reporting these shellfish, with respect to their poundage on a shell-free basis.[6] In the tables given herewith they are all reported on the basis of pounds of meats without shells. The following statement shows the equivalents used:

[6] In all statistical reports of the Bureau of Fisheries it has been customary to report the oysters, clams, scallops, and mussels on the basis of pounds of meats. Through misunderstanding of the State reports, the 1923 poundage reported (and to a lesser extent that of 1922), included the shells of some of these mollusks.

Variety	Customary unit of measure with shells	Equivalent weight with shells	Equivalent weight of meats as given in table
		Pounds	*Pounds*
Oysters:			
Native—			
Washington	Sack	120	24
Oregon and California	do	120	18
Eastern and Japanese	Bushel	70	7
Clams:			
Hard and cockle	do	60	8
Soft	do	60	10
Pismo	Dozen	24	6
Razor	Sack	100	36
Mixed	Bushel	60	9
Scallops	do	40	6
Mussels	do	60	10
Abalone	Dozen	60	10

It should be pointed out also that not all of the statistics in this section are strictly comparable. Those for 1922 were collected in a canvass by the bureau's agents, and those for 1923, 1924, and 1925 were collected largely by the States (which require reports from the various fishing operators) and supplemented with canvassing by the bureau's agents (see explanation, p. 419).

As bearing on the comparability of the statistics collected by various agencies, the records of California for the year 1922, as collected by the California Fish and Game Commission and by the Bureau of Fisheries, may be of significance. The statistics collected by the State agency were secured by means of duplicates of sales slips, which all fish dealers are required to transmit to the State authorities. This gives a bookkeeping record for compilation and must be considered as highly accurate, unless there is some loss through illegibility of slips and failure to transmit slips to the State. We believe these losses to be negligible. The statistics collected by the bureau were taken by means of a canvass by field agents, who derived most of their information direct from fishermen and wholesalers and used the State compilations to a certain extent. The use of the State figures was limited by the necessity of collecting the data on the catches of each type of gear and each vessel engaged in fishing. As such classification was not available from State compilations, the information was sought direct from operators and consisted largely of estimates of their catches.

From the table given herewith, it may be seen that the totals differ by about 1 per cent. The differences of various items exceed 11 per cent in only three cases. Two of these (the carp and catfish) are differences that probably arose from the restriction of the bureau's canvass to the lower portions of the rivers while the State statistics included the catch from the upper portions of the rivers. The third large difference (in mullet) may be due to confusion of names or to exclusion of the Salton Sea statistics from the State tabulations. The well-known staple fishes were reported in substantially the same amounts by both agencies. In many cases the comparison is closer than would be expected from independent collections of data, and, indeed, the two collections were not wholly independent, for the State figures were used where possible by the bureau's agents. On the whole, it may be concluded that the statistics are in sufficient agreement to be comparable within certain limits; and the agreement is closer than would be expected of entirely independent collections of data.

Comparison of the collection of fisheries statistics by the California Fish and Game Commission and the United States Bureau of Fisheries [1]

Variety	As collected by the California Fish and Game Commission	As collected by the Bureau of Fisheries	Per cent that the Bureau of Fisheries statistics are more (+) or less (−) than those of the California commission
	Pounds	*Pounds*	
Albacore and tuna	24,090,773	25,252,392	+5
Anchovies	652,516	652,516	0
Barracuda	6,250,218	6,284,065	+1
Bonito and skipjack	12,791,447	11,648,413	−9
Carp	66,913	55,054	[2] −18
Catfish	125,679	7,361	[2] −94
Flounders	12,158,553	11,692,376	−4
Grayfish	282,018	314,176	+11
Hake	74,516	78,763	+6
Hardhead	18,206	18,206	0
Herring	341,621	341,614	0
Kingfish	581,863	579,754	0
"Lingcod"	568,481	569,821	0
Mackerel	2,495,928	2,498,197	0
Mullet	30,946	148,628	[2] +471
Pilchard or sardine	93,399,900	92,114,542	−1
Pompano	16,422	16,494	0
Rockbass	316,051	285,494	−10
Rockfishes	4,262,678	4,219,650	−1
Sablefish	268,554	268,905	0
Salmon	7,235,124	7,236,580	0
Sculpin	42,121	44,176	0
Sea bass:			
Black	97,354	87,559	−10
White	2,981,488	2,904,054	−3
Shad	1,109,445	1,133,270	+2
Sheepshead	18,205	18,245	0
Skates	121,210	121,753	0
Smelt	830,140	728,406	−7
Steelhead	2,490	2,490	0
Striped bass	684,198	678,820	−1
Surf fishes	237,634	236,431	−1
Swordfish	23,256	24,363	+5
Tomcod	32,114	31,344	−2
Whitebait	84,007	84,007	0
Whitefish	30,270	32,184	+6
Yellowtail	3,414,423	3,416,572	0
Other fish	279,651	273,193	−2
Total	176,025,413	174,099,868	−1

[1] The material used herewith are the data on 1922 production of fishes, exclusive of salt cod.
[2] See discussion in text, p. 452.

As the State-collected statistics of California are considered the more reliable of the two sets available, they have been used in the tables given in this section. In those tables requiring the values as well as quantities of California fish the 1922 statistics were omitted because there are no values available for the specific quantities reported by the State.

The comparative tables that follow give the statistics on fishermen, vessels, and boats for the Pacific Coast States as a whole for the years 1922 to 1925, inclusive, and for each State separately; on quantities and values, by species, of the yield of the fisheries of the Pacific Coast States for the years 1923 to 1925, inclusive; on quantities and values, by species, for Washington and Oregon, 1922 to 1925, inclusive;

on quantities, by species, for California, 1918 to 1925, inclusive, and on values, by species, for California, for the years 1923 to 1925. Separate tables are given, showing the yield by species, of the fisheries prosecuted by California fishermen off the coast of Mexico and off the coast of California.

Comparative statistics of the personnel and fishing craft employed in the fisheries of the Pacific Coast States, 1922 to 1925

Items	1922	1923	1924	1925
Vessel fishery:	*Number*	*Number*	*Number*	*Number*
Fishermen	3, 162	3, 932	3, 597	4, 418
Vessels	526	555	560	673
Tonnage	10, 265	11, 095	12, 064	13, 361
Shore fishery:				
Fishermen	8, 439	10, 309	11, 762	12, 438
Motor boats	4, 173	5, 100	5, 727	5, 424
Rowboats	1, 041	657	676	1, 019

Comparative statistics of the yield of the fisheries of the Pacific Coast States, 1923 to 1925

Species	1923		1024		1925	
FISH	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Albacore	12, 514, 833	$1, 627, 193	17, 695, 362	$1, 828, 812	22, 206, 923	$2, 333, 600
Anchovies	307, 074	19, 202	346, 951	1, 984	123, 919	1, 232
Barracuda	7, 200, 575	575, 285	7, 128, 523	257, 022	8, 005, C01	340, 341
Bonito	1, 115, 247	47, 310	1, 038, 369	29, 130	866, 530	25, 983
Carp	532, 312	14, 483	455, 223	12, 930	443, 772	12, 393
Catfish	130, 516	23, 333	351, 960	51, 977	366, 279	54, 942
Cod:						
Fresh	(1)	(1)			1, 027	58
Dry salted	5, 078, 711	253, 936	6, 584, 819	366, 856	7, 541, 146	421, 180
Flounders	2, 074, 483	74, 260	2, 269, 743	63, 068	2, 811, 858	78, 147
Grayfish	419, 763	1, 887	489, 639	12, 229	413, 881	3, 809
Hake	78, 969	789	60, 780	1, 519	22, 017	441
Halibut	25, 015, 540	3, 319, 876	15, 973, 183	2. 138, 170	19, 256, 185	2, 177, 125
Halibut, "California"	2, 426, 837	392, 749	2, 576, 261	348, 759	2, 451, 759	334, 136
Hardhead	9, 563	96	19, 023	761	24, 028	961
Herring	903, 080	10, 124	619, 064	10, 438	1, 535, 617	21, 810
Kingfish	411, 564	10, 301	384, 317	8, 892	536, 654	12, 868
"Lingcod"	(1)	(1)	928, 988	40, 600	1, 437, 216	64, 005
Mackerel	3, 592, 446	144, 082	3, 240, 534	86, 834	3, 522, 419	97, 754
Mullet	74, 225	8, 065	61, 971	3, 343	36, 807	2, 619
Pilchard or sardine	159, 197, 006	704, 280	242, 685, 958	2, 079, 727	315, 294, 986	2, 087, 756
Pompano	32, 918	13, 298	17, 579	7, 855	10, 536	4, 808
Rock bass	357, 269	30, 301	466, 208	38, 876	330, 285	28, 543
Rockfishes	6, 136, 813	294, 977	5, 051, 200	223, 231	5, 927, 306	284, 248
Sablefish	3, 014, 772	156, 871	2, 989, 185	140, 001	3, 512, 464	210, 512
Salmon	106, 089, 172	7, 208, 526	101, 960, 651	7, 825, 101	139, 848, 020	10, 149, 961
Sculpin	60, 466	6, 046	109, 070	10, 213	226, 456	22, 419
Sea bass:						
Black	226, 995	22, 168	231, 404	4, 163	189, 072	3, 602
White, or squeteague	2, 520, 263	224, 869	1, 515, 584	185, 086	1, 920, 295	252, 144
Shad	1, 778, 009	66, 870	2, 716, 081	87, 054	3, 711, 112	141, 585
Sheepshead	31, 628	639	24, 267	493	48, 811	1, 058
Skates	141, 198	791	141, 316	2, 070	184, 771	3, 651
Skipjack or striped tuna	11, 462, 522	298, 085	3, 780, 971	179, 210	14, 235, 089	751, 609
Smelt:						
Silver	1, 073, 736	43, 661	1, 179, 418	86, 401	977, 333	61, 270
Eulachon	1, 188, 390	11. 882	1, 210, 153	12, 103	1, 557, 940	23, 193
"Sole"	7, 205, 939	290, 268	9, 101, 728	315, 795	8, 995, 969	341, 732
Steelhead trout	4, 259, 527	301, 505	4, 835, 099	270, 894	4, 026, 070	282, 840
Striped bass	909, 573	90, 957	661, 777	87, 493	843, 773	116, 628
Sturgeon	208, 178	16, 726	261, 712	16, 930	281, 129	17, 976
Surf fishes	394, 792	20, 638	332, 865	15, 961	348, 929	18, 881
Swordfish	11, 691	1, 468	31, 833	3, 610	27, 045	3, 851
Tomcod	47, 551	3, 754	42, 948	982	14, 508	363
Tuna:						
Bluefin	3, 301, 087	165, 885	3, 241, 110	291, 306	3, 803, 677	342, 140
Yellowfin	10, 836, 925	600, 412	3, 063, 398	244, 389	13, 237, 898	1, 066, 421
Mixed	662, 370	35, 471	546, 538	48, 577	426, 853	38, 430

[1] Included with rockfishes.

Comparative statistics of the yield of the fisheries of the Pacific Coast States, 1923 to 1925—Continued

Species	1923		1924		1925	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
FISH—continued						
Whitebait	67, 818	$1, 356	122, 483	$2, 449	70, 968	$3, 903
Whitefish	39, 908	2, 089	273, 077	14, 391	222, 112	12, 034
Yellowtail	3, 979, 611	217, 050	4, 714, 149	375, 156	3, 179, 891	272, 717
Other fish	237, 073	9, 762	376, 640	18, 658	252, 852	11, 496
Total	387, 358, 947	17, 363, 666	451, 909, 112	17, 857, 499	595, 309, 788	22, 539, 174
SHELLFISH						
Crabs	2, 588, 748	253, 879	3, 085, 814	224, 668	4, 708, 858	370, 008
Crawfish	141, 800	12, 000	12, 200	966	128, 250	12, 255
Sea crawfish or spiny lobster	1, 092, 858	225, 656	1, 027, 312	199, 650	1, 486, 406	289, 785
Shrimp	1, 148, 015	71, 305	1, 589, 098	160, 811	1, 495, 995	151, 386
Clams:						
Cockle	4, 815	3, 973	845	571	399	299
Hard	79, 825	17, 276	204, 212	26, 659	221, 585	36, 299
Mixed	3, 877	2, 076	7, 407	3, 333	9, 276	6, 182
Pismo	59, 487	16, 656	73, 287	35, 178	80, 811	40, 406
Razor	430, 698	53, 839	557, 084	77, 874	982, 019	137, 837
Soft	52, 469	12, 752	55, 175	18, 447	64, 137	31, 575
Mussels	10, 004	3, 002	8, 204	1, 119	4, 324	631
Oysters:						
Eastern	113, 764	62, 319	88, 700	45, 938	67, 232	33, 994
Native	696, 240	327, 970	661, 770	346, 752	673, 066	354, 350
Japanese	9, 800	7, 000	15, 680	9, 997	28, 000	16, 000
Scallops			4, 200	1, 155	6, 000	1, 650
Abalone	317, 547	60, 367	449, 362	249, 646	470, 732	261, 507
Octopus	162, 670	12, 599	270, 825	9, 707	230, 019	18, 450
Squid	1, 180, 446	7, 680	6, 831, 029	409, 350	1, 891, 220	119, 167
Other shellfish	1, 270	77	363	28	4, 121	186
Total	8, 094, 333	1, 150, 426	14, 942, 567	1, 821, 849	12, 561, 450	1, 881, 967
WHALE PRODUCTS						
Sperm oil	362, 835	19, 782	67, 875	3, 620	135, 495	6, 901
Whale oil	6, 019, 793	407, 950	4, 403, 963	314, 475	1, 667, 858	123, 257
Other whale products	3, 114, 000	100, 306	2, 373, 500	54, 771	1, 318, 833	29, 225
Total	9, 496, 628	528, 038	6, 845, 338	372, 866	3, 122, 186	159, 383
Grand total	404, 949, 908	19, 042, 130	473, 697, 017	20, 052, 214	610, 993, 424	24, 580, 524

Comparative statistics of the personnel and fisheries craft employed in the fisheries of Washington, 1922 to 1925

Items	1922	1923	1924	1925
	Number	*Number*	*Number*	*Number*
Vessel fishery:				
Fishermen	1,811	1,945	1,639	2,338
Vessels	318	267	217	303
Tonnage	6,330	6,980	6,175	7,931
Shore fishery:				
Fishermen	3,109	3,454	4,551	5,055
Power boats	1,158	1,751	2,036	1,945
Rowboats	248	289	261	330

Comparative statistics of the yield of the fisheries of Washington, 1922 to 1925

Species	1922		1923		1924		1925	
FISH	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Carp	375,160	$12,054	383,705	$11,511	379,258	$11,376	286,137	$8,584
Catfish			1,230	62				
Cod:								
Fresh	(1)	(1)	(1)	(1)			1,027	58
Dry salted	1,175,875	86,395	3,680,711	184,036	3,700,791	176,815	4,125,538	183,456
Flounders	85,211	2,454	195,600	4,092	188,273	3,778	260,665	6,678
Grayfish	6,359	22	59,400	85	97,005	247	41,519	86
Halibut	18,467,422	1,904,915	24,151,374	3,183,820	15,329,569	2,040,881	18,516,341	2,079,833
Herring	260,338	2,605	425,389	4,254	183,444	1,836	669,843	4,495
"Lingcod"	(1)	(1)	(1)	(1)	476,926	15,025	695,494	21,413
Rockfishes	[2] 361,082	[2] 9,234	[2] 579,259	[2] 17,097	295,187	10,715	442,500	17,321
Sablefish	1,021,700	42,866	2,226,480	112,074	1,894,527	103,394	2,442,400	167,123
Salmon:								
Blueback or sockeye	5,101,380	543,743	3,664,245	514,257	5,052,576	658,923	10,211,758	1,296,596
Chinook	10,969,802	946,422	13,217,424	1,374,204	24,697,911	2,086,769	23,756,404	2,291,041
Chum	6,319,808	137,190	8,701,085	190,158	12,219,145	253,973	11,492,502	261,319
Humpback	144,683	5,262	33,096,940	960,590	498,250	22,932	35,308,770	1,290,554
Silver	14,816,994	546,495	12,950,359	473,258	16,158,108	930,501	15,194,897	1,031,258
Shad	48,039	769	88,767	2,710	193,442	1,940	254,610	5,086
Skates	4,227	27	7,210	74	10,179	103	1,287	26
Smelt:								
Silver	238,414	19,946	267,356	19,512	457,506	45,750	225,664	20,317
Eulachon	1,154,002	11,542	911,195	9,111	983,353	9,835	1,249,264	18,841
"Sole"	130,886	3,931	119,904	3,637	266,377	7,986	231,191	10,229
Steelhead trout	475,687	34,075	1,400,973	100,902	1,143,453	66,439	1,718,786	113,399
Sturgeon	267,782	18,670	84,057	6,798	86,205	6,109	119,799	7,799
Surf fishes	50,927	2,616	53,743	2,224	43,896	2,194	80,456	5,755
Tomcod			784	13	424	4		
Other fish	1,660	143	89	4				
Total	61,480,438	4,331,376	106,357,279	7,174,483	84,355,805	6,457,525	127,326,882	8,841,267
SHELLFISH								
Crabs	1,172,092	59,221	1,153,665	57,683	1,145,587	66,578	952,345	65,080
Shrimp	62,000	7,439	34,657	4,504	38,012	5,702	35,761	5,363
Clams:								
Hard	92,433	11,424	79,825	17,276	203,412	26,479	221,585	36,299
Razor	949,086	106,905	381,268	47,659	524,205	72,842	892,887	123,992
Oysters:								
Eastern	45,332	34,068	44,954	38,235	36,022	23,362	10,332	9,608
Native	554,640	251,400	681,840	323,770	650,700	342,447	663,348	350,042
Japanese	35,336	27,131	9,800	7,000	15,680	9,997	28,000	16,000
Scallops					4,200	1,155	6,000	1,650
Octopus	20,225	640	52,377	1,573	101,534	3,137	105,570	6,423
Trepang or sea cucumbers							4,100	185
Total	2,931,144	498,828	2,438,386	497,700	2,722,352	551,699	2,919,928	614,642
WHALE PRODUCTS								
Sperm oil	260,625	12,163	347,250	18,500	67,875	3,620	86,625	4,620
Whale oil	1,762,500	94,000	1,375,500	91,500	1,471,875	98,125	142,125	11,370
Other whale products	1,130,000	30,180	744,000	18,510	606,000	12,488	210,000	4,550
Total	3,153,125	136,343	2,466,750	128,510	2,145,750	114,233	438,750	20,540
Grand total	67,564,707	4,966,547	111,262,415	7,800,693	89,223,907	7,123,457	130,685,560	9,476,449

[1] Included with rockfishes. [2] Includes fresh cod and "lingcod."

Comparative statistics of the personnel and fishing craft employed in the fisheries of Oregon, 1922 to 1925

Items	1922	1923	1924	1925
	Number	*Number*	*Number*	*Number*
Vessel fishery:				
Fishermen	20	15	25	36
Vessels	4	3	6	8
Tonnage	48	44	68	80
Shore fishery:				
Fishermen	3,999	4,230	4,335	4,909
Power boats	1,718	2,042	2,178	2,224
Rowboats	501	233	283	539

Comparative statistics of the yield of the fisheries of Oregon, 1922 to 1925

Species	1922		1923		1924		1925	
FISH	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Carp							62,700	$1,881
Flounders			5,000	$150				
Halibut	239,095	$20,567	864,166	136,056	510,977	$81,373	577,742	75,713
Herring			93,750	1,876				
"Lingcod"	21,198	513	77,500	2,325	51,630	1,549	58,592	1,617
Rockfishes	2,270	88	62,510	1,875	39,223	1,172	31,296	858
Sablefish	57,108	2,528	250,000	12,500	161,348	8,067	347,592	17,271
Salmon:								
Blueback or sockeye	935,789	114,980	2,065,031	278,837	436,340	52,356	352,799	42,336
Chinook	12,650,132	757,546	17,360,898	2,430,544	19,605,761	2,352,669	21,420,267	2,357,695
Chum	128,385	1,413	1,136,268	13,126	2,998,456	29,986	2,338,345	34,082
Silver	4,378,922	125,428	6,716,662	335,430	10,278,835	411,154	10,246,525	625,360
Shad	578,003	11,332	403,859	6,072	983,422	10,561	1,016,776	31,381
Smelt, eulachon	217,350	2,174	277,195	2,771	226,800	2,268	308,676	4,352
"Sole"	25	1					2,243	112
Steelhead trout	1,820,734	136,802	2,855,543	200,181	3,604,558	197,053	2,307,062	169,410
Striped bass							6,000	600
Sturgeon	216,765	13,257	124,121	9,928	175,507	10,821	161,330	10,177
Surf fishes			15,000	750				
Tomcod			5,000	400				
Other fish	5,343	267						
Total	21,251,119	1,186,896	32,312,503	3,432,821	39,072,857	3,159,029	39,237,945	3,372,845
SHELLFISH								
Crabs	730,802	36,499	359,283	47,737	433,411	31,474	522,201	35,402
Crawfish	68,936	9,226	141,800	12,000	12,200	966	128,250	12,255
Clams:								
Razor	58,720	7,290	49,430	6,180	32,879	5,032	89,132	13,845
Soft	13,800	8,278	5,286	1,429	14,621	2,631	20,128	3,719
Hard					800	180		
Oysters, native	11,250	3,750	14,400	4,200	11,070	4,305	9,693	4,300
Octopus			71	4				
Total	883,507	65,043	570,270	71,550	504,981	44,588	769,404	69,521
Grand total	22,134,626	1,251,939	32,882,773	3,504,371	39,577,838	3,203,617	40,007,349	3,442,366

Comparative statistics of the personnel and fishing craft employed in the fisheries of California, 1922 to 1925

Items	1922	1923	1924	1925
Vessel fishery:	*Number*	*Number*	*Number*	*Number*
Fishermen	1,331	1,972	1,933	2,044
Vessels	209	285	337	362
Tonnage	3,887	4,071	5,821	5,350
Shore fishery:				
Fishermen	3,136	2,625	2,876	2,474
Power boats	1,297	1,307	1,513	1,255
Rowboats	292	135	132	150

Comparative statistics of the yield of the fisheries of California, 1918 to 1925

Species	1918	1919	1920	1921
FISH	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Albacore	7,265,422	13,630,899	18,876,647	15,276,727
Anchovies	867,851	1,609,548	569,774	1,946,881
Barracuda	4,837,594	5,824,957	8,201,335	7,625,102
Bonito	2,440,831	3,504,041	873,498	320,737
Carp	312,774	261,388	134,420	102,126
Catfish	204,876	164,856	112,305	148,116
Cod, dry-salted	4,713,018	2,086,200	2,473,800	805,383
Flounders	2,574,108	1,147,584	1,204,252	1,077,886
Grayfish	403,093	612,683	811,349	539,333
Hake	218,672	133,181	141,981	90,218
Halibut	(1)	(1)	(1)	(1)

[1] Included with halibut, "California."

Comparative statistics of the yield of the fisheries of California, 1918 to 1925—Con.

Species	1918	1919	1920	1921
FISH—continued	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Halibut, "California"	4,753,691	4,859,498	4,444,890	3,795,757
Hardhead	27,861	49,291	13,323	75,811
Herring	7,938,280	4,289,899	274,364	542,124
Kingfish	975,095	609,175	461,459	391,085
"Lingcod"	915,836	1,063,136	687,954	425,543
Mackerel	4,076,084	2,702,682	3,048,040	2,975,259
Mullet	91,402	9,199	17,603	28,955
Pilchard, or sardine	157,652,811	153,877,170	118,520,914	59,323,305
Pompano	24,260	61,424	30,357	16,703
Rock bass	783,864	450,229	210,380	363,856
Rockfishes	7,889,838	5,333,313	5,600,848	4,687,879
Sablefish	498,937	334,950	781,032	1,022,642
Salmon	13,026,076	13,145,553	11,133,819	7,990,932
Sculpin	28,404	25,432	35,674	58,380
Sea bass:				
Black	248,795	185,270	148,037	127,431
White	1,683,603	2,520,210	2,660,984	2,643,398
Shad	2,383,635	1,573,738	1,409,768	862,897
Sheepshead	22,978	17,972	14,567	23,925
Skates	246,231	252,776	88,931	60,164
Skipjack	3,023,847	6,897,484	7,957,427	1,138,993
Smelt	796,984	756,980	744,187	765,073
"Sole"	7,027,767	5,528,685	3,821,748	4,870,870
Steelhead trout	21,819	17,217	6,999	3,605
Striped bass	1,407,841	762,345	671,747	601,614
Surf fishes	198,167	191,341	181,131	242,774
Swordfish	18,442	18,252	12,513	14,803
Tomcod	48,536	31,310	37,237	41,779
Tuna:				
Bluefin		14,990,860	10,530,272	2,031,648
Yellowfin		348,081	1,965,024	1,237,016
Mixed	6,240,971	2,461,311	5,482,574	1,552,845
Whitebait	135,857	5,915	678	5,229
Whitefish		27,261	13,711	29,439
Yellowtail	11,798,205	5,005,265	2,704,937	2,490,796
Other fish	858,774	654,745	680,695	1,358,748
Total	258,683,130	258,033,315	217,793,245	120,734,447
SHELLFISH				
Crabs	1,618,992	1,305,024	1,220,568	800,952
Spiny lobsters	930,827	1,089,465	1,189,776	1,277,848
Shrimp	722,178	813,035	818,042	909,844
Clams:				
Cockle	5,991	3,304	2,407	1,934
Mixed	19,363	9,912	11,981	8,975
Pismo	166,421	104,379	74,754	54,877
Soft	52,174	50,429	38,854	36,100
Mussels	8,053	5,849	5,519	1,533
Oysters:				
Eastern	136,137	151,543	112,116	76,712
Native	5,892	13,793	8,961	1,014
Abalone	120,584	151,841	180,365	297,853
Octopus	32,739	21,492	70,740	56,266
Squid	361,714	3,698,242	508,219	432,559
Other shellfish	21,031	269,722	96,836	4,062
Total	4,202,096	7,688,030	4,339,138	3,960,529
WHALE PRODUCTS				
Sperm oil			13,125	9,375
Whale oil	22,500	3,120,000	4,425,000	1,561,065
Other whale products		1,500,000	2,390,000	696,000
Total	22,500	4,620,000	6,828,125	2,266,440
Grand total	262,907,726	270,341,345	228,960,508	135,961,416

Comparative statistics of the yield of the fisheries of California, 1918 to 1925—Con.

Species	1922	1923	1924	1925
FISH	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Albacore	13,231,823	12,514,833	17,695,302	22,206,923
Anchovies	652,516	307,074	346,951	123,919
Barracuda	6,250,218	7,200,575	7,128,523	8,005,601
Bonito	929,065	1,115,247	1,038,369	866,530
Carp	66,913	148,607	75,965	94,935
Catfish	125,670	120,286	351,960	366,279
Cod, dry-salted	1,680,000	1,308,000	2,884,028	3,415,608
Flounders	1,711,733	1,873,883	2,081,470	2,551,193
Grayfish	282,018	360,363	392,634	372,332
Hake	74,516	78,969	60,780	22,017
Halibut	(1)	(1)	132,637	162,102
Halibut, "California"	3,403,484	2,426,837	2,576,261	2,451,759
Hardhead	18,206	9,563	19,023	24,028
Herring	341,621	383,950	435,620	865,774
Kingfish	581,863	411,564	384,317	536,654
"Lingcod"	568,481	467,300	400,432	683,130
Mackerel	2,495,928	3,592,446	3,240,534	3,522,419
Mullet	30,946	74,225	61,971	36,807
Pilchard, or sardine	93,399,900	159,197,006	242,685,958	315,294,986
Pompano	16,422	32,918	17,579	10,536
Rock bass	316,051	357,269	466,208	330,285
Rockfishes	4,262,678	4,950,244	4,716,790	5,453,510
Sablefish	268,554	538,292	933,310	722,472
Salmon	7,235,124	7,090,260	10,015,269	9,525,753
Sculpin	42,121	60,466	109,070	226,456
Sea bass:				
Black	97,354	226,995	231,404	189,072
White	2,981,488	2,520,263	1,515,584	1,920,295
Shad	1,109,445	1,285,383	1,539,217	2,439,726
Sheepshead	18,205	31,628	24,267	48,811
Skates	121,216	133,088	131,137	183,484
Skipjack	11,862,382	11,462,522	3,780,971	14,235,089
Smelt	830,140	806,380	721,912	751,669
"Sole"	7,043,336	7,086,035	8,835,351	8,762,535
Steelhead trout	2,490	3,011	87,088	222
Striped bass	684,198	909,573	661,777	837,773
Surf fishes	237,634	326,049	288,969	268,473
Swordfish	23,256	11,691	31,833	27,045
Tomcod	32,114	41,767	42,524	14,508
Tuna:				
Bluefin	2,838,193	3,301,087	3,241,110	3,803,677
Yellowfin	7,337,405	10,836,925	3,063,308	13,237,898
Mixed	692,352	662,370	546,538	426,853
Whitebait	84,007	67,818	122,483	70,968
Whitefish	30,270	39,908	273,077	222,112
Yellowtail	3,414,423	3,979,611	4,714,149	3,179,891
Other fish	279,651	236,984	376,640	252,852
Total	177,705,413	248,089,105	328,480,450	428,744,961
SHELLFISH				
Crabs	860,328	1,075,800	1,506,816	3,234,312
Spiny lobsters	1,016,776	1,092,858	1,027,312	1,486,406
Shrimp	990,349	1,113,358	1,551,086	1,460,234
Clams:				
Cockle	4,208	4,815	845	399
Mixed	5,294	3,877	7,407	9,276
Pismo	48,373	59,487	73,287	80,811
Soft	57,210	47,183	40,554	44,009
Mussels	7,312	10,004	8,204	4,324
Oysters:				
Eastern	74,325	68,810	52,678	56,900
Native				25
Abalone	312,087	317,547	449,362	470,732
Octopus	98,588	110,222	166,291	133,449
Squid	209,641	1,180,446	6,831,029	1,891,220
Other shellfish	12,696	1,270	363	21
Total	3,097,187	5,085,677	11,715,234	8,872,118
WHALE PRODUCTS				
Sperm oil	37,875	15,585		48,870
Whale oil	6,862,500	4,044,293	2,932,088	1,525,733
Other whale products	3,136,000	2,370,000	1,767,500	1,108,833
Total	10,036,375	7,029,878	4,699,588	2,683,436
Grand total	101,438,975	200,804,720	344,895,272	440,300,415

Comparative statistics of the value of the yield of the fisheries of California, 1923 to 1925

Species	1923	1924	1925
FISH			
Albacore	$1,627,193	$1,828,812	$2,333,600
Anchovies	19,292	1,984	1,232
Barracuda	575,285	257,022	340,341
Bonito	47,310	29,130	25,983
Carp	2,972	1,554	1,928
Catfish	23,271	51,977	54,942
Cod, dry salted	69,900	190,041	237,724
Flounders	70,018	59,290	71,469
Grayfish	1,802	11,982	3,723
Hake	789	1,519	441
Halibut	(1)	15,916	21,579
Halibut, "California"	392,749	348,759	334,136
Hardhead	96	761	961
Herring	3,994	8,602	17,315
Kingfish	10,301	8,892	12,868
"Lingcod"	23,366	24,026	40,975
Mackerel	144,082	86,834	97,754
Mullet	8,065	3,343	2,619
Pilchard or sardine	704,280	2,079,727	2,087,756
Pompano	13,298	7,855	4,808
Rock bass	30,301	38,876	28,543
Rockfishes	250,314	211,344	266,069
Sablefish	32,207	34,540	26,118
Salmon	638,122	1,025,838	919,720
Sculpin	6,046	10,213	22,419
Sea bass:			
Black	22,168	4,163	3,602
White	224,869	186,086	252,144
Shad	58,088	74,553	105,118
Sheepshead	639	493	1,058
Skates	717	1,937	3,626
Skipjack	298,085	179,210	751,609
Smelt, silver	24,149	40,651	40,953
"Sole"	286,631	307,809	331,391
Steelhead trout	422	7,402	31
Striped bass	90,957	87,493	116,028
Surf fishes	17,664	13,707	13,126
Swordfish	1,468	3,610	3,851
Tomcod	3,341	978	363
Tuna:			
Bluefin	165,885	291,306	342,140
Yellowfin	600,412	244,389	1,066,421
Mixed	35,471	48,577	38,430
Whitebait	1,356	2,449	3,903
Whitefish	2,089	14,391	12,034
Yellowtail	217,050	375,156	272,717
Other fish	9,758	18,658	11,495
Total	6,756,362	8,240,945	10,325,062
SHELLFISH			
Crabs	148,459	126,616	269,526
Sea crawfish or spiny lobster	225,656	199,650	289,785
Shrimp	66,801	155,109	146,023
Clams:			
Cockle	3,973	571	299
Mixed	2,076	3,333	6,182
Pismo	16,656	35,178	40,406
Soft	11,323	15,816	27,856
Mussels	3,002	1,119	631
Oysters:			
Eastern	24,084	22,576	24,386
Native			8
Abalone	60,367	249,646	261,507
Octopus	11,022	6,570	12,027
Squid	7,680	409,350	119,167
Turtles	77	28	1
Total	581,176	1,225,562	1,197,804
WHALE PRODUCTS			
Sperm oil	1,282		2,281
Whale oil	316,450	216,350	111,887
Other whale products	81,796	42,283	24,675
Total	399,528	258,633	138,843
Grand total	7,737,066	9,725,140	11,661,709

[1] Included with halibut, "California."

Comparative statistics of the yield of the fisheries off the California coast, 1918 to 1925

Species	1918	1919	1920	1921
FISH	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Albacore	7,263,895	13,553,025	18,876,647	15,274,528
Anchovies	867,851	1,609,548	569,774	1,946,881
Barracuda	3,885,691	4,038,852	4,585,388	4,588,900
Bonito	2,264,164	2,903,688	672,243	237,859
Carp	312,774	261,388	134,420	102,126
Catfish	204,876	164,856	112,305	148,116
Cod, salted	4,713,018	2,086,200	2,473,800	805,383
Flounders	2,574,108	1,147,584	1,204,252	1,077,113
Grayfish	400,478	612,683	798,721	539,333
Hake	218,672	133,181	141,981	90,218
Halibut	(1)	(1)	(1)	(1)
Halibut, "California"	2,837,987	2,523,895	2,767,351	2,482,324
Hardhead	27,861	49,291	13,323	75,811
Herring	7,938,280	4,289,899	274,364	542,124
Kingfish	975,095	608,561	461,411	389,390
"Lingcod"	915,836	1,063,130	687,954	425,543
Mackerel	4,005,906	2,654,596	2,997,308	2,914,613
Mullet	89,657	7,539	17,513	17,140
Pilchard or sardine	157,652,811	153,877,179	118,517,729	59,323,305
Pompano	24,260	61,424	30,126	16,333
Rock bass	776,645	442,555	207,075	355,702
Rockfishes	7,876,926	5,265,664	5,503,187	4,641,156
Sablefish	498,937	334,950	781,032	1,022,642
Salmon	13,026,076	13,145,553	11,133,819	7,990,932
Sculpin	28,404	25,432	35,674	58,008
Sea bass:				
Black	210,432	126,997	89,869	87,196
White	1,528,750	2,445,556	2,408,522	2,143,323
Shad	2,383,635	1,573,738	1,409,768	862,897
Sheepshead	22,488	17,972	14,402	23,925
Skates	246,231	252,776	88,931	60,164
Skipjack	3,023,847	6,885,369	7,942,338	1,138,853
Smelt	788,923	751,870	730,475	765,738
"Sole"	7,027,767	5,528,685	3,821,023	4,870,158
Steelhead trout	21,819	17,217	6,999	3,605
Striped bass	1,407,841	762,345	671,747	601,614
Surf fishes	198,167	191,341	181,131	242,774
Swordfish	18,442	18,252	12,240	14,803
Tomcod	48,536	31,310	37,237	41,779
Tuna:				
Bluefin	----------	14,990,800	10,530,272	1,971,813
Yellowfin	----------	348,081	1,477,905	1,200,600
Mixed	6,240,971	2,194,584	5,245,412	1,384,739
Whitebait	135,857	5,915	678	5,229
Whitefish	----------	27,191	8,859	28,639
Yellowtail	11,658,259	4,871,763	2,486,537	2,139,626
Other fish	588,886	636,943	649,940	1,345,561
Total	254,931,059	252,539,444	210,811,742	123,988,576
SHELLFISH				
Crabs	1,618,992	1,305,024	1,220,568	800,952
Spiny lobsters	195,750	256,894	247,156	334,271
Shrimp	722,178	747,130	818,042	909,844
Clams:				
Cockle	5,991	3,304	2,407	1,934
Mixed	19,303	9,912	8,148	8,975
Pismo	166,421	104,379	74,754	54,877
Soft	52,174	50,429	38,854	36,100
Mussels	8,053	5,849	5,519	1,533
Oysters:				
Eastern	136,137	151,543	112,116	76,712
Native	5,892	13,793	8,901	1,014
Abalone	120,584	151,841	161,343	296,234
Octopus	32,739	21,492	70,740	56,266
Squid	361,714	3,698,242	508,219	432,559
Other shellfish	20,196	14,483	19,918	1,787
Total	3,466,184	6,534,315	3,296,745	3,013,098
WHALE PRODUCTS				
Sperm oil	----------	----------	13,125	9,375
Whale oil	22,500	3,120,000	4,425,000	1,561,065
Other whale products	----------	1,500,000	2,390,000	696,000
Total	22,500	4,620,000	6,828,125	2,266,440
Grand total	258,419,743	263,693,759	220,936,612	129,278,114

[1] Included with halibut, "California."

Comparative statistics of the yield of the fisheries off the California coast, 1918 to 1925—Continued

Species	1922	1923	1924	1925
FISH	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Albacore	13, 231, 823	12, 488, 199	17, 280, 346	21, 684, 942
Anchovies	652, 516	307, 074	346, 951	123, 919
Barracuda	4, 721, 448	5, 135, 824	4, 733, 779	5, 945, 605
Bonito	883, 143	478, 771	836, 182	770, 232
Carp	66, 913	148, 607	75, 965	94, 935
Catfish	125, 679	129, 286	351, 960	366, 279
Cod, salted	1, 680, 000	1, 398, 000	2, 884, 028	3, 415, 608
Flounders	1, 711, 193	1, 873, 708	2, 081, 196	2, 551, 193
Grayfish	282, 018	360, 363	392, 634	372, 332
Hake	74, 516	78, 969	60, 780	22, 017
Halibut	(1)	(1)	132, 637	162, 102
Halibut, "California"	2, 586, 945	1, 544, 699	1, 527, 778	1, 351, 456
Hardhead	18, 206	9, 563	19, 023	24, 028
Herring	341, 621	383, 950	435, 620	862, 974
Kingfish	581, 698	403, 435	383, 927	536, 604
"Lingcod"	568, 481	467, 300	400, 432	683, 130
Mackerel	2, 466, 762	3, 553, 951	3, 227, 300	3, 506, 103
Mullet	24, 364	10, 007	24, 496	21, 651
Pilchard or sardine	93, 399, 900	159, 197, 006	242, 685, 958	315, 294, 986
Pompano	16, 050	19, 780	13, 059	9, 111
Rock bass	311, 362	328, 039	380, 620	310, 061
Rockfishes	4, 238, 480	4, 932, 350	4, 684, 065	5, 449, 694
Sablefish	268, 554	538, 292	933, 310	722, 472
Salmon	7, 235, 124	7, 090, 260	10, 015, 269	9, 525, 753
Sculpin	41, 940	60, 466	109, 070	226, 456
Sea bass:				
Black	83, 692	75, 740	88, 677	102, 904
White	2, 245, 268	1, 928, 386	904, 755	925, 623
Shad	1, 109, 445	1, 285, 383	1, 539, 217	2, 439, 726
Sheepshead	18, 183	31, 111	23, 427	47, 748
Skates	121, 210	133, 988	131, 137	183, 484
Skipjack	10, 115, 712	4, 579, 077	1, 356, 426	8, 768, 114
Smelt	822, 928	798, 840	715, 280	749, 798
"Sole"	7, 043, 111	7, 085, 085	8, 828, 380	8, 756, 338
Steelhead trout	2, 490	3, 011	87, 088	222
Striped bass	684, 198	909, 573	661, 777	837, 773
Surf fishes	237, 634	326, 049	288, 969	268, 473
Swordfish	23, 256	11, 056	31, 833	25, 612
Tomcod	32, 114	41, 767	42, 524	14, 508
Tuna:				
Bluefin	2, 811, 283	3, 218, 000	3, 241, 110	3, 803, 677
Yellowfin	1, 205, 023	428, 896	680, 759	2, 963, 620
Mixed	671, 890	427, 166	485, 401	385, 463
Whitebait	84, 007	67, 818	122, 483	70, 968
Whitefish	27, 779	34, 503	250, 663	219, 430
Yellowtail	3, 111, 131	2, 968, 596	2, 863, 012	2, 586, 621
Other fish	270, 509	189, 520	349, 798	233, 929
Total	166, 249, 599	225, 481, 554	316, 769, 101	407, 417, 674
SHELLFISH				
Crabs	860, 328	1, 075, 800	1, 506, 816	3, 234, 312
Spiny lobsters	376, 310	384, 381	294, 356	432, 059
Shrimp	900, 349	1, 113, 358	1, 551, 086	1, 460, 234
Clams:				
Cockle	4, 208	4, 815	845	399
Mixed	5, 294	3, 757	7, 407	9, 265
Pismo	48, 317	59, 487	73, 287	80, 811
Soft	57, 210	47, 183	40, 554	44, 009
Mussels	7, 312	10, 004	8, 204	4, 324
Oysters:				
Eastern	74, 325	68, 810	52, 678	56, 900
Native				25
Abalone	304, 679	311, 027	448, 362	470, 572
Octopus	98, 588	110, 222	166, 291	133, 394
Squid	209, 641	1, 176, 065	6, 831, 029	1, 891, 220
Other shellfish	175	1, 128	363	
Total	3, 036, 736	4, 366, 037	10, 981, 278	7, 817, 524
WHALE PRODUCTS				
Sperm oil	37, 875	15, 585		48, 870
Whale oil	6, 862, 500	4, 644, 293	2, 932, 088	1, 525, 733
Other whale products	3, 136, 000	2, 370, 000	1, 767, 500	1, 108, 833
Total	10, 036, 375	7, 029, 878	4, 699, 588	2, 683, 436
Grand total	179, 322, 710	236, 877, 469	332, 449, 967	417, 918, 634

[1] Included with halibut, "California."

Comparative statistics of the yield of the fisheries prosecuted by California fishermen in waters off the coast of Mexico, 1918 to 1925

Species	1918	1919	1920	1921	1922	1923	1924	1925
FISH	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Albacore	1,527	77,874		2,199		26,634	415,016	521,981
Barracuda	951,903	1,786,105	3,615,947	3,036,262	1,528,770	2,064,751	2,394,744	2,059,996
Bonito	176,667	600,353	201,255	82,878	45,922	636,476	202,187	96,298
Flounders				773	540	175	274	
Grayfish	2,615		12,628					
Halibut, "California"	1,915,704	2,335,603	1,677,539	1,313,433	816,539	882,138	1,048,483	1,100,303
Herring								2,800
Kingfish		614	48	1,695	165	8,129	390	50
Mackerel	70,178	48,086	50,732	60,646	29,166	38,495	13,234	16,316
Mullet	1,745	1,660	90	11,815	6,582	64,216	37,475	15,156
Pilchard or sardine			3,185					
Pompano			231	370	372	13,138	4,520	1,425
Rock bass	7,219	7,674	3,305	8,154	4,089	29,230	85,588	20,224
Rockfishes	12,912	67,649	97,661	46,723	24,198	17,894	32,725	3,816
Sculpin				312	181			
Sea bass:								
Black	38,363	58,273	58,168	40,235	13,662	151,255	142,727	86,168
White	154,853	74,654	252,462	500,075	736,220	591,877	550,829	994,672
Sheepshead	490		165		22	517	840	1,063
Skipjack		12,115	15,080	140	1,746,670	6,883,445	2,424,545	5,466,975
Smelt	8,061	5,110	13,712	9,335	7,212	7,540	6,632	1,871
"Sole"			725	712	225	950	6,971	6,197
Swordfish			273			635		1,433
Tuna:								
Bluefin				59,835	26,910	82,997		
Yellowfin			487,119	37,016	6,132,382	10,408,029	2,382,639	10,274,278
Mixed		266,727	237,162	168,106	20,462	235,204	61,137	41,390
Whitefish		70	4,852	800	2,491	5,405	22,414	2,682
Yellowtail	139,946	133,502	218,400	351,170	303,292	1,011,015	1,851,137	593,270
Other fish	269,888	17,802	30,755	13,187	9,142	47,464	26,842	18,923
Total	3,752,071	5,493,871	6,981,503	5,745,871	11,455,814	23,207,611	11,711,349	21,327,287
SHELLFISH								
Sea crawfish or spiny lobster	735,077	832,571	942,620	943,577	640,466	708,477	732,956	1,054,347
Abalone		13,181	19,022	1,619	7,408	6,520	1,000	160
Clams:								
Mixed			3,833			120		11
Pismo					56			
Octopus								55
Squid						4,381		
Other shellfish	835	255,239	76,918	2,275	12,521	142		21
Total	735,912	1,100,991	1,042,393	947,471	660,451	719,640	733,956	1,054,594
Grand total	4,487,983	6,594,862	8,023,896	6,693,342	12,116,265	23,927,251	12,445,305	22,381,881

FISHERIES OF MARYLAND AND VIRGINIA, 1925

The statistics contained in this report are based on the regular canvass of the fisheries of Maryland and Virginia for the calendar year 1925.[7] The statistics of the oyster industry, however, represent the oyster season of 1924–25. This report also includes comparative statistics of the production of shad, alewives, crabs, and oysters in the two States for various years from 1880 to 1925. Statistics of the shad and alewife fisheries of the Potomac River for 1926 (following the practice of making an annual canvass of these fisheries, beginning with 1919) and comparative statistics of the production of shad for various years from 1896 to 1926 and of alewives for various years from 1909 to 1926 are given on page 394.

[7] The canvass was made by Winthrop A. Roberts, Rob Leon Greer, R. N. Burrows, W. A. Galloway, and C. E. Brandon.

EARLIER PUBLICATIONS

Some of the earlier publications relating to the fisheries of Maryland and Virginia, and published in Washington, D. C., follow:

1887. Maryland and its fisheries. By R. Edward Earll. *In* The Fisheries and Fishery Industries of the United States, by G. Brown Goode et al., Sec. II, Pt. X, pp. 421–448.
Virginia and its fisheries. By Marshall McDonald. *Ibid.*, Sec. II, Pt. XI, pp. 449–473.
History and methods of the fisheries. *Ibid.*, Sec. V, Vol. I, xi+808 pp., and Vol. II, xx+881 pp. and atlas of 275 pls.

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. Commissioner of Fish and Fisheries, 1888 (1892), pp. 323–351.

1894. The oyster industry of Maryland. By Charles H. Stevenson. Bulletin, U. S. Fish Commission, Vol. XII, 1892 (1894), pp. 203–297.

1895. A statistical report on the fisheries of the Middle Atlantic States. By Hugh M. Smith. Bulletin, U. S. Fish Commission, Vol. XIV, 1894 (1895), pp. 339–467.

1899. The shad fisheries of the Atlantic coast of the United States. By Charles H. Stevenson. Appendix, Report of the U. S. Commissioner of Fish and Fisheries for 1898 (1899), pp. 101–269.
Notes on the extent and condition of the alewife fisheries of the United States in 1896. By Hugh M. Smith. *Ibid.*, pp. 31–43.

1901. Statistics of the fisheries of the Middle Atlantic States (1897). By C. H. Townsend. Appendix, Report, U. S. Commissioner of Fish and Fisheries for 1900 (1901), pp. 195–310.

1904. Statistics of the fisheries of the Middle Atlantic States (1901). By Barton W. Evermann. Appendix, Report, U. S. Commissioner of Fish and Fisheries for 1902 (1904), pp. 433–540.

1905. The crab industry of Maryland. By Winthrop A. Roberts. *In* Report of the U. S. Commissioner of Fisheries for 1904 (1905), pp. 415–432.

1907. Statistics of the fisheries of the Middle Atlantic States for 1904. *In* Report of the U. S. Commissioner of Fisheries for 1905 (1907), 122 pp.

1911. Fisheries of the United States, 1908. Special Reports, Bureau of the Census.

1911. Shad and alewife fisheries (1909). *In* Report of the U. S. Commissioner of Fisheries for 1910 (1911), pp. 27–28.

1914. Oyster industry (1912). *In* Report of the U. S. Commissioner of Fisheries for 1913 (1914), pp. 40–49.

1915. The menhaden industry of the Atlantic coast. By Rob Leon Greer. Appendix III, Report of the U. S. Commissioner of fisheries for 1914 (1915), 27 pp. 7 pl.

1917. Crab industry of Maryland and Virginia (1915). *In* Report of the U. S. Commissioner of Fisheries for 1916 (1917), pp. 60–64.
Shad and alewife industry of Chesapeake Bay and tributaries (1915). *Ibid.*, pp. 65–72.

1919. Crab industry of Chesapeake Bay. By E. P. Churchill, jr. Appendix IV, Report of the U. S. Commissioner of Fisheries for 1918 (1920), 25 pp., XII pls.

1920. The oyster and the oyster industry of the Atlantic and Gulf coasts. By E. P. Churchill, jr. Appendix VIII, Report of the U. S. Commissioner of Fisheries for 1919 (1921), 51 pp., XXIX pls., 5 figs.

1922. 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. Bureau of Fisheries Document No. 932, pp. 77–136.

COMMON AND SCIENTIFIC NAMES OF FISHES

Following is a list of the common and scientific names of the fishes of Maryland and Virginia included in this report:

Alewives	*Pomolobus æstivalis.* *Pomolobus pseudoharengus.*
Angelfish	*Chætodipterus faber.*

Black bass	*Micropterus salmoides.* *Micropterus dolomieu.*
Bluefish	*Pomatomus saltatrix.*
Bonito	*Sarda sarda.*
Bowfin	*Amiatus calvus.*
Butterfish	*Poronotus triacanthus.*
Carp	*Cyprinus carpio.*
Catfish	Siluridæ (species).
Cobia or coalfish	*Rachycentron canadum.*
Cod	*Gadus callarias.*
Crevalle (including blue runner)	Caranx (species).
Croaker	*Micropogon undulatus.*
Drum, black	*Pogonias cromis.*
Drum, red, or redfish	*Sciænops ocellatus.*
Eels	*Anguilla rostrata.*
Flounders	*Paralichthys dentatus.* Pleuronectidæ (species).
Gizzard shad	*Dorosoma cepedianum.*
Goldfish	*Carassius auratus*
Haddock	*Melanogrammus æglifinus.*
Hake	Urophycis (species).
Harvestfish	*Peprilus alepidotus.*
Hickory shad	*Pomolobus mediocris.*
Hog-choker	*Achirus fasciatus.*
King whiting	Menticirrhus (species).
Mackerel	*Scomber scombrus.*
Menhaden	*Brevoortia tyrannus.*
Mullet	*Mugil cephalus.* *Mugil curema.*
Pigfish	*Orthopristis chrysopterus.*
Pike	Esox (species).
Pinfish	*Lagodon rhomboides.*
Pompano	Trachinotus (species).
Scup or porgy	*Stenotomus chrysops.*
Sea bass	*Centropristes striatus.*
Sea robin	Prionotus (species).
Shad	*Alosa sapidissima.*
Sharks	Selachii (species).
Sheepshead	*Archosargus probatocephalus.*
Skates	Batoidei (species).
Spanish mackerel	*Scomberomorus maculatus.*
Spot	*Leiostomus xanthurus.*
Squeteagues or "sea trout"	*Cynoscion regalis.* *Cynoscion nebulosus.*
Striped bass	*Roccus lineatus.*
Sturgeon	*Acipenser sturio.*
Suckers	Catostomidæ (species).
Sunfish	Centrarchidæ (species).
Swellfish	*Tetraodon maculatus.*
Tautog	*Tautoga onitis.*
Thimble-eyed mackerel	*Scomber colias.*
Tomcod	*Microgadus tomcod.*
Tripletail	*Lobotes surinamensis.*
White perch	*Morone americana.*
Whiting	*Merluccius bilinearis.*
Yellow perch	*Perca flavescens.*
Crabs	*Callinectes sapidus.*
Crawfish	Cambarus (species).
Shrimp	*Crangon vulgaris.*
Squid	*Loligo pealei.*
Clams, hard	*Venus mercenaria.*
Oysters	*Ostrea elongata.*
Scallops	*Pecten irradians.*
Terrapin	Malaclemmys (species).

GENERAL STATISTICS

The fisheries and fishery industries of Maryland and Virginia in 1925 gave employment to 39,091 persons, of whom 25,856 were engaged in fishing operations, 9,671 in the wholesale fishery trade, and 3,564 in the canning, salting, smoking, and by-products industries. The investment amounted to $19,322,844, of which amount $10,635,397 were invested in vessels, boats, fishing apparatus, and shore and accessory property used by the fishermen, $4,259,205 in property and cash capital in the wholesale fishery trade, and $4,428,242 in property and cash capital in the canning, salting, smoking, and by-products industries. The products of the fisheries of these two States amounted to 333,205,769 pounds, valued at $13,948,060. The products of the canning and other fishery industries had a value of $4,936,664.

Compared with 1920, there was a decrease of 1,670, or about 5 per cent, in the number of persons engaged; an increase of $1,046,911, or 5.73 per cent, in the investment; and a decrease of 197,544,115 pounds, or 37.22 per cent, in the quantity, with an increase of $1,207,668, or 9.48 per cent, in the value of the products of the fisheries. The decrease in quantity of products was due largely to a smaller catch of menhaden in Virginia. The output of the canning and other fishery industries showed a decrease of $1,388,621, or 21.95 per cent, in value.

The following tables contain condensed statistics of the fisheries and fishery industries of Maryland and Virginia for 1925 and comparative statistics of the products of the fisheries and of shad, alewives, crabs, and oysters for various years from 1880 to 1925.

Fisheries of Maryland and Virginia, 1925

Items	Maryland		Virginia		Total	
	Number	*Value*	*Number*	*Value*	*Number*	*Value*
PERSONS ENGAGED						
On vessels fishing	1,795		2,005		3,800	
On vessels transporting	518		467		985	
In shore or boat fisheries	9,320		11,673		20,993	
Shoresmen	47		31		78	
Total	11,680		14,176		25,856	
INVESTMENT						
Vessels, fishing, steam			44	$2,219,912	44	$2,219,912
Tonnage			5,010		5,010	
Outfit				237,643		237,643
Vessels, fishing, motor	37	$45,900	97	501,125	134	547,025
Tonnage	303		1,004		1,307	
Outfit		12,825		74,207		87,032
Vessels, fishing, sail	354	499,850	42	41,450	396	541,300
Tonnage	4,120		403		4,523	
Outfit		138,605		12,500		151,105
Accessory motor boats			126	34,600	126	34,600
Vessels, transporting, steam			1	51,875	1	51,875
Tonnage			76		76	
Outfit				1,204		1,204
Vessels, transporting, motor	168	464,250	265	471,900	433	936,150
Tonnage	2,483		2,697		5,180	
Outfit		68,925		63,750		132,675
Vessels, trasporting, sail	74	195,650	15	26,850	89	222,500
Tonnage	2,520		387		2,907	
Outfit		19,835		2,475		22,310
Boats, motor	4,135	1,144,589	4,053	1,264,085	8,188	2,408,674
Boats, sail, row, etc	3,271	166,422	5,436	198,530	8,707	364,952

Fisheries of Maryland and Virginia, 1925—Continued

Items	Maryland		Virginia		Total	
INVESTMENT—continued						
Apparatus, vessel fisheries:	*Number*	*Value*	*Number*	*Value*	*Number*	*Value*
Purse seines	9	$4,400	42	$78,200	51	$82,600
Otter trawls	1	100	8	1,150	9	1,250
Crab dredges			109	4,210	109	4,210
Oyster dredges	1,506	32,482	192	5,390	1,698	37,872
Scallop dredges			8	24	8	24
Crab scrapes	12	75			12	75
Tongs	14	99	17	116	31	215
Clam picks or hoes			32	17	32	17
Apparatus, shore fisheries:						
Haul seines	192	29,410	226	43,755	418	73,165
Purse seines	3	800	2	200	5	1,000
Gill nets	4,578	86,654	17,815	75,327	22,393	161,981
Pound nets	985	268,040	2,727	1,304,140	3,712	1,572,180
Fyke nets	2,947	26,665	1,184	26,447	4,131	53,112
Stop nets	1	300	8	1,870	9	2,170
Dip nets	1,159	1,030	759	666	1,918	1,696
Otter trawls	1	35	1	75	2	110
Minor nets	6	31			6	31
Lines, hand and trot		11,868		14,663		26,531
Slat traps or baskets			54	710	54	710
Pots, eel, etc	7,864	8,260	2,289	3,160	10,153	11,420
Spears	2	3	31	50	33	53
Crab scrapes	936	4,936	455	1,837	1,391	6,773
Crab dredges			11	320	11	320
Oyster dredges	484	6,870	260	3,905	744	10,775
Scallop dredges			677	2,058	677	2,058
Tongs, nippers, rakes, and forks	7,043	58,707	5,663	38,705	12,706	97,412
Clam picks or hoes			586	295	586	295
Shore and accessory property		133,975		394,410		528,385
Total		3,431,591		7,203,806		10,635,397
PRODUCTS						
Alewives:	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Fresh	7,480,114	$78,502	17,886,647	$208,953	25,366,761	$287,455
Salted	200,400	4,582	23,600	770	224,000	5,352
Smoked	20,400	1,200			20,400	1,200
Anglefish			4,050	225	4,050	225
Black bass	35,609	6,760	57,418	7,734	93,027	14,494
Bluefish	57,743	7,803	157,258	18,858	215,001	26,661
Bonito	16,300	925	288,110	15,891	304,410	16,816
Bowfin			24,775	753	24,775	753
Butterfish	276,575	15,694	5,836,357	252,298	6,112,932	267,992
Carp	198,353	16,698	462,419	30,997	660,772	47,695
Catfish	474,719	26,005	534,330	32,057	1,009,049	58,062
Cobia or coalfish			3,260	265	3,260	265
Cod			17,000	406	17,000	406
Crevallo			701,445	25,376	701,445	25,376
Croaker	2,602,861	63,326	22,649,295	648,090	25,252,156	711,416
Drum:						
Black	25,150	472	228,180	3,529	253,330	4,001
Red, or redfish	4,160	107	125,390	2,243	129,550	2,350
Eels:						
Fresh	197,862	23,423	181,948	21,900	379,810	45,323
Salted	67,200	8,064			67,200	8,064
Flounders	118,078	7,704	581,817	37,902	699,895	45,606
Gizzard shad	31,025	973	350,283	8,785	381,308	9,758
Goldfish	400	20	2,600	129	3,000	149
Haddock			2,000	80	2,000	80
Hake			11,800	232	11,800	232
Harvest fish	3,700	428	42,325	1,488	46,025	1,916
Hickory shad	20,561	1,132	235,127	11,034	255,688	12,166
Hog-chokers, salted	23,525	1,379			23,525	1,379
King whiting	3,600	424	122,838	8,919	126,438	9,343
Mackerel	9,460	980	11,840	1,234	21,300	2,214
Menhaden	7,000	25	150,485,623	1,434,681	150,492,623	1,434,706
Mullet	14,509	999	122,072	8,161	136,581	9,160
Pigfish	1,000	34	140,799	7,558	141,799	7,592
Pike	71,691	16,456	17,855	2,983	89,546	19,439
Pinfish			1,400	130	1,400	130
Pompano	250	70	4,584	1,003	4,834	1,073
Scup or porgy	45,000	3,100	402,274	27,928	447,274	31,028
Sea bass	54,700	3,788	51,340	4,568	106,040	8,356
Sea robin			50,000	71	50,000	71
Shad	1,260,152	264,388	6,103,704	1,372,491	7,363,856	1,636,879
Sharks			17,154	1,021	17,154	1,021
Sheepshead			122	17	122	17

Fisheries of Maryland and Virginia, 1925—Continued

Items	Maryland		Virginia		Total	
PRODUCTS—continued	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Skates			23,600	$148	23,600	$148
Spanish mackeral	290	$65	127,445	16,679	127,735	16,744
Spot	208,377	11,485	1,768,206	88,090	1,976,583	99,575
Squeteagues or "sea trout"	1,480,209	88,733	12,444,450	579,563	13,924,659	668,296
Striped bass	1,413,999	240,388	821,309	151,027	2,235,308	391,415
Sturgeon	19,225	4,321	65,977	16,167	85,202	20,488
Sturgeon cavair and roe	2,500	2,500	5,353	5,752	7,853	8,252
Suckers	3,775	155	4,113	250	7,888	405
Sunfish	7,733	322	400	20	8,133	342
Swellfish			35,000	49	35,000	49
Tautog	400	24	2,870	225	3,270	249
Thimble-eyed mackeral	5,000	100	13,700	428	18,700	528
Tomcod	800	25	17,400	420	18,200	445
Tripletail			25	4	25	4
White perch	629,485	59,278	427,275	35,230	1,056,760	94,508
Whiting	80,000	800	33,600	716	113,600	1,516
Yellow perch	231,861	25,379	79,687	7,338	311,548	32,717
Other fish	4,720	70	970	65	5,690	135
Crabs:						
Hard	[1] 7,321,116	303,507	[2] 18,531,994	523,733	[3] 25,853,110	827,240
Soft	[4] 2,325,245	264,276	[5] 1,422,250	157,981	[6] 3,747,495	422,257
Crawfish	400	40			400	40
Shrimp	550	275			550	275
Squid	38,000	2,440	415,825	23,607	453,825	26,047
Clams, hard:						
Public	[7] 109,720	46,450	[8] 1,048,544	400,908	[9] 1,158,264	447,358
Private			[10] 32,008	21,426	[10] 32,008	21,426
Oysters, market:						
Public	[11] 28,650,678	3,102,960	[12] 9,546,327	1,036,500	[13] 38,197,005	4,139,460
Private	[14] 1,106,042	152,547	[15] 11,013,366	1,367,761	[16] 12,119,408	1,520,308
Oysters, seed:						
Public	[17] 13,300	765	[18] 9,855,769	358,555	[19] 9,869,069	359,320
Private			[20] 79,450	2,518	[20] 79,450	2,518
Scallops			[21] 360,732	74,272	[21] 360,732	74,272
Terrapin	1,430	1,000	8,400	4,400	9,830	5,400
Turtles	1,033	53	2,700	49	3,733	102
Alewife scales			100,000	10,000	100,000	10,000
Total	56,977,985	4,863,419	276,227,784	9,084,641	333,205,769	13,948,060

[1] 21,963,348 in number.
[2] 55,595,982 in number.
[3] 77,559,330 in number.
[4] 6,975,735 in number.
[5] 4,266,750 in number.
[6] 11,242,485 in number.
[7] 13,715 bushels.
[8] 131,068 bushels.
[9] 144,783 bushels.
[10] 4,001 bushels.
[11] 4,092,954 bushels.
[12] 1,363,761 bushels.
[13] 5,456,715 bushels.
[14] 158,006 bushels.
[15] 1,573,338 bushels.
[16] 1,731,344 bushels.
[17] 1,900 bushels.
[18] 1,407,967 bushels.
[19] 1,409,867 bushels.
[20] 11,350 bushels.
[21] 60,122 bushels.

Fishery industries of Maryland and Virginia, 1925

Items	Canning, salting, smoking, and by-products industries					
	Maryland		Virginia		Total	
	Number	*Value*	*Number*	*Value*	*Number*	*Value*
Establishments	36	$1,087,203	50	$2,093,239	86	$3,180,442
Persons engaged	1,733		1,831		3,564	
Wages paid		374,613		551,924		926,537
Cash capital		607,900		639,900		1,247,800
Products		1,741,765		3,194,899		4,936,664

Products of the fisheries of Maryland and Virginia for various years from 1880 to 1925

Years	Maryland		Virginia		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
1880	95,712,570	$5,221,715	158,874,609	$3,124,444	254,587,179	$8,346,159
1887	107,981,976	3,514,182	97,635,402	1,606,811	205,617,378	5,120,993
1888	114,788,113	3,813,199	101,318,814	1,836,155	216,106,927	5,649,354
1890	143,905,576	6,019,165	185,282,705	3,636,351	329,188,281	9,655,516
1891	141,177,827	6,460,759	183,993,834	3,647,845	325,171,661	10,108,604
1897	88,588,018	3,617,306	277,993,949	3,179,498	366,581,967	6,796,804
1901	82,975,245	3,767,461	378,183,358	4,613,384	461,158,603	8,380,845
1904	81,128,866	3,336,560	355,315,798	5,584,354	436,444,664	8,920,914
1908	113,796,000	3,306,000	312,515,000	4,716,000	426,311,000	8,022,000
1920	59,530,795	4,198,668	471,219,089	8,541,724	530,749,884	12,740,392
1925	56,977,985	4,863,419	276,227,784	9,084,641	333,205,769	13,948,060

NOTE.—The statistics for 1908 in this table are from data published by the Bureau of the Census.

Comparative statistics of the crab product of Maryland and Virginia, various years, 1880 to 1925

Years	Maryland					
	Crabs, hard		Crabs, soft		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
1880	1,166,667	$46,850	(1)	(1)		
1887	2,757,638	36,969	1,636,530	$133,788	4,394,168	$170,757
1888	2,674,675	37,438	2,208,829	161,331	4,883,504	198,769
1890	2,388,099	31,723	4,056,110	228,690	6,444,209	260,413
1891	2,776,898	37,460	4,828,872	266,256	7,605,770	303,716
1897	5,333,316	39,949	4,115,879	177,637	9,449,195	217,586
1901	9,824,793	85,884	4,303,582	202,563	14,128,375	288,447
1904	12,665,282	168,996	5,732,865	189,851	18,398,147	358,847
1908	12,786,000	124,000	7,587,000	195,000	20,373,000	319,000
1915	22,491,675	335,375	7,602,207	329,276	30,093,882	664,651
1920	5,165,703	248,160	3,897,271	494,784	9,062,974	742,944
1925	7,321,116	303,507	2,325,245	264,276	9,646,361	567,783

Years	Virginia						Grand total	
	Crabs, hard		Crabs, soft		Total			
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
1880	2,139,200	$32,088	(1)	(1)				
1887	626,820	15,479	(1)	(1)				
1888	956,843	24,669	(1)	(1)				
1890	2,584,794	28,210	440,310	$26,054	3,025,104	$54,264	9,469,313	$314,677
1891	2,208,071	32,683	585,956	29,379	2,794,027	62,062	10,399,797	365,778
1897	5,331,398	28,331	1,068,116	39,914	6,399,514	68,245	15,848,709	285,831
1901	6,113,277	52,863	1,288,424	65,972	7,401,701	118,835	21,530,076	407,282
1904	10,356,052	179,575	1,910,654	92,909	12,266,706	272,484	30,664,853	631,331
1908	23,001,000	239,000	2,082,000	87,000	25,083,000	326,000	45,456,000	645,000
1915	18,765,148	242,754	1,484,238	74,402	20,249,386	317,156	50,343,268	981,807
1920	12,465,342	401,295	1,171,737	164,269	13,637,079	565,564	22,700,053	1,308,508
1925	18,531,994	523,733	1,422,260	157,981	19,954,244	681,714	29,600,605	1,249,497

[1] Statistics not available.

NOTE.—The statistics for 1908 in this table are from data published by the Bureau of the Census.

Comparative statistics of the shad and alewife product of Maryland various years, 1880 to 1925

Years	Maryland					Virginia	
	Shad		Alewives		Total	Shad	
	Pounds	*Value*	*Pounds*	*Value*	*Value*	*Pounds*	*Value*
1880	3,774,426	$140,926	9,203,959	$139,667	$280,593	3,171,953	$134,496
1887	4,040,820	146,951	11,062,270	89,273	236,234	3,815,126	172,272
1888	4,868,435	176,655	11,511,774	110,291	286,946	7,056,473	321,634
1890	7,127,486	242,909	19,706,994	143,793	386,702	7,266,207	228,897
1891	6,224,873	211,575	17,418,850	131,245	342,820	6,498,242	207,394
1896	5,541,499	166,551	17,667,315	126,050	292,601	11,170,519	307,055
1897	5,799,563	159,365	17,139,459	123,453	282,818	11,529,474	304,448
1901	3,111,181	120,602	13,747,157	91,308	211,910	6,972,212	366,203
1904	2,912,249	159,772	14,484,970	137,982	297,754	7,419,899	439,625
1908	3,937,000	247,000	28,805,000	157,000	404,000	7,314,000	486,000
1909	3,252,688	272,869	23,637,320	155,499	428,368	6,030,200	488,336
1915	1,454,535	191,517	12,567,580	131,779	323,296	4,714,134	658,010
1920	1,867,196	355,217	7,071,688	177,190	532,407	7,293,805	1,145,106
1921	1,807,074	347,396	6,504,845	144,584	491,980	6,909,176	1,199,594
1925	1,260,152	264,388	7,700,914	84,284	348,672	6,103,704	1,372,491

Years	Virginia—Continued			Grand total			
	Alewives		Total	Shad		Alewives	
	Pounds	*Value*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
1880	6,925,413	$76,800	$210,796	6,946,379	$275,422	16,129,372	$215,967
1887	4,401,635	29,585	201,857	7,855,946	319,223	15,463,905	118,858
1888	6,453,005	40,369	362,003	11,924,908	498,289	17,964,779	150,660
1890	10,641,698	91,674	320,571	14,393,693	471,806	30,408,692	235,467
1891	11,013,485	93,905	301,209	12,723,115	418,969	28,432,335	225,150
1896	12,197,607	63,024	370,079	16,712,018	473,606	29,864,922	189,074
1897	13,689,510	70,841	375,289	17,329,037	463,813	30,828,969	194,294
1901	13,913,444	115,424	481,627	10,083,393	486,805	27,660,601	206,732
1904	14,603,866	90,733	530,358	10,332,148	599,397	29,088,836	228,715
1908	37,885,000	171,000	657,000	11,251,000	733,000	66,690,000	328,000
1909	27,787,980	128,375	616,711	9,282,888	761,205	51,425,300	283,874
1915	16,054,130	165,950	823,960	6,168,669	849,527	28,621,710	297,729
1920	16,665,100	259,258	1,404,364	9,161,001	1,500,323	23,736,788	436,448
1921	18,834,164	245,945	1,445,539	8,716,250	1,546,990	25,339,009	300,529
1925	17,910,247	209,723	1,582,214	7,363,856	1,636,879	25,611,161	294,007

NOTE.—The catch of shad and alewives in these States, outside of the Chesapeake Bay region, is included for some years but is practically negligible. In 1925 it amounted to 4,180 pounds of shad, valued at $647, and 5,247 pounds of alewives, valued at $142, in Maryland and 30,313 pounds of shad, valued at $5,741, and 811,065 pounds of alewives, valued at $3,163, in Virginia, included in the above table.
The statistics for 1908 in this table are from data published by the Bureau of the Census.

Oyster industry of Maryland and Virginia for various years from 1880 to 1925

Years	Maryland			Virginia			Total		
	Bushels	*Pounds*	*Value*	*Bushels*	*Pounds*	*Value*	*Bushels*	*Pounds*	*Value*
1880	10,600,000	74,200,000	$4,730,476	6,837,320	47,861,240	$2,218,376	17,437,320	122,061,240	$6,948,852
1887	8,148,217	57,037,519	2,683,435	[1] 2,921,140	20,447,980	1,002,901	11,069,357	77,485,499	3,686,336
1888	8,531,658	59,721,606	2,877,790	3,664,433	25,651,031	1,336,012	12,196,091	85,372,637	4,213,802
1890	10,450,087	73,150,609	4,854,746	6,074,025	42,518,175	2,482,348	16,524,112	115,668,784	7,337,094
1891	9,945,058	69,615,406	5,295,866	6,162,086	43,134,602	2,524,348	16,107,144	112,750,008	7,820,214
1897	7,254,934	50,784,538	2,885,202	7,023,848	49,166,936	2,041,083	14,278,782	99,951,474	4,926,885
1901	5,685,561	30,798,927	3,031,518	6,067,669	42,473,683	2,021,915	11,753,230	82,272,610	5,653,433
1904	4,429,650	31,007,550	2,417,674	7,612,289	53,286,023	3,459,676	12,041,939	84,293,573	5,877,350
1908	6,232,000	43,624,000	2,228,000	5,075,000	35,525,000	2,348,000	11,307,000	79,149,000	4,576,000
1912	5,510,421	38,572,947	2,127,759	6,206,098	43,442,686	2,286,340	11,716,519	82,015,633	4,414,099
1920	4,547,471	31,832,297	2,291,120	3,963,569	27,744,983	2,348,961	8,511,040	59,577,280	4,640,081
1925	4,252,860	29,770,020	3,256,272	4,356,416	30,494,912	2,765,334	8,609,276	60,264,932	6,021,606

[1] Exclusive of the James and Potomac Rivers.

NOTE.—The statistics for 1908 in this table are from data published by the Bureau of the Census.

MARYLAND

The fisheries of Maryland in 1925 gave employment to 19,725 persons, of whom 1,795 were on vessels fishing, 518 on vessels transporting fishery products, 9,320 in the shore or boat fisheries, and 8,092 on shore in connection with the fisheries, in wholesale establishments, canneries, and other fishery industries.

The investment in the fisheries and fishery industries amounted to $8,053,239 and includes 391 motor and sail fishing vessels valued at $545,750, with a net tonnage of 4,423 tons and outfits valued at $151,430; 242 motor and sail transporting vessels valued at $659,900, with a net tonnage of 5,003 tons and outfits valued at $88,760; 7,406 motor, sail, row, and other boats valued at $1,311,011; fishing apparatus employed on vessels, to the value of $37,156, and on boats, to the value of $503,609; and shore and accessory property valued at $133,975. Additional shore property employed in the wholesale fishery trade and other fishery industries amounted to $2,891,048 in value and cash capital to $1,730,600.

The products of the fisheries amounted to 56,977,985 pounds, with a value to the fishermen of $4,863,419. The principal species, arranged in the order of their value, included oysters, 29,770,020 pounds, or 4,252,860 bushels, valued at $3,256,272; crabs, 9,646,361 pounds, or 28,939,083 in number, valued at $567,783; shad, 1,260,152 pounds, valued at $264,388; striped bass, 1,413,999 pounds, valued at $240,388; squeteagues or "sea trout," 1,480,209 pounds, valued at $88,793; alewives, fresh, salted, and smoked, 7,700,914 pounds, valued at $84,284; and croaker, 2,602,861 pounds, valued at $63,326.

Compared with 1920, there was a decrease of 1,658, or 7.75 per cent, in the number of persons employed in the fisheries and fishery industries of Maryland but an increase of $486,805, or 6.43 per cent, in the investment. There was a decrease in the products of the fisheries of 2,552,810 pounds, or 4.29 per cent, in the quantity, with an increase of $664,751 or 15.83 per cent in the value. There was a small decrease in the value of the products of the canning and other fishery industries amounting to $10,100 or 0.58 per cent.

Fisheries by apparatus.—The vessel fisheries of Maryland in 1925 yielded 6,879,398 pounds of products, valued at $951,678, consisting principally of oysters, taken mostly with dredges. The yield of the shore or boat fisheries amounted to 50,098,587 pounds of products, valued at $3,911,741. The most productive forms of apparatus were tongs and rakes, with a catch of 22,084,416 pounds of oysters and clams, valued at $2,225,706; pound nets, with a catch of 12,519,118 pounds of alewives, butterfish, catfish, croaker, shad, squeteagues, striped bass, white perch, and other species, valued at $478,697; lines, used chiefly in the crab fishery, 6,825,544 pounds, valued at $295,697; haul seines, 2,300,760 pounds, valued at $157,718, the more important species taken being alewives, carp, catfish, croaker, striped bass, and white perch; dip nets, 1,690,250 pounds, valued at $159,155, consisting chiefly of crabs; gill nets, 1,311,820 pounds, valued at $219,616, the more important species being shad, striped bass, and white perch; dredges, 1,264,851 pounds of oysters, valued at $169,293; and crab scrapes, 1,252,140 pounds of crabs, valued at $118,925. The products of the vessel fisheries and of the shore or boat fisheries are shown separately in the following tables:

Yield of the vessel fisheries of Maryland in 1925, by apparatus and species

Species	Oyster dredges		Purse seines		Crab scrapes		Otter trawls	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Bluefish			11,750	$980				
Croaker			41,420	2,071				
Spot			3,125	250				
Squeteagues			119,040	11,904				
Striped bass			150,262	27,050			2,000	$300
White perch			3,963	595			2,000	160
Crabs:								
Hard					5,165	$195		
Soft					12,200	1,450		
Oysters, market:								
Public	[1] 6,502,041	$903,423						
Private	26,432	3,300						
Total	6,528,473	906,723	329,560	42,850	17,365	1,645	4,000	460

[1] Includes 21,250 pounds of oysters, valued at $2,100, taken with tongs.

Yield of the shore or boat fisheries of Maryland in 1925, by apparatus and species

Species	Pound nets		Gill nets		Haul seines		Fyke nets	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Alewives:								
Fresh	7,163,039	$72,285	59,183	$2,014	200,939	$2,984	56,953	$1,219
Salted	198,000	4,477	2,000	100			400	5
Smoked					20,400	1,200		
Black bass	5,909	1,175	1,900	314	15,882	3,110	11,878	2,151
Bluefish	10,912	1,069	26,406	4,484	875	100		
Bonito	6,000	350						
Butterfish	276,575	15,694						
Carp	33,367	2,138	12,856	1,268	125,174	11,079	21,476	1,605
Catfish	173,026	9,862	32,656	1,605	107,419	5,705	161,218	8,767
Croaker	1,456,632	30,957	15,576	969	1,062,175	28,289	4,983	125
Drum:								
Black	24,950	464	200	8				
Red	3,360	87	200	8	600	12		
Eels, fresh	8,019	865	78	9	8,022	905	12,195	1,630
Flounders	94,828	5,858			1,500	138	6,500	640
Gizzard shad	23,475	741			2,550	132	5,000	100
Goldfish					400	20		
Harvest fish	3,700	428						
Hickory shad	18,163	941	1,898	171	500	20		
Hog chokers, salted	23,525	1,379						
King whiting	3,600	424						
Mackerel	9,460	980						
Menhaden	7,000	25						
Mullet	4,435	332	2,976	172	1,625	181	5,473	314
Pigfish	800	24	200	10				
Pike	9,104	1,985	10,871	2,562	22,002	5,415	29,714	6,494
Pompano	250	70						
Scup or porgy	31,000	2,400						
Sea bass	2,400	128						
Shad	704,255	146,550	522,270	111,880	32,027	5,718		
Spanish mackerel	290	65						
Spot	90,479	3,046	46,297	4,075	66,413	3,969		
Squeteagues	1,239,706	65,797	6,725	810	64,378	6,117		
Striped bass	462,993	76,865	399,059	68,276	352,714	59,574	19,437	3,643
Sturgeon	2,000	620	17,225	3,701				
Sturgeon caviar	500	500	2,000	2,000				
Suckers	2,125	85					1,650	70
Sunfish					7,633	307	100	15
Tautog	400	24						
Thimble-eyed mackerel	5,000	100						
Tomcod	800	25						
White perch	243,098	21,098	116,368	12,139	142,545	12,841	119,011	12,345
Whiting	80,000	800						
Yellow perch	52,691	5,434	34,496	3,020	45,737	5,928	98,937	10,997
Other fish	4,720	70						
Crabs:								
Hard	532	40						
Soft					19,190	3,971		
Squid	38,000	2,440						
Turtles			380	21	60	3	18	1
Total	12,519,118	478,697	1,311,820	219,616	2,300,760	157,718	554,943	50,181

Yield of the shore or boat fisheries of Maryland in 1925, by apparatus and species—Continued

Species	Lines		Purse seines		Eel pots and spears		Minor nets	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Black bass							40	$10
Bluefish	7,800	$1,170						
Bonito	10,300	575						
Carp							5,480	548
Catfish	400	66						
Croaker	19,125	765	2,950	$150				
Eels:								
Fresh	9,900	1,088			159,648	$18,926		
Salted					67,200	8,064		
Flounders	15,200	1,063					50	5
Scup or porgy	14,000	700						
Sea bass	52,300	3,660						
Shad							1,600	240
Spot			2,063	145				
Squeteagues	28,560	2,285	21,800	1,820				
Striped bass			27,444	4,660			90	20
White perch							2,500	100
Crabs:								
Hard	6,599,044	276,698						
Soft	68,340	7,599						
Crawfish							400	40
Shrimp							50	25
Turtles	575	28						
Total	6,825,544	295,697	54,257	6,775	226,848	26,990	10,210	988

Species	Tongs and rakes		Dredges		Dip nets		Crab scrapes	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Crabs:								
Hard					425,525	$15,205	290,850	$11,369
Soft					1,264,225	143,700	961,290	107,556
Shrimp					500	250		
Oysters:								
Market, public	20,913,886	$2,034,464	1,234,751	$165,073				
Market, private	1,049,510	145,027	30,100	4,200				
Seed, public	13,300	765						
Clams, hard	[1] 109,720	46,450						
Terrapin	[2] 1,430	1,000						
Total	22,087,846	2,227,706	1,264,851	169,293	1,690,250	159,155	1,252,140	118,925

[1] Includes 2,000 pounds of hard clams, valued at $1,000, taken by hand.
[2] Taken by hand.

Summary of the yield of the fisheries of Maryland in 1925

Species	Shore fisheries		Vessel fisheries		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Alewives:						
Fresh	7,480,114	$78,502			7,480,114	$78,502
Salted	200,400	4,582			200,400	4,582
Smoked	20,400	1,200			20,400	1,200
Black bass	35,609	6,760			35,609	6,760
Bluefish	45,993	6,823	11,750	$980	57,743	7,803
Bonito	16,300	925			16,300	925
Butterfish	276,575	15,694			276,575	15,694
Carp	198,353	16,698			198,353	16,698
Catfish	474,719	26,005			474,719	26,005
Croaker	2,561,441	61,255	41,420	2,071	2,602,861	63,326
Drum:						
Black	25,150	472			25,150	472
Red	4,160	107			4,160	107
Eels:						
Fresh	197,862	23,423			197,862	23,423
Salted	67,200	8,064			67,200	8,064
Flounders	118,078	7,704			118,078	7,704
Gizzard shad	31,025	973			31,025	973
Goldfish	400	20			400	20
Harvest fish	3,700	428			3,700	428
Hickory shad	20,561	1,132			20,561	1,132
Hog-chokers, salted	23,525	1,379			23,525	1,379
King whiting	3,600	424			3,600	424
Mackerel	9,460	980			9,460	980

Summary of the yield of the fisheries of Maryland in 1925—Continued

Species	Shore fisheries		Vessel fisheries		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Menhaden	7,000	$25			7,000	$25
Mullet	14,509	999			14,509	999
Pigfish	1,000	34			1,000	34
Pike	71,691	16,456			71,691	16,456
Pompano	250	70			250	70
Scup or porgy	45,000	3,100			45,000	3,100
Sea bass	54,700	3,788			54,700	3,788
Shad	1,260,152	264,388			1,260,152	264,388
Spanish mackerel	290	65			290	65
Spot	205,252	11,235	3,125	$250	208,377	11,485
Squeteagues	1,361,169	76,829	119,040	11,904	1,480,209	88,733
Striped bass	1,261,737	213,038	152,262	27,350	1,413,999	240,388
Sturgeon	19,225	4,321			19,225	4,321
Sturgeon caviar	2,500	2,500			2,500	2,500
Suckers	3,775	155			3,775	155
Sunfish	7,733	322			7,733	322
Tautog	400	24			400	24
Thimble-eyed mackerel	5,000	100			5,000	100
Tomcod	800	25			800	25
White perch	623,522	58,523	5,963	755	629,485	59,278
Whiting	80,000	800			80,000	800
Yellow perch	231,861	25,379			231,861	25,379
Other fish	4,720	70			4,720	70
Crabs:						
Hard	7,315,951	303,312	5,165	195	7,321,116	303,507
Soft	2,313,045	262,826	12,200	1,450	2,325,245	264,276
Crawfish	400	40			400	40
Shrimp	550	275			550	275
Squid	38,000	2,440			38,000	2,440
Clams, hard, public	109,720	46,450			109,720	46,450
Oysters:						
Market, public	22,148,637	2,199,537	6,502,041	903,423	28,650,678	3,102,960
Market, private	1,079,610	149,247	26,432	3,300	1,106,042	152,547
Seed, public	13,300	765			13,300	765
Terrapin	1,430	1,000			1,430	1,000
Turtles	1,033	53			1,033	53
Total	50,098,587	3,911,741	6,879,398	951,678	56,977,985	4,863,419

Summary by counties

Counties	Persons engaged	Investment	Products	
	Number	*Dollars*	*Pounds*	*Value*
Anne Arundel	1,258	351,008	3,633,839	$300,128
Baltimore	2,168	2,776,387	1,118,321	134,921
Calvert	657	121,727	1,761,169	172,038
Caroline	60	7,877	130,683	14,563
Cecil	159	74,437	1,410,119	60,226
Charles	545	75,620	1,051,951	102,369
Dorchester	4,057	1,352,132	10,952,248	1,104,098
Harford	213	54,569	432,480	25,411
Kent	774	218,815	4,211,307	338,428
Prince Georges	31	2,803	58,985	5,723
Queen Annes	1,058	196,241	5,757,415	427,041
St. Marys	1,123	191,600	3,680,596	294,720
Somerset	4,471	1,792,897	8,111,844	848,019
Talbot	1,983	610,231	8,989,328	630,641
Wicomico	605	108,470	1,676,042	175,124
Worcester	563	118,425	4,001,658	229,969
Total	19,725	8,053,239	56,977,985	4,863,419

Salt-fish industry.—Alewives are the only species of importance salted in Maryland, the output in 1925 amounting to 2,677,490 pounds, valued at $48,412. The number of firms engaged was as follows: In Talbot County, 4; in Harford, Anne Arundel, Cecil, and Dorchester Counties, 1 each.

Canning industry.—The pack of fishery products in cans in Maryland in 1925 amounted to 122,281 cases, valued at $764,691, of which

104,379 cases, valued at $703,869, were canned oysters. The remainder of the pack consisted of 3,186 cases of canned alewives, valued at $5,728, and 14,716 cases of canned alewife roe, valued at $55,094. Of the total pack of canned products, 89,999 cases, consisting of canned oysters, are credited to Baltimore City.

By-products.—The most important source of by-products in Maryland is the oyster-shell crushing industry, which in 1925 yielded 63,709 tons of poultry grit, valued at $643,889, and 27,488 tons of lime, valued at $76,747. The greater part of this industry is in Baltimore. In addition, there were produced 360 tons of dry scrap, valued at $7,150, and fish oil to the value of $1,200.

Wholesale trade.—In 1925 there were 316 wholesale fishery establishments in Maryland valued at $1,803,845, with a cash capital amounting to $1,122,700 and employing 6,312 persons, to whom were paid $1,662,282 in wages.

The important features of each of the above fishery industries are shown in the following tables:

Quantity and value of fishery products prepared in Maryland in 1925

Items	Baltimore City		Remainder of State		Total	
	Number	*Value*	*Number*	*Value*	*Number*	*Value*
PRODUCTS CANNED						
Oysters:						
4-ounce (4 dozen to case) [1] ..... cases..	12,944	$74,504	223	$367	13,167	$74,871
5-ounce (4 dozen to case) ..... do....	45,215	289,705	11,809	71,702	57,024	361,407
6-ounce (4 dozen to case) ..... do....	12,008	119,434	2,023	19,381	14,031	138,815
8-ounce (2 dozen to case) ..... do....	3,902	22,370			3,902	22,370
10-ounce (2 dozen to case) ..... do....	14,872	94,592	300	1,940	15,172	96,532
12-ounce (2 dozen to case) ..... do....	1,058	9,611	25	263	1,083	9,874
Total ..... do....	89,999	610,216	14,380	93,653	104,379	703,869
Alewives:						
18-ounce (2 dozen to case) [2] ..... do....			3,186	5,728	3,186	5,728
Alewife roe:						
10-ounce (4 dozen to case) ..... do....			6,800	29,920	6,800	29,920
18-ounce (2 dozen to case) [3] ..... do....			7,916	25,174	7,916	25,174
Total ..... do....			14,716	55,094	14,716	55,094
PRODUCTS SALTED						
Alewives ..... pounds..			2,677,490	48,412	2,677,490	48,412
Grand total		610,216		202,887		813,103

[1] Includes a few cases packed in 3-ounce cans, reduced to the equivalent of 4-ounce cans.
[2] Includes some cases packed in 10-ounce cans, reduced to the equivalent of 18-ounce cans.
[3] Includes some cases packed in 19-ounce cans, reduced to the equivalent of 18-ounce cans.

NOTE.—In addition to the above products, 586,870 pounds of fish, valued at $200,360, were smoked by 3 firms in the State, the greater part of which were from the Great Lakes and the Pacific coast.

Quantity and value of by-products manufactured from fishery products in Baltimore City and various counties in Maryland in 1925

By-products	Baltimore City		Anne Arundel and Dorchester Counties		Somerset and Talbot Counties		Total	
	Tons	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*
Ground oyster shells:								
Poultry grit	36,145	$374,214	4,175	$45,925	23,389	$223,750	63,709	$643,889
Lime	14,685	39,169	2,412	12,410	10,391	25,168	27,488	76,747
Dry scrap and oil (from waste fish and crab shells)..						7,666		7,666
Total		413,383		58,335		256,584		728,302

Investment, persons engaged, and wages paid in the wholesale trade of fresh fishery products in Maryland in 1925, by localities

Localities	Establishments		Cash capital	Number of persons engaged	Wages paid
	Number	Value			
Annapolis and Eastport	4	$57,100	$4,800	118	$16,500
Galloways and Mayo	3	6,200	1,700	38	6,425
Nutwell and Shady Side	3	7,650	1,800	36	7,100
Baltimore	69	829,120	681,200	1,071	705,140
Solomons and Broomes Island	6	20,525	3,800	98	13,800
Perryville and Northeast	3	4,100	2,500	12	4,348
Benedict and Rock Point	4	5,300	2,900	71	9,750
Bishops Head, Crocheron, and Elliott	3	6,300	11,200	106	18,048
Cambridge	17	158,200	155,950	874	182,913
Hoopers Island	7	32,350	23,500	372	39,863
Hudson, Honga, and Secretary	3	11,200	10,000	95	27,120
Wingate and Toddville	6	24,500	20,500	255	28,379
Chestertown	3	500	900	15	3,000
Rock Hall	9	3,600	3,900	58	12,111
Chester	17	42,575	28,550	260	67,290
Blakistone, Compton, and Ridge	4	4,100	2,100	52	8,450
Crisfield	83	416,050	71,500	1,660	318,086
Deal Island, Chance, and Wenona	12	34,300	16,200	224	48,136
Inverness and Rumbley	4	5,100	2,900	52	11,800
Mount Vernon and Marion Station	5	34,650	10,100	169	38,300
Smith Island	25	10,800	13,400	108	8,150
Oxford, Neavitt, and Newcomb	6	24,575	11,000	142	17,638
St. Michaels and Claiborne	3	29,500	11,000	145	27,692
Tilghman Island	6	20,650	18,200	155	26,725
Salisbury, Bivalve, and Nanticoke	4	12,300	9,800	109	14,918
Girdletree	3	1,500	1,700	10	350
Ocean City and Newark	4	1,100	1,600	7	250
Total	316	1,803,845	1,122,700	6,312	1,662,282

VIRGINIA

The number of persons engaged in the fisheries and related industries of Virginia in 1925 was 19,366, of whom 2,005 were on fishing vessels, 467 on vessels transporting fishery products, 11,673 in the shore or boat fisheries, and 5,221 engaged as shoremen connected with the fisheries and in the wholesale fishery trade, canning, and other fishery industries.

The amount of capital invested in the fisheries and fishery industries was $11,269,605 and included 464 fishing and transporting vessels valued at $3,313,112, with a net tonnage of 9,577 tons and outfits valued at $391,779; 9,615 boats valued at $1,497,215; fishing apparatus with a value of $1,607,290; shore and accessory property to the value of $3,424,709; and cash capital amounting to $1,035,500.

The products of the fisheries amounted to 276,227,784 pounds, valued at $9,084,641. The principal species, arranged in the order of their value, were as follows: Oysters, 30,494,912 pounds, or 4,356,416 bushels, valued at $2,765,334; menhaden, 150,485,623 pounds, valued at $1,434,681; shad, 6,103,704 pounds, valued at $1,372,491; crabs, 19,945,244 pounds, valued at $681,714; croaker, 22,649,295 pounds, valued at $648,090; squeteagues, 12,444,450 pounds, valued at $579,563; clams, 1,080,552 pounds, valued at $422,334; butterfish, 5,836,357 pounds, valued at $252,298; and alewives, 17,910,247 pounds, valued at $209,723.

Compared with 1920, there was a decrease of 12 in the number of persons engaged in the fisheries and fishery industries and an increase of $560,106, or 5.23 per cent, in the investment. The products of the fisheries showed a decrease of 194,991,305 pounds, or 41.38 per cent, in the quantity but an increase of $542,917, or 6.36 per cent, in the value. There was a decrease in the value of the products of the canning and other fishery industries amounting to $1,376,521, or 30.10 per cent.

Fisheries by apparatus.—The products of the vessel fisheries of Virginia in 1925 amounted to 159,439,533 pounds, valued at $2,138,-127, consisting chiefly of menhaden taken with purse seines, 146,008,-200 pounds, valued at $1,416,422; oysters taken with dredges and tongs, 7,505,033 pounds, or 1,072,148 bushels, valued at $624,881; and crabs taken with dredges, 3,345,587 pounds, valued at $115,595. In the shore or boat fisheries the most productive form of apparatus used is the pound net, the catch amounting to 66,244,102 pounds, valued at $2,959,881. The species taken in the largest quantities with pound nets were alewives, croaker, squeteagues or "sea trout," butterfish, shad, and menhaden. Tongs, nippers, rakes, forks, and clam picks or hoes, used chiefly in taking oysters, yielded a catch of 24,035,361 pounds, valued at $2,400,112. The catch with lines, consisting principally of hard crabs, amounted to 15,138,799 pounds, valued at $424,086. Gill nets took 3,463,948 pounds, valued at $338,-951, the principal species being croaker and shad. The catch with haul seines amounted to 3,977,704 pounds, valued at $190,503, the principal species being croaker, spot, squeteagues or "sea trout," and carp. Dredges took 1,658,043 pounds, valued at $171,819; dip nets, 790,215 pounds, valued at $83,746; fyke nets, 1,243,694 pounds, valued at $83,499; crab scrapes, 482,124 pounds, valued at $45,141; pots, 183,115 pounds, valued at $13,305; slat traps, 318,310 pounds, valued at $8,612; stop nets, 83,000 pounds, valued at $8,240; otter trawls, 51,000 pounds, valued at $2,500; spears, 15,000 pounds, valued at $1,880; and purse seines, 264,404 pounds, valued at $1,311. The products of the vessel and shore fisheries are shown separately in the following tables:

Yield of the vessel fisheries of Virginia in 1925, by apparatus and species

Species	Purse seines		Otter trawls	
	Pounds	*Value*	*Pounds*	*Value*
Croaker			1,492,000	$59,680
Flounders			152,000	12,160
Haddock			2,000	80
King whiting			17,750	1,775
Menhaden	146,008,200	$1,416,422		
Scup or porgy			14,000	700
Sea bass			18,000	2,230
Spot			30,000	2,270
Squeteagues			22,400	1,690
Total	146,008,200	1,416,422	1,748,150	80,585

Species	Dredges		Tongs	
	Pounds	*Value*	*Pounds*	*Value*
Crabs, hard	3,339,187	$113,145		
Clams, hard	6,400	2,450	2,000	$692
Oysters, market:				
Public	651,420	78,624	9,100	970
Private	3,488,926	428,016	5,600	184
Scallops	2,400	800		
Total	7,488,333	623,035	16,700	1,846

Yield of the vessel fisheries of Virginia in 1925, by apparatus and species—Con.

Species	Clam picks or hoes		By hand	
	Pounds	*Value*	*Pounds*	*Value*
Clams, hard	19, 120	$7, 533	8, 880	$3, 475
Oysters, seed, public			150, 150	5, 231
Total	19, 120	7, 533	159, 030	8, 706

Yield of the shore or boat fisheries of Virginia in 1925, by apparatus and species

Species	Pound nets		Gill nets		Haul seines		Fyke nets	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Alewives:								
Fresh	17, 313, 300	$195, 952	98, 000	$2, 675	79, 097	$2, 143	136, 250	$2, 683
Salted	23, 600	770						
Angelfish	2, 730	172						
Black bass					57, 218	7, 724	200	10
Bluefish	74, 468	10, 064	15, 475	1, 887	18, 256	2, 616		
Bonito	288, 110	15, 891						
Bowfin					24, 695	745	80	8
Butterfish	5, 834, 085	252, 178	200	8	1, 705	90	367	22
Carp	9, 115	638	150	23	315, 326	17, 664	50, 978	4, 047
Catfish	119, 040	9, 306			120, 825	6, 911	181, 240	10, 362
Cobia or coalfish	3, 260	265						
Cod	17, 000	406						
Crevalle	700, 445	25, 326			1, 000	50		
Croaker	16, 945, 456	489, 837	1, 704, 373	42, 922	1, 568, 158	30, 351	413, 008	8, 084
Drum:								
Black	226, 630	3, 504			1, 000	20	550	5
Red	120, 190	2, 113			4, 200	108		
Eels	69, 497	9, 766			3, 150	366	11, 411	1, 161
Flounders	370, 280	22, 098	200	8	10, 985	574	19, 592	1, 471
Gizzard shad	46, 844	1, 532			250, 109	6, 051	53, 330	1, 202
Goldfish					1, 150	57	1, 450	72
Hake	11, 800	232						
Harvest fish	42, 325	1, 488						
Hickory shad	186, 961	9, 458	5, 000	250	11, 566	406	2, 000	40
King whiting	81, 553	5, 539	300	25	13, 820	665		
Mackerel	11, 840	1, 234						
Menhaden	4, 213, 019	16, 948						
Mullet	6, 900	436	100, 384	6, 832	13, 165	798	1, 623	95
Pigfish	39, 471	2, 248	1, 050	67	73, 931	3, 509	699	38
Pike	600	120	1, 050	210	12, 288	1, 854	3, 917	799
Pinfish	200	10			1, 200	120		
Pompano	4, 084	903			500	100		
Scup or porgy	387, 574	27, 158						
Sea bass	12, 215	1, 048						
Sea robin	50, 000	71						
Shad	4, 996, 559	1, 109, 648	1, 043, 337	247, 658	10, 738	2, 755	53, 010	12, 417
Sharks	17, 154	1, 021						
Sheepshead	122	17						
Skates	23, 600	148						
Spanish mackerel	118, 974	15, 482	2, 000	100	6, 471	1, 097		
Spot	799, 654	37, 198	228, 329	10, 045	662, 694	35, 979	7, 479	440
Squeteagues	11, 790, 230	539, 982	159, 010	7, 004	381, 871	25, 269	19, 699	1, 275
Striped bass	475, 686	84, 466	68, 930	13, 103	175, 698	32, 295	99, 795	20, 923
Sturgeon	60, 527	14, 790	4, 200	1, 065	1, 250	312		
Sturgeon caviar and roe	4, 585	4, 984	750	750	18	18		
Suckers					870	48	3, 043	186
Sunfish	400	20						
Swellfish	35, 000	49						
Tautog	2, 870	225						
Thimble-eyed mackerel	13, 700	428						
Tomcod	17, 400	420						
Tripletail	25	4						
Tuna	320	17						
White perch	115, 384	9, 180	27, 960	3, 239	123, 338	7, 722	142, 543	13, 609
Whiting	33, 600	716						
Yellow perch	6, 845	692			31, 412	2, 086	41, 430	4, 560
Other fish	350	18						
Crabs:								
Hard			1, 250	80				
Soft			2, 000	1, 000				
Squid	415, 825	23, 607						
Turtles	2, 700	49						
Alewife scales	100. 000	10, 000						
Total	66, 214, 102	2, 959, 881	3, 463, 948	338, 951	3, 977, 704	190, 503	1, 243, 694	83, 499

Yield of the shore or boat fisheries of Virginia in 1925, by apparatus and species—Continued

Species	Lines		Stop nets		Otter trawls		Purse seines	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Angelfish	1,320	$53						
Bluefish	49,059	4,291						
Carp			83,000	$8,240				
Croaker	486,300	15,616			40,000	$1,600		
Drum, red	1,000	22						
Flounders	18,760	791			10,000	800		
King whiting	9,415	915						
Menhaden							264,404	$1,311
Pigfish	25,648	1,696						
Scup or porgy	700	70						
Sea bass	20,125	1,190			1,000	100		
Spot	40,050	2,158						
Squoteagues	71,240	4,343						
Striped bass	1,200	240						
White perch	6,450	563						
Other fish	300	30						
Crabs:								
Hard	14,393,397	390,863						
Soft	13,835	1,245						
Total	15,138,709	424,086	83,000	8,240	51,000	2,500	264,404	1,311

Species	Dip nets		Pots, eel, etc.		Slat traps		Spears	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Alewives, fresh					260,000	$5,500		
Carp					3,850	385		
Catfish			105,425	$5,088	7,800	390		
Eels			77,690	8,217	5,200	520	15,000	$1,880
Hickory shad					29,600	880		
Shad					60	13		
Suckers					200	16		
White perch					11,600	908		
Crabs:								
Hard	93,500	$1,953						
Soft	696,715	81,793						
Total	790,215	83,746	183,115	13,305	318,310	8,612	15,000	1,880

Species	Dredges		Tongs, nippers, rakes, forks, clam picks, and hoes		By hand		Crab scrapes	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Crabs:								
Hard	659,960	$16,771					44,700	$921
Soft					272,276	$29,723	437,424	44,220
Oysters, market:								
Public	196,525	22,250	8,478,274	$920,266	211,008	14,390		
Private	466,200	64,995	5,862,094	788,209	1,196,146	86,541		
Oysters, seed:								
Public			8,718,619	320,125	981,400	33,015		
Private			22,750	1,138	56,700	1,380		
Scallops	335,358	67,803	1,200	350	21,774	5,319		
Clams, hard:								
Public			927,216	352,848	84,928	33,910		
Private			25,208	17,176	6,800	4,250		
Terrapin					8,400	4,400		
Total	1,658,043	171,819	24,035,361	2,400,112	2,839,432	212,928	482,124	45,141

Summary of the yield of the fisheries of Virginia in 1925

Species	Shore fisheries		Vessel fisheries		Total	
	Pounds	*Value*	*Pounds*	*Value*	*Pounds*	*Value*
Alewives:						
Fresh	17,886,647	$208,953			17,886,647	$208,953
Salted	23,600	770			23,600	770
Angelfish	4,050	225			4,050	225
Black bass	57,418	7,734			57,418	7,734
Bluefish	157,258	18,858			157,258	18,858
Bonito	288,110	15,891			288,110	15,891
Bowfin	24,775	753			24,775	753
Butterfish	5,836,357	252,298			5,836,357	252,298
Carp	462,419	30,997			462,419	30,997
Catfish	534,330	32,057			534,330	32,057
Cobia or coalfish	3,260	265			3,260	265
Cod	17,000	406			17,000	406
Crevalle	701,445	25,376			701,445	25,376
Croaker	21,157,295	588,410	1,492,000	$59,680	22,649,295	648,090
Drum:						
Black	228,180	3,529			228,180	3,529
Red	125,390	2,243			125,390	2,243
Eels	181,948	21,900			181,948	21,900
Flounders	429,817	25,742	152,000	12,160	581,817	37,902
Gizzard shad	350,283	8,785			350,283	8,785
Goldfish	2,600	129			2,600	129
Haddock			2,000	80	2,000	80
Hake	11,800	232			11,800	232
Harvest fish	42,325	1,488			42,325	1,488
Hickory shad	235,127	11,034			235,127	11,034
King whiting	105,088	7,144	17,750	1,775	122,838	8,919
Mackerel	11,840	1,234			11,840	1,234
Menhaden	4,477,423	18,259	146,008,200	1,416,422	150,485,623	1,434,681
Mullet	122,072	8,161			122,072	8,161
Pigfish	140,799	7,558			140,799	7,558
Pike	17,855	2,983			17,855	2,983
Pinfish	1,400	130			1,400	130
Pompano	4,584	1,003			4,584	1,003
Scup and porgy	388,274	27,228	14,000	700	402,274	27,928
Sea bass	33,340	2,338	18,000	2,230	51,340	4,568
Sea robin	50,000	71			50,000	71
Shad	6,103,704	1,372,491			6,103,704	1,372,491
Sharks	17,154	1,021			17,154	1,021
Sheepshead	122	17			122	17
Skates	23,600	148			23,600	148
Spanish mackerel	127,445	16,679			127,445	16,679
Spot	1,738,206	85,820	30,000	2,270	1,768,206	88,090
Squeteagues	12,422,050	577,873	22,400	1,690	12,444,450	579,563
Striped bass	821,309	151,027			821,309	151,027
Sturgeon	65,977	16,167			65,977	16,167
Sturgeon caviar and roe	5,353	5,752			5,353	5,752
Suckers	4,113	250			4,113	250
Sunfish	400	20			400	20
Swellfish	35,000	49			35,000	49
Tautog	2,870	225			2,870	225
Thimble-eyed mackerel	13,700	428			13,700	428
Tomcod	17,400	420			17,400	420
Tripletail	25	4			25	4
Tuna	320	17			320	17
White perch	427,275	35,230			427,275	35,230
Whiting	33,600	716			33,600	716
Yellow perch	79,687	7,338			79,687	7,338
Other fish	650	48			650	48
Crabs:						
Hard	15,192,807	410,588	3,339,187	113,145	18,531,994	523,733
Soft	1,422,250	157,981			1,422,250	157,981
Clams, hard:						
Public	1,012,144	386,758	36,400	14,150	1,048,544	400,908
Private	32,008	21,426			32,008	21,426
Squid	415,825	23,607			415,825	23,607
Oysters, market:						
Public	8,885,807	956,906	660,520	79,594	9,546,327	1,036,500
Private	7,524,440	939,745	3,494,526	428,200	11,013,366	1,367,761
Oysters, seed:						
Public	9,700,019	353,140	150,150	5,231	9,855,769	358,555
Private	79,450	2,518			79,450	2,518
Scallops	358,332	73,472	2,400	800	360,732	74,272
Terrapin	8,400	4,400			8,400	4,400
Turtles	2,700	49			2,700	49
Alewife scales	100,000	10,000			100,000	10,000
Total	120,788,251	6,946,514	169,439,533	2,138,127	276,227,784	9,084,641

Summary by counties

Counties	Persons engaged	Investment	Products	
			Pounds	Value
	Number	*Dollars*	*Pounds*	*Value*
Accomac	3,175	1,412,182	41,275,492	$1,651,491
Arlington	66	70,390	30,591	4,943
Caroline	9	425	6,350	625
Charles City	237	13,325	242,018	42,080
Chesterfield	22	655	33,000	4,675
Dinwiddie	8	270	27,350	1,125
Elizabeth City	1,143	1,077,279	15,205,633	953,161
Essex	184	21,592	336,394	40,083
Fairfax	69	12,304	108,417	15,275
Gloucester	953	204,153	9,343,417	527,096
Henrico	21	1,945	277,000	7,776
Isle of Wight	387	89,340	2,856,827	192,987
James City	126	25,060	702,189	92,492
King and Queen	67	6,452	288,680	29,122
King George	113	28,314	457,260	38,725
King William	204	185,990	547,991	59,594
Lancaster	2,381	1,719,272	47,317,013	764,769
Mathews	1,125	555,945	12,557,881	873,593
Middlesex	1,175	170,606	2,369,675	209,956
Nansemond	210	63,637	2,002,891	149,492
New Kent	71	5,850	187,336	21,060
Norfolk	1,354	1,090,295	4,484,511	293,160
Northampton	1,216	506,163	12,705,068	567,777
Northumberland	2,560	3,255,096	101,096,696	1,337,725
Prince George	64	7,700	220,130	20,343
Princess Anne	312	59,788	2,221,618	134,589
Prince William	46	10,546	113,525	14,424
Richmond	203	42,560	474,363	56,279
Spotsylvania	14	335	45,450	1,203
Stafford	79	17,817	209,930	20,369
Surry	61	12,853	274,268	28,269
Warwick	387	86,855	3,113,458	191,565
Westmoreland	458	92,755	1,616,816	107,319
York	866	421,856	13,478,546	631,499
Total	19,366	11,269,605	276,227,784	9,084,641

Wholesale fishery trade.—In 1925 there were 218 establishments engaged in the wholesale fishery trade in Virginia, valued at $937,060, using a cash or working capital amounting to $395,600, and employing 3,359 persons, to whom $917,263 were paid in wages.

Menhaden industry.—There were 15 menhaden factories operated in Virginia in 1925, valued at $1,399,729, as compared with 18 factories, valued at $1,727,063, in 1920, and the cash or working capital used amounted to $326,000. The number of persons engaged in the factories was 598, to whom $225,199 was paid in wages. The number of vessels operated in 1925 was 43, valued at $2,324,912, with a net tonnage of 5,088 tons and outfits valued at $260,345. The apparatus used on vessels, consisting of purse seines, was valued at $78,200. There were also 126 accessory gasoline boats employed, valued at $34,600. The number of persons employed on vessels was 1,466. The number of menhaden utilized in the factories was 248,847,550, valued at $1,423,612, as compared with 536,879,567, valued at $2,192,837 in 1920. The manufactured products included 18,247 tons of dry scrap and fish meal, valued at $950,739, and 2,669,074 gallons of oil, valued at $1,330,799, as compared with 40,212 tons of dry scrap and fish meal, valued at $3,035,169, and 2,053,363 gallons of oil, valued at $546,198, in 1920.

Miscellaneous industries.—In 1925 there were canned 5,669 cases of alewives, valued at $9,317; 53,252 cases of alewife roe, valued at $178,421; and 6,093 cases of other fishery products, valued at $48,823. There were salted 6,206,748 pounds of alewives, valued at $158,768.

The by-products industry produced 1,308 tons of dry scrap and fish meal, valued at $50,997; 32,389 gallons of fish oil, valued at $13,876; 24,872 tons of poultry grit, valued at $264,705; and 27,133 tons of lime, valued at $188,474. The poultry grit and lime were prepared from oyster shells.

The detailed statistics of the industries above referred to are given in the following tables:

Investment, persons engaged, and wages paid in the wholesale trade in fresh fishery products in Virginia in 1925, by localities

Localities	Establishments		Cash capital	Number of persons engaged	Wages paid
	Number	Value			
Accomac, Atlantic, and Belinda	3	$13,350	$2,700	62	$7,600
Chincoteague Island	25	45,550	26,100	235	47,620
Franklin City, Greenbackville, and Sinnickson	12	11,250	7,000	74	13,140
Guilford, Hacksneck, and Hopkins	3	1,150	1,400	8	450
Onancock and vicinity	8	6,000	6,300	22	2,850
Quinby	4	3,900	1,800	54	3,900
Sanford	5	4,650	3,100	71	5,900
Saxis	9	4,650	5,900	69	10,075
Tangier	20	11,100	11,500	52	7,975
Wachapreague	3	5,500	3,600	84	13,550
Hampton and Phoebus	14	294,700	67,900	456	139,509
Bertrand and Irvington	4	13,110	3,900	67	11,750
Millenbeck and Merry Point	7	15,200	4,100	107	19,250
Morattico, Mollusk, and Monaskon	7	15,700	3,600	156	22,750
Weems and White Stone	12	5,600	5,200	123	28,702
Urbanna, Remlik, and Water View	5	13,000	7,700	135	26,160
Norfolk	13	264,700	140,000	613	326,199
Portsmouth	5	94,750	38,000	195	77,372
Bayford and Broadwater	5	4,900	2,600	49	7,500
Cape Charles	5	4,400	1,400	35	6,360
Capeville and Magotha	4	3,300	2,300	35	5,175
Cheriton and Oyster	4	8,700	3,200	60	14,800
Willis Wharf	7	41,300	11,700	186	31,560
Blackwells and Mila	4	4,750	1,650	46	5,950
Cowart, Lewisetta, and Lilian	3	2,900	2,000	44	5,623
Sampsons Wharf and Tipers	5	2,700	1,400	31	3,100
Sharps and Simonson	4	8,650	1,800	76	14,400
Newport News	3	5,300	4,100	33	11,843
Messick, Odd, and Yorktown	4	7,000	13,000	32	13,810
Miscellaneous localities	11	19,300	10,650	149	32,390
Total	218	937,060	395,600	3,359	917,263

The menhaden industry of Virginia in 1925

Items	Number	Value	Items	Number	Value
Factories	15	$1,399,729	Steam vessels, fishing	42	$2,264,912
Cash capital		326,000	Tonnage	4,956	
Wages paid factory employees		225,199	Outfit		253,933
Persons in factories	598		Gasoline vessels, fishing	1	60,000
Persons on vessels	1,466		Tonnge	132	
Menhaden utilized	248,847,550	1,423,612	Outfit		6,412
Products:			Accessory gasoline boats	126	34,600
Dry scrap tons	14,792	742,542	Apparatus on vessels: Purse seins (total length 12,612 yards)	42	78,200
Fish meal do	3,455	208,197			
Oil gallons	2,669,074	1,330,799			

Quantity and value of canned and salted fishery products and by-products manufactured in Virginia in 1925

Items	Number	Value	Items	Number	Value
Canned:			Salted: Alewives....pounds..	6,206,748	$158,768
Alewives, 15-ounce (2 dozen to case) [1]..........cases..	5,668	$9,317	By-products:		
Alewife roe—			Dry scrap and fish meal ....tons..	1,308	50,977
15-ounce (2 dozen to case) [2]..........cases..	46,366	154,290	Fish oil..............gallons..	32,389	13,876
18-ounce (2 dozen to case)..............cases..	6,886	24,131	Poultry grit...........tons..	24,872	264,705
			Lime.................do....	27,133	188,474
Total............do....	53,252	178,421	Total...................	....	518,032
Other products.......do....	6,093	48,823	Grand total..............	....	913,361
Total............do....	65,013	236,561			

[1]Includes a few cases packed in 18-ounce cans reduced to the equivalent of 15-ounce cans.
[2]Includes some cases packed in 7½, 10, and 17 ounce cans reduced to the equivalent of 15-ounce cans.

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TRADE IN FRESH AND FROZEN FISHERY PRODUCTS AND RELATED MARKETING CONSIDERATIONS IN GREATER ST. LOUIS, MO.[1]

By R. H. Fiedler

Agent, United States Bureau of Fisheries

CONTENTS

INTRODUCTION

The present survey is the eighth of a series of trade investigations made by the Bureau of Fisheries, the cities previously canvassed being Louisville, Ky.; Pittsburgh, Pa.; Chicago, Ill.; Minneapolis and St. Paul, Minn.; Seattle, Wash.; Boston, Mass.; and New York City, N. Y. The following report is based on the calendar year 1926 as to amounts of fish handled and the spring of 1927 for marketing conditions.

The author wishes to express his appreciation to the fish trade for its interest, cooperation, and many courtesies extended while the information for this survey was being collected. Thanks are especially due to George J. Goettling and William Goettling of the Geo. J. Goettling Co.; W. A. Meletio and Frank J. Girse of the Meletio Seafood Co.; G. Roettger of the Faust's Fulton Market Co.; and Carl A. Lammers of the Booth Fisheries Co., for supplying data and helpful suggestions throughout the course of this survey.

Greater St. Louis is situated on the Mississippi River, near the geographical center of the United States, near the center of population, the center of agricultural production, and the center of many of the sources of raw materials. Being neither eastern nor western, northern nor southern, its population represents a mythical cross section of the United States. The city of St Louis, considered alone, is the most American city in the United States, with the smallest number of foreign-born citizens of any metropolitan city, according to the fourteenth United States census report.

[1] Appendix VI to the Report of the U. S. Commissioner of Fisheries for 1927. B. F. Doc. 1026.

FINDINGS

Through this study it has been found that—

1. Greater St. Louis is supplied with fresh and frozen fishery products by 28 States and 4 Canadian Provinces.
2. Wholesale dealers distribute fresh and frozen fishery products to 17 States.
3. Wholesale houses are in close proximity to terminal team tracks and cold-storage warehouses, thereby minimizing time and expense in intracity transportation of fishery products.
4. Consumer preference for fresh-water fishery products has been replaced by a more general use of salt-water fishery products.
5. Six fishery products constitute 75 per cent of the trade, 4 of which are salt-water products and 2 fresh-water products.
6. The popularity of whiting has been due, in no little degree, to its being prepared for cooking and to its sale as a whiting sandwich by hot-fish shops.
7. Most of the retail fish stores handling fishery products every day in the week cater largely to the Jewish, Italian, and colored trade.
8. The gentile trade deals largely with grocery stores that handle fishery products only one or two days a week.
9. These grocery stores, while handling quantities of fish in the round or viscerated are inclined to handle prepared packaged products more readily.
10. Cold-storage facilities afforded in greater St. Louis have tended to stabilize the fish trade.
11. Frozen fishery products amount to over one-half of the receipts.
12. Wholesale dealers prefer to have shipments made in boxes.
13. Wholesale dealers prefer fishery products prepared and packaged at the point of production as far as consistent with the type of fish.
14. The annual per capita consumption of fish in the round is about 12 pounds and of the edible portion about 9 pounds.

SOURCES OF SUPPLY OF FISHERY PRODUCTS

The fisheries of 28 States and 4 Canadian Provinces contribute in supplying greater St. Louis with fishery products. During 1926, 13,127,000 pounds of fishery products were received in this market, of which 9,099,000 pounds, or 69 per cent, were salt-water varieties, and 4,028,000 pounds, or 31 per cent, were fresh-water varieties. Of the total amount, Massachusetts sent the largest supply, amounting to 4,583,000 pounds, consisting entirely of salt-water varieties. Florida was second with 1,384,000 pounds, consisting of 946,000 pounds of fresh-water varieties and 438,000 pounds of salt-water varieties. Washington was third with 1,324,000 pounds, consisting entirely of salt-water varieties. Louisiana was fourth with 1,166,000 pounds, consisting almost entirely of fresh-water varieties. New York was fifth with 749,000 pounds, consisting entirely of salt-water varieties. Other States or Provinces, in order of importance, were: New Jersey, Illinois (quantities of these fish were reshipped through Chicago and did not originate in the State), British Columbia, Maryland, Ohio, Mississippi, Arkansas, Texas, Virginia, Wisconsin, Tennessee, Manitoba, Missouri, Connecticut, New Brunswick, Maine, Michigan, Georgia, Minnesota, Nova Scotia, Alabama, Kentucky, Iowa, Rhode Island, Pennsylvania, California, and North Carolina.

TABLE 1.—*Amount of fresh and frozen fishery products received in greater St. Louis, Mo., by States and Provinces where produced*

State or Province	Pounds	Per cent of total	State or Province	Pounds	Per cent of total
Massachusetts	4,583,000	35	Ohio	369,000	3
Florida	1,384,000	11	Mississippi	331,000	3
Washington	1,324,000	10	Arkansas	229,000	2
Louisiana	1,166,000	9	Texas	190,000	1
New York	749,000	6	Virginia	146,000	1
New Jersey	671,000	5	All other States or Provinces	[2] 581,000	3
Illinois	[1] 601,000	5			
British Columbia	417,000	3			
Maryland	386,000	3	Total	13,127,000	100

[1] About 260,000 pounds of these products were distributed through Chicago and were produced at points outside of the State.

[2] Includes products produced in the following States or Provinces, ranked in order of importance: Wisconsin, Tennessee, Manitoba, Missouri, Connecticut, New Brunswick, Maine, Michigan, Georgia, Minnesota, Nova Scotia, Alabama, Kentucky, Iowa, Rhode Island, Pennsylvania, California, and North Carolina.

TABLE 2.—*Sources of supply of the fishery products received in greater St. Louis*

Product	Maine	Massachusetts	Rhode Island	Connecticut	New York	New Jersey	Maryland	Virginia	North Carolina	Georgia	Florida	Alabama	Mississippi	Louisiana	Texas	Pennsylvania	Ohio
Black bass					x			x			x		x				
Bass, white																x	x
Bass, striped																	x
Bass, sea					x												
Bluefish					x												
Bonito					x												
Bream											x						
Buffalo fish											x	x	x	x	x		
Butterfish		x			x												
Carp											x		x	x			
Catfish										x	x	x	x	x	x		x
Cod		x															
Crappie											x		x				
Eels		x			x						x				x		
Flounders		x			x												
Grouper											x						
Haddock		x			x												
Herring, sea		x															
King mackerel											x						
Lake herring																	x
Mullet					x						x						
Perch, white (fresh-water)												x	x	x	x		x
Perch, white (salt-water)					x												
Perch, yellow																	x
Pike, blue																x	x
Pike, grass											x						
Pike, sauger																	x
Pike, yellow																	x
Pollock		x			x												
Pompano											x						
Red snapper					x						x	x			x		
Sand eels		x			x												
Scup		x			x												
Shad							x				x						
Sheepshead (fresh-water)																	x
Smelts, eastern					x												
Sole		x			x												
Spanish mackerel					x	x					x				x		
Spoonbill cat												x	x	x	x		
Spot					x												
Sunfish											x						
Tilefish					x												
Trout, lake																	x
Trout, sea					x						x			x			

TABLE 2.—*Sources of supply of the fishery products received in greater St. Louis*—Continued

Product	Maine	Massachusetts	Rhode Island	Connecticut	New York	New Jersey	Maryland	Virginia	North Carolina	Georgia	Florida	Alabama	Mississippi	Louisiana	Texas	Pennsylvania	Ohio
Whiting		x			x	x											
Clams		x							x								
Crab meat							x	x		x							
Crabs, hard					x		x						x				
Crabs, soft							x	x	x								
Frogs											x		x	x	x		
Lobsters	x	x															
Mussels					x												
Oysters			x	x	x	x	x	x									
Pulpo					x												
Scallops	x				x												
Shad roe							x										
Shrimp					x					x	x	x	x	x	x		
Squid		x			x												
Turtles											x		x	x	x		
Winkles					x												

Product	Illinois	Chicago, Ill.	Kentucky	Tennessee	Missouri	Iowa	Arkansas	Minnesota	Wisconsin	Michigan	Washington	California	Nova Scotia	New Brunswick	Manitoba	British Columbia
Black bass			x	x												
Bass, white						x										
Bass, striped			x	x												
Bluefish		x														
Buffalo fish	x		x	x	x		x									
Buffalo fish, alive	x															
Carp	x		x	x	x	x	x	x	x							
Carp, alive	x															
Catfish	x		x	x	x		x									
Catfish, alive	x															
Crappie	x		x	x				x								
Eels	x		x	x			x						x			
Flounders		x														
Haddock		x														
Halibut		x									x					x
Herring, sea													x			
Lake herring		x						x	x							
Mackerel		x											x	x		
Perch, white (fresh-water)	x	x		x		x	x	x	x							
Perch, yellow	x	x						x	x	x						
Pike, blue		x														
Pike, grass		x	x						x							
Pike, sauger		x				x										
Pike, yellow		x						x	x						x	
Red snapper		x														
Rockfish (red snapper)											x					
Sablefish	x										x					x
Salmon		x									x					
Shad											x					
Smelts, eastern		x												x		
Smelts, western											x					
Spoonbill cat	x		x	x			x									
Sturgeon	x				x		x									
Suckers	x						x		x							
Sunfish	x	x	x	x	x		x									
Trout, lake		x							x	x						
Trout, rainbow					x											
Trout, salmon		x														
Tullibee		x						x							x	
Whitefish		x							x	x					x	
Caviar							x									
Crabs, hard											x					
Crawfish					x											
Frogs			x	x	x		x									
Lobsters		x										x				
Scallops													x			
Shad roe											x					
Squid													x			
Turtles	x			x			x									

RECEIVING POINTS

Of the total fresh and frozen fishery products received in greater St. Louis, 5,655,000 pounds, or 43 per cent, are received by freight, 7,257,000 pounds, or 55 per cent, by express, and 215,000 pounds, or 2 per cent, by barge.

Express shipments.—All express shipments carried by the American Railway Express Co. or the Southeastern Express Co. are received at their terminal at the Union Depot in the vicinity of Twentieth and Clark Streets. Fish arriving by express in less-than-carload lots are delivered to the consignees' door without further charge than that included in the regular tariff rate. In some cases, where the fish are urgently needed, the consignee calls at the express terminal in person and obtains the shipment, although no allowance is made the consignee for performing this transportation service. When express shipments are received in carload lots and nondelivery from the terminal to the consignees' door is specified, a charge is made by the express company for such delivery. Usually a carload express shipment is composed of parcels for various consignees. In some cases the express company delivers the goods of only one person without further charge. The consignee who obtains this service usually receives the largest shipment in the particular car. The other consignees must truck their goods themselves or hire it done by a trucking firm. In other cases, particularly with shipments of fish from the west, no free delivery is made.

Freight shipments.—Freight shipments are received over four routes from the east, three from the west, and three from the south. The freight terminals of these various trunk-line railroads are situated both in St. Louis and East St. Louis; the latter city is directly east across the Mississippi River. Shipments arriving by freight over these lines usually are handled by a terminal railroad company, which switches the freight cars of fish to various convenient localities in St. Louis known as terminal team tracks. No charges are assessed the consignee for the transfer of his carload freight shipments by the terminal railroad company, as all such charges are absorbed in the tariff rate charged for transporting the commodity over the trunk-line railroad. In many instances team tracks are situated less than one-half mile from the majority of the wholesale fishery establishments. While the traffic over the arteries between the team tracks and the wholesale fishery establishments is somewhat heavy at intervals, the loss of time in intracity transportation of fishery products is of no great importance. Most of the wholesale fishery firms do their own trucking to and from the freight tracks, as well as any needed trucking between the express terminals. Should the contents of a freight shipment be urgently desired, the wholesaler will instruct the carrier of the shipment to leave the car containing that shipment at its freight terminal and his trucks will then call for the shipment. This method of obtaining the freight shipments is sometimes a little quicker than waiting for the terminal railroad company to switch the car to a team track, which sometimes requires half a day.

Barge shipments of live fish.—During 1926, 215,000 pounds of live fish, consisting of buffalo fish, carp, and catfish, were received in greater St. Louis. All originated in Illinois. These live fish are shipped in barges from the point of origin to the foot of Franklin

Street in St. Louis. Here they are unloaded into tanks of water on trucks, or into containers without water, and then transported to the wholesale establishment, where they are held in tanks of running water pending sale.

In addition to the live fish, 72,000 pounds of live soft crabs, crawfish, lobsters, and turtles were received in 1926. The method of shipping these products is described under the subject "containers" in the latter portion of this report.

PRODUCTION

The waters surrounding greater St. Louis support no extensive commercial fishery. A few fishermen make small catches of buffalo fish and other species in surrounding streams, but the catch amounts to only a few thousand pounds annually. The fishermen dispose of their catches locally to wholesalers or by peddling direct to the consumer.

RESHIPMENT OF FISHERY PRODUCTS

Greater St. Louis is favorably situated for the distribution of fishery products. During 1926, 1,191,000 pounds, or 9 per cent, of the fresh and frozen fishery products received in this market, and large amounts of cured and canned fish, were distributed in the several States, including and adjoining Missouri, and also the States directly to the south. Direct and fast rail communication with the principal cities in these States is available.

Reshipment by States.—During 1926 Illinois received the largest amount of fish distributed from greater St. Louis, amounting to 344,000 pounds; Missouri was second, receiving 305,000 pounds; Oklahoma was third, receiving 165,000 pounds; and Arkansas was fourth, receiving 131,000 pounds. Other States that receive fishery products from greater St. Louis, ranked in order of importance, were Texas, Tennessee, Mississippi, Kansas, Indiana, Louisiana, Iowa, Kentucky, Alabama, Nebraska, Florida, Ohio, and New Mexico.

TABLE 3.—*Amount of fresh and frozen fishery products distributed by greater St. Louis fish dealers, by the States receiving these products*

State	Pounds	Per cent of total	State	Pounds	Per cent of total
Illinois	344,000	30	Kansas	27,000	2
Missouri	305,000	25	Indiana	24,000	2
Oklahoma	165,000	14	Louisiana	15,000	1
Arkansas	131,000	11	Iowa	13,000	1
Texas	78,000	6	Other States	[1] 20,000	2
Tennessee	35,000	3			
Mississippi	34,000	3	Total	1,191,000	100

[1] Includes fresh and frozen fishery products distributed to the following States, ranked in order of importance: Kentucky, Alabama, Nebraska, Florida, Ohio, and New Mexico.

Reshipment by species.—It is interesting to note that the varieties reshipped in the largest quantities from this market are those that have been received from distant production points. During 1926 whiting led the reshipments, with 259,000 pounds; halibut was second, with 215,000 pounds; catfish third, with 212,000 pounds; haddock fillets fourth, with 116,000 pounds; and oysters fifth, with 111,000 pounds. Quantities of 33 other products also were reshipped.

TABLE 4.—*Amount of fresh and frozen fishery products distributed by greater St. Louis fish dealers, by species*

Species	Pounds	Species	Pounds
Whiting	259,000	White perch (fresh-water)	17,000
Halibut	215,000	Buffalo fish	13,000
Catfish	212,000	Frogs	13,000
Haddock (fillets)	116,000	Red snapper	10,000
Oysters	111,000	Black bass	9,000
Spanish mackerel	42,000	Carp	7,000
Crappie	36,000	Yellow perch	7,000
Salmon	23,000	Other products [1]	48,000
Smelt, eastern	22,000		
Shrimp	19,000	Total	1,191,000
Lake trout	17,000		

[1] Includes sablefish, lobsters, whitefish, shad roe, red rockfish, spoonbill cat, soft crabs, scallops, blue pike, pulpo, flounders, pompano, crab meat, cod, sunfish, sole, white bass, clams, mackerel, and tilefish.

LOCAL MARKETING

WHOLESALE TRADE

The wholesale fisheries trade is conducted at various places throughout the city, although most of it is centered in the wholesale commission section, where Broadway crosses Franklin Avenue. None of the firms has direct rail communication with any railroad, although terminal team tracks for unloading freight shipments are situated less than one-half mile from the wholesale commission section.

In 1926 there were 12 wholesale establishments engaged in handling 13,127,000 pounds of 74 varieties of fresh and frozen fishery products with a wholesale value of approximately $3,200,000. The total investment was $574,000, and the cash or working capital amounted to $104,500. There were 208 persons engaged in the trade, receiving $262,000 in wages.

The wholesale dealers are equipped to handle shipments in an efficient and regular manner. Some of the wholesalers repack, grade, inspect, and freeze or otherwise prepare the fishery products for the local trade. Most firms have large rooms for repacking and grading, several have freezing plants on their premises, others have cold storage supplied by a local cold-storage firm, while still others have insulated cold rooms in which to hold fish for several days. Local sales are made at the wholesale house at a market price stated over the telephone or by direct contact. Small orders are wrapped in paper and the larger ones are packed in baskets. Free deliveries are made by the wholesalers within the greater St. Louis area. Some of the wholesale firms have regular routes covered by their trucks each day or at regular intervals. Orders are taken by the drivers and are delivered when wanted. Out-of-town shipments are packed in boxes and usually are sold f. o. b. St. Louis. A charge sometimes is made for the container.

COMMON AND SCIENTIFIC NAMES OF FISHERY PRODUCTS HANDLED

Following is a list of common and scientific names of fishery products handled by the wholesale and retail fisheries trade in greater St. Louis, to which reference is made in this report:

Common name	Other common names	Scientific name
Bass, black		Micropterus sp.
Bass, sea	Blackfish	*Centropristes striatus.*
Bass, striped	Rock	*Roccus lineatus.*
Bass, white		*Roccus chrysops.*
Bluefish		*Pomatomus saltatrix.*
Bonito	Bonito mackerel	*Sarda sarda.*
Bream (Florida)		Centrarchidæ sp.
Buffalo fish		*Ictiobus cyprinella.*
Butterfish		*Poronotus triacanthus.*
Carp	German carp	*Cyprinus carpio.*
Catfish	Bullhead	Ameiurus sp. and Ictalurus sp.
Cod		*Gadus callarias.*
Crappie		Pomoxis sp.
Eels	Common eel, silver eel	*Anguilla rostrata.*
Flounders		Pleuronectidæ sp.
Grouper		*Epinephelus mycteroperca.*
Haddock		*Melanogrammus aeglifinus.*
Halibut		*Hippoglossus hippoglossus.*
Herring, lake (cisco)		Leucichthys sp.
Herring, sea	Sardine	*Clupea harengus.*
King mackerel	Kingfish	*Scomberomorus regalis.*
Mackerel	Common mackerel, native mackerel.	*Scomber scombrus.*
Mullet	Jumping mullet	*Mugil cephalus.*
Perch, white (fresh-water)	Sheepshead, fresh-water drum, gaspergou.	*Aplodinotus grunniens.*
Perch, white (salt-water)		*Morone americana.*
Perch, yellow		*Perca flavescens.*
Pike, blue		*Stizostedion glaucum.*
Pike, grass (pickerel)	Jacks	Esox sp.
Pike, sauger		*Stizostedion canadense griseum.*
Pike, yellow	Yellow	*Stizostedion vitreum.*
Pollock		*Pollachius virens.*
Pompano		*Trachinotus carolinus.*
Red snapper	Gulf red snapper	*Lutianus blackfordi.*
Red rockfish	Western red snapper	Sebastodes sp.
Sablefish	Black cod	*Anaplopoma fimbria.*
Salmon	Pacific salmon	Oncorhynchus sp.
Sand eels		*Ammodytes americanus.*
Shad		*Alosa sapidissima.*
Scup	Porgie	*Stenotomus chrysops.*
Sheepshead (fresh-water) Lake Erie.		*Aplodinotus grunniens.*
Sole		Pleuronectidæ sp.
Smelts, eastern		Osmerus sp.
Smelts, western		Argentinidæ sp.
Spanish mackerel		*Scomberomorus maculatus.*
Spoonbill cat	Paddlefish	*Polyodon spathula.*
Spot	Lafayette	*Leiostomus xanthurus.*
Sturgeon, river		*Acipenser rubicundus.*
Suckers		Catostomidæ sp.
Sunfish		Centrarchidæ sp.
Tilefish		*Lopholatilus chamæleonticeps.*
Trout, lake		*Cristivomer namaycush.*
Trout, rainbow		*Salmo irideus.*
Trout, salmon		*Salmo gairdneri.*
Trout, sea	Weakfish, squeteague	*Cynoscion regalis.*
Tullibees		*Leucichthys tullibee.*
Whitefish		*Coregonus clupeaformis.*
Whiting	Jack salmon	*Merluccius bilinearis.*
Clams	Little neck, cherristone	*Venus mercenaria.*
Crabs	Blue crab, hard crab, soft crab	*Callinectes sapidus.*
Crawfish		Cambarus sp.
Frogs		Rana sp.
Lobsters		*Homarus americanus.*
Mussels		*Mytilus edulis.*
Oysters		*Ostrea elongata.*
Scallops	Bay scallop, sea scallop	*Pecten irridians, Pecten majellanicus.*
Shrimp		*Peneus setiferus.*
Pulpo	Octopus, devilfish	*Octopus vulgaris.*
Squid	Boned squid	Loligo sp.
Turtles (fresh-water)		Trionychidæ sp. Chelydridæ sp. Testudinidæ sp.
Winkle	Periwinkle	*Littorina littorea.*

IMPORTANT COMMERCIAL PRODUCTS

While 74 varieties of fishery products are handled by the trade in greater St. Louis, 6 of these, amounting to 9,873,000 pounds, constitute 75 per cent of the trade. Four of these are not common to this locality, while two represent species that formerly were caught in large quantities locally but now are shipped in from distant points.

TABLE 5.—*Fishery products upon which 75 per cent of the trade is based* [1]

Rank	Product	Rank	Product
1	Whiting.	4	Catfish.
2	Halibut.	5	Oysters.
3	Buffalo fish.	6	Haddock.[2]

[1] Tables 5, 6, and 7 are to be considered together as regards the relative rank of importance of the products as a whole.
[2] Fillets.

In years past the trade in greater St. Louis preferred varieties of Great Lakes and local fresh-water fish. When near-by supplies became insufficient, shipments were received from more distant points. As other cities were drawing upon the same supply and shipments became unsteady with intermittent high and low prices, the fisheries trade became more or less erratic, with the trade during the summer months almost at a standstill. Stabilization was needed if the trade was to remain in a prosperous condition. About 1915 a search was made for varieties of fish that would be available in steady quantities throughout the year at a fairly uniform price. Various species were introduced, including the whiting. This fish readily gained favor with the trade and sales increased steadily, so that now it ranks first in importance in this market.

Whiting is taken chiefly along the coastal waters of Massachusetts and New Jersey during the late spring, summer, and fall months, where it is frozen in the round, boxed, and held in cold storage. As supplies are needed, they are shipped to St. Louis, usually in carload lots, where they are again placed in cold-storage warehouses pending sale.

The vast majority of whiting sold are beheaded, viscerated, and skinned in St. Louis, ready for cooking, and then sorted according to sizes of one to a pound, two to a pound, three to a pound, and so on. The finished product might be called a whiting "stick." As it is virtually boneless, it is especially acceptable to children as well as adults.

Dealers in greater St. Louis say that the whiting has become popular in this market because it resembles varieties of fish once popular, the supply is steady, and it can be graded and sold by number as well as by weight. This is especially acceptable to the restaurant dealer, as he knows the cost of the fish in each portion served.

Barbecue stands and hot-fish shops (an American modification of the European fish and chip shops) have aided in popularizing whiting in greater St. Louis. These shops range in size from an out-of-door lunch counter to a restaurant or hot-fish shop that makes a specialty of selling only cooked whiting. On one of the main highways near St. Louis is such a shop handling only whiting of a size of about three to a pound. The whiting "sticks" are cooked in hot fat and then placed on a steam table, where they are kept hot until sold. A sufficient number are cooked to supply the trade expected at a given time. Portions are served as a whiting sandwich, consisting of a whiting and two slices of bread, which sells for 15 cents. During the course of a year this establishment sold 72,000 pounds of this fish and as high as 2,200 pounds in one week. The trade is best during the summer, particularly on Friday, Saturday, and Sunday. Ice chests capable of holding a reserve supply of 3,600 pounds of fish were installed in a building adjoining the shop.

PRODUCTS OF MODERATE IMPORTANCE

In this class of fishery products are some that have been important in this market and are now of secondary importance because the supply is limited or too seasonal. There are others, also, which ranked in the third class in years past but now are becoming more important. It is believed that in future years some of these species will rank among those commercially important. The 15 species of this group amount to 2,626,000 pounds and constitute 20 per cent of the trade.

TABLE 6.—*Fishery products upon which 20 per cent of the trade is based* [1]

Rank	Product	Rank	Product.
7	Lake herring.	15	Sablefish.
8	Spanish mackerel.	16	Red snapper (Gulf).
9	Carp.	17	Salmon.
10	Frogs.	18	Whitefish.
11	Shrimp.	19	Spoonbill cat.
12	Tilefish.	20	Crappie.
13	Lake trout.	21	White perch (fresh-water).
14	Black bass.		

[1] Tables 5, 6, and 7 are to be considered together as regards the relative rank of importance of the products as a whole.

PRODUCTS OF SLIGHT IMPORTANCE

Limited quantities of 53 fishery products, amounting to 628,000 pounds, or 5 per cent of the trade, are marketed in greater St. Louis. Many of these products are used mainly by the foreign trade, some are species of which the supply is declining, and some are unpopular in this market.

TABLE 7.—*Fishery products upon which 5 per cent of the trade is based* [1]

Rank	Product	Reasons for limited sale
22	Blue pike	Seasonal variety; relatively high priced.
23	Sunfish	Limited supply; high priced.
24	Smelts, eastern	Seasonal variety.
25	Tullibees	Limited supply; used largely for smoking and substituted for ciscoes and whitefish.
26	Lobsters	Limited supply; high priced.
27	Flounders	Not well known; demand increasing.
28	Yellow perch	Seasonal variety.
29	Crabs, hard	Poor shipper; too many losses en route.

[1] Tables 5, 6, and 7 are to be considered together as regards the relative rank of importance of the products as a whole.

TABLE 7.—*Fishery products upon which 5 per cent of the trade is based*—Continued

Rank	Product	Reasons for limited sale
30	Sauger pike	Limited supply; seasonal.
31	Crawfish	Used mainly by hotels and restaurants.
32	Sheepshead (Lake Erie)	Seasonal variety.
33	Yellow pike	Seasonal variety; relatively high priced.
34	Crabs, soft	Seasonal variety; poor shipper; popular.
35	Herring, sea	Used mainly by the Italian trade.
36	Scallops	Not well known; becoming popular.
37	Shad roe	Limited supply; seasonal; high priced.
38	Pompano	Seasonal variety; high-priced; popular.
39	Eels	Limited local supply and price too high for eastern supply.
40	Red rockfish, western	Substituted for red snapper, but the quality is considered not as good.
41	Cod	Not well known on this market.
42	Turtle	Used mainly by hotels and restaurants.
43	Smelts, western	Accepted when eastern smelts are not available; quality considered medium.
44	Butterfish	Considered poor quality in this market; some smoked.
45	Bream	Limited supply; usually arrives in poor condition.
46	Striped bass	Used mainly by the Italian trade.
47	Sole	Not well known; demand increasing for fillets.
48	Crab meat	Scarcity and high prices.
49	Mackerel	Unpopular; not well known.
50	Grouper	Unpopular; not highly esteemed; not well known.
51	Clams	Used mainly by hotels and restaurants.
52	Shad	Seasonal variety; high priced.
53	King mackerel	Used mainly by the Italian trade.
54	Pulpo (octopus)	Do.
55	Scup	Do.
56	Suckers	Used mainly by the Jewish trade.
57	Grass pike	Seasonal variety; unpopular.
58	White bass	Limited supply; seasonal variety; popular.
59	Squid	Used mainly by the Italian trade.
60	Bluefish	Limited supply; relatively high priced.
61	Mullet	Used mainly by the Italian trade.
62	Sea bass	Do.
63	Bonito	Do.
64	White perch (salt-water)	Do.
65	Pollock	Do.
66	Sand eels	Do.
67	Spots	Do.
68	Sea trout	Do.
69	Sturgeon	Limited supply.
70	Winkles	Used mainly by the Italian trade.
71	Mussels	Do.
72	Rainbow trout	Limited supply; high priced; used mainly by hotels and restaurants.
73	Salmon trout	Do.
74	Caviar (in bulk)	Do.

A study of Table 7 reveals that the sale of 16 products is limited to the Italian trade; 13 are restricted because of a limited supply; 14, because of the high price; 11, because the products are seasonal; 6, because the products are not well known; 6, because the sale of the products is limited mainly to hotels and restaurants; 4, because the products are considered of medium or poor quality; 3, because the products are poor shippers; and 3, because the products are generally unpopular.

RETAIL TRADE AND FISH STORES

During this survey the author visited 62 retail stores that handled fish every day in the week either entirely or in connection with poultry and fruits or vegetables, and a study was made of the retail merchandizing of fish in these stores. Most of these retail stores cater entirely to the Jewish, colored, or foreign trade, except for a few stores in outlying districts and those in the new Union Market, which cater to a mixed trade.

Interior construction.—The display fixtures and appurtenances of the majority of the stores outside of Union Market are much alike. Those selling live fish have a glass aquarium in the window displaying carp, buffalo fish, and catfish. Those having window displays of fresh fish show these products on crushed ice in metal pans. Others have no window displays. One side of the interior usually contains a wooden, metal-lined display case of various dimensions, ranging from 5 to 8 or more feet in length, 2½ feet high, sloping to the front, and about 3 feet wide. Crushed ice is placed in the bottom of such a case, upon which the fish are laid. Sometimes the fish are placed in porcelain pans, the pans resting on crushed ice. Usually a glass cover fits over the top of the case to keep off insects and dust. An ice box of much the same dimensions as the display case, but with a wooden cover instead of glass, is used for storing the reserve supply of fish. Some of the larger firms have insulated cold rooms for storing the reserve supply. Some of the firms that sell live fish have an auxiliary metal or concrete tank containing live fish in the rear of the storeroom.

Should other products be sold, one usually finds opposite the fish display cages containing live poultry or counters upon which are displayed fruits and vegetables.

Window displays.—Window displays of fishery products were made by 27 stores at all times. Of these, 20 consisted of glass aquaria and 7 of cured, fresh, or frozen fish. Occasional displays were made by 7 other firms. Of the window displays of cured, fresh, or frozen fish, 7 were inclosed in glass, 3 used the original containers to display cured fish, and 9 used metal pans filled with crushed ice, upon which the fresh or frozen fish were displayed. Of the latter, 4 placed the fish, garnished with greens, first in porcelain pans and then on the crushed ice.

Inside displays.—Inside displays were made by 60 firms, of which 50 were metal-lined display cases (described above) filled with crushed ice, directly upon which the fish were laid. Earthen jars for holding oysters were sunk, neck deep, in the crushed ice. Sunken white porcelain counters were used by 4 stores. These were filled with crushed ice and the fish were arranged in porcelain pans laid upon the ice. Raised-edge metal-covered tables were used by 3 stores, while 3 other stores used only their ice boxes with the lids left off during business hours for displaying the fish. The majority of the stores held quantities of fish in reserve, of which 46 had ice boxes solely for this purpose and 10 had insulated cold rooms.

Wrapping paper.—Standard white or brown paper only was used by 14 firms for wrapping all packages of fish, 7 used only newspaper, while 41 used first a layer of standard paper and then an outer wrapper of newspaper. In most instances those firms using only standard wrapping paper ranked excellent in sanitary conditions, those using one wrapper of each kind of paper ranked fair or good, and those using only newspapers as poor. Retailers stated that newspapers tend to impart an inky taste and odor to the fish, and thus in most instances the first wrapper is of standard paper.

Payment for retail sales, deliveries, and advertising.—Retails ales were made for cash only in every store except 7, which intimated that credit sometimes was extended to a few regular customers. Deliveries of retail purchases were made by only 3 stores, and then only in the immediate vicinity. Advertising was done by 12 stores or firms, daily, weekly, or monthly, at intervals. One wholesaler stated that billboard advertising was used at times. The consensus of opinion among the dealers is that newspaper advertising is the most effective.

Prices.—Prices were adjusted by 55 retailers, meaning that the retail price is raised or lowered according to the wholesale price. An attempt is made by the retail shops to sell a variety at approximately the same price during the season unless the wholesale price fluctuates more than 6 or 7 cents. Only two stores marked the fishery product with the price or variety, and one had signs on the walls quoting prices on certain varieties.

Class of trade.—Of the retailers 26 stated that 75 per cent or more of their trade was colored; 9, Jewish; 6, gentile; 2, foreign; 2, about equal between the colored and Jewish trade; and 17, a mixed trade among all races or creeds. Upon analysis it may be judged that the majority of the retail stores cater to a trade other than the gentile. It was found that the latter trade, which buys more or less but one day a week, obtains fishery products from the grocery or meat store.

Sanitary conditions.—Sanitary conditions in the stores were rated as follows: First, excellent; second, good; third, fair; fourth, poor; fifth, very poor. The author rated 6 stores as having excellent sanitary conditions, 9 as good, 37 as fair, 9 as poor, and 1 as very poor.

Trade during the week.—Inquiry was made as to the trade during the week, and the retailer was asked to state the day upon which most of his business was done, the day of second importance, the day of third importance, and so on. It was found that Monday, Tuesday, and Wednesday invariably were listed as second or third, and that Thursday, Friday, and Saturday were ranked mostly first or second. On Sunday 42 retailers remained open until about noon, and most of these retailers ranked this day as either second or third. The stores catering to the Jewish trade reported Thursday as the busiest day; Friday was busiest with those catering to the gentile and mixed trade, and Saturday and Sunday with those catering to the colored trade. Following is a table showing the results of the inquiry into the trade during the week:

TABLE 8.—*Trade during the week for 62 retail fish stores selling fish every day of the week, greater St. Louis, Mo., 1927*

Rank	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
First				19	32	24	8
Second	27	27	30	19	26	29	21
Third	29	29	29	24	4	7	12
Fourth	3	4	3			2	
Fifth	3	2					1
Total reporting	62	62	62	62	62	62	[1] 42

[1] 20 stores not open.

UNION MARKET

The new Union Market, situated in the entire square surrounded by Sixth Street, Broadway, Lucas Avenue, and Morgan Street, was constructed by the city at a cost of $1,500,000. The market is on the ground floor. On the second floor is a garage, where cars may

FIG. 1.—Union Market (retail), St. Louis, Mo.

be parked by persons marketing. All kinds of food products are sold in this market, including fruits, vegetables, meats, groceries, delicatessen foods, and sea food. The sea-food division is a separate section, set off from the rest of the market with a partition. Four fisheries firms occupy stalls in this department.

The fixtures in the sea-food department are arranged for the proper and sanitary display of sea foods. Each stall consists of a counter with a white-tile front. Midway between the floor and the top of the front of the counter is a brass shelf, upon which to rest a market basket. The top of the counter is a series of sunken porcelain pans about 8 inches deep and 3 feet long, much resembling a series of kitchen sinks, placed end to end. Crushed ice is placed in these trays, and on this fish are displayed, either directly upon the ice or in porce-

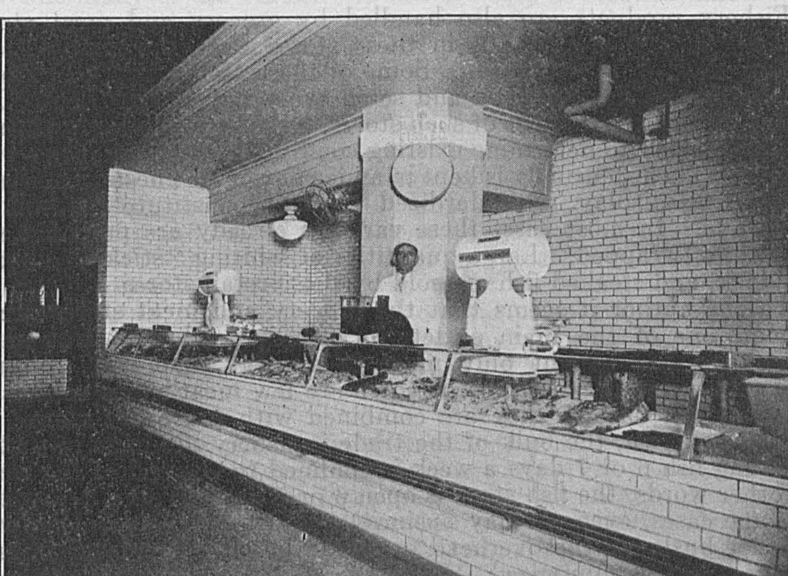

FIG. 2.—A section of the sea-food department of the new Union Market, St. Louis, Mo.

lain pans. Some of the displays are attractively arranged with garnishes, and present a very appetizing product. Extending up from the top of the front of the counter for about 12 inches and then inward for about 12 inches is a glass covering. Electric lights inclosed in nickel boxes, with the light reflected down upon the fish, are arranged along the top section of the glass inclosure. The fish can not be handled by the customer, but can be handled easily by the salesmen. To the rear of each stall are tables upon which to clean or otherwise prepare the fish. Each stall is provided with hot and cold running water. Insulated cold rooms are provided in the basement for each dealer. The floors of the aisles are of polished concrete and the walls are of tile. Electric lights hung from the ceiling provide general light. In the summer all the exits and windows are provided with screens, to exclude both insects and dust. Each salesman is required to wear white clothes. The interior of this market is clean, sanitary, and of pleasing appearance. Prices for fishery products are as low, if not lower, than in some other stores, and the products sold are of the best grade.

While the interior of the building is well arranged for the display of food products, the exterior lacks the appearance of a market. One can not see into the interior except through the exits. It is believed that patronage would be encouraged if show windows or ordinary windows were placed around the entire four sides, so that one might see into the interior. People passing the market could then see the bountiful display of food products and possibly might be induced to enter and purchase. Replacement of the heavy, cumbersome doors at the entrance with some less heavy would make access and departure easy for a person with a market basket.

GROCERY AND MEAT STORES

Fishery products are also handled by grocery and meat stores throughout the city. It is in these stores that the gentile trade makes most of its purchases. Some of these stores handle fish only one or several days a week and some every day during Lent. Because of the large number of such stores, no survey was made of these outlets for fish to determine existing conditions, although a few were visited. The fish usually is kept in an ice box or ice chest. Generally there is no display. Standardized varieties constitute the bulk of the trade. In most cases these varieties already are prepared and sometimes wrapped. Large quantities of whiting "sticks," fillet of haddock, and steaked fish are sold by these retail stores.

To the author it seems that the grocery and meat stores are to become one of the main outlets for fishery products. Not many years ago one bought only meat in a meat shop and groceries in a grocery store. At present there are few meat shops conducted as such, but usually they are combined with a grocery store. As has been shown, the bulk of the trade in fishery products in a store handling fish 6 or 7 days a week is confined to the end of the week. In other words, the fish store is open 6 or 7 days to do a 3-day, and in some cases, even a 1-day business. When conducted along with another business, the overhead on each of the consolidated lines of business can be minimized. However, to induce the grocer or meat dealer to handle fish, the product must be made attractive, standard, and easy for him to handle, and he must make a profit from its sale. This inducement is being given him in greater St. Louis, where such varieties as whiting, halibut, and haddock, either skinned, filleted, or steaked in packages, or in bulk, are supplied by the wholesale trade.

COLD-STORAGE FACILITIES

During 1926, 6,761,000 pounds of frozen fish were handled in this market, consisting mainly of halibut, salmon, Spanish mackerel, and whiting. In most cases these fish are frozen at the point of production. Excellent sharp-freezing equipment is available in St. Louis and quantities of fish are frozen there. Cold-storage warehouses are favorably situated with respect to connection with railroad lines and the large wholesale houses.

Carload-freight shipments of frozen fish intended for cold storage and fresh-fish shipments intended for freezing are switched directly to a siding at any one of the three cold-storage warehouses, where the contents are unloaded from the freight car into the warehouse. These three cold-storage establishments have siding space in which to unload about 20 cars at one time. Two of these warehouses are within one-half mile and one warehouse within three-fourths mile of the majority of the wholesale fish houses.

SIZES OF FISH

Virtually every variety of fish received in greater St. Louis is sold according to a certain size. Usually each variety is divided into three size classifications—viz, small, medium, and large. Some varieties, however, have only two classifications, and where the size of the fish is fairly uniform no sizes are stated. This is the case with salmon, as each variety has a fairly uniform size.

FORM IN WHICH FISH ARE RECEIVED

While many of the varieties of fish are sold as steaked, filleted, or skinned fish in this market, comparatively few of these varieties are received in this condition originally. Possible exceptions are the fillet of haddock, a few skinned whiting, fleeced buffalo fish and carp, and skinned catfish. Fish received in the round, fresh or frozen, are prepared by the wholesalers for the consumer in the style that he prefers. Wholesalers in greater St. Louis are of the opinion that their trade would be benefited if more of the varieties were prepared at the point of production to suit local needs. A variety could be more nearly standardized and the force, as now required by these inland wholesalers to prepare these fish, could be reduced. By properly preparing the fish at the point of production the waste products would accumulate at one central place and the utilization of this waste for making by-products could assume greater and possibly more profitable proportions.

SHIPPING CONTAINERS

Inasmuch as the greater St. Louis market handles standardized and graded varieties of fish, it follows that most of the fish are received in standard containers. Boxes predominate for shipments from the west coast, the Great Lakes, Canadian points, Massachusetts, and New Jersey, ranging from the 10, 15, and 25 pound smelt boxes and the 100-pound "Lake Erie" box to the large 200 and 350 pound North Pacific halibut boxes. Except for filleted and skinned fish shipped from New York City, the shipments of fish from the Middle Atlantic States arrive in standardized sugar and flour barrels having an approximate capacity of 200 pounds. Shipments of fish from the South Atlantic, Gulf, and Mississippi River States also usually arrive in sugar and flour barrels, but the capacity is restricted to 150 to 175 pounds of fish, due to the large amount of ice required to keep the products fresh while in transit. Some of the southern shippers place up to 200 pounds of fish in the barrels. This overcrowds them and leaves a smaller space for ice, with the result that these overcrowded shipments do not arrive in as good condition in St. Louis as those containing less fish and more ice. Dealers in St. Louis suggest that less fish and more ice be placed in the barrels when shipped from southern points, especially during warm weather.

Incorporated in the table following are the fresh and frozen fishery products received in this market, the sizes in which received, form in which received, and the usual containers. There is shown also the style in which the products usually are sold and the sizes and styles preferred by the consumer.

TABLE 9.—*Trade categories of fishery products received in greater St. Louis, Mo.*

Product	Form in which received	Usual containers and sizes	Sizes or grades of product			Condition in which marketed	Consumer's preference
			Small	Medium	Large		
Bass, black	Fresh; viscerated	200-pound barrels	Order size, ¾ to 1½ pounds.	Medium, 1½ to 2½ pounds.	Large, over 2½ pounds, up.	Viscerated	Order size or medium, viscerated.
Bass, sea	do	do	Sizes not specified			do	Any size, viscerated.
Bass, striped	Fresh; round	do		Medium, ½ pound	Order size, ¾ to 1 pound.	Round	Either size, round.
Bass, white	do	100-pound box with handles.		do	do	do	Do.
Bluefish	Fresh; viscerated	200-pound barrels	Small, 3 pounds and under.		Large, 3 to 5 pounds.	Viscerated	Large size, viscerated.
Bonito	Fresh; round	do	Sizes not specified			Round	Any size, round.
Bream	do	do		Medium, ½ pound and under.	Large, over 1 pound.	do	Large, round.
Buffalo fish	Alive; fresh; head off; fleeced; viscerated; round.	150 and 200 pound barrels; 100-pound boxes; alive in barges.	Small, 1 to 2 pounds	No. 2, 2 to 3 pounds	No. 1, over 3 pounds.	Head off; viscerated; fleeced; live.	No. 1, and fleeced, head off; viscerated; live.
Butterfish	Fresh; round	200-pound barrels			Large, ⅓ to ½ pound.	Round, fresh; round, smoked.	Large, round, fresh or smoked.
Carp	Alive; fresh; head off; fleeced; viscerated; round.	150 and 200 pound barrels; alive in barges.	Small, 1 to 2 pounds	No. 2, 2 to 3 pounds	No. 1, over 3 pounds.	Head off; fleeced; viscerated; live.	Head off; viscerated No. 1 and fleeced; live.
Catfish	Alive; fresh; head off; skinned; viscerated.	do	Small, ⅓ to 1 pound	Medium, 1 to 3 pounds.	Large, over 3 pounds	Head off; viscerated; skinned; steaks; live.	Medium or large; skinned or steaks; live.
Cod	Fresh; head off; viscerated.	200-pound barrels	Scrod, 1½ to 2 pounds.	Market, 2½ to 10 pounds.	Large, over 10 pounds.	Head off; viscerated or steaked.	Large; steaked.
Crappie	Fresh; round	do		Medium, ½ pound	Order size, over ¾ pound.	Round	Either size; round.
Eels	Fresh; round; viscerated.	200-pound barrels; mixed with other fish.	Small, ½ to 2 pounds		Large, over 2 pounds	Round; viscerated; skinned.	Large; skinned.
Flounders	Fresh; round; filleted.	200-pound barrels; filleted; 15-pound boxes.	Sizes not specified			Round or filleted	Filleted.
Grouper	Fresh; viscerated	200-pound barrels	do			Viscerated	As shown.
Haddock	Fresh; frozen; viscerated; filleted.	Filleted, 15-pound boxes; other 200-pound barrels.	Scrod, 1 to 2½ pounds.		Large, over 2½ pounds.	Viscerated or filleted.	Filleted.
Halibut	Fresh; frozen; head off; viscerated.	Fresh, 200-pound boxes; frozen; 300-350 pound boxes.	Chicken, 3 to 9 pounds	Small medium, 10 to 50 pounds, large medium, 50 to 80 pounds.	Whale, over 80 pounds.	Steaks	Chicken, small or large, medium, steaked.

Herring, lake (cisco).	Fresh; frozen; round; viscerated.	100-pound boxes with handles.	Baby whitefish, ¾ to 1 pound.			Round; viscerated; smoked.	As shown.
Herring, sea	Frozen; round	50-pound boxes	Sizes not specified; usually run 2 fish to 1 pound.			Round	Do.
King mackerel	Fresh; viscerated	200-pound barrels		Medium, 3 to 7 pounds	Large, over 7 pounds	do	Medium, round.
Mackerel	Frozen; round	120-pound boxes		Medium, 2½ pounds	Large, over 2½ pounds.	do	As shown.
Mullet	Fresh; round	200-pound barrels	Sizes not specified, usually small sizes.			do	Small sizes; round.
Perch, white (fresh-water).	Fresh; frozen; round.	100-pound boxes with handles.	Small, ½ to 1 pound	Medium, 1 to 3 pounds	Large, over 3 pounds	do	Small or medium round.
Perch, white (salt-water).	Fresh; round	200-pound barrels	Sizes not specified			do	Any size, round.
Perch, yellow	Fresh; frozen; round; viscerated.	100-pound boxes with handles.		Medium, under ½ pound.	Large, over ½ pound	Viscerated	Medium, viscerated.
Pike, blue	Fresh; round; viscerated.	do		No. 2, ¾ to 1 pound	No. 1, over 1 pound	Round or viscerated	No. 2, round or viscerated.
Pike, grass (pickerel).	do	Mixed with other fish in 100-pound boxes with handles.	Sizes not specified			do	Any size, round or viscerated.
Pike, sauger	Fresh; frozen; round; viscerated.	100-pound boxes with handles.	No. 3, under ¾ pound.	No. 2, ¾ to 1 pound	No. 1, over 1 pound	do	No. 1 and No. 2, round or viscerated.
Pike, yellow	Fresh; round; viscerated.	do		Medium, 2 to 4 pounds	Large, over 4 pounds	do	As shown.
Pollock	Fresh; viscerated	200-pound barrels	Sizes not specified			Viscerated	Any size; viscerated.
Pompano	Fresh; round	do		Medium, ¾ to 2 pounds.	Large, over 2 pounds	Round	Medium; round.
Red snapper	Fresh; frozen; round; drawn; head off; viscerated.	do	Small; drawn, 2 to 4 pounds.	Headless, medium, 3 to 5 pounds.	Headless, large, 5 to 10 pounds.	Head off; viscerated; drawn.	Any size; head off; viscerated; drawn.
Rockfish	Frozen; viscerated	350-pound boxes	Sizes not specified			Head off; viscerated	Any size; head off; viscerated.
Sablefish	Frozen; head off; viscerated.	300-350 pound boxes	do			Head off; viscerated; and steaks.	Any size; steaked.
Salmon	Fresh; frozen; head off; viscerated.	Fresh, 100 or 200 pound boxes; frozen, 350-pound boxes.	Sizes not specified, sold by variety as each variety is usually about the same size.			Steaks	Chinook, silver, fall; as steaks.
Sand eels	Fresh; round	200-pound barrels	Sizes not specified			Round	Any size, round.
Shad	do	100-pound boxes; 150-pound barrels.	Sizes not specified, marketed according to whether buck or roe.			do	Any size, roe, round.
Scup	do	200-pound barrels	Sizes not specified			do	Any size, round.
Sheepshead (fresh-water).	do	100-pound boxes with handles.		Medium, ¾ to 1 pound	Large, over 1 pound	do	As shown.

TABLE 9.—*Trade categories of fishery products received in greater St. Louis, Mo.*—Continued

Product	Form in which received	Usual containers and sizes	Sizes or grades of product			Condition in which marketed	Consumer's preference
			Small	Medium	Large		
Sole	Fresh; round; filleted.	Round, 200-pound barrels; filleted, 30-pound boxes.	Small, ¾ to 1 pound.	Medium, over 1 pound.		Round or filleted.	Small, filleted.
Smelts, eastern	Frozen; round	10, 15, and 25 pound boxes.	No. 2, 20 fish to 1 pound.	No. 1, 12 to 15 fish to 1 pound.	Jumbo, 8 to 12 fish to 1 pound.	Round	No. 1 and jumbo, round.
Smelts, western	do	10-pound boxes		No. 1, 12 to 15 fish to 1 pound.		do	As shown.
Spanish mackerel	Fresh; viscerated	200-pound barrels	Small, 1 to 1½ pounds.	Medium, 1½ to 2 pounds.	Large, over 2 pounds.	Viscerated	Large, viscerated.
Spoonbill cat	Fresh; head off; viscerated.	do	Small, 1 to 3 pounds.	Medium, 3 to 5 pounds.	Large, 5 to 20 pounds.	Head off; viscerated; or steaks.	Medium and large steaks.
Spot	Fresh; round	do	Sizes not specified			Round	Any size, round.
Sturgeon, river	Fresh; round; head off; viscerated; skinned.	200-pound barrel, mixed with other fish.	do			Head off; viscerated; or smoked.	Any size, smoked.
Suckers	do	200-pound barrels	do			Head off; viscerated; skinned.	Any size; head off; viscerated; skinned.
Sunfish	Fresh; round	do		Medium, under ½ pound.	Large, over ½ pound	Round	Large, round.
Tilefish	Fresh; head off; viscerated.	200 and 250 pound barrels.	Small steak, under 6 pounds.		Large steak, over 6 pounds.	Head off; viscerated or steaked.	Large, steaks.
Trout, lake	Fresh; viscerated; frozen; head off; viscerated.	Fresh, 100-pound boxes with handles; frozen, 150-pound boxes with handles.	No. 1, 2 to 4 pounds	Medium, 4 to 6 pounds.	Large, over 6 pounds	Head off; viscerated.	Large; head off; viscerated.
Trout, rainbow	Fresh; round	10 to 50 pound boxes	Small, 3 fish to 1 pound.	Medium, 2 fish to 1 pound.	Large, over 1 pound.	Round	Medium, round.
Trout, salmon	Fresh; head off; viscerated.	100-pound boxes	Sizes not specified			Head off; viscerated.	Any size; head off; viscerated.
Trout, sea	Fresh; viscerated	200-pound barrels	do			Viscerated	Any size, viscerated.
Tullibees	do	100-pound boxes with handles.	do			Smoked; fresh	Any size, smoked.
Whitefish	Fresh; frozen; viscerated.	Fresh, 100-pound boxes; frozen, 150-pound boxes.		Medium, 1½ to 3½ pounds.	Jumbo, over 4 pounds.	Viscerated	Either size, viscerated.
Whiting	Frozen; round; head off; viscerated; skinned.	Skinned, 15-pound boxes; round, 125 to 160 pound boxes.	Small, 3 fish to 1 pound.	Medium, 2 fish to 1 pound.	Large, 1 fish to 1 pound.	Head off; viscerated; skinned.	All sizes; head off; viscerated; skinned.
Caviar	Prepared	20-pound pails	According to variety, no sizes specified.			Prepared	Any variety.

Clams in shell	Fresh	90-pound sacks; 180-pound boxes; 270-pound barrels.	Little neck, 1,000 to 1 bushel; cherrystone, 800 to 1 bushel.	Medium, 500 to 1 bushel.	Large, 200 to 1 bushel.	In shell	As shown.
Crabs, hard	Alive	30-pound boxes	Sizes not specified			Green or cooked in shell.	Do.
Crabs, soft	do	Crab trunk with trays.	Culls, 3½ inches wide.	Medium, 4 to 4½ inches wide; primes, 5 to 5½ inches wide.	Jumbo, 6 to 7 inches wide.	Alive	Medium; alive.
Crab meat	Fresh	1 and 5 pound tins in boxes and barrels.	Claw; meat of claw	Lump, body meat	Backfin, meat of backfin.	Fresh	As shown.
Crawfish	Alive	10 and 15 pound baskets and sacks.		Medium	Large	Alive	Large, alive.
Frogs	Fresh; viscerated; head off.	100 and 150 pound boxes; 200-pound barrels.	Baby, 2½ to 4 pounds to 1 dozen; small, 6 pounds to 1 dozen.	Medium, 8 pounds to 1 dozen.	Jumbo, over 10 pounds to 1 dozen.	Viscerated	As shown.
Lobsters	Alive	50 to 100 pounds to a barrel.	Baby	Medium	Large	Alive, cooked (whole)	Baby and medium.
Lobsters, cooked	Fresh	50 and 100 pound barrels.		Medium, 1½ pounds		Cooked (whole)	As shown.
Mussels	Fresh in shell	270-pound barrels	Size not specified			In shell	Do.
Oysters, shucked	Fresh	1-gallon cans packed 15 or 20 cans to a barrel.	Counts	Extra selects	Chesapeake selects; Chesapeake standards.	Fresh	Chesapeake selects or standards.
Oysters in shell	do	270-pound barrels	Blue point	Half shell	Medium rockaways; box rockaways.	In shell	As shown.
Scallops, meat	do	9-pound cloth sacks, packed 10 to 20 sacks to a barrel.		Medium, bay	Large, sea	Fresh	Large, sea.
Shad roe	do	1, 3, and 5 gallon pails in barrels.	Small, under ¼ pound per pair.	Medium, ¼ to ½ pound per pair.	Large, over ¾ pound per pair.	do	Medium or large.
Shrimp, green	Fresh; head off	125-pound barrels	Small	Medium	Large	Green or cooked	Do.
Shrimp, cooked	Fresh; peeled	5-pound tins, 100 pounds to barrel.			do	Cooked, peeled	As shown.
Pulpo	Frozen	15-pound boxes		Medium, 2 to 2½ pounds.	Large, over 2½ pounds.	Frozen	Do.
Squid	do	120-pound boxes	Small, about 1 pound		Large, over 1 pound	do	Do.
Turtles	Alive	200-pound barrels	According to variety, no sizes specified.			Alive	Do.
Turtle meat	Fresh	do	do			Fresh	Do.
Winkle	Fresh; in shell	do	Sizes not specified			do	Do.

Green shrimp arrive in barrels holding about 150 pounds, while the cooked shrimp come in 5-pound tins, about 100 pounds to the barrel. Lobsters are received in ordinary slat barrels with a net weight of 50 to 100 pounds. Scallops are received in 9-pound cloth sacks (1 gallon), 10 to 20 sacks to a barrel. Live hard crabs arrive in 30-pound boxes and soft crabs in the Chesapeake crab box, which is known as a "crab trunk," so-called because of its several layers of trays. Crawfish are received in 10 and 15 pound baskets and sacks. Shell clams are received in 70-pound sacks, 180-pound boxes, and 270-pound barrels. Shell oysters are received in barrels containing about 270 pounds, while shucked oysters arrive in 1-gallon cans, 15 or 20 cans to a barrel. Live fish are brought down the Mississippi River in specially constructed barges. Shad roe is received in 1, 3, and 5 gallon pails, packed in barrels. Pulpo is received in 15-pound boxes and squid in 120-pound boxes. Frogs arrive in barrels with a net weight of 100, 150, or 200 pounds, depending on the weather. Caviar is received in pails of various sizes. All shipments of fresh fishery products are packed in ice.

Some of the local wholesalers express a desire for the adoption of standard boxes for the shipment of products received in their market. This is especially true of fish shipments. For the shipment of the smaller varieties of fish, such as Spanish mackerel, flounder, catfish, and similar varieties, the 100-pound box is suggested; the 140-pound box for varieties of medium size, such as the red snapper, buffalo fish, and carp; and the 200 or 300 pound box for larger varieties, like the halibut. A box of larger proportions is cumbersome to handle. The smaller and medium sized boxes should be equipped with handles extending not more than 4 inches over each end. Each container should provide for the proper amount of fish, with sufficient space remaining for snow or ice to insure preservation en route.

From a selling standpoint, the contents of such containers will represent a standard net weight for each class of fishery product. Then, should occasion warrant, the contents could be sold by the container, eliminating weighing and rehandling at the market. From the standpoint of transportation, an express or freight car could be filled more completely. The extension handles make picking up and setting down easy, and eliminate the possibility of upending the boxes while in transit. The 100 and 140 pound boxes, being of medium size, can be handled easily by two men.

Shipments made in containers of this style present a better appearance upon arrival at their destination. The fish lie flat in the boxes, and loss due to spoilage (caused by the breaking of the body wall of fish packed in containers not conforming to their size) will be eliminated. Also, the lower layers will not present that "squashed" appearance, which is frequently seen in fish packed in boxes or barrels of larger dimensions and holding a greater quantity of fish.

Shrinkage of shipments made in boxes is about 1 per cent less than when made in barrels. While this amount is of no great significance in the case of a single package, the aggregate will amount to several hundred pounds in a carload shipment.

The use of stencils instead of shipping tags is suggested where possible for marking the name and address of the consignee on the container. Such stenciling should always be done on each end of the boxes.

ESTIMATED POPULATION OF THE GREATER ST. LOUIS AREA, 1926

The estimated population of the greater St. Louis area in 1926, including 22 separate municipalities, and covered by the section 16 by 21 miles according to "A Study of Principal American Markets"[2] for 1927, was as follows:

Missouri:	
St. Louis	834, 392
Clayton	3, 126
Ferguson	2, 030
Jefferson Barracks	1, 000
Jennings	3, 725
Kenwood	1, 298
Kirkwood	4, 604
Luxemburg	2, 000
Maplewood	9, 208
Overland	1, 000
Richmond Heights	2, 500
University City	9, 960
Webster Groves	11, 207
Wellston	7, 433
Illinois:	
East St. Louis	72, 726
Belleville	27, 503
Brooklyn	1, 769
Fairmount City	1, 500
Granite City	18, 271
Madison	4, 996
Venice	4, 023
Washington Park	1, 663
Total	1, 025, 934

PER CAPITA CONSUMPTION OF FISH

The estimated population of greater St. Louis in 1926 was 1,025,934. During this period, 13,127,000 pounds of fresh and frozen fishery products were received in greater St. Louis. Of this amount 1,191,000 pounds were reshipped, leaving 11,936,000 pounds for consumption, making an annual per capita consumption of these products, in the round, of about 12 pounds. Considering only the edible portion, amounting to 9,295,000 pounds, the annual per capita consumption is about 9 pounds.

In the survey of the fisheries trade in New York City, it was stated that the per capita consumption of fish was influenced by the large foreign-born, Jewish, and Catholic populations and to the unusually large number of transients. While the fisheries trade in greater St. Louis depends to some extent on the Jewish population as well as the negro population for a large percentage of its trade, it is believed that these are minor factors in influencing consumption and that the trade has been developed to a large degree among all races and creeds by the efficient methods employed by the wholesalers, coupled with advertising. As has been shown, the trade is supplied largely with filleted, steaked, or skinned varieties of fish. It is easy for the retailer to handle these, for the housewife to cook, and, as the portions contain few or no bones, they are eaten readily by children as well as adults.

[2] Published by the 100,000 group of American Cities, Chicago, Ill.

TABLE 10.—*Summary of greater St. Louis market survey*

Item	Quantity
Number of wholesale fish dealers	12
Number of retail dealers handling fish every day in the week	62
Number of fish products handled	74
Products on which bulk of trade is based (75 per cent)	6
Amount ... pounds	9,873,000
Products of moderate importance (20 per cent)	15
Amount ... pounds	2,626,000
Products of slight importance (5 per cent)	53
Amount ... pounds	628,000
Reasons for limited sale—	
Used mainly by the Italian trade	16
Limited supply	13
High price	13
Seasonal variety	11
Not well known	6
Used mainly by hotels and restaurants	6
Considered medium or poor quality	4
Poor shipper	3
Unpopular	3
Principal containers:	
Boxes—	
Fresh-water fish ... pounds	100-140-150-175
Salt-water fish ... do	10-15-25-125-150-200-350
Barrels—	
Fresh-water fish ... do	200
Salt-water fish ... do	200
Quantity of products handled in 1926 ... do	13,127,000
Quantity shipped to other States (9 per cent) ... do	1,191,000
Quantity consumed in greater St. Louis ... do	11,936,000
Quantity consumed in greater St. Louis area, reduced to the edible portion ... do	9,295,000
Estimated population of greater St. Louis, 1926 ... number	1,025,934
Per capita consumption of fresh and frozen fishery products, 1926 (edible portion) ... pounds	9
Per capita consumption of fresh and frozen fishery products, 1926 (in the round) ... do	12

HEALTH REGULATIONS GOVERNING FISH STORES

Stores in St. Louis handling fish are subject to the following regulations, as stated in the Sanitary Code of the Division of Health of the City of St. Louis, for 1927:

SEC. 73. Powers of inspectors: The said inspectors shall have power to enter all markets, stores, houses, or other places where food products are offered for sale for human food. When such human food products are found on inspection to be tainted, diseased, corrupted, or unwholesome from any cause, the said inspector shall condemn the same as unfit for human food, mutilate or mark the same in such a manner as he may deem best to indicate condemnation of the same, and order the same to be immediately disposed of otherwise than for food.

If, under this section, any shipment of fish received in St. Louis is condemned upon arrival, the consignee is given a receipt by the division of health, showing that such goods were officially condemned. This receipt acts in lieu of payment to the shipper for this shipment and officially declares that the fish covered by the receipt arrived at destination in bad order, either due to fault of the shipper or the carrier. If the carrier is at fault, the claim for reimbursement for the value of the fish carried in this shipment can be taken up with them and payment is made more certain.

SEC. 78. Shops to be kept clean: Every person * * * shall keep his meat (fish) shop or stand properly cleaned and free from all foul smells and nuisances of every description * * *.

Section 79 states in substance that from the 1st day of May to the last day of October of each year all substances intended for human food or drink shall be screened or otherwise protected to prevent access of insects.

Section 80 states in substance that no meat or meat products (fish) intended for human food may be displayed on the sidewalk or other public place within the city.

Any of the above sections that are applicable apply to products in cold storage also.

REGULATIONS GOVERNING THE SALE OF FISH

The sale in Missouri of certain species of fish obtained in the waters of Missouri and elsewhere, and the sale of fish caught in a certain manner, are subject to the following regulations, as stated in the game and fish laws of Missouri, chapter 37, article 11, for 1927–28:

SEC. 5621. * * * It shall be unlawful for any person to ship or offer for shipment any fish which has been killed, or taken by use of spear or gig, * * *. [Fish gigged or speared are permitted for family consumption only and can not be sold.] It shall be unlawful for any person or persons, firms, or associations, whatsoever, to catch, kill, take, ship, convey, or transport, or cause to be transported, any species of game fish from the waters of this State, as herein provided, for commercial purposes. The term "game fish" shall include bass of all species, crappie, goggle-eye, trout of all species, and all other species known as game fish not specially named herein * * *.

SEC. 5625. It shall be unlawful for any person, firm, or partnership to offer for sale, sell, or ship for market purposes, when caught or taken from the waters of this State, any of the following-named game fish: Channel catfish, rainbow trout, crappie, large-mouth black bass, small-mouth black bass, rock bass, black perch or green sunfish, pike perch, yellow perch, white bass, yellow bass, blue bream * * *. Bass from without the State may be sold or shipped only on permit is sued by the game and fish commissioner * * *.

SEC. 5627. * * *. It shall be unlawful to sell or offer for sale any of the following-named fish mentioned below which are less than the length specified for each: Trout, 8 inches; pike, 11 inches; jack salmon, 11 inches; crappie, 8 inches; black bass, 11 inches; white or striped bass, 8 inches; sunfish, 6 inches; blue or channel catfish, 13 inches; white perch, 10 inches; said fish to be measured from the end of nose to fork of tail * * *.

SEC. 5636. * * *. It shall be unlawful for any person, firm, or corporation to solicit, by correspondence, printed cards, circulars, shipping tags, advertisement, or otherwise, any illegal shipments, consignments, or delivery of game and fish contrary to the laws of this State, whether taken within or without this State * * *.

TABLE 11.—*Directory of sea-food dealers in St. Louis, Mo.*

[W = wholesaler; R = retailer]

WHOLESALE AND RETAIL

Dealers	Symbols	Fish handled							Other goods			
		Live	Fresh	Frozen	Oysters	Other shellfish	Canned	Cured	Poultry	Dairy products	Delicatessen	Groceries
Biddle Fish Market, 72-73 Biddle Market	WR	x	x	x	x							
Booth Fisheries Co., 409 Franklin Ave	W		x	x	x	x		x				
Bruno Fish Co., 906-8 North 6th St	WR		x	x	x	x		x				
Bruno-Franz Sons, 919 North Broadway	W		[1] x	[1] x					x			
Consumers Commission Co., 718 North 4th St	W		[1] x	[1] x					x			
Faust's Fulton Market Co., 922 North Broadway	W		x	x	x	x	x	x			x	
Franz, Walter, 716 North 4th St	W		[1] x	[1] x					x			
French Market Fish & Oyster Co., 1234 South Broadway	WR		x	x	x	x		x				
Goettling, George J., & Co., 812 North 3d St	W		x	x	x	x		x				
Grafton Fish Co., 2011 Franklin Ave	WR	x	x	x	x							
Haase, A. C. L., & Sons Fish Co., 415 North 2d St	W							x				
Kopperman Fish Co., 1121 Franklin Ave	W							x				
Lynch, E. L., Poultry Co., 807 North 4th St	W		[1] x	[1] x					x			
Mathis Fish & Oyster Co., 3112 Easton Ave	WR		x	x	x	x	x	x				
Meletio Seafood Co., 820-822 North Broadway	WR		x	x	x	x	x	x			x	x
Mississippi Live Fish Market, 1307 Biddle St	WR	x	x	x	x				x			
North Side Fish Co., 2332a Russell Blvd	W		x		x							
Progressive Commission Co., 819 North 3d St	W		[1] x	[1] x					x			
St. Clair Fish Co., 101 Collinsville Ave., East St. Louis, Ill	WR		x	x	x	x	x	x				
Uhrig Bros., 812 North 4th St	W		[1] x	[1] x					x			

[1] Frogs only.

TABLE 11.—*Directory of sea-food dealers in St. Louis, Mo.*—Continued

RETAIL ONLY

Dealers	Fish handled							Other goods				
	Live	Fresh	Frozen	Oysters	Other shellfish	Canned	Cured	Poultry	Dairy products	Delicatessen	Fruit and vegetables	Groceries
American Live Fish Co., 2706 Market St	x	x	x	x								
Barth-Bernard Fish & Poultry Co., 1923 South Broadway	[2] x	x	x	x	x			x	x		x	
Barth, Harry, Fish Market, 3322 Laclede Ave	x	x	x	x				x	x			
Bernstein Fish Co., 5546 Ridge Ave		x									x	
Biddle Fish Market, 1217 North 13th St	x	x	x	x		x		x				
Blackstone Fish Market, 1303 Blackstone Ave	x	x	x									
Bodeman, William, 1109 East Gano Ave		x	x									
Booth Fisheries Co., Union Market		x	x	x	x		x					
Bruno Fish Co., Union Market		x	x	x	x		x					
Buerger Fish & Oyster Co., 1504 North Taylor Ave		x	x	x	x	x	x					
Busy Bee Fish Market, 1019 North Vandeventer Ave		x	x	x							x	
Central Fish Market, 111 North 15th St		x	x	x			x					
Ciluffo, Clemente, 1003 North 7th St		x	x	x	x		x					
Davis Fish Market, 1314 Biddle St	x	x						x				x
Dellas Fish Market, 1146 Walton St		x									x	
Dien and Sobel, 1306 North Pendelton Ave		x	x								x	
Easton Avenue Fish & Oyster Market, 4146 Easton Ave		x	x	x				x				
Ehrlich, H., 4606 Page Blvd		x										
Ehrlichs Market, 5645 Easton Ave	x	x									x	
Franklin Fish & Oyster Co., 2636 Franklin Ave		x	x	x							x	
Goldstein, Nat B., Fish Market, 2803 Market St		x	x	x	x	x	x					x
Gordon, I., 2833 Dickson St	x	x									x	
Heil, Edward C., 621 North Broadway				[3] x								
Jacks Fish Market, 2630 Market St	x	x	x	x				x			x	x
Jefferson Fish Market, 2323 Franklin Ave		x		x				x				x
Jenner Fish & Poultry Co., 4501 North 19th St	x	x	x	x				x				
Kentucky & Tennessee Live Fish Market, 2820 Market St	x	x	x	x				x				
Lasky, Joseph, 1505 Biddle St		x										
Lazaroff Fish Market, 2818 North Newstead Ave		x	x	x				x				x
Leonard Fish Market, 3223 Franklin Ave		x	x	x	x	x						x
Liberty Live Fish & Poultry Co., 2325 Franklin Ave	x	x	x	x				[4] x			x	x
Lynn Meat Co., 800 North 6th St.[4]		x	x	x	x	x	x					
Meletio Seafood Co., Union Market		x	x	x	x	x	x					
Millers Fish & Oyster Market, 5711 Easton Ave		x	x	x		x	x					
Nekola, Charles, Union Market		x	x	x	x	x	x					
Newman, Max, 1804 North Taylor Ave		x		x				x			x	x
North St. Louis Fish Market, 3609 North 11th St	x	x	x	x								
Peoples Fish Market, 4407 Easton Ave		x									x	
Quality Fish Market, 1265 Bayard Ave		x									x	
Remley-Leber Market, 6th St. and Franklin Ave.[5]		x	x	x	x		x					
Roodman Fish Co., 2224 Franklin Ave		x	x	x	x	x	x				x	x
Rosen, William, 1914 Biddle St	x	x	x	x								
St. Louis Fish Co., 2722 Franklin Ave	x	x	x	x							x	
St. Louis Fish Market, 2124 Market St		x	x	x				x			x	x
Sanitary Market, 4265 West Easton Ave		x	x	x				x				x
Sarah Live Fish Market, 1010 North Sarah St	x	x	x	x				x				
Seiler, Charles, 1926 Biddle St	x	x										
Square Deal Live Fish Market, 1205 North 13th St	[2] x	x	x	x								
Star Live Fish Co., 2702 Chauteau Ave	x	x	x	x				x				x
Swailes, John & Son, 3214 Franklin Ave		x		x		x						x
Thomas Market, 709 North 6th St.[5]		x	x	x	x	x	x					
Tocco, Anton, 620 Biddle St		x	x		x							
United Fish and Poultry Co., 2607 Franklin Ave		x	x	x				x				x
Western Fish & Oyster Co., 2028 Market St		x	x	x			x	x			x	x

[2] Includes goldfish.
[3] Operates restaurant.
[4] Also meats.
[5] Operated as a department in a public market.

TABLE 12.—*Short-line travel distance and freight and express rates on fresh and frozen fish and oysters from principal sources of supply to St. Louis, Mo.*

[Prepared by the Interstate Commerce Commission, Bureau of Traffic. Distances shown were taken from War Department mileages or War Department mileages in connection with Official Railway Guide. Notes to reference symbols are grouped at end of table]

Points of origin	Short-line travel, distance in miles	Rate in cents per 100 pounds			
		Fresh or frozen fish		Fresh or frozen fish and oysters	
		Carload, freight	Less-than-carload, freight	Carload, express	Less-than-carload, express
DOMINION OF CANADA					
British Columbia:					
Prince Rupert	2,726	187½	495	D393	ƒ1300
Vancouver	2,486	{ 187½ A290 }	495	D393	ƒ865
Manitoba: Winnipeg	1,032	108½	224	E290	ƒ490
New Brunswick: Loggieville	1,885	108	213	----------	ƒ525
Nova Scotia:					
Halifax	1,948	108	215½	----------	ƒ580
Lockeport	2,097	126½	241½	----------	ƒ580
UNITED STATES					
Alabama:					
Birmingham	486	70	162	----------	√X 190 ƒ221
Mobile	657	B111½	173½	----------	√X 226 ƒ274
Tuscaloosa	535	74½	173	----------	√X 179 ƒ210
Arkansas:					
Clarendon	333	96	160	----------	ƒ195
Felsenthal	516	115	191½	----------	ƒ232
Helena	338	57½	134	----------	ƒ191
Lake City	272	85	142	----------	√X 154 ƒ176
Marianna	313	90½	151	----------	ƒ191
Readland	435	109½	182½	----------	ƒ232
California: San Francisco	2,199	187½	495	C393	ƒ742
Connecticut:					
New London	1,179	110½	166	----------	ƒ326
Noank	1,186	110½	166	----------	ƒ337
South Norwalk	1,097	110½	166	----------	ƒ311
Florida:					
Apalachicola	882	C137	300½	----------	√X 273 ƒ304
Jacksonville	929	D118	218½	----------	√X 289 ƒ322
Key West	1,451	E179½	311	----------	√X 407 ƒ446
Okeechobee	1,203	F167½	341½	----------	√X 335 ƒ364
Panama City	820	C137	393	----------	√X 247 ƒ285
Pensacola	746	G111½	173½	----------	√X 247 ƒ285
Punta Gorda	1,222	H145	344	----------	√X 341 ƒ375
Welaka	987	I	261	----------	√X 294 ƒ326
Georgia:					
Brunswick	887	94	218½	----------	√X 273 ƒ311
Savannah	872	94	218½	----------	√X 273 ƒ311
Illinois:					
Bath	153	33	65½	----------	ƒ124
Beardstown	113	28½	56½	----------	ƒ124
Browning	122	29½	58½	----------	ƒ124
Chicago	284	39½	79	----------	ƒ154
Depue	238	37½	75	----------	ƒ154
Grafton	41	20½	40½	----------	√X 67 ƒ 71
Havana	145	33	65½	----------	ƒ124
Peoria	162	32	63½	----------	ƒ124
Iowa:					
Clinton	300	39½	79	----------	ƒ154
Dubuque	362	42½	85	----------	ƒ169
Kentucky:					
Hickman	214	40½	104½	----------	√X 112 ƒ124
Paducah	171	35	66½	----------	√X 96 ƒ124
Louisiana:					
Atchafalaya River	704	121½	202½	√	A247 √B205 ƒ274
Berwick	748	126½	209½	√A	267 √B226 ƒ319
Houma	788	149½	248	----------	√X 247 ƒ285
Lake Arthur	776	155	257½	√A	267 √B226 ƒ307
Monroe	501	114½	190½	----------	√X 237 ƒ262
Morgan City	748	126½	209½	√A	267 √B226 ƒ319
Naples	652	121½	201½	----------	√X 226 ƒ262
New Orleans	699	74½	173½	----------	√X 247 ƒ285
Plaquemine	708	132 [illegible]	173½	√A	247 B205 ƒ274
Maine: Rockland	1,479	110½	166	----------	ƒ386

TABLE 12.—*Short-line travel distance and freight and express rates on fresh and frozen fish and oysters from principal sources of supply to St. Louis, Mo.*—Continued

Points of origin	Short-line travel, distance in miles	Rate in cents per 100 pounds: Fresh or frozen fish: Carload, freight	Rate in cents per 100 pounds: Fresh or frozen fish: Less-than-carload, freight	Rate in cents per 100 pounds: Fresh or frozen fish and oysters: Carload, express	Rate in cents per 100 pounds: Fresh or frozen fish and oysters: Less-than-carload, express
UNITED STATES—continued					
Maryland:					
Baltimore	932	107½	158	----------	√X 217 ƒ292
Crisfield	1,047	110½	166	----------	ƒ300
Princess Anne	1,117	110½	166	----------	ƒ300
St. Michaels	981	110½	166	----------	ƒ300
Massachusetts:					
Boston	1,217	110½	166	----------	ƒ337
Provincetown	1,361	110½	166	----------	ƒ360
Michigan: Charlevoix	680	79½	119	----------	ƒ244
Mississippi:					
Biloxi	629	74½	173½	----------	√X 226 ƒ274
Gulfport	641	74½	173½	----------	√X 226 ƒ262
Natchez	633	71½	166½	----------	√X 226 ƒ262
Vicksburg	525	68	157½	----------	√X 205 ƒ236
Missouri:					
Cassville	306	83½	138½	----------	ƒ176
Hornersville	241	85	142	----------	√X 127 ƒ139
Mingo [1]	178	52	85	----------	----------
Winfield	56	21	45½	----------	√X 67 ƒ 75
New Jersey:					
Beach Haven	1,038	120½	176	----------	ƒ300
Manasquan	1,043	110½	165	----------	ƒ300
Port Monmouth	1,090	110½	165	----------	ƒ300
Port Morris [1]	1,099	110½	166	----------	----------
New York:					
Greenport	1,150	123	183½	----------	ƒ326
New York City	1,053	110½	166	----------	ƒ300
Sayville	1,107	117	175	----------	ƒ300
North Carolina:					
Morehead City	1,103	74	200	----------	√X 289 ƒ334
Wilmington	1,021	84	185	----------	√X 282 ƒ322
Ohio:					
Cleveland	536	69½	103½	----------	ƒ221
Sandusky	483	67½	100½	----------	ƒ221
Toledo	437	63½	94½	----------	ƒ210
Pennsylvania: Erie	631	82	122½	----------	ƒ244
Rhode Island:					
Newport	1,212	110½	166	----------	ƒ337
Warren	1,253	110½	166	----------	ƒ387
Tennessee:					
Memphis	305	52½	122½	----------	√X 154 ƒ176
Tiptonville	269	54½	127	----------	√X 112 ƒ124
Union City	211	39½	92	----------	√X 112 ƒ124
Texas:					
Corpus Christi	1,018	146	223½	√A	379 √B320 ƒ379
Galveston	850	146	223½	√A	320 √B267 ƒ341
Houston	802	146	223½	√A	320 √B267 ƒ330
Ingleside	1,015	146	223½	√A	379 √B320 ƒ379
Karnack	554	146	223½	----------	ƒ277
La Porte	829	146	223½	√A	320 √B267 ƒ330
Nacogdoches	657	146	223½	----------	ƒ307
Orange	781	146	223½	√A	278 √B232 ƒ307
Port Lavaca	955	146	223½	√A	362 √B304 ƒ364
Rockport	1,040	146	223½	√A	379 √B320 ƒ379
Virginia:					
Hampton	1,000	103½	150	----------	√X 247 *273
Norfolk	1,005	103½	150	----------	√X 247 *273
Portsmouth	1,006	103½	150	----------	√X 247 *273
Washington: Seattle	2,332	187½	495	C393	ƒ742
Wisconsin:					
Bay City	563	45½	96	----------	ƒ232
Green Bay	478	45½	96	----------	ƒ232
Manitowoc	441	45½	96	----------	ƒ247
Port Washington	389	45½	96	----------	ƒ184

[1] Not an express station.

EXPLANATION OF REFERENCE MARKS GOVERNING THE FREIGHT RATES

The freight rates quoted are subject to Rule 32 of the classification (except as noted), which reads as follows:

"SECTION 1. When ice or other preservative is in bunkers of the car, no charge will be made for its transportation; but if ice is taken by consignee, charge shall be made on actual weight of the ice in bunkers at destination and at carload rate applicable on the freight which it accompanies; if not taken by consignee it becomes the property of the carrier.

"SEC. 2. When ice or other preservative is loaded in body of car for protection of the freight, provided the rules of the carriers permit such loading, no charge will be made for its transportation; but if taken by consignee, charge shall be made on actual weight of the ice or other preservative in car at destination and at the rate applicable upon the freight which it accompanies; if not taken by consignee it becomes the property of the carrier.

"SEC. 3. No allowance in weight will be made for ice or other preservative placed in the same package with the freight (see exception)."

Exception.—In connection with shipments from Florida, the following rule will govern instead of section 3, quoted above (taken from Glenn's I. C. C. A-556):

"When ice is placed in the same package with freight, charges will be assessed on basis of the net weight of the freight and containers."

A. Passenger train service.

B. Minimum weight 8,000 pounds; 90 cents for minimum weight, 12,000 pounds; 64 cents for minimum weight, 20,000 pounds.

C. Minimum weight 8,000 pounds; 111½ cents for minimum weight, 12,000 pounds; 78½ cents for minimum weight, 20,000 pounds.

D. Minimum weight 12,000 pounds; 78½ cents for minimum weight, 20,000 pounds.

E. Minimum weight 12,000 pounds; 119½ cents for minimum weight, 20,000 pounds.

F. Minimum weight 12,000 pounds; 111½ cents for minimum weight, 20,000 pounds.

G. Minimum weight 8,000 pounds; 90 cents for minimum weight, 12,000 pounds; 64 cents for minimum weight, 20,000 pounds.

H. Minimum weight 12,000 pounds; 96½ cents for minimum weight, 20,000 pounds.

I. Jacksonville combination: To Jacksonville, 18½ cents minimum weight, 24,000 pounds. Beyond Jacksonville, 118 cents minimum weight, 12,000 pounds, or 78½ cents minimum weight, 20,000 pounds.

EXPLANATION OF REFERENCE MARKS GOVERNING THE EXPRESS RATES

A.—Fish and oysters, any quantity rates.

B.—Oysters in shell, any quantity rates.

C.—Applies on fish and fish roe in carloads. Minimum weight, 20,000 pounds net weight.

D.—Applies on fish in carloads. Minimum weight, 20,000 pounds. Fresh fish, net weight;' rozen, smoked, dried, or cured fish, gross weight.

E. Applies on fish in carloads. Minimum weight, 20,000 pounds. Classification weight basis (see note 1).

‡. Second class any quantity rates. Classification weight basis (see note 1).

X. Rates applying on fresh fish in barrels; also on oysters in shell. Rates named apply on fresh fish in barrels. They will also apply on fresh fish in boxes when the net weight of the shipment is 150 pounds or more. The charges on fresh fish must be assessed on the net weight of the fish plus 25 per cent for ice. The following estimated weight will apply on oysters in the shell: Flour barrel, estimated weight 200 pounds per barrel. Sugar barrel, estimated weight 250 pounds per barrel.

✓. Shipments of fresh fish in sugar barrels, when in lots of 10 barrels or more, from one consignor to one consignee will be charged 10 per cent less than the charge determined at rates named.

•. Any quantity rates applying on fish and oysters. Will not apply on shipments of fresh fish in flour or sugar barrels or on oysters in the shell.

NOTE 1.—Classification weight basis: Fish, fresh, frozen, dried, salted, pickled, or otherwise preserved or cured. Gross weight, except that fresh or frozen fish shipped with ice must be charged for on the basis of 25 per cent added to the net weight of the fish, unless actual gross weight is less at time of shipment.

On mixed shipments of fish and oysters shipped with ice, charge on the basis of 25 per cent added to the net weight of the fish, plus the weight of the oysters as specified hereunder.

The minimum billing weight of any iced shipment under this rule is 40 pounds, unless the gross weight is less.

Oysters: When shipped in bulk, estimate 12 pounds per gallon.

In glass jars, estimate 24 pints at 45 pounds, 36 pints at 65 pounds, 48 pints at 90 pounds, and 48 half pints at 50 pounds.

The following estimated weight will apply to oysters in metal cans with or without ice, when packed in boxes: $\frac{1}{16}$-gallon can, 1¼ pounds each; pint cans, 1½ pounds each; standard or ¾ cans, 2 pounds each; ¼-gallon cans, 2½ pounds each; full quart cans, 3 pounds each; half-gallon cans, 6 pounds each; gallon cans, 12 pounds each.

Gross weight will apply when less than the estimated weights shown above. The minimum billing weight for any shipment of oysters is 30 pounds, unless the actual gross weight is less or unless the percentage allowance from gross weight authorized in the official express classification makes a lower billing weight.

Carloads: Minimum billing weight, 12,000 pounds on the following basis:

When in the shell, actual weight. Shucked oysters in carriers, estimate at 12 pounds per gallon. Shucked oysters in naked cans without other packing, charge on the basis of actual weight of the oysters and containers.

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PROGRESS IN BIOLOGICAL INQUIRIES, 1926[1]

INCLUDING THE PROCEEDINGS OF THE DIVISIONAL CONFERENCE, JANUARY 4 TO 7, 1927

By ELMER HIGGINS

Assistant in Charge of Scientific Inquiry

CONTENTS

[1] Appendix VII to the Report of the United States Commissioner of Fisheries for 1927. B. F. Doc. 1029.

FOREWORD

As indicated by the table of contents, the following report of the division of scientific inquiry is presented in two parts: Part I is a condensed statement of the chief results of the investigations conducted by the division during the calendar year; Part II is a transcript of the proceedings of the divisional conference held January 4 to 7, 1927. While both parts treat of the work of the division, it will be seen that the accounts of the various investigations, as given in the proceedings of the conference, are less detailed in nature but include the general and historical bearings of the problems, in most cases stressing the practical significance of results. The accounts of the investigations given in the first section are more nearly restricted to the detailed results obtained during the current year, and therefore supplement the more general treatment.

The divisional conference of January, 1927, was the first meeting of its kind ever held by the Bureau of Fisheries. There have been many fisheries conventions, in which the bureau's investigators have participated; there have been frequent conferences between the officers of the bureau and smaller groups of workers interested in particular problems; but never before, except, perhaps in the early days of the Fish Commission, has the entire staff of the division of inquiry been assembled for a general consideration of its problems. The undertaking was an experiment, therefore, and it yet remains to be determined if the experiment be a success or if it will be repeated. It can hardly be doubted, however, that the efficiency of the bureau's work will be increased materially by overcoming the effects of the isolation that surrounds the field investigators by bringing them into contact with others in the same and associated fields, by the mutual exchange of ideas, and by the friendly criticism of their fellows on the staff. General satisfaction and approval were expressed by all who were in attendance.

The conference was planned for the midwinter season, when field work is at a minimum; and the investigators' regular visits to Washington, which formerly were scattered through the year, were delayed or hastened in order to bring the staff together at one time. The meeting of the advisory committee on scientific investigations of the bureau, appointed by Secretary Hoover, was also scheduled to occur at this time; and the bureau was further fortunate in having as guests noted visitors of other departments, who were visiting Washington in connection with their own work. Approximately 40 persons took part in the discussions, including the commissioner, deputy commissioner, chiefs of the divisions, investigators of the division of scientific inquiry, members of the advisory committee on scientific investigation, and several invited guests. The program continued through 3½ days, and included many carefully prepared papers, followed by extended and stimulating discussion.

Several evening gatherings of a social nature were arranged privately, also affording opportunity for personal contact and acquaintanceship among members of the staff and materially contributing to the development of a real *esprit de corps.*

Because of the comprehensive treatment of the various fields of investigation by the investigators at the conference, it is considered worth while to publish the transcript of the proceedings. Although most of the discussion was of such an informal nature that it has been deleted editorially, the papers and parts of the discussion are included herewith in the belief that they present a more complete and readable statement of the widespread and complex activities of the division of scientific inquiry in the interests of fishery conservation than could well be presented in the regular report.

Part I.—INVESTIGATIONS CONDUCTED DURING 1926

INTRODUCTION

During 1926 the work of the division of scientific inquiry has shown, in increasing degree, the effect of the conscious and deliberate effort to center attention upon the problems of the fisheries as a distinct branch of marine biology. While none of the lines of investigation under way in 1925 have been abandoned, no effort has been spared to so conduct the work that results of practical benefit to the fisheries and to the fishery administrator may speedily be attained; and it is believed that gratifying progress, comparing well with that of the past and promising much for the future, has been made.

It should not be understood by this that only temporary and insignificant problems, bearing solely on immediate needs, have been undertaken; for it is realized that the big problem that the fishery biologist faces—the problem that enlists his deepest concern and demands his best effort—is the task of conserving or rebuilding a dwindling fish supply. The problem has not always been attacked directly, but in all cases a necessary groundwork has been laid as the basis for more immediately productive studies in the future.

The practical utility of the bureau's investigations is becoming more apparent to the public at large, and with public confidence has come a demand for additional investigations. The Congress and many State fishery departments have responded with greater financial support, and as a result it is confidently believed that the science of fishery husbandry and the conservation of aquatic resources will be advanced more rapidly during the coming years than ever before.

Perhaps the outstanding accomplishments during the past year are the development and application of principles of oyster culture to the varying conditions found on the Atlantic seaboard, the scientific regulation of the Alaska salmon fishery, and the development of aquiculture as applied to fresh-water fishes. Extensive surveys have been made of the oyster industry from Cape Cod through Long Island Sound, and on the southern shore of Long Island, in South Carolina, Georgia, Mississippi, and Texas; and recommendations on which the various States may base an oyster-cultural program have been offered. Hydrobiological conditions differ so greatly in the various localities that different procedures must be followed to increase oyster production. There have been discovered great areas, now barren, which, without doubt, can be utilized for the production of oysters. Other areas, which have been depleted by overfishing, can be restocked; and in many cases the yield and quality of beds now productive can be increased materially.

Not only have these field observations been of aid in drafting general oyster-cultural programs, but fundamental researches upon the feeding and reproduction of oysters have contributed to our knowledge and made possible the more complete utilization of the present supply and a material increase in reproduction in unfavorable areas or seasons. Thus, through these studies of physiology, the fact of hibernation at a temperature below 41° F. has been reaffirmed;[2] at which time, as feeding is discontinued, it may be possible to market, without danger to the public health, oysters from areas that, during warm weather, may be condemned because of slight pollution. Likewise, through studies of the physiology of reproduction, it has been possible to induce spawning under experimental conditions. The possibility, therefore, is by no means remote that spawning on the natural beds likewise may be induced artificially during seasons when natural spawning would not occur otherwise, thus materially increasing the supply of oysters by insuring an abundant supply of seed. In addition, studies on the ecology and behavior of oyster larvæ have resulted in the designing of highly efficient spat collectors, making it possible, at small cost, to harvest a profitable crop of seed oysters on bottoms where setting does not occur naturally.

Congress has vested the control of the Alaskan fisheries in the Department of Commerce, and the regulations promulgated by the Secretary are administered by the Commissioner of Fisheries. Perhaps in no other locality has it been realized so keenly that fishery regulations must rest upon a solid foundation of biological knowledge; and it has been one of the most important functions of the division of scientific inquiry, with the extensive cooperation of the Alaska division, to conduct the biological researches which make possible the scientific husbanding of the great salmon fisheries. The past year has marked the culmination of a long period of investigation of the biology of the Pacific salmon. As a result of these studies, an understanding of many of the factors that cause the fluctuation in supply has been gained. To be able to predict the degree of abundance of any species of fish in future years is one goal of all fishery investigators, and it now appears that eventually reliable predictions concerning the magnitude of the runs of salmon in certain localities may be made a year or more in advance. The realization of these hopes will not only make possible the fullest control of the supply through regulation of the fishery, but will afford economic protection to the industry in years when poor runs are anticipated, which should result in the saving of millions of dollars.

Gratifying results in the newly initiated work in aquiculture also have been obtained. The first year's pond experiments at Fairport, in which the ponds were fertilized to increase plankton production and in which various plankton-feeding species of fish were used as forage for the game species, has resulted in a marked increase in total production. Results of equal promise have followed the bureau's investigations in the treatment and control of diseases of hatchery-reared fish. Because of the greater demand in recent years for larger fingerlings for stocking streams and lakes, fish-culturists have attempted to rear their stocks to larger sizes. The effectiveness of the hundreds of hatcheries throughout the country has been les-

[2] Based on experiments initiated before, but completed after, the end of the calendar year 1926.

sened materially, however, by the heavy mortality of the older fish. The bureau's efforts, therefore, are of great importance, for its studies on nutrition and diseases have made possible an increased output of the larger fingerlings from hatcheries that formerly suffered the ravages of disease.

Studies of the Atlantic marine fisheries have been prosecuted with increased vigor. Contributions to the basic knowledge of the biology of the region have been made through studies of the fish fauna, plankton, and oceanography of the Gulf of Maine; the fauna of Chesapeake Bay; cod-egg production in Massachusetts Bay; and migrations of the adult cod on the shore and offshore banks. The key to the fluctuation in the mackerel supply also has been discovered in the phenomenon of dominant year classes. These investigations disclose the fact that the mackerel in the tremendous catches of the past two years are the progeny of but two successful spawning years. It is believed that continued observations will make possible the forecasting of the immediate future success or failure of the mackerel fishery.

The extent and effectiveness of the bureau's investigations has been increased materially by the cooperation of various State departments. During the past year, work was conducted in cooperation with the States of North Carolina, Texas, Arkansas, Minnesota, Michigan, Wisconsin, Washington, Oregon, and California. The States provided men, laboratories, boats, and other equipment, and have been enthusiastic over the results obtained.

An important conference of the North American Committee on Fishery Investigations was held at St. Johns, Newfoundland, on July 9, 1926, for the purpose of further coordinating the efforts of the several nations interested in the fisheries of the North Atlantic region. Dr. H. B. Bigelow, Elmer Higgins, and O. E. Sette represented the United States; W. A. Found, Dr. A. H. Leim, and H. E. Tanner represented Canada; and D. James Davies, A. C. Goodrich, and G. F. Sleggs were the Newfoundland representatives. No representatives from France or Portugal were present. The various fishery investigations were considered by the committee and recommendations of extension or modification were made in some cases. The importance of statistics in the codfishery of the entire region was dwelt upon, and plans for participation by Newfoundland in the investigation of the oceanography of that region were made.

Undoubtedly the most serious handicap to the proper development of effective fishery conservation in the United States is the almost uniform lack of adequate statistics of the fisheries. While there has always been a more or less general realization of the economic value of records of total annual yield, the numbers of persons engaged, and the amount of investment in the fisheries, less attention has been given to the need for determining the relative abundance of the fish stock, year by year, as an indication of the state of the fisheries. It has been announced repeatedly that the aim of the division of scientific inquiry is to study fluctuations in the fisheries and to determine their immediate causes; but in nearly every case it has been impossible to attack the problem from a quantitative standpoint, which is by far the most important aspect, because of the lack of suitable statistical data. The yield per unit of effort, such as the boat catch per day, has long been recognized as a useful index of abundance of fish in the sea, but the present records can not be analyzed on that basis. Suitable statistics must contain these essential details; they must be uniform throughout the range of a fishery, continuous, free from bias, and stored in central places in such a way that they may be preserved for subsequent analysis by fishery investigators. Only the State governments have authority to enforce the collection of these records; and inasmuch as the various States divide jurisdiction over the shore and lake fisheries, it is necessary that concerted action be taken and that some central agency supervise and coordinate the States' activities in this direction. It seems essential, therefore, in order to obtain that intimate knowledge of fish life upon which all rational regulation must depend, that the Bureau of Fisheries should take a leading part in bringing to the attention of the State governments this need, and in advising them concerning the character of legislation necessary to set up an adequate statistical system. The bureau should serve as the coordinating agency in bringing the statistics together and making them available to the biologist. This the bureau is prepared to do, and it is anticipated that material progress toward the accomplishment of such a program will be made during the coming year.

The following progress reports, covering the most important investigations conducted by the division during the calendar year 1926, were prepared in the main by the investigators in charge.

FISHERIES OF THE ATLANTIC AND GULF COASTS

LIFE HISTORIES AND MIGRATIONS OF COD, POLLOCK, AND HADDOCK

Investigations of the great codfisheries of the New England coast, begun several years ago, were continued. The first method of attack has been to conduct tagging experiments to determine the movements and segregation of the various stocks of cod, pollock, and haddock that inhabit the region, and to study the development and early life history of the eggs and larvæ of these fishes.

Tagging operations in 1926 received a late start, owing to the conditioning of the newly acquired vessel, *Albatross II*. The *Halcyon*, which has carried on this investigation ever since it was begun in April, 1923, has been taken out of service.

The first cruise of the *Albatross II* was made to the northeast peak of Georges Bank, where, fishing from August 13 to 19, 1,014 cod, 23 pollock, and 66 haddock were tagged. The depth of water was nearly uniform (at 47 fathoms), and it was possible to utilize for tagging about 75 per cent of the total number of fish caught.

The second cruise was directed to southwest Georges Bank and Nantucket Shoals from September 5 to 11, where 1,606 cod, 10 pollock, and 114 haddock were tagged; but of these, only 5 fish were caught on Georges Bank.

The *Albatross II* fished off Mount Desert, Me., from August 20 to 23 and from September 26 to October 1, tagging 945 cod, 6 pollock, and 461 haddock. At the Bureau of Fisheries' Woods Hole biological station 946 cod were tagged on January 6 and 7, 1926. These fish had been held as a brood stock since November, 1925, and after spawning were tagged and liberated from the station's dock.

Exclusive of the Woods Hole fish, 40,097 cod, pollock, and haddock have been caught and tagged at sea from 1923 to 1926. A complete statistical summary follows:

Item	1923	1924	1925	1926
Number of cruises	7	9	16	4
Days of actual fishing	43	51	76	28
Hours of actual fishing	333	318.5	461	167
Number of cod tagged	7,618	6,209	10,420	3,565
Number of pollock tagged	2,215	916	949	89
Number of haddock tagged	411	3,223	3,891	641
Total number of fish tagged	10,244	10,348	15,260	4,245
Average number of fish tagged per day	238	203	201	185
Average number of fish tagged per hour	30.76	32.5	33.1	25.4

According to localities, the number of fish tagged is divided as follows:

Item	1923	1924	1925	1926
Massachusetts, south of Cape Cod	10,231	4,384	6,143	1,730
Massachusetts, north of Cape Cod	13	163	314	0
New Hampshire	0	8	5	0
Maine	0	5,793	8,798	1,412
Georges Bank	0	0	0	1,103

The total number of recaptures up to December 31, 1926, amounted to 1,940 and consisted of 1,742 cod, 72 pollock, and 126 haddock.

Scale samples were taken from all fish tagged in 1926, as well as during 1924 and 1925. All the samples taken during 1924 (over 10,000) have been mounted and about 1,000 have been studied.

Although tagging operations during 1926 were not as extensive as during the preceding three years, some very instructive results were obtained. It is believed that the year 1927 will produce results of great interest to this investigation, for not only is it planned to operate on an enlarged scale, but many of the experiments begun during the preceding four years will be one year nearer completion and in some cases may be terminated successfully. The outstanding results of the investigation during 1926 are as follows:

1. On the one cruise made to Nantucket Shoals (September 5–11), it was found that the stock of cod differed considerably in size from the fish present there during the period from the beginning of the investigation in 1923 up to 1925. Heretofore, cod less than 18 inches in length were caught rarely, and 22 to 32 inch fish predominated; but in 1926 large fish were scarce, fish below 18 inches were common, and the predominating sizes were 16 to 22 inches. Some intimation of this exodus of large fish and entry of small fish was had in the preceding fall and could be traced to August, 1925, when the bottom-water temperature was 15° C. (59° F.) and the cod were much scattered and bunched. How unusual this high water temperature is can not be known until the investigation has continued further.

In each of the tagging years (1923, 1924, and 1925), a definite migration of tagged cod occurred from Nantucket Shoals to the waters between Rhode Island and southern New Jersey. As the stock of fish present on Nantucket Shoals during 1926 was composed of much smaller cod than during the preceding years, it was of interest to note how this difference would affect the catches of cod made between Rhode Island and New Jersey during the winter and thereby gain some idea as to how much Nantucket Shoals contributes to the southern migration.

It was found that small cod were far more abundant than usual around Marthas Vineyard during the fall of 1926, enough so to receive special comment in the newspapers and trade magazines. Furthermore, fishing-boat captains along the western Long Island and New Jersey coasts asserted that large cod were not plentiful during the fall of 1926, but that small cod, below 22 inches in length, were much more numerous than for many years past. These data indicate that the Nantucket Shoals stock of cod contributes a large part of the fish that migrate south each fall to the Middle Atlantic States.

2. No recaptures have been reported of the 1,000 cod tagged on northeast Georges Bank during August, 1926. It is probable that these fish have not yet made extensive migrations (it is not certain that they ever will) and that no fishing vessels have been operating within the immediate vicinity of the tagging grounds.

3. As a result of the cod tagging along the shores of eastern Maine during 1924 and 1925, it was found that if these cod migrate at all they go to the Bay of Fundy and occasionally to the eastern coast of Nova Scotia. These same results obtained during 1926.

4. Very little is known definitely concerning the whereabouts and habits of cod and haddock between 1½ and 7 inches in length in the western Atlantic. This year, by means of a 30-foot otter trawl, quite a few cod and haddock, 2 to 5 inches in length, were taken on Georges Bank. The stomach of one Georges Bank pollock contained 12 haddock, 2½ to 4 inches in length, but other pollock examined contained none. Although these data are not extensive, the indications are that young cod and haddock of these sizes (they are less than two years old) are present in large numbers on Georges Bank, Browns Bank, and other offshore fishing grounds.

5. A study of scales has shown that cod off southern Massachusetts grow at the rate of about 7 inches each year for the first three years.

A more complete discussion of the cod problem is given on page 601 of this report.

The investigations of the spawning grounds and the early development and distribution of cod, haddock, and pollock in New England waters, carried on since 1924 by Dr. Charles J. Fish, assisted by Marie P. Fish and Robert A. Goffin, were interrupted during the past year because of the condemnation of the *Fish Hawk* and the necessity for making extensive repairs on the *Albatross II*. Therefore, the material obtained to date has been arranged and examined. It includes two series—one from Massachusetts Bay and one from the region of the Grand Banks.

The immediate problem in Massachusetts Bay involved a determination of the value of that area as a production center and also as a nursery for the large numbers of eggs and larvæ, which we have reason to believe are being carried in constantly from the east. The results to date indicate that local production in Massachusetts

Bay does not maintain the supply of fish in that area, and that in all probability the inshore spawning grounds north of Cape Cod, as a whole, are not selfsupporting but must rely on immigration from other areas. It is to be expected that some of the cod eggs that drift west into the Gulf of Maine will hatch before they leave the bay; but this probably does not alter the situation in any way, for the current that carries them in will transport them out again. A report on this work will be submitted in the near future.

Biological collections from the region of the Grand Banks supplement, to a surprising degree, the hydrographical observations made by the Ice Patrol on the currents in that area. Each of the three principal water masses of the region—the Labrador current, Gulf Stream, and "banks water"—is characterized by its own particular pelagic faunas and can often be defined as accurately by net collections as by temperatures and salinities.

In 1921, a series of hauls taken over the zone where the Labrador current and the Gulf Stream meet indicated clearly the sharp line of demarcation between the Arctic and the Atlantic faunas. The present investigation is limited to the area east of Newfoundland and is concerned with the meeting of the Labrador current and the third great mass—the "banks water."

The reports of the Ice Patrol have shown that a large drift of coastal water moves east from the vicinity of Cape Race and spreads over the whole region of the Grand Banks except the northeastern part. The plankton collections indicate clearly the faunal difference in these two water masses. The most northerly station yielded a true Arctic community, but the more southerly ones, along the western margin of the banks, were of a boreal coastal nature, although far from land.

It may be that the Grand Banks are not dependent entirely upon local production to maintain their supply of bottom invertebrates (fish food) but are constantly enriched by an influx of the pelagic young of species from the coast, which, sinking to the bottom, find a favorable environment in the comparatively shallow water of the banks. If this be true, and both the hydrographical and biological evidence support it, the Grand Banks are unique among fishing grounds in that an offshore drift continually adds to the resident bottom invertebrate community upon which the cod feed, while two great ocean currents transport enormous quantities of microscopic plants and animals, which, killed in the mixing zone of the sudden temperature changes, sink to the bottom and insure a rich source of nourishment for the crabs, upon which the fish feed.

In the course of the investigation several interesting minor observations were made. A great difference was found in the size of cod eggs from Massachusetts Bay and those from the region of the Grand Banks, the former averaging 1.5 millimeters and the latter 1.28 millimeters. The cod eggs collected in the region of the Grand Banks on June 5 to 17, 1924, ranged from 1.1 to 1.55 millimeters, and averaged 1.28 millimeters.

These eggs were found to average between 1.2 and 1.3 millimeters everywhere except at the most northerly station (approximately 390 miles north of the tip of the Grand Banks), where a surprising average of 1.42 millimeters was found, no eggs being less than 1.35 millimeters. The total absence of cleavage stages at this station (the earliest eggs having the embryo well developed) indicates that they may have been carried for a long distance or belong to an entirely different race of fish. The force of the Labrador current at this point, the low temperature, and the number of planktonic forms that occur here and at no other station tend to substantiate the former possibility.

Although the significance of the differences of the means has not been determined statistically, it appears, on the basis of the collections alone, that temperature has a decided effect on the size of cod eggs, causing them to average larger during the colder periods and decrease in size as the water becomes warmer. Thus in Massachusetts Bay eggs averaged smallest in December and May and largest in February. In the region of the Labrador current the largest average was found at the northernmost station and the smallest at the more southerly ones when the summer warming of the water had become noticeable. In the North Sea a similar condition was noted by Ehrenbaum, who found cod eggs averaging 1.46 millimeters in January and 1.3 millimeters in April.

Following are the average sizes of 50 cod eggs taken in Massachusetts Bay at various times:

Date	Millimeters
Dec. 11, 1924	1.458
Dec. 17, 1924	1.495
Jan. 7, 1925	1.494
Feb. 6, 1925	1.529
Mar. 10, 1925	1.501
Apr. 8, 1925	1.513
May 20, 1925	1.488

The average size of cod eggs from the Grand Banks in June, 1924, was 1.2 to 1.3 millimeters; from the polar current in June, 1924, 1.42 millimeters; and from Massachusetts Bay on June 5, 1926, 1.425 millimeters.

Experiments were carried on at Gloucester and on the Boars Head fishing grounds to determine whether the seasonal fluctuations in the average size of cod eggs are due to temperature. In general the results appear to be significant, the eggs fertilized at 0° C. averaging 1.447 millimeters and those fertilized at about 8° C. averaging 1.4106 millimeters. The increase in size at a reduced temperature corresponds with the observations made on eggs taken in the field.

The investigation in Massachusetts Bay was not confined to the young of the cod, haddock, and pollock, but included eggs and larvæ of all other species taken with them.

There are at least 61 species of fishes that either have been taken in their larval forms about Woods Hole or may be expected in collections there. Thus far a bibliography for each species has been gathered, including original illustrations and notes on distribution, and the missing links in developmental histories have been listed. The collections are being searched at present to fill these gaps.

MACKEREL

During 1926, the investigations on the mackerel fishery, in cooperation with the division of fishery industries, were continued by

O. E. Sette, assisted by R. A. Nesbit and R. A. Goffin. The program contemplates the simultaneous collection of biological and statistical data and their analysis to provide an understanding of the life history of the species and the fluctuations of the fishery. During the 1926 season an observer was stationed at the principal mackerel receiving ports for the purpose of interviewing mackerel fishermen as fish were landed and securing data on the locality, dates, size of catch, and fishing effort involved, as well as taking measurements, scales, etc. of the mackerel landed. During the season over 1,200 vessel skippers were interviewed, over 25,000 mackerel were measured, and about 3,500 scale samples were taken. Other data were collected at Woods Hole, Mass.

Analyses of the 1925 and 1926 data on sizes and ages have proceeded as rapidly as possible with the present limited personnel. Although they are yet far from complete it is now fairly certain that the unusually large catches of 1925 and 1926 were composed largely of mackerel that originated in one spawning season, provisionally determined to be that of 1923. The preliminary age analysis of the stock of mackerel present during the past two years leads us to believe, further, that the 1921 spawning season was more than normally successful; that the 1922 season was practically a failure; that the 1923 season was extraordinarily successful; and the 1924 season was probably average in production. This at once gives the clue to one cause of fluctuations in the mackerely fishery—that is, unequal increments in various years. It is believed that continued observations of this sort eventually will permit the forecasting of immediate future success or failure of the mackerel fishery.

The steamer *Gannet* was detailed to mackerel investigations for about five weeks during the spawning season in Massachusetts Bay, and was engaged in making tow-net hauls and taking oceanographic data. An incomplete analysis of the plankton collected showed that an abundance of mackerel eggs and larvæ was present during and immediately after the spawning season. This is significant, inasmuch as very few mackerel eggs and no larvæ had been found previously in the Gulf of Maine. It had been thought heretofore that the Gulf of St. Lawrence, where large quantities of mackerel eggs and larvæ had been taken by the *Princess* and *Acadia* in the Canadian fisheries expedition of 1914–15, and again on the *Cheticamp* expedition of 1917, was the only important spawning ground for American mackerel. The 1926 cruise in Massachusetts Bay demonstrated the presence of comparable quantities of eggs and larvæ in this locality, thus extending our knowledge of the mackerel spawning grounds. It is possible that more extensive work of this nature may indicate even greater ranges for important breeding places of the mackerel.

Tagging operations in 1926 were very limited, only 599 fish being tagged off the coast of Delaware in April. Two of these fish were recaptured, one of them on the date of tagging at virtually the place of release. The other was retaken in August off Cape Cod. Twelve fish tagged in 1925 were reported recaptured during 1926. It will be recalled that all of the mackerel tagged in 1925 were released along the coast of New England, and the recaptures during the same season indicated a general spread of mackerel from the points of release. The recaptures in the next year (1926) occurred from Fire

Island to Gloucester, most of them to the southwestward of the place of release. The tagging operations have been too limited to warrant any definite conclusions. It is hoped to continue them in 1927, when a more suitable tag may be devised.

SMELTS OF NEW ENGLAND

A general account of the natural history, fish-cultural propagation, and conservation of the Atlantic smelt, with a history of the smelt fisheries, by Dr. William C. Kendall, to which reference was made in a previous report of this division, has been published. That account is being supplemented by another paper on the smelts of the genus Osmerus, which embraces life histories, age, rate of growth, racial peculiarities, etc. The original plan to include Pacific species of the genus has been simplified by a recent reviewer of Pacific smelts, who has relegated all but one species (formerly regarded as Osmerus) to other genera. Work on the smelts is discussed at greater length on page 614.

MULLET

The gray-mullet (*Mugil cephalus*) investigation in the south Atlantic States was continued during 1926 at Beaufort, N. C., by Elmer Higgins and Robert O. Smith. The tagging experiment was extended, 1,000 fish being tagged and liberated at Beaufort during July, August, and September. Because of the difficulty of securing uninjured fish in quantity from commercial hauls, a beach seine was operated by the investigators and crew. This made possible the tagging of mullet and at the same time the tracing of the growth of mullet spawned in the preceding fall. Due to various factors, among which might be mentioned more effective advertising, smaller commercial catch, and the different sizes of fish tagged, 34 tags were returned during the year, an average of 3.39 per cent, or one returned for every 29.5 fish tagged. In some cases, 2 to 5 individuals from the same school were returned. All tags were received from North Carolina, except two from the upper portion of the South Carolina coast, thus confirming the results of previous experiments. There were no returns from fish tagged in 1925.

The assumption that so-called "Cape mullet" constitute a distinct division of the local stock seems to be corroborated by analyses of commercial catches during 1926. These fish appear at Beaufort about the middle of September, and are plentiful until the first of November. Length-frequency studies of Cape mullet that were taken in a number of commercial hauls indicate that these fish are intermediate in size between the local O and I classes. However, during the latter part of this season (mid October to mid November) it was virtually impossible to separate local O-class and "Cape" mullet on the basis of average length, inasmuch as some of the commercial Cape mullet averaged extremely small in size.

Study of the growth of mullet, particularly the O-class, was continued and significant results were obtained. Juvenile mullet of 22 millimeters body length appear at Beaufort by the middle of January. They become more abundant during February, March, and April, but there is little growth until the middle of April, when the water temperature reaches about 20° C. In May the rate of growth increases rapidly and continues, at an average of approximately 2 centimeters per month, through October.

In the hope of observing spawning, a number of large mullet were placed in a tank of running sea water at the fisheries laboratory at Beaufort on October 27. From time to time the roe in killed specimens was examined, and while it appeared to be healthy, the eggs did not mature. The roe had not ripened when the last specimen died on January 14, 1927. Various methods of estimating the number of eggs in the ovaries of a fish of 367 millimeters body length were tried. Different methods gave results varying between 759,000 and 1,526,000. The eggs are not spherical but are more nearly an ovate spheroid, the long axis being 0.61 millimeter and the short axis 0.57 millimeter. In all parts of the ovary the eggs are in the same stage of development. This meager evidence, combined with the observed disappearance of roe mullet from inside waters during October and the compact size group of young fish, leads to the conviction that the spawning season is short.

Observations throughout the season on the selectivity of commercial gear, in conjunction with samples of the commercial catch, show that the strain of the fishery falls most heavily on three age classes: "Cape mullet" approximately 1 year old, 2-year gray mullet that will spawn the following fall, and roe mullet chiefly 3 years old. The yearling stock that appears at Beaufort in the middle of January as individuals less than 1 inch long and attains a total length of about 7 inches by October seldom is taken.

SHORE FISHERIES OF NORTH CAROLINA

Life-history studies of various food fishes have been undertaken at the fisheries biological laboratory at Beaufort, N. C. The eggs of the pigfish (*Orthopristis chrysopterus*) and those of the anchovy (*Anchoviella epsetus*) were secured and their development was studied. The development of the larvæ and the rate of growth of the young fish, too, have been followed. Special attention was given to the food consumed by the young fish and the changes that take place in the diet with age, together with the change in environment chosen by the fish as they develop. Similar studies, relative to the rate of growth, food, and environment of young sheepshead (*Archosargus probatocephalus*), young spot (*Leiostomus xanthurus*), and young white perch (*Bairdiella chrysura*), were undertaken. This work was carried on by Dr. Samuel F. Hildebrand and Irving L. Towers.

Other work at the Beaufort laboratory is discussed elsewhere in this report.

TEXAS MARINE FISHERIES

In accordance with plans outlined in 1925, an investigation of the biology of the important food fishes of coastal Texas has been undertaken. A field station has been established at Corpus Christi, Tex., where John C. Pearson, with the aid of a boat and crew furnished by the State fishery authorities, is making extensive and systematic collections. Variations in the commercial fishery have been followed, but so erratic and limited is the fishery in most localities, due to legislative restriction, that few data of value can be secured.

The major facts in the life histories of the three leading food fish—redfish (*Sciænops ocellatus*), spotted trout (*Cynoscion nebulosus*), and drum (*Pogonias cromis*)—are being ascertained. Collections of fish of all sizes, from larval stages to mature adults, have been made regularly over a wide range of localities and afford an understanding of the habits and movements, spawning age, and rates of growth of these valuable species. Preliminary findings of this study are given at greater length in another section of this report (p. 627).

FOOD HABITS OF SHARKS

Further observations on the food and reproductive habits of various sharks that enter into the catch of a commercial shark fishery at Big Pine, Fla., were made during the winter months of the past year. The stomachs and reproductive organs of about 1,500 sharks were examined carefully, with the object of ascertaining, if possible, the actual damage done to food fishes by these scavengers of the sea. Ten species of sharks were observed in the commercial catch, although the larger part of this catch comprised only five species.

The food habits of the various species differed somewhat, but the amount of food fish eaten by all species was found to be very small. Refuse, crustaceans, and nonfood fish seemed to make up the bulk of the food. However, the fact that most sharks do much damage to commercial fishing gear probably warrants their unlimited utilization.

FISHERIES OF THE PACIFIC COAST

The bureau's salmon investigations on the Pacific coast are conducted as an integral part of the program of the International Pacific Salmon Investigation Federation, and hence are closely coordinated with work undertaken by Canada and the Pacific Coast States. The activities of this federation, therefore, are of direct interest to the readers of this report.

The third meeting of the executive committee of the International Pacific Salmon Investigation Federation was held in Seattle on December 2, 1926. At this meeting a program committee, consisting of Dr. W. H. Rich, chairman, Dr. C. H. Gilbert, Dr. W. A. Clemens, of the Biological Board of Canada, and Prof. J. O. Snyder, representing the California Fish and Game Commission, presented a research program that was adopted unanimously by the executive committee. This program is presented in full elsewhere in this report (p. 635).

After the presentation of this program, the various items were taken up separately and discussed in detail. A committee was appointed to consider the improvement of the statistics of the salmon fisheries and consisted of Dr. W. A. Clemens, chairman, N. B. Scofield, of the California Fish and Game Commission, and Dr. W. H. Rich. Another committee was appointed to consider the matter of adequate fishways over high dams. The members of this committee are N. B. Scofield, chairman, C. R. Pollock, supervisor of fisheries for the State of Washington, and Maj. J. A. Motherwell, chief inspector for British Columbia of the Department of Fisheries of the Dominion of Canada. In view of the recent development of a certain type of mechanical fishway, which has been advertised widely as having solved the problem of getting fish over high dams, the committee presented the following resolution, which was adopted by the executive committee:

Whereas constant and nation-wide propaganda has been maintained in newspapers, engineering and technical magazines, etc., conveying the impression, based on the partial success of the experimental fishway at the Baker River Dam, near Concrete, Wash., that a complete solution has been reached of the problem of safeguarding salmon runs jeopardized by the construction of dams; and

Whereas in the opinion of this federation no solution of this problem has yet been reached that can properly be considered as of general application; and

Whereas in the opinion of this federation the problem connected with each dam is individual and distinct; and

Whereas much of the work at Baker River Dam has so far been experimental and results there are not yet conclusive: Therefore, be it

Resolved, That the International Pacific Salmon Investigation Federation, at its meeting on December 2, 1926, strongly disapprove the propaganda mentioned as being unwarranted and misleading; and further be it

Resolved, That a copy of this resolution be presented to newspapers and periodicals and to such officials and others as may be interested.

ALASKA SALMON

The salmon investigations in Alaska have been continued under the direction of Dr. C. H. Gilbert, special assistant, and Dr. W. H. Rich, chief investigator of salmon fisheries. The tagging experiments in the channels of southeastern Alaska were continued, and a total of 13,100 salmon, representing four distinct species, were tagged and liberated. The results have not yet been compiled, but a report by Doctor Rich, covering the results of the tagging done in this district in 1924 and 1925, was published during the past year as Document No. 1005.

In addition to the tagging experiments conducted in the channels of southeastern Alaska, efforts were made, in cooperation with the fishery authorities of Canada, British Columbia, and the States of Washington, Oregon, and California, to tag fish caught in the ocean mainly by trolling. These fish are of two species—the chinook or king salmon and the silver salmon. Including the work done by all agencies, approximately 2,500 fish were tagged along the coast between Monterey Bay and the outside coast of southeastern Alaska. While the data are not yet sufficiently complete to warrant final conclusions, it appears quite certain that these fish range quite widely up and down the coast. The troll fishery for salmon thus assumes an interstate and international character, and this fact will have an important bearing on the nature of the methods adopted for the care of such of the salmon resources as are affected by trolling.

The intensive study and analysis (by means of scale examinations) of the salmon runs in a large number of the more important salmon streams of Alaska has been continued by Doctor Gilbert. Counting wiers for the enumeration of the spawning escapements have been maintained, as for a number of years past, in the Karluk and Chignik Rivers, at two of the streams that enter Olga Bay, Kodiak Island, at Thin Point and Morzhovoi Bay, Alaska Peninsula, and in

Egegik River, Bristol Bay. Plans are being made now for the construction of a counting weir in the Kvichak River, Bristol Bay. During 1926 particular interest attached to the run in the Karluk River, as this was the first return from a known escapement—that of 1921, the first year in which the counting weir was operated in this river. As the escapement of 1921 was one of the best on record (1,325,654 fish), a good run was expected and materialized. The total run, including the fish taken for commercial purposes and the escapement contained somewhat more than 4,500,000 fish. This indicates a return of approximately three fish for each one that escaped to the spawning grounds. Just how constant this productivity will be, remains to be determined by the returns in future years from known escapements; but it is a noteworthy accomplishment to have secured such data as these on a stream of the size and commercial importance of the Karluk. This intensive study of escapements and runs is considered to be of the utmost importance to the understanding of the factors that cause fluctuations in abundance in these great fisheries.

In addition to the detailed studies of the commercial catch and spawning escapement carried on by Doctor Gilbert at Karluk, a study of the history of the salmon in fresh water and of their seaward migration has been undertaken by Doctor Rich, assisted by Seymour P. Sm.th. In order to determine the number of young fish that migrate seaward, approximately 47,000 seaward migrants were marked during 1926, and the future runs of adult fish will be examined carefully for the return of marked fish. The total run of adults and the number of marked fish returning as adults will be determined, and from this it is believed that a fairly reliable measure of the total number of young salmon in the seaward migration each year can be determined with some accuracy. Such marking exper.-ments will be continued in the Karluk River over a period of years in order to permit a study of the correlation between the size of the seaward migration and the future runs.

Considerable time was spent on Karluk Lake, which was mapped and sounded; and extensive observations of all spawning streams were made. The past year was one of exceedingly low water, and many of the spawn:ng beds made early in the season were left exposed by the end of the summer. Further observations will be necessary to determine whether such conditions will affect the survival of the eggs. The study of such factors as this, which undoubtedly affect to a marked degree the survival of young salmon during their fresh-water life, is considered to be of prime importance, and plans have been made to continue these observations as a routine part of the intens.ve study of the Karluk River salmon.

SALMON OF THE COLUMBIA RIVER

The salmon-marking experiments conducted on the Columbia River by Harlan B. Holmes yielded greater returns during the season of 1926 than ever before. As in former years, the cooperation of the Oregon Fish Commission (especially in paying rewards for records of the recovery of marked fish) was responsible for a great part of the success of the work. The most pleasing returns obtained during the past season were from a lot of 50,000 yearling sockeyes, which, after their adipose and right ventral fins were removed, were liberated from the hatchery at Herman Creek in February, 1924. As a result of this marking, approximately 2,300 four-year-olds returned to the Columbia River and were taken in the commercial fishery. In addition, 96 of these fish succeeded in evading the commercial fishing gear and returned to the hatchery from which they were liberated, and their spawn was taken for artificial propagation. These 96 spawners produced a stock of eggs greater by one-half than that required to produce the fingerlings that were marked. Additional returns from this experiment are to be expected in 1927. Results such as these give promise of the possibility of maintaining commercially significant runs of salmon by artificial propagation.

A second experiment with sockeyes yielded 2,500 four-year-olds from 100,000 marked yearlings. In this experiment, however, none returned to the tributary in which the fingerlings were liberated. Why they did not return to their home tributary is an important question, to which there is no reliable answer as yet. This problem will be given special attention when future returns are being studied. The importance of this question lies in the fact that unless the fish return to the place of liberation the run can not be perpetuated by artificial propagation. A hatchery that is able to produce an entirely satisfactory return to the commercial fishery may fail in the long run because of inability to secure a breeding stock.

An experiment with chinook salmon conducted at the Big White Salmon River hatchery yielded 265 four-year-olds in 1926, bringing the total of returns from the experiment to 359. With the 5 and 6 year olds yet to return, this experiment gives promise of being the most successful of those with chinooks to date. As was pointed out a year ago, the greater returns from this experiment than from those in which fingerlings of the same class of fish were liberated at an older age, would indicate that the best time to liberate fingerlings of the fall run of chinooks is during the spring of their first year. More direct information on this important question is being sought by means of a series of experiments in which fingerlings from a single lot of eggs will be marked and liberated at various ages. A similar experiment is already under way with chinooks of the spring run. Comparison of the results of these two experiments should be enlightening, and it is hoped that they may point the way to more successful hatchery operations. For a more complete account of this work see p. 645.

Mr. Holmes also has continued an investigation of the blueback salmon of the Columbia River. The most important development during the past season was the observation that the seaward migrants from the Okanogan River spawning beds were so heavily infested with the encysted larvæ of tapeworms as to have their vitality greatly reduced thereby. An effort is being made to discover the alternate host of the tapeworm, in the hope that the infestation of the salmon may be reduced in the future.

HERRING OF ALASKA

During the season of 1926, George A. Rounsefell continued the herring investigation in Alaska, confining his activities to Prince William Sound, Cook Inlet, and Shuyak Straits. Preserved samples also were obtained from the Shumagin Islands and Golovin Bay. Study of the racial characters of the herring has disclosed the existence of local races, which knowledge will be of great value in drafting regulations, as it indicates the relative independence of the fishing areas. Weights of herring are being tabulated in an effort to determine when the herring in each locality reach a condition suitable for packing.

The present data, although not conclusive, indicated the presence of dominant year groups, which may be one explanation for the great fluctuations in abundance. Further study may show the possibility of foretelling such periods. The investigation is discussed at greater length on p. 650 of this report.

During 1927 it is planned to continue the investigation, commencing the field work in April with some experimental tagging and continuing with the collection of samples in one locality throughout the season.

FISHERIES OF INTERIOR WATERS

COREGONINÆ OF THE GREAT LAKES

Dr. Walter Koelz has continued his investigations of the white fishes, and in addition to publishing Document No. 1001, "Fishing Industry of the Great Lakes," has completed the revision of the Coregoninæ, in which systematic relations and natural history of these fishes in the Great Lakes and Lake Nipigon are given in great detail, together with descriptions of several new species. This work, which is now ready for publication, embodies the most extensive and complete study of coregonine fishes in North America that has ever been made and lays the groundwork for an understanding of fishery conditions in the Great Lakes as a basis for protecting these rapidly declining fisheries.

The investigations on the herring of Lake Huron by Dr. John Van Oosten, described in the last annual report, were continued during 1926. The statistical data on the catch having been found wholly inadequate, biological data were sought which might furnish some clue to the trend of the intensity of fishing. That this fishing is very intense is suggested by the paucity of old fish in the commercial catches. Herring are known to reach an age of 11 years, yet extremely few individuals reach the sixth year of their life—the second year after most of them first join the schools of commercial sizes. The majority of the herring do not even reach the fifth year of life, and relatively few 3-year-old fish, many of which enter the commercial catches for the first time in the fall, escape the nets to return a year later as 4-year-old fish.

The biological data indicate, by the shifting in the age composition of the commercial catches, that the intensity of the fishing has steadily increased in recent years. In 1921 the 4-year-old fish were more numerous than the 2-year-olds, but since 1921 the former have become progressively less and the latter progressively more abundant each successive year. So intense does commercial fishing appear to be that a year class is virtually wiped out during its year of abundance in the commercial catches. Although at present the herring are wholly unprotected and appear to be abundant in Lake Huron, each year the fishery is being prosecuted with increased vigor, for as the abundance of the more desirable species of coregonines decreases, the demand for the herring increases. It is evident from the biological data, however, that in all probability the herring can not withstand further exploitation without disastrous results. The results of this investigation are given in greater detail on p. 662 of this report.

Whitefish material has been collected by Doctor Van Osten from Lake Huron every year since 1923. These data indicate that the whitefish taken by gill nets in summer are younger than those taken in the fall. The summer catch consists principally of 4-year-old fish, a large percentage of which is sexually immature though of legal size. The fall catch consists mostly of 6-year-old fish, the 7-year-old individuals being second in abundance. The youngest fish taken in these samples were in the fourth year of life, the oldest in the thirteenth. Most of the fish of a year class probably do not spawn until the sixth year of life. This result was unsuspected, as it is generally believed that the whitefish attains sexual maturity in its third year. There is some evidence, however, that this is true in the case of the Lake Erie whitefish.

SURVEY OF SANDUSKY BAY IN LAKE ERIE

In response to an appeal from the Izaak Walton League at Fremont, Ohio, a preliminary survey was made of conditions in the Sandusky Bay region, with special reference to the destructiveness of commercial nets (especially the seines) to game fish. All complaints were considered and investigated. It was concluded that the commercial fishermen of the Sandusky Bay region were not as destructive of fish life in general, or of strictly game fish in particular, as many sportsmen alleged. On the contrary, it appeared very probable that the seiners, by capturing carp and goldfish, were aiding in preserving conditions necessary for the existence of game fish and waterfowl.

BIOLOGICAL SURVEY OF THE UPPER MISSISSIPPI RIVER

In July, 1926, A. H. Wiebe was assigned to make a biological survey of the upper Mississippi River. The object of this survey was to determine if the pollution from the cities of Minneapolis and St. Paul is destroying life in the Mississippi River. The part of the river covered by this survey extends from just above Minneapolis to just above Winona, about 110 miles below St. Paul.

The field work was carried on during August and September. After the completion of the field work (September 30) the plankton and the bottom samples were moved to the University of Wisconsin, at Madison, for study. The samples were analyzed and a report was prepared.

The investigation showed that pollution from the Twin Cities is a factor in the destruction of life in the Mississippi River from Minneapolis down to Red Wing, at the head of Lake Pepin, as is shown in more detail on p. 669.

KEOKUK DAM AND THE FISHERIES OF THE UPPER MISSISSIPPI RIVER

Immediately after the dam was constructed across the Mississippi River between Keokuk, Iowa, and Hamilton, Ill., there was begun a study of the effect of this and other changes in the Mississippi River upon the fisheries above the dam. The investigation was under the direction of Dr. R. E. Coker, then director of the fisheries biological station at Fairport, Iowa. An investigation of this kind necessarily involved observations over a long period of time. The process of adjustment of living animals to the changing conditions of environment in a stream is so gradual that safe conclusions can be drawn only after years of study. It would have been desirable if the observations could have been continued year after year without interruption, but this was not possible. The problem has not been out of mind, however, and studies have been made from time to time and tentative reports have been prepared. The time now seems ripe to put into form for publication the considerable data secured in the investigation. Accordingly, during the past year Doctor Coker undertook to complete the report and to make additional observations in the field. Accompanied by H. L. Canfield, he visited the Mississippi River at various points between Lake City, Minn., and Canton, Mo. The additional data gathered this year are now being incorporated in the report, which is nearing completion.

WESTERN TROUTS AND OTHER COLLECTIONS

In addition to investigating the New England smelt fisheries, Dr. W. C. Kendall also was occupied intermittently in studying and classifying trout material contained in numerous hitherto unstudied or little studied collections of trout from the Western States and Alaska, which represent years of accumulation. Inasmuch as these specimens were collected before the regions from which they came were affected by extensive fish-cultural distribution of nonindigenous species, this study is expected to throw greatly needed light upon the relationship of western species, and particularly upon the much-mooted problem of the so-called rainbow and steelhead trouts.

The wide fish-cultural distribution of these species and the varied experience with them in the east and abroad have given rise to a number of questions concerning them, and from time to time inquiries have been received for information and opinion. An inquiry particularly difficult to answer was from Doctor Ehrenbaum, of Hamburg, Germany, who wished to ascertain the specific identity of rainbow trout imported into Germany. Doubtless the rainbow-trout eggs sent to Germany were from the same two or three different species that seem to compose the mixture that (at least in the past) has been distributed from the hatcheries under the one name, "rainbow trout."

During the summer, through the Bureau of Fisheries, five specimens of rainbow trout, which were the result of introduction, were received from H. L. Kelly, executive officer of the fish and game commission of the Territory of Hawaii, with the request that they be identified.

Concerning these trout, Doctor Kendall replied that according to his view there are two sorts of "rainbow trout." One sort comprises *Salmo shasta* and closely related species, which are supposed not to be habitually sea run. The other sort comprises the migratory fish that has received the name of "steelhead" (*S. gairdnerii*). This name originally signified the migratory fish only; but there are other forms, perhaps distinct species and perhaps nonmigratory, that are more closely related to the migratory steelhead than they are to *S. Shasta*. These also have been popularly regarded as "rainbow trout."

Doctor Kendall regards the Hawaiian trout as the steelhead type of trout, but that does not signify necessarily that they were the migratory form; that is to say, the eggs that produced these fish may not have been taken from migratory fish (at the time recognized as such), but from trout supposed to be rainbows. While they are fish that have entered largely into the bureau's fish-cultural rainbow-trout output, they are not of the *Salmo shasta* category. The fish in question may or may not have been from migratory stock or from fish that are occasionally sea run.

Doctor Kendall was unable to say what the proper technical name of this fish should be, but suggested that not much violence to the present taxonomic situation or any greater confusion than now exists would ensue if they should be called *Salmo irideus*.

Late in the season specimens of so-called steelhead trout were received for identification from Prof. J. R. Dymond, of the biological department of Toronto University, Toronto, Canada, which he had collected in British Columbia and Washington. A specimen from Kalama, Wash., appeared to differ somewhat from those from Vancouver Island and Prince Rupert, as it did also from other specimens from the Columbia River and from specimens collected by Doctor Rich in Naknek Lake, Alaska, with which it was compared.

During the year other collections and specimens were received for study or identification. Particular mention should be made of the collection of Greenland chars made by Dr. Walter Koelz on the McMillan expedition in 1925. Also, a collection of salmonids, mostly chars, from Labrador, was delivered to Doctor Kendall in November by Columbus Iselin, a Harvard student, who conducted an oceanographic expedition, sponsored by Dr. Henry B. Bigelow, along that coast. The collection, although not large, was representative and well preserved, and the observations recorded in accompanying notes added much to the knowledge of conditions in that region, as pertain to the Salmonidæ.

A few specimens of salmon (*Salmo salar*) and recorded observations confirm the statement made by Abe Bromfield, McMillan's Eskimo interpreter, that there is no commercial salmon fishery beyond about 50° north latitude, but that in one or two places farther north one or more individuals occasionally are taken in cod traps. However, Bromfield asserted that a salmon fishery is carried on in Ungava Bay, concerning previous reports to that effect there has been some doubt.

The chars collected comprised two species—one that has been regarded as *Salvelinus fontinalis* and the other as *S. stagnalis*. The first occurred only in lower Labrador, while the second was found along the entire coast. Both are sea run.

INVESTIGATIONS PERTAINING TO FISH-CULTURAL OPERATIONS

TROUT CULTURE

Feeding experiments with various diets and with several species of trout were continued during the summer by Dr. H. S. Davis and M. C. James at the Holden (Vt.) experimental hatchery. A more detailed account of the work at the station may be found on p. 675.

A comparison of three common foods—beef heart, beef liver, and sheep liver—indicated clearly the superiority of beef liver when trout are to be reared to a larger size than the small fingerlings commonly used for stocking waters. Apparently any one of the three foods is satisfactory with steelhead, rainbow, and brook trout when the fish are to be planted early in the season. However, when brook trout were held to the age of 6 months, beef liver was found to be markedly superior as a food and reduced the mortality approximately one-half and produced twice the growth of its nearest competitor—sheep liver.

A comparison of cooked sheep liver with the raw liver as ordinarily fed yielded conflicting results, probably due to a number of complicating factors. With brook trout the superiority of raw liver became more marked as the experiment progressed, and at the end of 103 days the total mortality among the fish fed cooked liver was four times as great as among those on a raw diet.

With young rainbow trout cooked liver showed a superiority over the raw product over a period of 94 days, both as regards mortality and growth. Inasmuch as many commercial growers have reported favorable results from the use of cooked food, it is planned to continue experiments along these lines.

Nothing has been found that offers any prospect of entirely replacing the fresh-meat diets. However, three substances were tried, which yielded very encouraging results as substitutes for part of the meat, and in mixture may even be superior to the pure-meat diets. These are soy-bean oil meal, a dried shrimp product, and fresh-water mussel meal.

Soy-bean oil meal is manufactured from the residue after the oil has been expressed from the bean. An important property is the high percentage of protein, which more closely resembles animal protein in structure than do proteins from vegetable sources. Experiments with this meal were unsuccessful at first, but after adjusting the quantity to a basis of 50 per cent meal and 50 per cent meat, both brook and lake trout fingerlings were maintained for several months with nominal loss, although the growth did not quite equal that of the controls. Further experiments will be undertaken on a larger scale, but it is believed that this material will be most useful as a food for yearlings and adult fish.

The waste from shrimp factories, under the name of "shrimp bran" and "shrimp meal," frequently have been used in trout diets with more or less beneficial results. These products usually contain a large percentage of chitinous shell, which is of little value except as roughage and is entirely unsuited to feeding small fish. The dried shrimp used at Holden is a special grade, consisting of the abdomen only, which has been freed from the surrounding shell. After being soaked in water for several hours, it can be ground sufficiently fine to serve as food for fish 2 to 3 inches long and upwards. When used alone it is inadequate, as shown by a sharp increase in the mortality; but the addition of sheep liver quickly brought the mortality back to normal. A continuation of the experiment on the basis of 50 per cent shrimp and 50 per cent sheep liver resulted in practically no losses and an exceptionally rapid growth.

The results with "clam" meal were particularly encouraging, although, owing to the small amount available, it was possible to try it on a small scale only. A lot of steelhead fingerlings fed beef heart with 25 per cent "clam" meal over a period of 97 days showed a mortality less than one-half as great and a growth over one-fourth greater than the controls fed beef liver. The meal is made from the dried "meats" of fresh-water mussels and is a by-product of the mussel-shell industry. Inasmuch as it is impossible to obtain a satisfactory grade of this meal in quantity, an attempt will be made to manufacture it at the Fairport (Iowa) biological station.

A series of experiments to determine the effect of sunlight on young trout yielded very interesting results. Various lots of fish from the same source were placed outdoors in different compartments of the same trough, with some compartments covered so as to exclude all direct light, others were covered with ordinary window glass, which would absorb the ultra-violet rays, while some compartments were exposed entirely. All lots were fed alike, and the flow of spring water was abundant, so that on the hottest summer days there was no appreciable difference in temperature between head and foot compartments of the same trough. The only difference in the various lots was the rather abundant algal growth in the exposed compartment, but it is not thought that this would react to the disadvantage of the fish.

Lake trout in advanced fry and fingerling stages showed losses of 18.4 per cent in the covered lot and 33.7 per cent in the exposed lot. A repetition of the experiment, using advanced fry and fingerlings of rainbow trout, gave even more striking results. In this case, over a period of about two months, the protected fish suffered a loss of only 1.2 per cent; in the glass-covered group the loss was 3.5 per cent; while among the fish that were entirely uncovered there was a mortality of 38.1 per cent. No record of the weights of the lots was taken, but plainly the condition of the fish was correlated with the mortality, inasmuch as the groups exposed to sunlight, which suffered the greatest loss, showed poor condition and comparatively slow growth.

On the face of the results it would appear that ultra-violet light is injurious to trout, at least in the younger stages, and that the common practice of protecting trout at the hatcheries from direct sunlight is based on sound reasoning. It should be pointed out, however, that the fish were held in shallow troughs and that the results may not be applicable to fish held in ponds or raceways. Further experiments on the influence of light are planned for the near future.

The initial steps in an extensive program of selective breeding of brook trout have been taken at the Holden station. By a rigid selection of the parent stock it is planned to develop strains in which desirable characters will become fixed and thus create a brood stock that will exhibit superior qualifications with regard to disease resistance, rapid growth, early maturity, prolific egg production, and greater vigor. During the past season, eggs were taken from fish selected for early maturity and rapid growth and also from fish characterized by desirable form and color. Fingerlings that show great resistance to disease and rapid growth have been segregated for future breeding purposes.

It is evident that practical results from these experiments can not be expected for some time, but it is believed that in a few generations it will be possible to develop a strain of brook trout much better adapted to hatchery requirements than the stock now available.

A necessary preliminary of the work in selective breeding is the expansion of the capacity of the Holden station. The construction of trout ponds has been continued during the past year, so that there are now in use eight rearing ponds, one small pond for brood stock, and several hundred feet of raceways. There is opportunity for the further extension of the pond system, and it is essential that a number of ponds and raceways be constructed in the near future if the progress of the investigations is not to be hampered seriously.

The abundance of good trout streams in the vicinity of the Holden hatchery has afforded an opportunity for the inauguration of much needed field work on certain ecological aspects of fish planting. It is planned to extend the scope of this work considerably during 1927. Cooperation has been maintained with the Vermont Department of Fish and Game in investigations of hatchery mortalities and a survey of waters for the purpose of formulating a stocking program.

POND CULTURE

The investigation of various problems relating to the propagation and rearing of pondfishes was inaugurated at the Fairport (Iowa) biological station during the summer of 1926 by Dr. H. S. Davis, assisted by Russell F. Lord and the station force. This is a field that has received very little attention in this country, although pond culture has reached a comparatively high stage of development in Europe. Details of the work are given on p. 678.

During the past summer 21 ponds were utilized in these investigations, which, although only preliminary in nature, already have yielded valuable results. The experiments were confined almost entirely to problems connected with the propagation of the largemouth bass and bluegill sunfish, but it is planned to broaden the scope of the work in the future so as to include other species of pondfishes.

One of the problems of fundamental importance in pond culture is the proper treatment of the ponds to produce the maximum amount of food. Questions arise as to the quantity and type of rooted vegetation, the advisability of wintering the ponds wet or dry, the effect on the rooted vegetation and plankton of cultivating the bottom and treating with lime. These and many other problems of a similar nature are receiving consideration in the experiments at Fairport.

Another line of investigation concerns the use of fertilizers as a means of increasing the basic food supply.

In rearing bass and other predaceous fishes, the use of forage fishes affords a promising line of investigation. The introduction of forage fishes is designed to furnish a supply of small fish that will serve as food for the bass. This not only will tend to prevent cannibalism, but as these fishes feed on plankton and plant materials will greatly increase the amount of food available to the bass.

During the past season three species of forage fishes—viz, goldfish, golden shiners (*Notemigonus crysoleucas*), and black-head minnows (*Pimephales promelas*)—were introduced into the bass ponds with excellent results. The black-head minnow promises to be especially desirable for the purpose, as it multiplies rapidly, continuing to spawn throughout the spring and early summer, so that a supply of small fish is always available. Furthermore, they are primarily bottom feeders, and consequently there is little direct competition with the young bass for food. Obviously, the use of forage fishes introduces a number of problems that are in urgent need of investigation. These include such questions as what is the most desirable species of forage fish to use with different game fishes, the advisability of introducing two or more species of these fish in the same pond, and the proper methods of handling them to obtain maximum results.

Other problems in pond culture that are being investigated relate to the number of brood fish required per unit area; the total yield of fish, both as to numbers and weight, that can reasonably be expected; and the advisability of rearing two or more species of food fishes in the same pond.

As in the case of trout an attempt is being made to develop superior strains of pondfish by selective breeding, special emphasis being placed on rapid growth.

PATHOLOGY OF FISHES

As in previous years, special attention has been paid by the pathologist, Dr. H. S. Davis, to a study of the diseases that are causing serious losses at the trout hatcheries. The Holden experimental hatchery affords exceptionally favorable conditions for such investigations, for here the fish are under close observation at all times and any outbreak of disease can be discovered in its early stages. During the summer of 1926, in addition to octomitiasis, which is now well under control, two infectious diseases appeared among the fingerling trout and caused considerable losses before control measures could be developed.

The most serious losses were caused by an infection of the gills, which had not previously been recognized. The disease appeared during June and July among fingerlings of brook, rainbow, steelhead, and black-spotted trout, and also among some small landlocked-salmon fingerlings. It is due to an infection with bacteria, which form a luxuriant growth over the surface of the gills. They occur as long, threadlike filaments, which usually lie side by side so as to form a more or less continuous layer over the surface of the epithelium. The bacteria are colorless, transparent, and very difficult to distinguish, even under high magnification. They are most abundant on the outer third of the gill filaments, where, evidently as the result of an irritation caused by their presence, there is a rapid proliferation of epithelial cells. This causes the free ends of the gill filaments to become greatly enlarged and in some cases distinctly club shaped. One of the most striking features of the disease is the fact that as a result of the rapid growth of the epithelium, the gill filaments often become fused, especially near the tips; and in extreme cases all the filaments of each gill may become united into a continuous mass.

In addition to the marked proliferation of epithelial cells, there is a greatly increased secretion of mucus over the gills, in which particles of sand and débris become entangled. Consequently, the gills present a very characteristic appearance, which furnishes the only reliable means of diagnosing the disease. In other respects the fish exhibit no characteristic symptoms, and in fact appear virtually normal until a very short time before death.

Fortunately the disease is controlled easily, one or two treatments with a solution of copper sulphate being all that is required. The fish were placed in a 1:2,000 solution of copper sulphate for one minute and then removed at once to running water. Only a few of the weakest fish were injured by the treatment, while nearly all the bacteria were destroyed. When followed by a second treatment the following day, the bacteria entirely disappeared and there was no recurrence of the disease.

An infection of the fins appeared in two instances among fish that were being held in hatchery troughs, but the disease did not spread widely. The disease first appeared in a trough of steelhead fingerlings but was quickly brought under control by a treatment with copper sulphate. Later in the season the same disease broke out in a trough of small rainbow fingerlings. In all probability it is a bacterial infection, but owing to the fact that several species of bacteria were always present on infected fins, it has not yet been possible to determine definitely which was the cause of the disease.

In most instances the infection is first noticeable on the pectoral fins, which become thickened and opaque, but later all the fins may become involved. A microscopical examination shows that infection first occurs on the outer margin of the fin and appears as a whitish discoloration. This is due to a thickening of the epithelium, which gradually extends toward the base of the fin. Later, the thickened region disintegrates and the fin rays become frayed and broken. Eventually the fins may be destroyed entirely, although in the majority of cases death intervenes before this occurs. The disease can be controlled by the copper-sulphate treatment, as used in the case of the gill disease.

"Fin trouble" is quite common in many hatcheries, and while it is not always due to the same cause, it is believed that in many cases it is the same as that which occurred at Holden.

During the spring of 1926 there were very heavy losses among the advanced brook-trout fry at the Holden station. This mortality occurred shortly after the fish began to feed, and in one lot the loss was virtually 100 per cent. This heavy mortality was confined to fish hatched from eggs that had been held in brook water or a mixture of brook and spring water. Fish hatched from eggs from the same source, but which had been held in spring water, suffered a mortality of only about 10 per cent. The cause of the excessive losses among these fish has not been determined definitely. Some of the loss undoubtedly was due to an infection with the protozoan parasite, *Octomitus salmonis*, and there is little doubt but that the mortality among the fish in spring water was due almost entirely to this parasite. However, another factor appears to have been involved in the heavy mortality among the fish in brook water. It is possible that the fish were weakened as a result of retarded development caused by the low temperature of the brook water. It is interesting to find that a similar mortality has occurred annually in several State hatcheries where the eggs are held in cold water to retard their development. In fact, the information at hand indicates that the common practice of holding eggs at a temperature just above freezing is objectionable and often results in greatly lowered vitality.

Octomitiasis has been prevalent at Holden for a number of years, and the losses from this disease were so large that all attempts to hold fingerling trout through the summer had been abandoned. However, during the past two summers, since the station has been used as an experimental hatchery, fingerlings have been carried through the summer with comparatively little loss from this disease. It has been found that while it is virtually impossible to get rid of Octomitus entirely, the severity of the infection can be reduced greatly by rearing the fingerlings in ponds, where they have more room than in the hatchery troughs and can obtain some natural food, such as insects and Entomostraca. In several instances, fish that had become heavily infected with Octomitus in the hatchery, when removed to ponds showed marked improvement within a week or ten days; and at the end of three or four weeks the parasites had disappeared very largely, the mortality was low, and the fish were making rapid growth.

In addition to work at the bureau's stations, the pathologist, at the request of the State authorities, visited several State hatcheries to investigate the causes for heavy losses among fish at these stations and to suggest remedial measures. He was consulted by a number of goldfish breeders, also, regarding mortality among their fish.

In March, 1926, an investigation was made at the Washington laboratory of the mortality occurring at the Central Station aquarium following chlorination of the water. Dr. R. S. Taylor, of the division of fishery industries, studied the chemical aspects of the problem, while M. C. James made observations on the biological phases. It was found that trout were killed by the concentrations found in the ordinary chlorine dosages (0.3 p. p. m.) of municipal water supplies. Survival in spite of such chlorination generally is due to a reduction in the concentration through interaction with organic matter and aeration.

A number of chemicals, all reducing agents, were found to be effective in eliminating all chlorine in an aquarium supply and at the same time were harmless to fish. Among these, sodium bisulphite and sodium thiosulphite were considered most satisfactory. A 1:1,000,000 concentration of the former is sufficient to neutralize the chlorine usually present in municipal waters, while sufficient thiosulphite must be introduced to give two or three parts per million.

Observations on the pathology of chlorine poisoning indicate that extremely small quantities have the same general effect on fish that much greater amounts have on higher animals. Death is the result of suffocation induced by inhibition of the respiratory action. Whether this is due to constriction of the arterioles or to edema at this point is uncertain. The most striking symptom in gassed fish is the congestion of the visceral blood vessels. It is noteworthy that after exposure to chlorine for any length of time fish will not recover when removed to chlorine-free water.

INVESTIGATIONS IN WISCONSIN LAKES

During July and August, 1926, limnological studies were continued on the lakes of northeastern Wisconsin by the Geological and Natural History Survey of that State in cooperation with the Bureau of Fisheries. Observations were made on 73 lakes, most of them situated in Vilas County. Forty-six of these were visited in 1925, but 27 were visited for the first time in 1926.

Biological and chemical laboratories were established in two buildings at the State forestry headquarters at Trout Lake, Wis. Two biologists, Dr. E. A. Birge and Prof. C. Juday, and two chemists, Loren C. Hurd and Rex J. Robinson, were engaged in this investigation.

In size, the various bodies of water ranged from a minimum of an acre or two to a maximum of 1,500 acres. The depths varied from 2 meters to 35 meters; in most of them the maximum depth does not exceed 15 meters.

The lowest surface temperature noted was 18° C., and the highest was 23.5°. The temperature of the bottom water in the deeper lakes varied from 4.7° C. to 10°, but the temperature of the bottom water in the shallow lakes was substantially the same as that of the surface.

A complete set of chemical and biological determinations on a sample of water comprised 14 different items, not including a reading of the temperature of the water at the time the sample was taken. A single series of samples, extending from surface to bottom, in Trout Lake, for example, included 83 different determinations in addition to 14 temperature readings taken at the time the samples were obtained. Field methods have been developed that make it possible to complete such a set of determinations in one day.

These lakes have relatively soft water; the fixed carbon dioxide ranges from a minimum of less than 1 cubic centimeter per liter of water to a maximum of a little more than 15 cubic centimeters. In 25 of these bodies of water the fixed carbon dioxide was less than 2 cubic centimeters per liter of water, but most of the others had between 5 and 10 cubic centimeters. The bottom water of some of these lakes possessed a distinctly larger amount of fixed carbon dioxide than the surface water; in Wild Cat Lake, for example, the surface water possessed 15.4 cubic centimeters per liter and the bottom water (11 meters) 22.3 cubic centimeters on August 24, 1926.

The lowest readings for hydrogen-ion concentration were obtained in the lakes having the softest water; that is, in those having less than 2 cubic centimeters of fixed carbon dioxide per liter of water. In such lakes the reaction varied from pH 5.2 to pH 6.5. In the lakes having a larger amount of fixed carbon dioxide the range was from pH 7 to pH 9.2. In the deeper lakes the bottom water usually gave lower readings than the surface water; in Trout Lake, for example, the range was from pH 7.6 at the surface to pH 6.6 at the bottom (32 meters).

The surface stratum in these lakes was well supplied with dissolved oxygen; the amount varied from 4 cubic centimeters to a little more than 7 cubic centimeters per liter. In some of the deeper lakes the lower water possessed very little or no dissolved oxygen at all.

The quantity of free ammonia in the surface water ranged from a minimum of 0.016 to a maximum of 0.68 milligram per liter of water. In lakes having a depth of 5 meters or more, the lower water usually contained a larger amount of free ammonia than the upper. In Lake Mary, on July 12, 1926, the surface water yielded 0.024 milligram of free ammonia per liter, and the bottom water (20 meters) 2.40 milligrams, or a hundred times as much as the surface. In most instances, however, the bottom water yielded not more than 5 to 10 times as much as the surface.

The amount of combined or organic nitrogen in the surface water varied from a minimum of 0.073 milligram per liter to a maximum of 0.88 milligram. The quantity of organic nitrogen depends chiefly upon the amount of plankton that is present. In some of the deeper lakes a larger amount of organic nitrogen was found in the lower than in the upper water, but the reverse was true in the majority of these lakes.

Most of the lakes contained no nitrite nitrogen, or only a trace; a few yielded measurable amounts of nitrite, the amount varying from 0.001 to 0.01 milligram per liter. Similar results were obtained for the nitrate nitrogen, but as much as 0.08 milligram per liter was noted in the bottom water of Trout Lake on August 14. In only a few instances did the nitrate nitrogen exceed 0.02 milligram per liter, and only a trace or none at all was found in the great majority of the samples.

The 1926 observations included the organic phosphorus as well as the soluble; only the latter was determined in 1925. No soluble phosphorus was found in the upper water of one lake and only a trace in another; in all of the other lakes the amount in the upper water varied from a minimum of 0.003 to a maximum of 0.015 milligram per liter. In many instances the soluble phosphorus was uniformly distributed from surface to bottom, but in others there was a more or less marked increase in the lower water. In Lake Mary there was no soluble phosphorus at the surface and at 3 meters, but 0.75 milligram per liter of water at 20 meters on July 12, 1926.

The quantity of organic phosphorus in the upper water varied from a minimum of 0.01 to a maximum of 0.05 milligram per liter, but it exceeded 0.04 milligram in only three lakes. In most of the lakes the upper water contained from two to four times as much organic phosphorus as soluble phosphorus. In some of the lakes the organic phosphorus was substantially the same from surface to bottom, but in others the lower water contained from two to four times as much as the upper.

The silica varied from only a trace or none at all to a maximum of 10 milligrams per liter in one lake. In most instances, however, the amount did not exceed 5 milligrams per liter, especially in the upper water. In some lakes there was a marked increase of silica in the lower water; in Trout Lake the surface water contained 3 milligrams and the bottom water (30 meters) 8 milligrams per liter on July 9, 1926.

The chlorides varied from 0.53 to 3.1 milligrams per liter of water; in most instances the amount was between 1 and 2 milligrams per liter.

Two to 10 liter samples of centrifuged water were evaporated for the purpose of obtaining the residue. These residues varied in amount from 12 milligrams to 88 milligrams per liter of water in the upper stratum. A maximum of 144 milligrams per liter was obtained in the lower water of one lake. In this connection it may be noted that the hard-water lakes of southeastern Wisconsin yield from 165 to 255 milligrams of residue per liter. These residues are now being used for the determination of the quantity of organic carbon, and quantitative determinations of other substances therein are also contemplated.

A Foerst electric centrifuge was used for the purpose of making a quantitative study of the plankton. This material was dried in an oven, weighed, ashed in an electric furnace, and then weighed a second time in order to ascertain how much organic matter it contained. The quantity of this organic matter varied from a minimum of 265 milligrams per cubic meter of water to a maximum of 10,875 milligrams. In most of the lakes, however, the amount ranged from 800 to 2,000 milligrams per cubic meter.

SHELLFISH AND TERRAPIN

OYSTERS

Owing to the increased appropriations for the oyster investigations, the program of work relating to this important fishery was considerably extended under the supervision of Dr. P. S. Galtsoff. The investigations made during the fiscal year consisted in (1) surveying the natural oyster beds and reefs, (2) study of the spawning of the oyster, (3) studies of the behavior of the oyster larvæ and of the conditions controlling setting in northern waters, (4) experiments in oyster-seed production and collection, and (5) study of the oyster drill.

SURVEYS OF THE NATURAL OYSTER REEFS AND BEDS

Texas.—In compliance with the request of the game, fish, and oyster commissioner of Texas, a survey of coastal waters was made by Dr. P. S. Galtsoff during February and March, 1926. The purpose of the survey was to determine what practical measures should be adopted in order to prevent further depletion of the natural reefs and to maintain, or if possible to increase, the production of oysters in the State.

The survey covered the region extending 170 miles along the coast of the Gulf of Mexico, from Corpus Christi to Galveston. Field observations were made in cooperation with the State authorities, who assigned the State boat *Pearl* to the investigator for this purpose. The *Pearl* covered 1,034 miles between Corpus Christi and Galveston, visiting the following localities: Corpus Christi and Nueces Bays, Corpus Christi Pass, Aransas Pass, Aransas Copano, Mesquite, San Antonio, Espiritu Santo, Matagorda, Lavaca, Karankawa, and Trespalacios Bays, Cedar Lakes, and West, Galveston, and East Bays.

The program of observations consisted in the examination of the bottoms, readings of temperature, determination of salinity, alkalinity, and turbidity of water; measurements of currents; examination of oyster reefs; and studies of the plankton.

It was found that oyster reefs in Texas coastal waters produce enormous quantities of oysters, some of which have little market value; on the other hand, bottoms suitable for oyster culture are rather scarce. It is necessary, therefore, to exploit the suitable bottoms to their full capacity by planting young oysters on them, and to use the overcrowded reefs as the source of an almost unlimited supply of seed oysters.

The following recommendations for the development of the oyster industry were based on this survey:

1. It is recommended that the State authorities encourage the development of oyster farming under private enterprise and discourage the exploitation of the natural beds as rapidly as the development of oyster farming will permit.

2. In the meantime, it is recommended that the State authorities aid in demonstrating the practicability of oyster farming and in increasing the production of the present natural beds by (*a*) the planting of single or culled young oysters over the bottoms in Aransas Bay, Mesquite Bay, Lavaca Bay north of Sandy Point, Kellers Bay, Karankawa Reef, mouth of Trespalacios Bay, and Matagorda Bay, between Portsmouth and Pallacios Points; (*b*) the planting of shells in Nueces Bay; (*c*) experimental planting of shells on Karankawa Reef and in other bays in order to determine the setting areas.

3. Certain biological data should be collected, as, for example, (*a*) observations of the time of spawning in various bays; (*b*) continuation of the taking of samples of water for further examination in the laboratory of the United States Bureau of Fisheries.

4. Where reefs form barriers, preventing the mingling of fresh water and sea water, it is suggested that the State encourage the cutting of passes through the reefs by permitting the use of the "mud shells" for commercial purposes.

South Carolina.—A survey was made in April, 1926, by Dr. P. S. Galtsoff and H. F. Prytherch, of the coastal waters of South Carolina for the purpose of determining the most suitable methods for conserving and building up the oyster industry. Headquarters were established at Beaufort, and an examination was made of the coastal region from Cape Romain to the Savannah River so as to cover the most important and representative oyster-growing localities. Determinations were made of the physical and biological characteristics of the oyster-growing regions as a basis for recommending such experimental planting operations and methods of culture as will bring about the greatest development of the oyster fishery and the most successful utilization of the oyster grounds. A report covering the results of the investigation has been published, together with a chart of the coast showing the general location and extent of the natural oyster beds and the distribution of salinity.

It was found that, with very few exceptions, the natural oyster beds are situated along the shores on the tidal flats and lie in a zone between low and high water mark. This is due largely to the fact that setting occurs, for the most part, in the zone between tide marks. There are areas of the bottom, however, below low-water mark in the tidal streams, sufficiently firm and unshifting, which can be utilized for growing oysters, which can be obtained as seed by planting brush and shells in the vicinity of the natural beds.

High-grade single oysters can be cultivated on these bottoms where setting does not occur, but their marketable quality will depend upon the environmental conditions in each locality and the care expended on the beds. Some of the natural oyster beds are depleted and should be restored and enlarged by a more extensive planting of shells.

The following recommendations are offered in order to restore the natural wealth of oyster resources, increase the production, and improve the quality of the oysters grown in South Carolina waters:

1. A greater quantity of shells should be returned to the natural beds.
2. The natural bed should be extended by planting shells on adjacent firm bottoms.
3. Depleted oyster beds should be restored by planting seed and adult oysters.
4. The closing of depleted areas until they are built up to a self-maintaining basis is advised.
5. The collection of set on brush and shells planted on tidal flats should be practiced.
6. Seed oysters should be transplanted to suitable bottoms below low-water mark.
7. The experimental transplanting of seed oysters on the tidal flats in the upper portions of the streams where setting does not occur should be undertaken.
8. Adult oysters should be transplanted when necessary to prevent overcrowding and to facilitate growth and fattening.
9. The development of oyster farming should be encouraged by leasing the grounds and protecting the private beds.

Massachusetts.—During the latter part of the summer a survey of important oyster grounds on Cape Cod was made by Dr. P. S. Galtsoff and H. R. Seiwell. The survey covered the following localities: Wareham River, on the Buzzards Bay side of the cape, and Waquoit, Cotuit, Centerville River, and Chatham on the ocean side. The first locality differs from the others in being chiefly an important seed-producing region, while most of the oyster bottoms on the ocean side of the cape can be regarded as growing grounds primarily. This especially refers to the Cotuit region (Osterville Harbor), where not a single young oyster can be found in spite of a very careful examination of the shores and bottoms made in August. It is difficult to tell why the set does not occur on this bay, where general conditions (namely, the character of the bottom, the temperature and salinity of the water, and the tidal currents) are favorable. The probable causes may be either the failure of oysters to spawn or the death of the oyster larvæ during their free-swimming period of life. It has been noticed that adult oysters were rather scarce, being scattered over a large area of bottom, a condition that, according to the experiments described later, should be regarded as unfavorable for successful spawning.

Waquoit Bay.—The oyster business in Waquoit Bay is of no importance at present. The main reason for the decline is the accumulation of eelgrass on the bottom, where it decays, giving off hydrogen sulphide in great abundance. A region free from eelgrass, and which appears to be excellent for oyster planting, was found at the mouth of Quostinet River. The salinity in this section of the bay ranges from 17 to 18 parts per thousand.

Chatham region.—Conditions similar to those found in Osterville Harbor were found in Oyster River, Oyster Pond, Mill Pond, and Stage Harbor. Observations made in this region indicate that setting occurs irregularly and is never abundant. The grounds, however, are excellent for growing oysters for market. The salinity in Oyster Pond and Mill Pond averages 30 parts per thousand.

Centerville region.—The natural oyster beds of this section, located in Bumps and Chequaquette Rivers, have been so depleted in the past 15 years that no oyster business is carried on there at present. A survey failed to show any mature oysters on the beds; consequently there were no seed oysters. Only a few small oysters, probably 2 or 3 years old, lying in clusters, were discovered on the bottom at the mouth of Bumps River. As no attempt at oyster culture has been made for about 12 years, the continual taking up of the mature oysters has exhausted the beds. The survey shows that the natural oyster beds can be developed again by planting mature oysters for spawning on the old oyster bed in Bumps River and the former value of the region as seed-producing ground thus be restored. This section is not suitable for raising marketable oysters, because in certain seasons of the year they turn yellow and acquire a disagreeable flavor, but it is very suitable for raising seed oysters to supply Hyannis, Chatham, and other farms nearby.

The results of the survey of Wareham River are discussed later in connection with the experiments on spat collectors.

Mississippi.—At the request of Hon. J. J. Kennedy, mayor of Biloxi, Miss., J. H. Weatherby, temporary investigator of the bureau. was detailed to make an investigation of the Mississippi Sound and adjacent waters. The observations were begun on October 15, and will be carried on throughout the year, covering various phases of the life history of the oyster. The purpose of the investigation is to determine the present conditions of the natural reefs and to work out the method by which the oyster crop in the State can be increased. The bill passed by the Louisiana Legislature, forbidding the citizens of the State of Mississippi to take oysters in Louisiana waters, and the fact that at present about 50 per cent of oysters canned in Mississippi are brought from Louisiana, make this investigation imperative. A preliminary survey of the reefs in the western section of Mississippi Sound was made in October by Dr. P. S. Galtsoff. Special attention was directed to the reefs near Pass Christian, where high mortality occurs rather regularly among the young oysters. Local oystermen attribute it either to the high salinity of water or to the destructive activity of conchs. The observations failed to support either view, as the salinity of the water was rather low and no conchs were found on the reefs.

Preliminary observations tend to show that the planting of shells on suitable bottoms will probably increase the production of oysters to such an extent that Mississippi consumers will be independent of Louisiana.

North Carolina.—A survey of Core and Pamlico Sounds has been undertaken in cooperation with the State fisheries commission, Mr. Seiwell, temporary investigator of the bureau, conducting the field work. Since 1920 over $300,000 has been spent by the State in planting oyster shells in these waters. It was the purpose of this investigation to ascertain the results of the planting operations; to determine the value of various sections of the sound as seed-producing and oyster-growing grounds; and to acquire fundamental knowledge regarding the physical, chemical, and biological conditions existing in these waters and controlling the growth and propagation of the oyster. Observations extending over a period of two months (November and December) indicate that in Pamlico and Core Sounds the currents, and consequently the distribution of the salinity, depend almost entirely upon the winds; that the fluctuations in the temperature of the surface water can be correlated directly with a rising or falling air temperature; that bottom temperatures are usually 2° to 3° C. lower than that of the surface; that the oxygen content of water varies from 1,000 milligrams per liter to 8.85, and free CO_2 varies from 2.2 to 6.8 milligrams per liter. Numerous determinations of Ca content in water were made, and many bottom and plankton samples were collected and analyzed. The work will be carried on throughout the year, and special attention will be directed to the study of spawning of oysters and abundance and distribution of set.

SPAWNING OF THE OYSTER

In the summer of 1926, experiments were conducted by Dr. P. S. Galtsoff at Woods Hole, Mass., on the spawning reactions of the oyster, which were studied under laboratory conditions. Both male and female oysters can be induced to spawn by raising the temperature of the water. However, at a constant temperature the female can be forced to spawn by adding sperm to the water. The details of this experiment are given at greater length on p. 653 of this report.

The following practical applications of the experiments can be made: 1. In certain localities the female oysters can be induced to spawn by adding sperm to the water.

2. For successful spawning, the oysters should be planted on the spawning grounds as densely as possible.

BEHAVIOR OF THE OYSTER LARVA AND CONDITIONS CONTROLLING SETTING IN NORTHERN WATERS

In addition to the practical experiments, studies were made in Milford Harbor by H. F. Prytherch in 1926 dealing primarily with the larval and subsequent attachment periods, both of which are of great importance from a scientific as well as practical standpoint.

Larval period.—In Milford Harbor oysters usually spawn between July 15 and August 1, the exact date varying somewhat each year. Then follows a light set about the 1st of August and a heavy set around the middle of the month. During the interval between spawning and setting the oyster larvæ supposedly swim about in the harbor. A large number of plankton collections were made, therefore, to determine their abundance, distribution, and growth. However, on examining these collections, made at various depths and different stages of the tide, it was found (1) that very few oyster larvæ were swimming about; (2) that of the few larvæ collected the majority were either a day or two old or were about 10 days old and nearly ready to set; (3) that when the tide was at low slack water the larvæ were most abundant; and (4) that the total number of larvæ found in daily collections, extending over a month, scarcely reached 100, while millions of them were found attached in the same place later.

In a series of bottom samples taken in the vicinity of the spawning beds many larvæ in the intermediate and late stages of development were found. This is but natural, for the oyster larvæ are adapted to either a free-swimming or a bottom existence.

These studies revealed the fact that the strong tidal currents cause the larvæ to settle to the bottom, thus avoiding their being carried out of the harbor. In other bodies of water, such as Great South Bay, Long Island, where the tidal currents are insignificant, the oyster larvæ were found to swim actively throughout the larval period. This investigation shows that the oyster larvæ, by settling to the bottom, are able to remain and set in the vicinity of the spawning beds, affording a sound basis for the development of inshore areas for the production of seed oysters.

Attachment or setting of oyster larvæ.—The location and distribution of the oyster beds in any locality is determined largely by the zone in which the oyster larvæ attach. This zone varies considerably in different regions, as, for example, in Long Island Sound and Milford Harbor setting occurs from the bottom to a point about 2 feet above low-water mark; in Great South Bay, Long Island, it occurs from the bottom to nearly high-water mark; while in South Carolina setting occurs between low and high water marks in the lower portions of a stream and only below low-water mark in the adjacent upper portions. Attempts to attribute the possible causes of this phenomenon directly to distribution of salinity, temperature, food content, and amount of sediment in the water have failed. In Milford Harbor, by means of floating and stationary spat collectors, tide gauge, and current meter, it has been found that the predominating factor controlling and limiting setting is the velocity of the tidal current; that heaviest setting occur during the period of low slack water, and continues as the tide begins to run flood, gradually becoming less intense as the velocity of the current increases, and finally ceases altogether when the current attains a velocity of approximately 10 centimeters, or one-third foot, per second. The upper limit of setting varies somewhat according to the tidal conditions, and especially the difference in levels of slack water at the time when setting occurs each year.

Drift-bottle experiments in Long Island Sound.—On September 18 to 21, 1926, 500 drift bottles, with drags attached, were released off

Stratford Point and Milford, Conn., by Mr. Prytherch. Up to the present time over 50 per cent have been recovered. The general drift of the water along the Connecticut coast from Bridgeport to New London is in an east-northeast direction. This shoreward movement of the water is due to a flood tide current that rotates gradually in a clockwise direction, so that by the last of flood it is running in a northeasterly direction.

These observations, together with studies of the distribution of the oyster larvæ, indicate (1) that a set on the offshore beds in Long Island Sound is obtained from oysters in their vicinity, and not from the inshore beds or those found in the bays and harbors; (2) in oyster-cultural operations on the offshore grounds the spawning beds should be located just seaward and southwest of the areas planted with shells.

OYSTER-SEED PRODUCTION AND COLLECTION

The studies and experiments made in 1925 by Mr. Prytherch in Milford Harbor, Conn., showed that such inshore bodies of water can be developed as oyster-seed producing areas by establishing spawning beds and planting suitable set collectors on the tidal flats. Several kinds of collectors were used successfully in obtaining a set, and of these, wirebaskets filled with oyster shells [8] proved to be the cheapest and most practical type. It was evident that the shape of the basket should be changed so as to enable the oyster larvæ to penetrate more easily and attach on the shells in the center. For the experiments in 1926 less expensive shell containers were constructed of spruce lath, triangular in shape, and each had a capacity of 2 bushels and covered an area of 2 square feet. The oyster shells used averaged 250 to the bushel.

At Milford, Conn., and Wareham River and Wellfleet, Mass., the lath crates were tested for the collection of seed oysters. A résumé of the experiments in each locality is as follows:

Milford, Conn.—In Milford Harbor, 1,000 bushels of oysters were planted on the tidal flats for a spawning bed, and over these oysters 300 lath crates, filled with shells, were set out. The crates were placed in various formations, so as to determine their value as seed collectors and the effect of their position and arrangement on the uniformity or intensity of the set. On August 15, a light set occurred in the harbor, but counting the oyster spat in the crates was not done until September 15, when they were large enough to be seen easily. The examination of the crates showed the following results:

1. An average of 2,000 spat per bushel was collected.
2. An average of 9 spat per shell was caught, giving the crop commercial value.
3. A light set, averaging 4 spat per shell, was obtained in the very center of the crates, and a heavier set, averaging 15 spat per shell, was found in the corners.
4. The maximum number of spat attached on a single shell was 35.
5. Shells in the top and bottom layers of the crate caught a heavier set than those in the middle layer.

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[8] Suggested by Capt. Charles E. Wheeler, manager, Connecticut Oyster Farms Co., Milford, Conn.

6. Crates closely packed together collected a heavier set than those set out alone.

Wareham River.—During the summer of 1926, observations and experiments with spat collectors were conducted in Wareham River, Mass., by Dr. P. S. Galtsoff and R. W. Crosley. In this region, the oystermen scatter oyster or scallop shells over the bars exposed at low water, and seed oysters usually are gathered and sold in October or November. The salinity of the water in this region varies from 14 to 29 parts per thousand; the mean tidal range is about 4 feet; the tidal currents, measured in September, 1921, are not very strong on the flats, seldom exceeding one-third foot per second.

On July 19, 50 crates were planted in various sections of the river. During the six weeks that the crates were in the water, eight of them were broken and carried out by the tide. All the losses occurred in the crates planted on the west side of the river, those on the east side sustaining the test successfully. In September the crates were examined and the seed oysters on the shells were counted.

The results of the count show (1) that setting occurs above low-water mark and was found to be heaviest about 1½ feet above the bar on which shells are planted by the local oystermen; (2) that the number of spat caught, per bushel of shell, varied from 1,900 to 45,000, according to the location of the crate.

Wellfleet Harbor.—Similar experiments with spat collectors were carried out in Wellfleet Harbor during the summer by Dr. Henry Federighi, temporary investigator of the bureau. It has been found that the type of crate used in the experiment was not suitable for regions where strong tidal currents occur. Of the 97 crates set out in various sections of the harbor, only 43 remained, the rest being washed away. Though there was no setting of commercial importance in the harbor, the crates placed in Herring River caught a fairly good set, varying from 1,200 to 2,900 spat per bushel.

The investigation in Wellfleet Harbor shows that the areas best suited for spat collection are Herring River, Duck Creek, Egg Island, and Blackfish Creek. The best setting takes place at a point midway between high and low water marks.

Briefly summarized, the results of the experiments and scientific studies show:

1. The conditions necessary for successful spawning and setting are to be found primarily in the harbors, bays, and river mouths.
2. Such inshore areas, if not grossly polluted, can be rehabilitated as prolific oyster-producing regions by the establishment of spawning beds.
3. As shown by laboratory experiments on spawning under adverse seasonal conditions, the oysters on these beds can be induced to spawn. This was successfully accomplished in Milford Harbor.
4. The oyster larvæ will remain and set in the vicinity of the spawning beds in spite of strong tidal currents and river discharge.
5. Triangular crates filled with shells can be placed on the tidal flats in the harbor and will collect from 2,000 to 50,000 oyster spat per bushel.
6. By means of the crates, from eight to ten times as many seed oysters can be collected on a given area as by ordinary methods of shell planting.

7. The crates can be planted on barren mud flats, and sand bottoms or directly over the spawning beds, thereby obtaining the maximum use of the limited inshore areas.

8. This type of crate can be used successfully, except in a few regions where the tidal currents are unusually strong.

OYSTER DRILL

At the request of the oyster companies operating in Chesapeake Bay, near Norfolk, Va., the bureau, since last October, has undertaken a systematic investigation of the oyster drill, with the view to discovering a method of checking the destruction of oyster beds by this pest. Dr. Henry Federighi, who is conducting this investigation, has established a laboratory (through the courtesy of the United States Public Health Service) at Craney Island, Norfolk, Va. The program of observations consists of a study of distribution, migration, propagation, and behavior of the organism. Field observations made during November and December show that at low winter temperature the drill becomes inactive. Further discussion of these studies may be found on page 658.

CLAMS OF THE PACIFIC COAST

During 1926 investigation of the clams of the Pacific coast was continued by H. C. McMillin, scientific assistant, and Prof. F. W. Weymouth, of Stanford University. Field work was carried on by Mr. McMillin from April to September. An examination of the commercial catch on the Washington beds indicated serious depletion. The beds at Massett, British Columbia, were examined and shells collected for growth study. Spawning was observed at Cordova, and the set of young (1-year-old) on various portions of the bed was determined. Swickshak Beach showed the heaviest set of any Alaskan bed. Data were collected here to determine the correct status of the form now described as *Siliqua patula* var. *alta*.

Shells were collected at new places, and material is now available for a study of growth on all important beds. A number of shells from animals of known sexes were measured, and norms of growth were constructed for each sex. Although the sexes are separate in this species, there is no significant difference between them when mature, and determinations made without reference to sex give valid results.

Razor clams move freely through the sand in a vertical direction. Observations indicate that they are closely confined to a limited area and do not migrate. Only part of them feed at one time and are in position to be taken by the diggers; the others remain inactive at some distance below the surface. The commercial digger covers the ground on successive days without apparent reduction in catch. It is difficult, therefore, to determine the abundance on any one bed. Depletion may show in the commercial catch, but a definite measure of the actual state of the resource can not be made. By marking the beach with permanent stakes, the same area can be dug each day and the catch recorded. A limited numbere of such observations indicate that beds that have been subject to heavy commercial digging will show a rapidly decreasing daily production.

The razor-clam beds of Washington are in urgent need of protection. Tourist and commercial digging have so reduced the population of the beds that only very young clams are commonly found. A short report of these conditions with recommendation for a size-limit regulation was submitted to the supervisor of fisheries of the State of Washington.

After examining canned samples of *Cardium corbis* and consulting with interested operators, a suitable method of processing this clam has been worked out. By using this species it is possible for the canneries to operate during the winter, when razor clams can not be obtained, and during the late summer, when there is a closed season for razor clams. The supply of this species is quite extensive and the product is of satisfactory quality.

SCALLOPS

The scallop investigations in North Carolina, begun in July, 1925, by J. S. Gutsell, have been continued through 1926. Special emphasis has been laid on spawning, growth, and longevity.

Spawning has been found to begin in the spring (if, indeed, it ceases at all through any season) and to continue to the end of the year. However, there is accumulating evidence, chiefly from the collections of small scallops, that the principal spawning occurs over a shorter period, beginning in early fall or late summer and extending through the fall, perhaps into the winter. New methods of collecting small scallops and of examining the collected material have given greatly improved results for this as for other aspects of the work, so that good evidence throughout 1927 is anticipated.

Growth data that show remarkable homogeneity of size grouping indicate an increase in length from 1½ inches in May to about 3 inches in the next fall or winter. Commercial destruction of scallops at Pivers Island and other known sources of supply in February, 1926, prevented extension of knowledge of later growth and normal longevity. These problems we hope to solve during the coming year.

On advice of the investigator, some modification of the scallop season by the State authorities aready has been made. It is hoped that when the present studies are completed, or sufficiently advanced, detailed recommendations of practical value may be made available to the State board, which has taken an active interest and to which thanks are due for cooperation.

FRESH-WATER MUSSELS

Undoubtedly the outstanding work carried out in 1926 in connection with fresh-water mussels, of value to the pearl-button industry for their shells, was performed at the Fairport (Iowa) fisheries biological laboratory by Dr. Max M. Ellis, of the University of Missouri, a special investigator of the bureau. After working on the problem several summers Doctor Ellis succeeded in developing a nutrient solution that serves as a medium for the development of mussels from the glochidial to the adult stage. This elimination of the parasitic stage in the life history of the mussels promises to simplify greatly the propagation work that the bureau is conducting with a few of the more important commercial species. Doctor Ellis plans to develop the use of this solution during the coming summer.

T. K. Chamberlain, director of the Fairport station, went to Arkansas to represent the bureau in devising more satisfactory regulations for the mussel fishery than the one in force. In company with representatives of the Arkansas fish commission, Mr. Chamberlain spent over three months in examining the state of the mussel fishery in Arkansas waters. A large number of shellers and shell buyers were interviewed, and tentative recommendations were drawn embodying alternate open and closed sections of the rivers, which were given publicity in the State press. Criticisms and suggestions were invited, which resulted in some minor changes, but the revised recommendations were acted upon favorably by the commission in November and are to go into effect on February 1, 1927.

The new series of sections alternately opened and closed differs from the old, mainly in that the average length per section is a little under 15 miles, as opposed to the 70 miles provided for in the program that failed. It will be possible now for all shellers who live along the river fronts to be within a convenient distance of some open territory at all times.

After completing the work in Arkansas, Mr. Chamberlain began a new series of mussel surveys in certain waters of the upper Mississippi. In these surveys it is planned to develop new methods, based upon those used by Doctor Weymouth in his studies of the salt-water clams of the Pacific coast.

A survey of the mussel beds of certain rivers in Virginia was made by H. O. Hesen, superintendent of fish culture at the Fairport station, to determine the effect of former plantings of commercial mussels taken from the Mississippi River. Mr. Hesen made fresh planting of several thousand young mussels, reared by the trough-culture method, which was employed on a small scale at Fairport during the summer. There was no indication that commercial mussels had become established in Virginia waters.

In connection with the studies of the life history of the more valuable fresh-water mussels, a particular study of the habits of the two species of gar found in the Mississippi in the vicinity of Fairport was made during the past summer by Doctor Ellis. One or both species of gar are the hosts for the glochidia of the most valuable of all the fresh-water mussels—the yellow sand shell (*Lampsilis anodontoides*).

TERRAPIN CULTURE

The experimental work in breeding diamond-back terrapins at the Beaufort (N. C.) fisheries biological station continued to give interesting results. Experiments in hybridizing Carolina and Texas terrapins were started in 1915. It was hoped that in cross-breeding the two species, a fast-growing animal with a flavor scarcely inferior to that of the Carolina terrapin might be produced.

A cooperative arrangement for hatching terrapins, entered into with the fisheries commission board of North Carolina in 1925, has been extended. An additional concrete pound, 125 feet in length and 64 feet in width, was constructed to hold 1,235 breeding terrapins, which the State has supplied. It is purposed to hatch a large number of terrapins and to hold these young animals at the station until they have attained a considerable size and have passed through the most critical stages of life, when they are to be liberated for restocking the sadly depleted waters. Several hundred young animals were liberated in the vicinity of Beaufort from 1914 to 1924, and as several of these animals have been recaptured the indications are that a fair percentage survives to reach maturity. In 1926 the surplus young, not needed for experimental purposes, were turned over to the State fisheries commissioner, and 1,881 individuals were liberated by him in suitable places in the sounds of North Carolina.

The total number of young terrapins secured in the fall of 1926 was 4,370, which is an increase of 1,402 over the hatch of 1925. All of these young, except 735, are the offspring of the bureau's experimental stock. The terrapins belonging to the State, in part, were received too late for the last breeding season, and the rest had not been in confinement long enough to have become acclimated. A much larger number of young, therefore, is expected in 1927. The diamond-back terrapin work is under the supervision of Dr. Samuel F. Hildebrand and in immediate charge of Charles Hatsel.

FISHERIES BIOLOGICAL LABORATORIES

Thirty investigators and others took advantage of the opportunities offered at the United States Fisheries Biological Laboratory at Woods Hole during the summer season of 1926.

Dr. J. O. Snyder, head of the zoology department of Stanford University, acted as director. The station was used to an unusual degree by permanent and temporary employees of the bureau, and research facilities were afforded to investigators from other Government departments, also, and to research workers from widely separated universities and colleges. Doctor Snyder expressed himself as in full sympathy with the change in policy with regard to privileges of this laboratory, inaugurated last year, whereby, in case of overcrowding, investigators are selected on the basis of the scientific program contemplated, accommodations being afforded only to those who are working on problems of special interest to the bureau and who have shown capacity for energetic and productive research. He expressed astonishment at the richness of the opportunities the station offers for the study of marine animals, suggesting that the failure to receive more numerous applications for these facilities must be due to misunderstanding or lack of information on the part of the younger investigators of the country.

The laboratories, library, and apparatus were in good condition, and apparently the needs of the various investigators were well taken care of. Boats and collecting apparatus were available at all times. The aquarium was in fine condition, and live material was supplied promptly upon request of investigators. The particularly efficient and willing service of Robert A. Goffin, the station collector, and Capt. Robert Veeder, of the steamer *Phalarope*, deserve mention. Raymond G. Hoffses, superintendent of the station, and Miss Jessie E. Drayton, who acted as secretary, assumed charge of the many details, which contributed to the general efficiency of the laboratory. Miss Regina M. Ford was active in the library. She brought together the peridodicals and scattered books, catalogued the separates that had accumulated, and arranged the duplicates on newly installed shelves. Alvin S. Eichorn placed the storeroom in order and made the customary inventory of material and apparatus.

In 1926, as during the previous year, the laboratory was again the headquarters of the oyster investigations conducted by Dr. P. S.

Galtsoff and his assistants. Doctor Galtsoff and H. R. Seiwell worked largely on the physiology of feeding and reproduction in oysters, and field observations on various problems in oyster culture were conducted by Dr. Henry Federighi and J. H. Weatherby.

The laboratory was made the center of the mackerel investigations, also, under the direction of O. E. Sette. W. C. Schroeder conducted his investigations on the life history of the cod and haddock and completed his manuscript on the fishes of Chesapeake Bay, which is to be published in collaboration with Dr. S. F. Hildebrand.

Dr. C. J. Fish and Marie P. Fish continued their investigations of the eggs and larvæ of the cod and other larval fishes occurring in the Woods Hole region.

Dr. F. G. Hall, of Duke University, assisted by Dr. Samuel Lepkovsky and Dr. Irving E. Gray, continued their excellent researches in the metabolism of fish, with reference to various degrees of salinity of water.

In addition to the staff of the bureau, researches were conducted by numerous private investigators. Dr. N. A. Cobb, nematologist, of the United States Department of Agriculture, continued his studies, with the aid of four assistants, on the nematode fauna of Woods Hole region. Dr. Edwin Linton and Dr. G. A. MacCallum carried on their studies of fish parasites, as they have done for many years past. Paul S. Conger, of the Carnegie Institution of Washington, working under the direction of Dr. Albert Mann, continued the study of the diatom flora, with particular attention to the bottom forms. Dr. C. B. Wilson carried on important studies in both parasitic and free-living copepods, and among other things completed the examination of a large number of collections made by the *Albatross* and other research vessels of the bureau.

Earle B. Perkins occupied the Harvard table while engaged on color changes in Crustacea. Dr. H. B. Stough, Dr. C. J. Connolly, Dr. W. E. Bullington, E. F. B. Fries, Dr. F. M. Baldwin, and E. G. Agersborg were also engaged on private researches. Dr. N. Borodin, of the Brooklyn Museum, visited the station in connection with his museum work.

The fisheries biological laboratory at Fairport, Iowa, has already been mentioned in connection with the work on the commercial fresh-water mussels, and also in connection with the studies in aquiculture made by Russell F. Lord under the direction of Dr. H. S. Davis. These are the major activities, but the station, under the direction of T. K. Chamberlain, has been the center of other important activities.

A. H. Wiebe, a special investigator for the bureau, made a biological survey of the upper Mississippi during the summer, using Fairport as headquarters. This investigation, while under the direction of the bureau, was financed largely by the States of Minnesota and Wisconsin and the municipalities of St. Paul and Minneapolis. The plankton collections made will be studied at the Fairport station by Mr. Wiebe.

An investigation begun by Dr. R. E. Coker some years ago, when he was director at the Fairport station, was taken up again during the past summer by Doctor Coker, at the bureau's request. This was a study of the effects of the dam across the Mississippi at Keokuk, Iowa, upon the fish population above and below the dam.

Work of special interest to the bureau was performed by a private investigator, George W. Hunter, of the University of Illinois, who occupied a table at the Fairport station throughout the summer. Mr. Hunter worked on fish parasites found in the vicinity of Fairport. In the course of his investigations he discovered a new species of tapeworm and a new species of nematode.

In connection with the aquicultural studies of Doctor Davis and Mr. Lord, the station was able to conduct considerable fish-cultural work on warm-water game fish. The fish produced were turned over to the division of fish culture.

The activities of the fisheries biological laboratory at Beaufort, N. C., were extended during the year. Dr. S. F. Hildebrand, the director, assisted by Charles Hatsel and Irving L. Towers, carried on experiments in diamond-back terrapin culture, the study of the life histories of several species of fish, and observations and experiments relative to the use of fish for controlling mosquito breeding.

A collection of 38 species of fish was made in the vicinity of Greenwood, Miss., in connection with investigations pertaining to the use of fish for mosquito control, carried on at that place during the summer of 1925. The fish have been identified, and a few undescribed forms appear to be included. The stomachs of many of the specimens have been examined for the food contents and a report on the collection is being prepared.

Investigations relative to the use of fish for controlling mosquito breeding, carried on for a number of years, were curtailed, owing to the urgency of other duties. Only limited observations and experiments, concerned principally with mosquito breeding in brackish water, were made in the vicinity of Beaufort.

Elmer Higgins, chief of the division of scientific inquiry, assisted by R. O. Smith and others, continued his investigations on the mullet fishery and of the Pamlico Sound fisheries from August to October. J. S. Gutsell continued his studies on the life history of the bay scallop.

Toward the end of the year, H. R. Seiwell and R. W. Crosley were detailed to Beaufort to study local oyster problems. The Navy Department sent two investigators, Dr. A. W. Bray and Dr. J. Paul Visscher, to the station in the summer to continue their previous studies on the prevention of the fouling of ships' bottoms. In addition, six independent investigators availed themselves of the privileges of the laboratory.

Prof. H. V. Wilson, of the University of North Carolina, made studies on the behavior of sponge cells; Dr. Bartgis McGlone, of the University of Pennsylvania, continued his studies of the previous summer on the effects of hydrogen-ion concentration on the fertilization of the eggs of sea urchins; Dr. Hoyt S. Hopkins, of New York University, studied respiration in the tissues of mollusks; Dr. Elinor H. Behre, of the University of Louisiana, studied color adaptation in fishes, especially in certain blennies and in a foolfish; Dr. Libbie H. Hyman, of the University of Chicago, worked on digestion in sponges; and H. Randolph Halsey, of Columbia University, made some studies pertaining to the fertilization of the eggs of the stone crab, *Menippe mercenaria*, and he also made studies of the effect on certain cytoplasmic bodies of the cell of centrifuging the eggs of sea urchins.

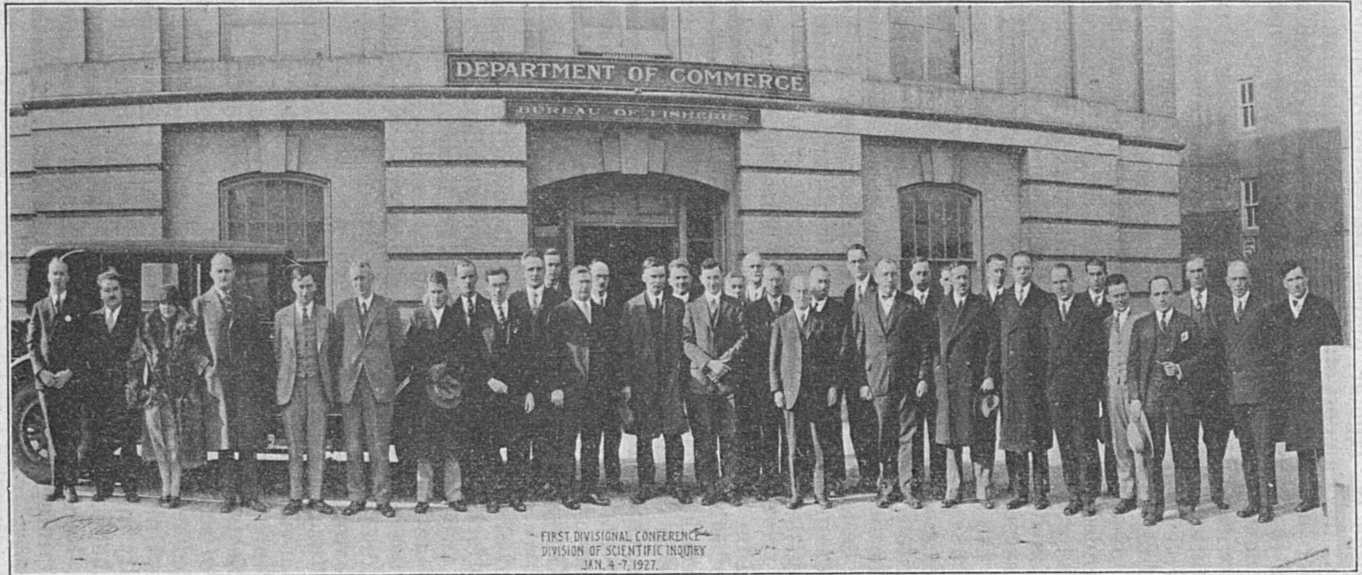

Fig. 1.—Officers and scientific staff of the Bureau of Fisheries present at the divisional conference. Reading from left to right: Herbert F. Prytherch, Dr. Henry Federighi, Mrs. Chas. J. Fish (Marie D. Fish), Dr. Chas. J. Fish, Wm. C. Schroeder, Dr. Henry B. Bigelow, Russell F. Lord, Dr. Walter Koelz, John C. Pearson, Dr. Paul S. Galtsoff, Robert O. Smith, Henry O'Malley, commissioner, Robert A. Nesbit, Irving L. Towers, Dr. Samuel F. Hildebrand, Dr. John Van Oosten, Dr. Herbert S. Davis, Dr. Wm. C. Kendall, Lewis Radcliffe, deputy commissioner, Dr. Chas. H. Gilbert, Dr. Willis H. Rich, Elmer Higgins, assistant in charge of scientific inquiry, Thos. K. Chamberlain, James S. Gutsell, Geo. A. Rounsefell, Capt. F. W. Wallace, Harlan B. Holmes, Frederick S. Norman, Milton C. James, H. Richard Seiwell, Isaac Ginsburg, Oscar E. Sette, assistant in charge of fishery industries, N. B. Scofield, Hermon O. Hesen, Abraham H. Wiebe.

Part II.—PROCEEDINGS OF THE DIVISIONAL CONFERENCE, JANUARY 4 TO 7, 1927

SYMPOSIUM ON FISHERIES AND FISHERY INVESTIGATIONS

OUR OPPORTUNITIES: OUR RESPONSIBILITIES

By Henry O'Malley, Commissioner of Fisheries

I am very glad to welcome you to this first conference of the division of scientific inquiry. We have an important work to perform, and I trust that the results of this conference will be such that we will want its annual repetition.

After you have had an opportunity to examine in some detail the work of the various investigators, I hope that you may be able to direct your efforts toward the most worthy goals, getting a perspective of the larger problems of the fisheries and realizing their gravity and importance to the Nation. You should have a self-consciousness as fishery investigators and a group consciousness as the scientific staff of the Bureau of Fisheries that will add to your respect for the dignity and significance of your daily tasks and increase your pride in your chosen calling.

You fishery investigators are favored persons. You have unprecedented opportunities, but with these opportunities there are equally great responsibilities.

The attitude of the people toward scientific investigation of the fisheries has undergone a distinct change in the last five years. While the tendency was noticeable many years before, it has been only very recently that we find dealers and fishermen, leaders of the industry, advocating fishery regulation, requesting technical advice, and calling upon us to draft appropriate legislation to protect the fisheries. While the fishery investigator formerly was looked upon as some kind of a queer, impractical person, a "bug hunter," he is now regarded by the more intelligent fishermen as an expert with a deeper insight and broader, more sympathetic understanding of the problems of the sea than many so-called "practical" men. This change of attitude on the part of the public has been reflected in the legislation of the States and Congress by increasing appropriations for research. While formerly congressional constituents demanded only the establishment of fish hatcheries, now, particularly in the marine fisheries, the demand is also for biological investigations, and funds for this purpose are being provided.

The fishery investigator of to-day stands on the threshold of a new era of scientific development. The new science of fishery biology is developing rapidly, both in this country and in Europe, and promises to become an important and honored member of the group of natural sciences. While systematic ichthyology in America is based upon the names Gill, Jordan, Gilbert, and Cope, the future development of fishery biology may well rest upon the names of many of you here present. Fishery biology is entering upon a virtually virgin field; there is no dearth of urgent and significant questions; in fact, every fishery in every section of the country offers a host of problems too numerous to mention and as yet untouched. Not only the practice of fishery conservation but the very fundamentals still await investigation.

The opportunities for fishery research offered by the Bureau of Fisheries are now superior to those ever before provided, and, needless to say, are superior to those of any private organization or institution. Few institutions have the financial resources of the Government for such work; none of them have the facilities for collecting data or the authority to make these data accessible. Few have access to library facilities equal to those found in Washington, and few can offer their investigators such freedom of movement, such breadth of field, as can the Bureau of Fisheries. The bureau investigator may pursue his subject to its ultimate and complete solution and satisfy the desire for scientific recognition, which so often is a powerful spur to activity. The bureau's employment offers opportunity for the making of a career. Academic honors and scientific recognition are now possible, and adequate compensation and the possibility of material advancement make the bureau's positions most desirable.

But along with all these opportunities, as I have said, come heavy responsibilities. We can not deny or ignore the fact that our fisheries are declining. A half century of the bureau's activities have not been sufficient to prevent depletion in some, commercial extinction in others. I should not care to say that the bureau's work has amounted to nothing, but we must conclude that our efforts have not been sufficient to maintain the fisheries in their former state of productiveness. We must, therefore, extend and more wisely direct our efforts; we must succeed in coordinating and organizing the efforts of our staff and of biologists throughout the country upon the problems of the maintenance of the annual yield.

Our responsibility toward the fisheries is emphasized by the childlike faith of the public in the efficacy of science. Science in industry has worked wonders. Science is introduced into business, into government, into every phase of daily life; and it is natural and, indeed, proper to expect science to maintain the fisheries for all time. This confidence is almost embarrassing, and in view of the complexity of the problems of conservation, this faith may well be shaken by the unavoidable slowness with which results are produced.

But results can be produced, I am very confident, through cooperation and organization. The division of inquiry must develop a comprehensive program of fishery investigation, in which each of you must take a part as a unit in a great machine.

It is my ambition to see this scientific staff grow in numbers and in effectiveness far surpassing previous experience. I want men of ability and vision, of industry and diligence, who are prepared to put the whole of their energies and interests into the shaping of their scientific careers in the bureau. Half interest and half time can never bring the results for which the bureau aims, and the dilettante naturalist can expect no Government subsidy through this bureau.

It is through cooperation that the great responsibility of your division can be discharged effectually. The principles of fishery investigation must be carried into execution, made applicable to the daily problems of fishery administration, and, above all, must produce results for the benefit of the fisheries. The individual investigator may be concerned with a theoretical problem, but even in the prosecution of highly technical scientific work the ultimate aim of fishery conservation must be kept clearly in mind. Some must develop principles, some must work upon their application, but the aims and objects of our work must be ever before us. We are all giving to the people of this country a service as real and as important as that of any agency of production. This service to be enduring and far reaching must be carried to the ultimate consumer or it fails completely.

Your immediate problem in this conference is to devise means and develop methods of effecting real fishery conservation, and I charge you with the responsibility of perfecting a program of action that will be more effective than any hitherto developed. I have no anxiety concerning your success, and I unhesitatingly place in your hands the development of the scientific work of this bureau, confident that through your whole-hearted endeavors the fishery industry and the American people will receive benefits that will be a source of pride to the bureau and to yourselves.

Mr. Higgins. Mr. O'Malley has laid down our work for us very pointedly, indeed. We all have our own ideas of how fishery conservation should be effected. It is now our duty, as he has told us, to coordinate these ideas, and therefrom to develop a policy. Before attempting to lay down a general policy for the bureau, it is necessary for us, I believe, to examine, as a background, the field in which we must work, and I have asked Mr. Sette, in charge of the division of fishery industries, who has at his command all of the available statistics, to review for us just what can be found out about the actual state of America's fisheries.

THE STATE OF AMERICA'S FISHERIES

By O. E. Sette
Assistant in charge, Division of Fishery Industries

The first thing we must face, in considering the status of our fisheries, is that we have an invisible resource. One can cruise timber and learn the remaining stand, and one can enumerate the acres of cultivated land, but the fisheries one can not see. All we know about the fisheries is what the fishermen bring to market, and therefore, in considering this subject, we have to deal entirely with the fisherman's catch. Moreover, it is only by a consideration of the past that we can understand the present or foresee the future, so that this discussion will deal largely with the record as it appears in the published statistics of the fisheries.

Our first records of this nature were made in 1880, 46 years ago, when the first census of the fisheries was taken. Since then there have been periodical censuses of the various regions. I have charted (fig. 2) a picture of these censuses.

The squares in the horizontal row across the top represent the years for which we have statistics of the fisheries of New England. You can see that they are scattered pretty well during the period. On the line below are the Middle Atlantic States. Below that are the South Atlantic, Gulf, Pacific coast, Great

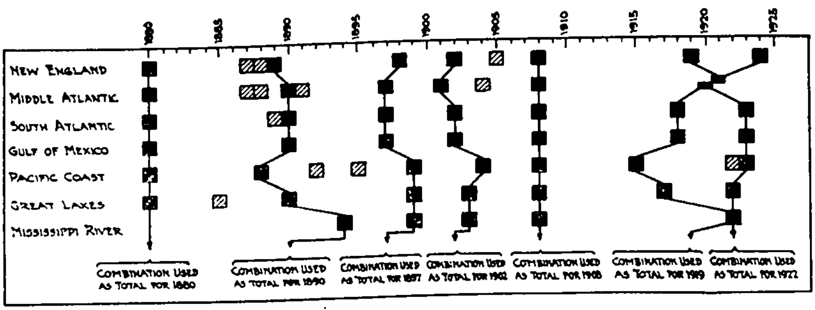

FIG. 2.—Years for which statistics are available on the fisheries of the various geographical sections of the United States, and combinations that were used in compiling totals

Lakes, and Mississippi River. You will notice immediately that there are only two years for which we have the statistics of the whole country—1880 and 1908. Even 1880 is incomplete because we haven't the Mississippi River. The remaining years are so scattered that it is impossible to compile the statistics of the country for any one year to show the total yield; but as a substitute I have compiled those that apply most nearly to the same year and include all of the regions as indicated on the chart. It is an imperfect compilation, but it is the best available.[4]

Referring to Figure 3, in 1880 the total yield of our fisheries, exclusive of Alaska, was less than 1,600,000,000 pounds. This has risen, with some fluctuation, to a total at the present time of nearly 2,200,000,000 pounds. The line of dashes represents the yield in the Atlantic coast section including the Gulf, which has fluctuated widely but shows an upward trend, running from about 1,500,000,000 to over 1,600,000,000 pounds in recent years. You will also notice that the Atlantic coast yields the greatest poundage of fish. The Pacific coast has grown from about 50,000,000 to about 400,000,000, an increase of approximately 800 per cent during the period covered. The Great Lakes and Mississippi River together have yielded about 150,000,000 pounds annually from 1890 to the present time.

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[4] In order to provide comparable statistics in the various years, all salt fish appearing in the reports has been converted to the equivalent amount of fresh fish. The statistics on oysters, clams, and scallops are in terms of meats, exclusive of shells. Statistics on seed oysters, shells, hides, oils, whale products, king crab (*Mimulus*), and frogs have been omitted.

Confining our attention now to the Atlantic coast, let us examine the components of the present-day catch of fish.

The largest single item in the catch is menhaden. Of the total catch (1,638,000,000 pounds), 770,000,000 pounds were of this species. Referring to Figure 4, we see that the poundage of menhaden was greater than that of all other fish combined and more than twice that of all shellfish. This great predominance of menhaden is not often appreciated, probably because this fish has not been used for food and thus is considered a "poor relation" among the fishes. But, despite our low esteem of this fish, it must certainly be a tremendous factor in the ecology of the sea. In fact, the relative amount in the catch probably underrates it as compared with other fish. For menhaden the fishermen receive only one-half cent a pound. For other fish the average price is 4 cents. If the fishermen were to get 4 cents a pound for menhaden, it would loom still larger in the catch.

Cod and haddock rank next in quantity to menhaden, each yielding over 90,000,000 pounds annually. Herring is fourth in quantity, with over 60,000,000

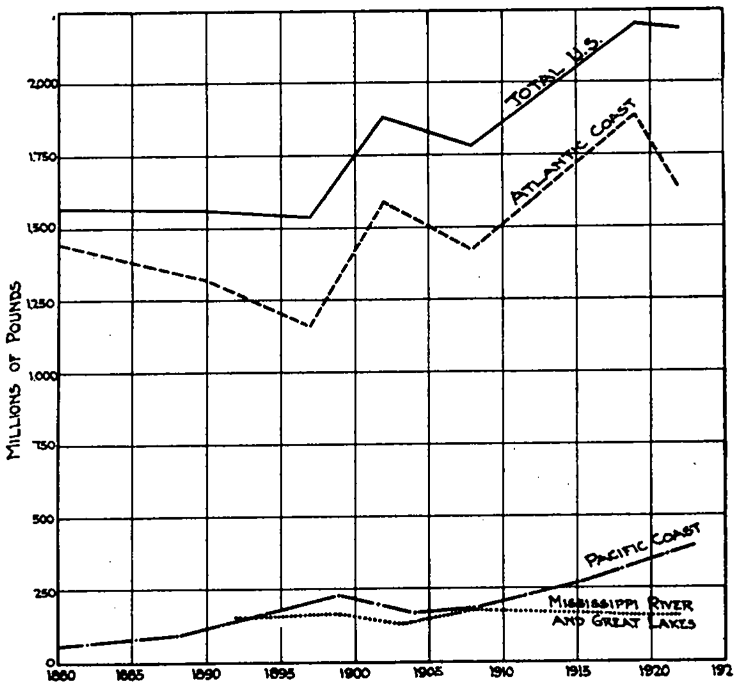

FIG. 8.—Yield of the fisheries of the various waters of the United States

pounds. The catches of mullet, alewives, squeteagues, and flounders are nearly equal—close to 40,000,000 pounds annually. Others follow, in order of quantity, as shown in Figure 5. It is interesting to note that two of our most esteemed fishes—halibut and bluefish—are near the bottom.

In order to get a group picture of the changes occurring in our fisheries I have compiled the statistics of several branches of the fisheries, grouping separately the fresh-water, anadromous, catadromous, shore, demersal, and pelagic fishes. Some explanation of these groupings may be in order. The fresh-water fishes include all those that nominally spend their lifetime in the rivers and are largely caught there by commercial fishermen, though they may be taken occasionally in brackish water. Some of the important species in this group are suckers, carp, catfish, sunfish, yellow perch, black bass, pike, and buffalofish. The statistics of these may not be complete, for the canvasses include the coastal streams only so far as the commercial fishery is relatively important. Among the anadromous fishes are the shads, alewives, striped bass, white perch, smelt, salmon, and sturgeon. The common eel comprises the catadromous group. Among the shore fishes I have included all species usually taken by inshore gear, such as pound nets, traps, weirs, haul seines, hook and line, and gill nets operated in inshore waters. Thus, the sea herring, which has some claims for inclusion among the pelagic fishes, was put into the shore group because it is taken mostly in weirs; and pollock, which is regularly taken among the demersal fishes, has also been included with the shore group because by far the largest part of the catch comes from inshore waters. Other species of importance in this group are squeteague, mullet, croaker, spot, butterfish, drum, king whiting, scup, and whiting (silver hake). Among the demersal

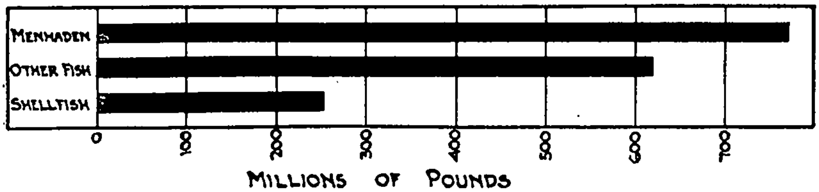

FIG. 4.—Relative size of the menhaden catch

fishes I have included cod, haddock, hake, halibut, flounders, snappers, groupers, etc. Among the pelagic fishes I have included all those taken primarily in offshore surface waters by such gears as purse seines, drift gill nets, and harpoons. These are menhaden, mackerel, swordfish, etc.

By consulting Figure 6 we may follow the changes in yield in these various groups. As might be expected, the group of pelagic fishes shows wide fluctuations from 340,000,000 to 930,000,000 pounds in various years. It also has had a decided upward trend since 1908. The demersal fishes as a group have had a fairly constant yield since 1890. The shore fishes reached a peak yield

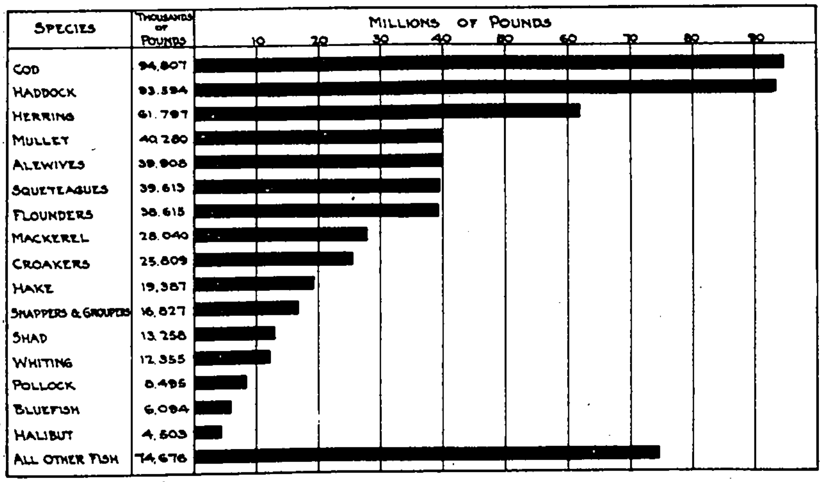

FIG. 5.—Relative quantities of various species of fish (excepting menhaden) taken annually on the Atlantic coast

in 1902 but have declined since. The anadromous fishes reached their peak yield prior to 1897, but have since then declined more severely than the shore fishes. There seems to be an orderly coherence in these trends when considered in terms of the accessibility to the fishermen of the various groups. The least accessible are the offshore surface fishes, which roam over relatively large areas and may be found only by much cruising in search of the wandering schools, and are caught with difficulty when found. These show only a tremendous fluctuation in yield and the trend, if any may be distinguished, seems upward. Next are the demersal fishes, found over extensive offshore areas but caught with greater certainty. These show a relatively constant yield. The shore fisheries are confined to a more limited area conducive to a more thorough exploitation. The fish in this group passed the climax of their yield in 1902 and since then have been taken in smaller quantities. The anadromous fishes are still more strictly confined to limited areas during their spawning runs when they are subject to intensive fishing, and their yield passed its climax some 10 years earlier than that of the shore fishes and has declined more severely.

We can not venture too far with general conclusions of this sort, however. Each of the above-mentioned groups is a complex of species that must be examined separately. For this purpose I have prepared a number of charts

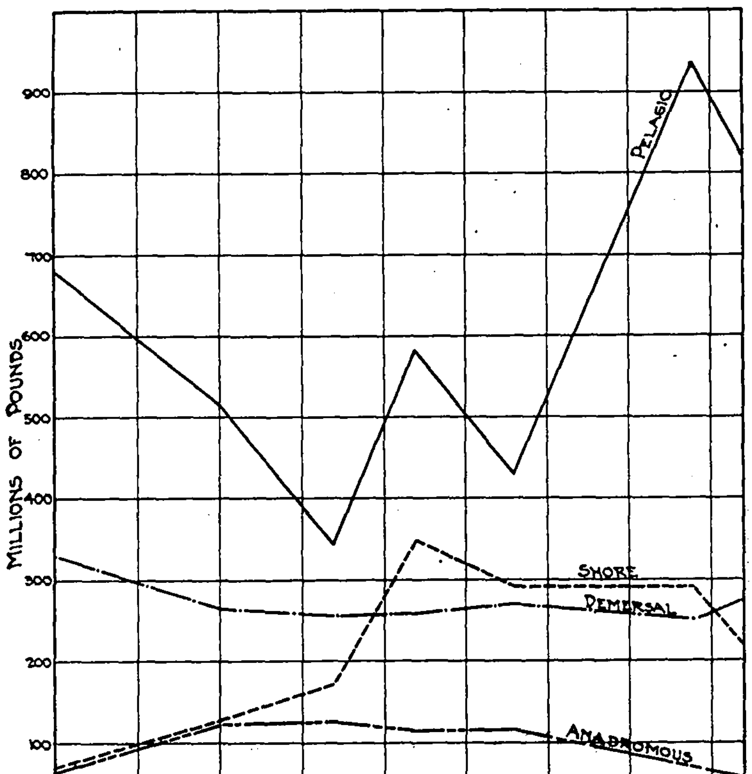

FIG. 6.—Yields of various groups of fishes on the Atlantic seaboard, 1880 to 1922

on a logarithmic scale to show the relative changes in yield of the more important species. The logarithmic scale reduces the curves to a convenient form for comparing rates of change, and in interpreting them the relative steepness of the slopes of the curves is the significant feature. Thus, if in a given period the yield of a species increases from 5,000,000 to 10,000,000 pounds, a 100 per cent increase, and another species increases from 12,000,000 to 24,000,000, also a 100 per cent increase, the slopes of the two curves will be the same. In other words, logarithmic plotting expresses the percentage increase or decrease.

Among the pelagic fishes (fig. 7), menhaden and mackerel fluctuate so much that it is difficult to say whether the trend is upward or downward. It seems slightly upward in the case of menhaden and slightly downward in the case of mackerel. Swordfish present a slight upward trend and Spanish mackerel (including cero) show a distinct downward trend.

Among the demersal fishes (fig. 8), cod and halibut show a general downward trend (more severe in the case of halibut), haddock show a general upward trend, as do also snappers and groupers, flounders show a most decided upward trend, and hake showed a slight upward trend until 1897 and thereafter a moderate downward trend.

All of the important anadromous fishes (fig. 9) show trends distinctly upward in the early years and downward in the later years. Shad and sturgeon reached peak productions earliest (1897) and declined most rapidly thereafter. Smelt reached peak production as early but declined less consistently. Striped bass and alewives, though showing a declining yield, have not fallen as rapidly and consistently as the others.

Among the shore fishes (fig. 10), four species—whiting, butterfish, spots, and croakers—show very marked upward trends. Scup and kingfish seem to

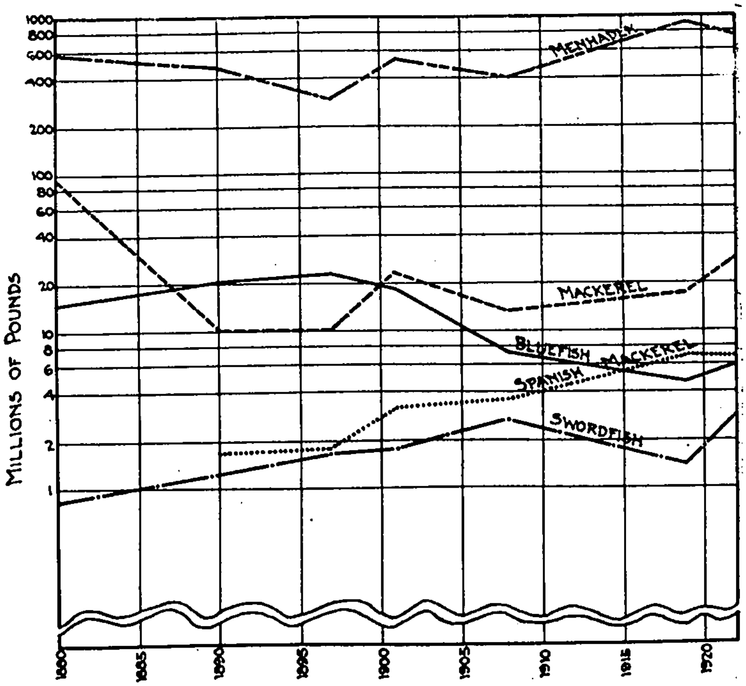

FIG. 7.—Changes in the yield of several important pelagic species on the Atlantic seaboard (on a logarithmic scale)

have maintained their yield at a fairly constant level. Squeteague and mullet grew in yield until 1902, and have since maintained it at nearly the same level. Herring and pollock show a rise and fall of considerable magnitude.

If we group the species that have declined most seriously in recent years (bluefish, cod, halibut, shad, and sturgeon), we find that they are all fish that were highly prized during early years and have been subject to intensive fishing for the longest time. Also, if we group those showing greatly increased yield in recent years (flounders, Spanish mackerel, haddock, snappers, groupers, croakers, spots, butterfish, and whiting), we find that they are species less in demand in former years but that have been exploited more lately. It would seem that in general the yield on the Atlantic coast has been held at a high level by replacing the staple fish of former days with new species, which were not greatly in demand in the earlier years. In some cases this may have been due to economic factors. The cod, for instance, among those that have declined, apparently has been affected by the decreased salt-fish trade; but in most cases the declining yields seem to be the result of depletion, and the total yield of

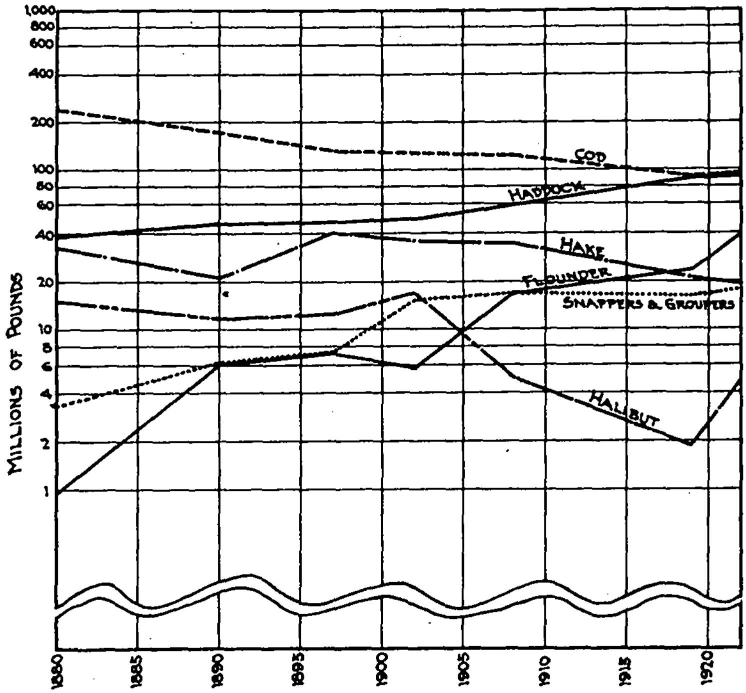

FIG. 8.—Changes in the yields of several important demersal fishes on the Atlantic seaboard (on a logarithmic scale)

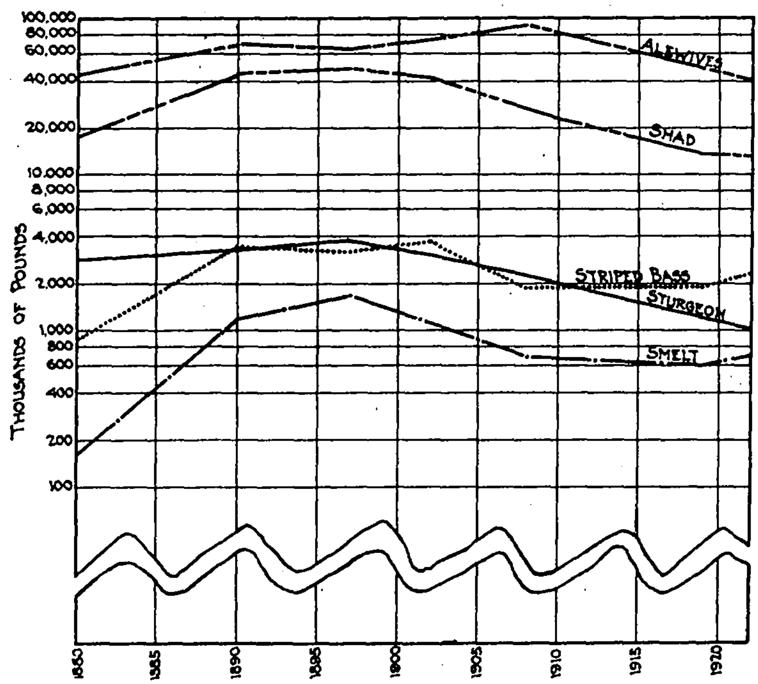

FIG. 9.—Changes in yields of several important anadromous fishes on the Atlantic seaboard (on a logarithmic scale)

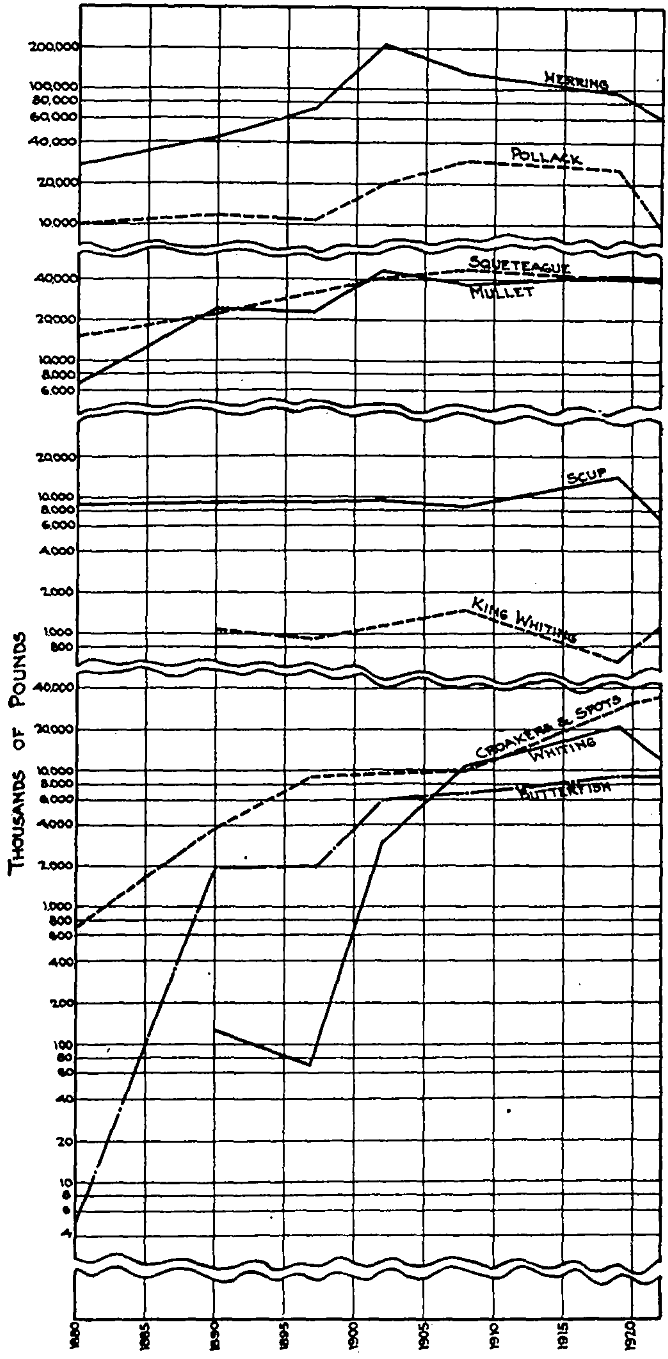

FIG. 10.—Changes in yield of important shore fishes on the Atlantic seaboard (on a logarithmic scale)

our fishes is being maintained only by drawing on new resources. If so, we have a disquieting picture. Our substitute species may decline when they are subjected to intensive fishing as long as the others have been.

Among the shellfishes we find similar tendencies. Referring to Figure 11, we see that oysters, crabs, and clams have declined moderately; lobsters have declined more; while shrimp is the only shellfish that has an upward trend in yield. Oysters, clams, and lobsters were fished more extensively in the earlier years and they began their decline first. The most intensive fishery for crabs began when the dredge was introduced in the early nineteen hundreds. This kept the yield up for over a decade, when it too declined. Similarly, the otter trawl, introduced into the shrimp fishery after 1908, has been responsible for greater yields, which are still continuing to increase. If it were not for the greater yield of shrimp, the shellfish fisheries would show a distinct decline since 1908.

Similar charts could be shown to demonstrate trends of the same nature in fisheries of other regions of the United States, but it will not be necessary to trouble you with the details. Suffice it to say, that while the Pacific Coast States show a remarkable upward trend in the total yield of their fisheries, the

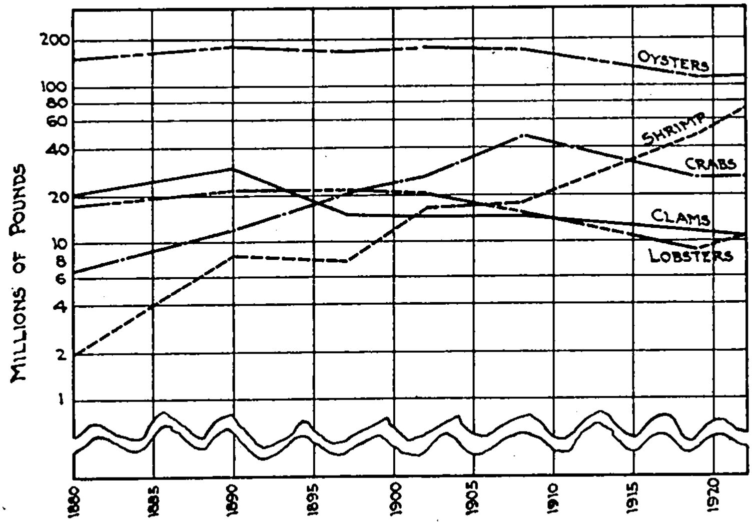

FIG. 11.—Changes in the yield of the important shellfish on the Atlantic seaboard (on a logarithmic scale)

salmon and halibut, which have been fished the longest time, are barely maintaining their yields. The great increase is due to the sardine and tuna fisheries of comparatively recent origin. As for the Great Lakes, Doctor Koelz, in his report, has shown that although they have a relatively constant yield, this constant yield has been maintained by the increased use of so-called "rough" fish, which to a marked extent, have replaced the fishes that formerly were considered more desirable. In the Mississippi River, we have a rise and decline during the period, and if we omit the mussel fisheries we find that the yield has declined quite markedly.

In conclusion, I wish to emphasize again that yield statistics have been used throughout this discussion. According to these statistics, our yield has been maintained and in some regions increased, but not by general increases in all species. On the contrary, many of the highly prized species have failed to provide yields comparable with those of former years. Their places have been taken by species that formerly were not sought after. While this does not mean that depletion is proven in every case where decreased yields occurred, it does point out the fact that there is need for critical studies of many species. If the yield of our fisheries is to be maintained, we must determine first what fluctuations in abundance are occurring, then find out whether they are due to natural or other causes, and finally determine what steps should be taken to conserve those species that are being depleted by agencies under the control of man. Until this is accomplished, we will not know the exact status of our fisheries

Hr. HIGGINS. I think that in addition it would be desirable for us to consider, from the angle of the fishing industry, some of the problems that need early solution. I believe that there is no one more closely in touch with the industry itself than Captain Wallace, editor of the Fishing Gazette, and he has consented to discuss with us some of these problems.

OUTSTANDING PROBLEMS OF THE FISHING INDUSTRY

By CAPT. F. W. WALLACE
Editor, Fishing Gazette, New York

The outstanding problem confronting the fishing industry to-day is that of providing a profitable market for all that our fishermen catch. The prosperity of the industry rests upon two things—(1) larger markets and (2) utilization of inedible fish and fish waste.

Dealing with the subject of larger markets, it undoubtedly is a fact that the people of this country are not consuming as much fish as are the citizens of other nations. This condition is all the more remarkable when it is considered that the United States possesses and has ready access to more prolific and more varied fishery resources than has any other nation.

In presenting my ideas to a body of men well versed in the history of the fishing industry, it will not be necessary for me to go into the details of present-day conditions. We all know that the demand has been for certain species, many of which are becoming scarce. The task before the industry is to expand the market for those varieties of fish than can be produced in abundance and at a reasonable price. On the Atlantic coast the haddock, cod, hake, pollock, cusk, skate, flounder, herring, whiting, and mackerel fall into this class, and there are many others—good, edible fish, but not appreciated as such—for which a market should be found.

Any expansion in the domestic market is not going to be made entirely by insisting that the public use more fish in their diet, but is more likely to be brought about by a radical change in current methods of marketing. Acquainting the public with the value and variety of fish as a food is necessary. Advertising campaigns are being conducted by various branches of the fishing industry, and these are worth while and comparable with the high quality of salesmanship employed by other food-producing industries. However, the main plank of the expansion platform is to give the public what it wants, and it doesn't want bones.

To my mind, fish bones, more than anything else, have deterred people from eating fish. Prehistoric man may have delighted in sharpening his teeth upon the bones of his rude provender, and some of our near ancestors were not averse to worrying a herring, but in this day of mush foods, seedless and stoneless fruits, filet mignons, and similar "easy-to-eat" fare, anything that has to be dissected upon the plate is regarded with disfavor. I have questioned children, asking them if they like fish. In most cases the answer was "Yes, but I don't like the bones." This fact has a great deal of influence with the mothers. They are always fearful that the children will get fish bones in their throats. As a result, fish very often is passed by in favor of other foods. The same is true of older people. They consider fish messy when they are compelled to separate meat from bones. In this hasty age, extra labor in cooking and eating is avoided.

Personally, I am very fond of fish. I invariably have fish for lunch at the lunch club maintained by the dealers in Fulton Market. At this club, naturally, we have the best of fish at all times, but I have noticed that my preference, and that of most of the members, is for filleted fish. Canned salmon, fresh salmon steaks, cod steaks, halibut, and swordfish owe much of their popularity to the fact that they are devoid of small bones; while the haddock fillet, the greatest advance made in the fish business in recent years, is now being marketed so extensively largely because it is boneless.

The fresh-fish fillet, as now produced in Boston, New York, and elsewhere (a piece of solid fish meat, skinless, boneless, wrapped in parchment paper, and shipped in handy packages) has proved that the American public will eat more fish if it gets it in a fashion that will insure less trouble in handling, preparing, and eating it; and when one notes the favorable reception accorded fish marketed in this manner, it is not impracticable to state that all fish, whenever possible, should be filleted at producing points and marketed as a piece of solid meat, wrapped in parchment or packed in such fashion that it can be handled with a minimum of trouble by the retail dealer, the chef, and the housewife. My observations over many years, in connection with various branches of the fishing industry and fish trade, have convinced me that unless we market most of our fish in this manner we shall never succeed in creating the larger market we hope for.

There is yet another obstacle to overcome in enlarging the market. This is the matter of quality—of freshness. The fresh fish, as received by the housewife or the restaurant in most localities, is a burlesque of the real thing. Even in the best hotels, we, who know fish, receive portions that are decidedly stale and unappetizing. A vast amount of stale fish is being served—enough to deter many people from eating it except at irregular intervals. Not only is the ultimate consumer receiving fish in a condition that fails to arouse enthusiasm, but the trade itself faces selling difficulties and heavy losses because of staleness and spoiling incurred by the present universal methods of shipping fish packed in ice in boxes and barrels.

There is a solution to this problem, and leaders in the trade have expressed their opinion that this solution lies in shipping fish in a frozen state. The drawback, however, is the public prejudice against frozen fish—a prejudice inspired by the unpalatability of fish frozen by the usual methods. Certain species—halibut and salmon, for instance—lend themselves admirably to freezing, but there are other species that, when thawed, taste like nothing at all. Experiments in brine freezing and with other methods have proved that fish can be frozen, kept for long periods in storage, shipped for considerable distances in adverse weather, and ultimately cooked and eaten without the consumer being able to detect any difference between frozen and strictly fresh fish. The success attending these experiments opens a new and desirable prospect for the fish trade, for freezing methods that will not change the composition of the fish or destroy its palatability make it possible for us to store fish when they are being caught, thus insuring a more even distribution later at a more even price. It means that we can ship greater distances, reduce the heavy losses in transit, and enlarge the market; it provides the retail dealer with a product that will not spoil before he can sell it; and the consumer will receive a piece of fish in a condition closely approximating that of freshly caught fish.

Some very bright minds in our industry are working along these lines. Personally, I believe that they are on the right track and that the future development of the fish trade rests upon giving the consumer a ready-to-cook boneless fish fillet with its quality and freshness maintained by shipment in a frozen state. In bringing about this desirable end the various governmental bodies, paternally interested in developing the fishing industries, can do much in stimulating action by the trade itself. There is a conservative element in our fishing industries that does not welcome innovations. "Get the fish on the market with the minimum of expense, labor, and trouble" is their motto, and this apathetic and stubborn attitude has not helped the business. In fact, it would almost appear that the adoption of modern methods in most cases was brought about by force, in the form of legislation, or by the competition of more progressive members. The Bureau of Fisheries and other organizations, by recognizing the absolute soundness of marketing fish in filleted and frozen form, are in a splendid position to convert the industry to this practice, and much more quickly than would be the case if the industry were left to discover this for itself.

Marketing of fish in fillet form involves numerous problems. The most important, perhaps, are those of labor and the profitable utilization of the waste. The labor problem is claiming the attention of many firms in the fillet business, and a way of mechanically cutting the fillets is being sought. Machinery is being used in some stages of the work, and one firm in Gloucester has evolved an ingenious series of machines which will virtually eliminate all hand labor in cutting the fillets. The Bureau of Fisheries might detail one of its officers to investigate labor-saving devices for fish cutting in use here and abroad and publish its findings for the information of the industry at large.

Before tackling the problem of waste utilization I would like to commend the bureau's interest in the maintenance of the quality of fresh fish from the time it is caught to the time it is placed on the consumer's plate. A great deal happens to a perfectly good fish within that period. In many cases it is sorely abused by exposure to sun and air, from pitchforks, and through general rough handling. These things are responsible for heavy losses to fishermen and dealers, and also, to a great extent, for the public apathy toward fish as a food. I have yet to find the person who does not enjoy a piece of strictly fresh fish, well cooked; but the quality of much of the fish marketed nowadays is not appetizing. The Bureau of Fisheries is investigating this very important problem. The publication of its recommendations for the better handling of fresh fish is going to be very helpful to the industry.

The freezing of fish presents numerous problems. One of these (the discoloration of fresh haddock fillets in cold storage) has proved an obstacle to the expansion of the frozen-fillet trade. Harden F. Taylor made a special study of this matter in connection with his firm's work in that line and claims to have overcome the trouble. However, all fish dealers are not able to engage the services of scientists like Mr. Taylor, and they look to the Government bureaus for help and advice. Every man in the fish business would like to learn the best method for freezing fish and maintaining its quality without deterioration. Packing frozen fish for shipment presents another interesting field for investigation, and this, too, might be made the subject of a survey by the Bureau of Fisheries.

Taking up the second subject, viz, the utilization of inedible fish and fish waste, the present-day waste, not only of fish but of time and effort, in the fish business is appalling. Those of you here who have been to sea with the fishermen can testify to the enormous quantity of so-called "trash" and "gurry" that is thrown overboard. This waste occurs in almost every branch of the fisheries. It should be remembered that it costs just as much to catch a dogfish, monkfish, or skate at it does to catch a cod, haddock, or halibut, and it is the discarding of these inedible and unmarketable species that adds to the cost of the fish that are marketed.

Fishing can be made a really profitable business when everything that the fisherman takes in his nets or on his hooks can be taken to port and marketed. Many fine, edible fish are cast back into the sea because there is no market for them. This is not right. We must make a market for them. I believe that filleting is going to help in providing an outlet for the unpopular varieties, because filleting will conceal their idenity and they will gain favor from their flavor and not from their original appearance. Good, edible varieties, of repulsive appearance in the round (such as cusk, wolf fish, ling, skate, monkfish and others), skinned and filleted will hold their own in flavor and appearance with any of the popular varieties.

But that is something that will follow expansion of the trade in fillets. We have a real problem in trying to create ways and means for utilizing the inedible fish and the waste from dressed fish. Fish meal, fertilizers, glue, oil, and other products can be manufactured from such waste, but efforts to develop this angle of the fisheries have been somewhat slow. There are fish-reduction plants on the market, for most of which the claim is made that they can do the work. Experiments made with some of them, however, have proven that they are useful only with certain classes of fish. Other plants are too costly and complicated, while some are barred from many of the fishing centers because of the odor from them while in operation.

Here, again, is a field of investigation for Government bureaus. An investigation and report that will advise fishermen and vessel owners how to take care of the gurry and waste fish on board their vessels, and which will determine the kind of appartus suitable for the manufacture of fish waste into useful products and the possible market for such products, will be of inestimable value to the fishing industry. The necessity for action along this line is most urgent. The costs of operating a fishing vessel or a fishery are increasing every year. The unit of investment is becoming greater, but the price received for the fish is not keeping pace. The fishermen are not receiving an adequate return for their labor in many fisheries, and if nothing is done to make their work more remunerative we will have no fishermen. The native American dropped out of the fisheries long ago; the Canadians and Newfoundlanders who took their places are also dropping out; and when the Europeans, who are taking their places, become Americanized, they will pass on also. Make fishing an attractive occupation financially and the young men of the seacoast towns and villages will turn away from the factories and take to the sea.

The vessel owner, as a rule, makes but little on his investment. Many fishing fleets show no profit from their fishing operations, but are maintained by wholesale producers for the purpose of insuring a supply of fish. Unless the full value is obtained from the fish caught—waste fish and offal included—a rise in the cost of the marketable product may be expected; and then fish will be so costly that it will become a luxury. By utilizing the waste and making a profit on it, the price of marketable fish to the consumer can be held at possibly a lower level than exists to-day.

The growth of the fillet business is creating a considerable tonnage of edible waste and bones. It is essential that some recovery be made here. Some companies are manufacturing flaked fish from the fillet cuttings, marketing the flakes in cans. These cuttings are being utilized also in the production of fish loaf. There is a field for investigations here, as the fillet waste is too valuable to be thrown into a glue factory or used as stock for cattle feed and for fertilizer. The bureau, I believe, has this problem in hand and is working upon it.

The bureau has many demands upon the time and knowledge of its skilled staff, and it is only natural that it conserve its efforts and confine its activities to problems worth while and for the good of the greatest number, and after a careful review of the subject upon which I was asked to speak, I believe I have presented the most important and the most pressing. Summed up briefly, it is (1) to help the industry give the public a bountiful supply of fish in the best possible condition and in the most attractive form, thereby expanding the market, and (2) to aid the fisherman to make the fullest use of our fishery resources by utilizing every pound of waste and thereby make his vocation more profitable.

Mr. Higgins. I think we all agree that Captain Wallace has pointed out a fruitful field of work. It is my understanding that the division of fishery industries is already engaged on problems of fishery technology that are particularly urgent. We should all bear in mind these problems of industry at the same time that we are carrying on our biological investigations, for if there were no economic problems, there would be no biological problems.

Captain Wallace. I noticed that in Mr. Sette's graphs of the cod and haddock fisheries he shows a considerable decline in the codfishery and a rise in the haddock. Would that not be from an economic cause? In the old days there was a great salt fishery conducted out of Gloucester and other New England ports. They wanted cod and would not take haddock. They brought them in for the dried salt codfish market. That business has practically passed out of existence. There is not the market for cod existing in the country to-day as there was years ago. Haddock has started to come up now. I wonder if there is such a thing as a decline in the actual quantity of the cod on the grounds. It would seem to me that there is still a large fleet of French fishermen coming across to the Grand Banks and taking codfish exclusively; also Portuguese. If you could get the statistics of what they are catching and compare them with those of about 20 years ago, you would be able to tell.

Mr. Sette. We don't know the cause exactly. The decline might be due to the failure of the salt-fish trade. I have been compiling statistics of the catch of foreign nations on the Grand Banks. I find that the Newfoundland catch, although it fluctuates, is now on relatively the same level that it was in 1850. It is interesting to note that they have an increased return per vessel and per man, probably indicating increased efficiency in fishing. It is up to the investigator to separate the economic from the biological causes in the case of any change in the quantities of fish caught.

Mr. RADCLIFFE. The outstanding point revealed by Mr. Sette's discussion is the need for continuous, regular statistics for each year. If we had regular statistics, interpreted by economic conditions that we know about at the time, then we would have some idea where we were heading in this matter.

In 1921 the whaling interests stopped all operations on the Pacific coast. It was simply for economic reasons—there were just as many whales. The same factor applies to many of the fisheries that have come into prominence in later years. Prior to 1890 there was no demand for many of the fish that now are important. The fisherman did not bring them in. The economic factor is important.

Mr. SETTE. When you really come down to the basis of this matter of yield of fisheries, the entire thing is economic. It is an economic impulse that causes men to fish for profit, and if investigators ignore the economic phase of the situation, they can't possibly explain what is happening.

Mr. HIGGINS. I have always felt that there was a great mass of information concerning fisheries that failed in getting over or producing results. I have not been able to decide whether it is because of the form of the investigation or solely because of the lack of an intermediary between the technical investigator and the fishery administrator—a go-between of some sort, an agency consciously developing and applying the results of theoretical research to fishery problems, to the actual formulation of regulations for the conservation or rehabilitation of a fishery. I believe the fishery investigators themselves necessarily must consider the final application of their investigations to the formulation of laws and regulations for the protection of fisheries, and in order that we may gain some more concrete notion of the problems of fishery administrators and of the actual application of fishery regulations I have asked Mr. N. B. Scofield, in charge of the department of commercial fisheries of the California Fish and Game Commission, to discuss some of these problems.

PROBLEMS OF THE FISHERIES ADMINISTRATOR

By N. B. SCOFIELD

In charge commercial fisheries, California Fish and Game Commission

I can speak only as regards our experiences in California, some of which I will give with the hope that the problems that have arisen there and the way in which we have attempted to meet them will offer some benefit to those who may have similar problems to meet, or to those who are in a position to advise where the work of conserving the fisheries is in process of organization.

The first problem has to do with organization. At the present time the States have jurisdiction over their fisheries, and for that reason are responsible for the care and protection of these fisheries. The majority of the States have fish and game commissions, whose business it is to conserve the fish and game resources of the State. The tendency is to divide the work of conserving the commercial fisheries among separate commissions, and in a number of States we have one commission looking after the game and sport fish and another commission looking after the commercial fisheries.

I believe it is a mistake to separate the two interests, for the antipathy that exists between the sportsman and the commercial fishman is thus intensified. In a State where the two factions are interested in the same species of fish it would be better to have only one commission as the arbiter between the warring factions, for with such an arrangement it is easier to come to an agreement. From the standpoint of economy in administration, in the enforcement of laws, and the operation of fish hatcheries, it is better to keep them together. Where there is a separate commission to administer the commercial fisheries there is a tendency to put in commissioners who are financially interested in the fisheries, for it is difficult to get any one to give his time who knows much about the fisheries and is able but who is not financially interested in some way. The general public knows very little about the commercial fisheries, especially the ocean fisheries, and for that reason is little interested in fisheries conservation. The result is that the commercial interests will dictate the policies of the commission; and it is a notorious fact that almost everyone is strong for conservation except when it hits his purse or his sport.

Many more people are interested in angling for sport, and they are strongly in favor of protection for all fish, especially if it is to protect them against the commercial fisherman. These ardent anglers frequently can be very helpful in having passed legislation to prevent the overexploitation of a fishery.

In California, you have probably guessed, we have one commission to administer the State's work on game and fish, including the commercial fisheries. The California commission was established in 1872 and was at first known as the California Fish Commission. It is evident that in the early days of the commission it was as much interested in the commercial species of fish as in any others. Its first act was to bring the shad into the State, and the shad is certainly a commercial fish and not a sportsmen's fish. Next, a hatchery for the chinook salmon was established, a fish that is mainly commercial in California. Next, the striped bass was introduced and thrived amazingly. It is a splendid fish for both food and sport, and for that reason is the cause of most of the quarrels between our sportsmen and commercial fishermen. As time went on and the commercial fisheries remained comparatively unimportant, the commission became more a sportsmen's organization, with sportsmen as commissioners.

It was not until 1897, more than 30 years after the establishment of the commission, that any attempt was made to carry on scientific investigations in connection with the commercial fisheries. At that time investigations were begun on the life history of the chinook salmon. From time to time after that zoologists were employed to investigate certain problems pressing for solution. These were along the line of determining facts concerning the life history of certain species of economic importance. These included salmon, striped bass, crab, spiny lobster, abalone, and Pismo clam.

While these investigations were in no case continuous or complete, and there was no organized program for the care of the various fisheries, the commission made remarkably good use of the information gained from the investigations in getting conservation laws passed by the legislature.

With the birth of the tuna-canning industry in southern California in 1912, there also arose an interest in the fisheries on the part of prospective investors and others, and as a result of this interest numerous technical questions were asked of the fish and game commission, which for a time it tried to answer by referring them to persons outside of the commission. It became evident to the commission that it needed to have some one steadily employed who could handle the correspondence relating to the fisheries—one who could familiarize himself with the problems of the growing fisheries.

In 1914 I accepted this position and was given an assistant, and a little later we were given a room with a telephone, and later we acquired a stenographer, and soon our own files and reference books. We grew to be looked upon as a part of the commission. To some we were an unnecessary part and were jokingly dubbed the "hot-air department."

I have given these details to show that the organized fisheries work of California was forced upon it by the growing fisheries industries. The two members of the department busied themselves with getting all the information they could on the fisheries subjects that were expected to come up at the 1915 session of the State legislature. During that session, the two members of the new department were present at all of the meetings of the fish and game committees of both the senate and house. We were there at the request of the chairmen of the two committees to give any technical information that might be desired by the committees. It was easier in those days, when we were hitting only the high spots, to answer the questions than it was later, when we knew more about it. With all that, our information was of a higher order than the committees were accustomed to getting, and that is not saying very much.

The fisheries laws, of California at least, are highly complicated, and the committees are glad to have State men with technical fisheries knowledge, as well as knowledge of game, continually present at the sessions, and the amount of work they turn over to these men would surprise you. Committee members will get technical letters from their constituents which they are unable to answer. They need advice as to how certain measures will appeal to their constituents. At all times we have been careful not to appear partisan, except, possibly, on the side of conservation. We are careful to give all the facts as we know them, so that the committee may draw its own conclusions. But, usually, members of the committee wish to know what our personal opinion is. The committees have more and more come to rely on the representatives of the commission, and there is no denying that the opinions of those representatives carry a great deal of weight. What we have done in this respect in California I think any State can do. These men, acting for the fish and game commission at Sacramento, are not politicians, nor are they lobbyists in the usual accepted sense. By this method most of the absurdities in the fisheries laws have been eliminated and good, protective measures have been adopted.

The law under which our commission was established was antiquated and did not meet the new conditions. Under the old law creating the commission the expenditure of money for scientific investigations could not be justified, and I believe this fault can be found in most of the old laws creating fish commissions and probably in some of the new ones as well. We presented a bill to the legislature which made it the duty of the commission to carry on investigations and to determine what measures are advisable for the conservation of any fishery. This bill passed without any opposition.

I do not see how any State fisheries department can get very far unless it has influence at the State capitol. I believe any fisheries department can gain the necessary influence by keeping men in attendance at the legislature who are honest and have tact and are scientifically trained. They should know the fisheries, of course. The advice and help of a lobbyist is a valuable asset to any State commission. That, I believe, will hold true for a Federal department or bureau.

To look back now over the past history of the California department of commercial fisheries it appears that chance was the controlling factor. At the very beginning we had a vague idea that the basis of our fisheries work must be accurate and complete statistics. We got a bill through during the 1915 session of the legislature that required fish dealers and canners to give the commission a monthly record of all fish received. This gave way to a much better law four years later which gives to the commission a carbon copy of every receipt issued to fishermen and which contain all the data desired. The same law required every fishing boat to register and to give a description of the boat and the gear used.

At the second legislative session after our organization we got through a fisheries tax which, together with the commercial fishing license already in existence, gave us adequate funds to enlarge the department.

We had the support of most of the fisheries people in these measures. The southern California tuna canners were for us. It so happened that the tuna fishermen were hard pressed to find bait—sardines or anchovies—and about the only place where the bait could be found was in the water around Catalina Island, which the sportsmen had succeeded a few years before in closing against the use of nets. The tuna canners wanted part of the island open for bait fishing, and they wanted and needed our help.

In the summer of 1915, while the Pacific division of the American association was meeting at San Diego, an afternoon was set aside for some papers and a discussion of tuna problems. One of the canners stated there that the tuna canners would like to know from the scientists how much fishing the albacore could stand without exhausting the supply. He said that the schools of albacore appeared to be getting smaller, although the fishery was then only two or three years old. Each year additional canneries were being built and the old canneries were being increased in size. He asked the very practical question: "Is there any way to tell how many albacore can be taken each year without ruining the supply?" If the canner could know that, he said, then he and others would know whether they should increase their investment or decrease it. Nobody had the answer and no one seemed to have a very clear idea of how to go to work to find the answer. It struck me that it would be a good thing if our embryo department were to set itself the task of working toward the answer of this interesting and practical albacore problem.

Later, when I read W. F. Thompson's paper on the Pacific halibut, where he answered that very question, in part, for the halibut, I made up my mind we needed him for the albacore work. Our success in getting the fisheries tax bill through made it possible for us to get Thompson in 1917. Under his direction, a scientific fisheries program was built, the basis of which was to find out how much fishing a fishery can stand.

After the employment of Thompson, and after we had used unsuitable quarters in southern California for carrying on the albacore work, we came to see that any adequate fisheries program should be a continuous one, and that we should have quarters of our own. The commission, it happened, had the money, so we built a State fisheries laboratory at Terminal Island, near the canneries of that district and near Fish Harbor.

This laboratory stands as a symbol of the scientific fisheries program that has been instituted, and it is believed that it will aid greatly in making the program a permanent one. Our great difficulty was to get men for our work. Mr. Thompson, as director of the laboratory, had to search the universities for likely young men with zoological training, and these men he had to train in the technique required in the fisheries work.

A serious problem at this stage was the matter of salaries. We were a part of an organization that paid very poor salaries. It was hard to get the salaries raised above those being paid in the departments of patrol and fish culture, and before we were able to convince the commissioners, the executive officer, the State civil service commission, and the State board of control that these fishery investigators should get at least as much as a teacher of science in a high school, we had lost nearly all our men. But this we have not regretted so much, for the fisheries program that we have adopted is a sort of religion with us, and wherever those men have gone they have been spreading the gospel.

The matter of salaries has now been largely overcome. About all that remains for us to do is to develop another lot of enthusiastic investigators and trust that we can keep them. Possibly by that time the laboratory will have become famous as the producer of those young men who have already gone forth, and we will be besieged by young zoologist applicants who are up in their mathematics and who delight in statistics, adding machines, rapid calculators, and the rest of the modern improvements.

I have been asked by that department of the National Research Council that has to do with States relations how we managed in California to sell our scientific work to the fisheries people. That is not so easy to answer.

It is of advantage to the fisheries interests to have a State department that has sufficient knowledge of their business to help shield them from ill-advised legislation. They recognize the scientific work as a method of obtaining at least part of the evidence that will prevent unnecessary restrictions being placed on the fisheries. They feel that they should be interested in the scientific work, for they are paying the bill. We did our best to get them, or some of them, to understand our work, but with little success. They were unable to judge as to whether or not we were making the proper use of the tax they were paying. At one time they contended that they could not see how our scientific work was benefiting them one nickel, but when they were told by a person on whom they looked as an authority that our work was of a high order they were satisfied that we were all right. Later, when our work was in danger of being curtailed by a governor just elected on an economy platform, the fisheries people were sure they could not exist without the scientific work.

At this time we had received but scant encouragement from zoologists and scientific men within the State, so we were surprised and delighted at the splendid letters these men wrote the governor about our work, in response to our appeal. From that time on the governor's office, as well as the members of the State board of control, took a greater interest in us, and it raised our standing within our own commission. People like you better after they have done something for you, and this holds with scientific people just as with anyone else.

One of the biggest of our department problems has been the enforcement of the State "fish reduction act," which would regulate the use of sardines for reduction purposes. This law was put through several years ago at the request of the sardine canners, who were alarmed at the wholesale destruction of sardines in reduction plants. Each cannery has its by-products plant, and when, after the armistice, the sardine market collapsed and the market for fish oil and meal remained high, the canners naturally wished to tide over the depression by using a liberal amount of sardines in their reduction plants. A law was put through by agreement between the fish and game commission and the canners which permitted the canners to use 25 per cent of the sardines for the manufacture of oil and meal. At first we had difficulty in preventing the canners from using more for reduction than the law allowed, but as we gained in experience and understanding of the intricate ways of the sardine-canning business we were better able to hold them down. We had many legal battles, all quite friendly ones, and succeeded in adding some very interesting court decisions to the State's fisheries history. The law was amended several times and will be changed again at this present session of the legislature. The enforcement of this act, together with all the conferences and correspondence, takes a great deal of our time and energy. We hope to get a law so simple this time that there will be no argument about it.

One of the latest things we have had to contend with is the floating reduction plant which purposed to operate outside the 3-mile limit and receive fish caught outside the 3-mile limit. The first one of these plants, a large concrete ship, was anchored about 4 miles from shore, but within Monterey Bay. When two purse-seine boats delivered sardines (some 90 tons) to this plant, we placed the fishermen under arrest, seized the two nets, valued at $4,000 each, and got a temporary injunction from the superior court of Santa Cruz County to prevent the company from operating the plant. They went to the Federal court for an injunction and damages against the commission and its officers. The Federal court decided that Monterey Bay was State territory. The company then appealed to the State supreme court and we are still awaiting a decision from that court. In the meantime, this plant moved down the coast and anchored off Santa Barbara, and at about the same time another and larger floating reduction plant, which had outfitted at Oakland, moved down to the same place after losing a suit in the superior court of Alameda County to enjoin the commission from interfering with their operations. With our patrol boats constantly on guard the fishermen were afraid to fish for these plants and one of them has given up and returned to port. The other is again asking for an injunction in the Los Angeles courts.

This illustrates a very interesting situation. The State's jurisdiction ends at the 3-mile limit, except possibly in bays in California. In some of our fisheries all of the fish are caught outside the 3-mile limit. In others, a large proportion are caught outside of that limit. Seventy-five per cent of the salmon caught by trolling off the coast of California are from outside the 3-mile limit. We have suspected that many of the salmon caught off the northern coast of California are from Oregon and Washington. Recent tagging experiments show that some of the salmon from the Sacramento River are caught by trollers off the coast of British Columbia. California fishermen go into the waters of Mexico for a part of their fish, on which Mexico attempts to collect an exhorbitant tax. Our problems have grown until they extend beyond the jurisdiction of the State.

This situation can be met in part by international treaties through the aid of our own Government, but we need also some sort of cooperation between States, as well—some plan whereby the States can look after their own local affairs but be under some sort of supervision by the central Government so that there will be coordinated control of the fisheries common to several States. Under the international fisheries treaty between the United States and Mexico we are trying to work out a plan under which the two Governments and the State of California can cooperate in the case of California's fisheries. Possibly this will work out as an example of how the State and the Government can cooperate.

Mr. Higgins. I should like to ask Mr. Scofield if he considers the plan of fishery administration, as worked out in California, applicable to other States on the Pacific and Atlantic coasts, and if the urge to conduct the scientific work necessary to put such a system into operation can come from the outside, such as from the Federal Government, the Bureau of Fisheries, or if it must come from the industries within these States?

Mr. Scofield. I think that that could well be started by the Federal Government or its agents. People in the States don't know, usually, that they need an organization of that sort, and if it is suggested directly, it seems to me they can be interested and should be able to get those in authority, for instance a fish and game commission, to act together with the industry and form a department. It seems to me it could be developed in the same way in which we proceeded in California.

Mr. Higgins. You think the Bureau of Fisheries could take a leading part in developing adequate administrations in the States?

Mr. Scofield. I think so. It would have been a great help to us.

Mr. Radcliffe. Isn't it virtually necessary that you have some clearing house of this kind? Your fish do not recognize boundary lines. Therefore, if you are going to have proper statistics, shouldn't there be some way of getting the several States to provide comparable ways of collecting statistics, such as a central clearing house?

Mr. Scofield. I think that would have to be done to get the statistics right.

Mr. Higgins. We all appreciate Mr. Scofield's review of the experience of California. California, I think I can say, has led the United States in wise fishery administration, and we can look to California as a model for all the other States in the matter of obtaining exact knowledge of the course of a fishery, through their excellent system of taking statistics.

I have something here that will prove of interest—an article by a rather caustic critic of the Ministry of Marine and Fisheries in England, whose criticisms are always interesting and sometimes very much to the point. He writes under the name of "Quibbon" in the Fish Trades Gazette in London.

There has just been issued, as an appendix to the report of the U. S. Commissioner of Fisheries for 1926, a modest pamphlet, of 36 pages, on "Progress in Biological Inquiries, 1925," by Dr. Willis H. Rich, the assistant in charge of scientific inquiry. The price of this paper is 10 cents, or fivepence (from the Superintendent of Documents, Government Printing Office, Washington, D. C.), which contracts with the price of similar publications issued by our stationery office. A perusal of it shows how enormously the United States has advanced in fisheries research in the last few years. Not so very long ago there was very little organized research, although many papers were published dealing with certain fishes or fisheries. After reading this report, it would appear that fishery research in America is now as intense and extensive as it is in Europe. Almost every field of inquiry is covered in a systematic way, and the methods which have been proved of utility are now adopted. The report is an able summary of what is being done. It is said that "the policy of stressing the study of the immediate rather than the ultimate causes of fluctuations in the abundance of fish of each species was continued"; and that "emphasis has been placed on the investigations giving the greatest promises of results of practical importance in the conservation and development of the fishery resources." This is as it should be. It is the duty of fishery departments everywhere to follow the same policy, leaving it to the universities, or other institutions (as the Marine Biological Association in this country), with more or less financial assistance from the State, to undertake the more theoretical researches—which, however, it must be said, may be ultimately of no less practical importance. It is pointed out that true conservation of the fisheries means not only guarding them against depletion, but making use of them to the greatest possible extent compatible with their perpetuation. The difficulty is to determine from year to year what the excess production is, and how much of the stock may be taken by man without endangering the future supply. We must know the causes of the fluctuations in the yield from year to year, and how these fluctuations may be controlled, if that be possible. The greatest difficulty the bureau has to contend with is the scarcity of properly trained men interested in fishery investigations. * * *.

Just what course scientific investigations of the fisheries should follow is a problem of greatest concern to all of us. I have asked Mr. Will F. Thompson, who has had many years of experience in fishery investigations of a rather technical type, to give us his ideas of what scientific investigations of the fisheries might well consist.

SCIENTIFIC INVESTIGATION OF MARINE FISHERIES

By WILL F. THOMPSON

Director of scientific investigations, International Fishery Commission, United States and Canada

It is generally accepted that the end and aim of governmental fisheries science is the conservation and the more adequate use of our fisheries. Under this, the detection and prevention of overfishing comes first, as far as the sea is concerned, for by far the greater number of our fishery industries are based upon species not capable of artificial propagation or culture of any kind. Next in order of importance comes the detection and foretelling of the great fluctuations in abundance due to natural causes, such as unusually abundant year classes. You will hear enough with respect to the latter before this conference is over. My purpose is to emphasize to you the great problems underlying the first great objective—the detection and prevention of overfishing.

I wish to do this because I am firmly convinced that they are not only really great problems, from an economic standpoint, but also truly great problems to the biologist. The men engaged upon these major problems are not confined in their work to the economic application of principles already discovered; they are formulating those principles and attacking problems in which the investigator in pure biology should be proud to be interested.

The fundamentals underlying the utilization of our sea fisheries have not yet attracted the attention they should. As one looks through the literature, it would appear as though the basic rule for the conduct of investigations has been the general one that everything connected with the fish or its environment, the ocean, is of importance and should be studied. This view is undoubtedly sound, but it is equivalent to saying that the study of everything on land is of importance when studying the production of beef cattle. The statement is too diffuse to have any meaning. It has led, in the case of the North Sea fisheries, to the comparative neglect of a really great problem—that of the nature of overfishing.

To say that our problem, or group of problems, is the study of the decline in productivity of certain fisheries is trite. That definition is commonly accepted without any thought as to its real significance. Suppose that we attempt to probe a little deeper into the yield of a species of fish. We find very shortly that we do not know what overfishing really consists in, that we have no measure of the strain a species will stand, that we do not know the character or type of the reaction of the supply to the demand. Our ignorance is intolerable in view of the greatness of the stake, and the presence of constantly decreasing yields for the effort involved should stir us to some sort of action. Regardless of theory, the abundance of fish must not go on decreasing, especially in the face of the fact that we are not at the crest of a period of exploitation but rather at the beginning of such an era.

This era of exploitation is accompanied by an era of constantly increasing efficiency, sufficient to mask for the time being whatever decline may really exist. One is tempted to date the beginning of intensive exploitation as far back as the application of steam to marine vessels and to railway transportation; yet since that time new apparatus, new internal-combustion engines, new methods of handling have been devised, so that we find ourselves under the constant necessity of redefining what we mean by an intensive fishery.

I am thinking specifically of such fisheries as those for the halibut, the plaice, and the albacore. The total yield may remain the same, yet when some accurate measure of fishing effort is used, it is seen that a far smaller catch is obtained for that effort and a far greater area is covered. One sees a constantly increasing intensity necessary to maintain the yield. With regard to other species, what reason have we to rely upon the belief that the most prolific and as yet untouched species will not follow in the path of the halibut and the plaice, in the face of the infinite threat of mankind's expanding powers?

I will use the halibut to illustrate my theme, as I am most familiar with it. The details of the decline in catch per skate of 210 hooks have not been worked out fully, but in so far as they have, the curve of abundance may be shown tentatively in Figure 12, where the decline is represented on a logarithmic scale to show that it is taking place at a steady rate of fall. The straight line, representing the rate of fall, is translated in Figure 13 into actual poundage per skate of 210 hooks to give a hypothetical curve of abundance.

In any subsequent remarks concerning abundance you will understand that by abundance I mean this yield per skate of 210 hooks. This is the most accurate measure of abundance we find at hand.

This decline represents only the older section of the banks, which constitutes now a more or less distinct fishery. The total yield from this has declined greatly in recent years; just how fast we do not yet know, but we may draw in a level line in Figure 13, representing the total yield as shown, for the purposes of discussion. Nor do we as yet know the intensity of the fishery from year to year, but we may calculate, from the yield per skate, what it must be to maintain the total yield, and we represent its increase by a tentative line, rising rapidly. In general our work supports these curves, as they would be modified by a declining yield.

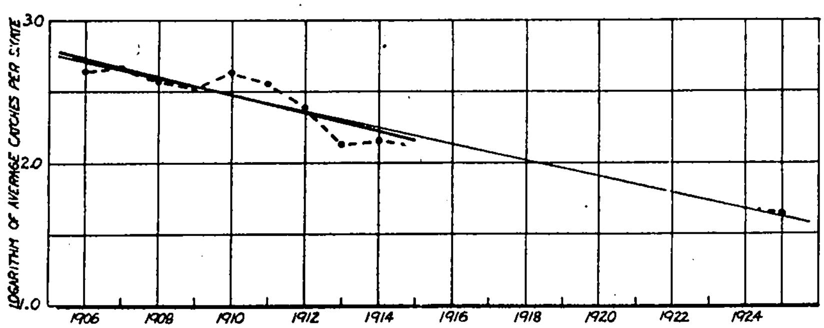

FIG. 12.—Rate of decline of halibut catch per unit of gear, represented on a logarithmic scale to show the steady rate of fall. Short straight line shows rate of fall as determined from data for 1906 to 1914, inclusive. Long straight line shows rate of fall as determined after addition of data for 1925.

I would call your attention to a fact that all the trade knows—that the economic effort involved for the yield obtained has steadily risen, just as is shown by the increased number of skates in Figure 13. It would seem to me that in this is to be found one of the worst phases of the dreaded overfishing. The latter might be defined as that condition of a fishery in which the cost of operation is a maximum for the yield obtained. Let us, for the time being, forget the fears for the very existence of the fishery and think only of this economic condition. The cost of operation of this fishery is raised automatically to the highest point the traffic will bear. It is, in very fact, making the public pay as dearly as it possibly can for what it gets. A very slight change in prices or costs would be disastrous. That may be overfishing. Every improvement in gear, in engines, or in vessels enables the intensity to rise, as I have seen myself, repeatedly, in the halibut fishery in such cases as the adoption of small hooks. And it must automatically result in decreased abundance, as shown by yield per standard hook. The reopening of the war-closed North Sea automatically resulted, by this reasoning, in a resumption of the preceding level of abundance as determined by economic factors, not necessarily by biological factors. It does not seem to me necessary to seek a biological explanation for this seemingly more stable lower level.

I have made this statement most emphatic for the purpose of clarity. In reality, we do not know enough about the relationship of these curves to discuss them intelligently. There are statistical, biological, and economic phases to this great problem, but in that equation, or series of equations, which will link these three graphs—of intensity, abundance, and yield—lies the problem of fisheries science as I see it.

It seems to me, from my experience with the halibut and my reading in fisheries reports, that it is possible to maintain the abundance at a higher level by restricting the fishery. Thus, the yield per skate on our Pacific coast is directly correlated with the cost of operations. Banks as far away as Kodiak Island yield now about 120 pounds per skate; near Cape Ommaney about 60; and in Hecate Straits 43. Of course, these areas may be on a continuous decline, but the rate of the decline is determined largely by economic conditions, and possibly it might be stopped easily. The question then arises, what might the yield be were the decline stopped at any particular level? Would it be noticeably less at the higher levels of abundance? It might be greater.

We must at once admit that there may be a remote possibility that a fixed level of abundance (say at 40 pounds to a skate) would remain at that level even though 40,000,000 pounds were taken out by a highly intensified fishery of 1,000,000 skates yearly; whereas a fixed level at 120 pounds to a skate might yield, without decline, about 20,000,000 as the result of the use of but one-sixth of a million skates. The difference in total yield of 20,000,000 might,

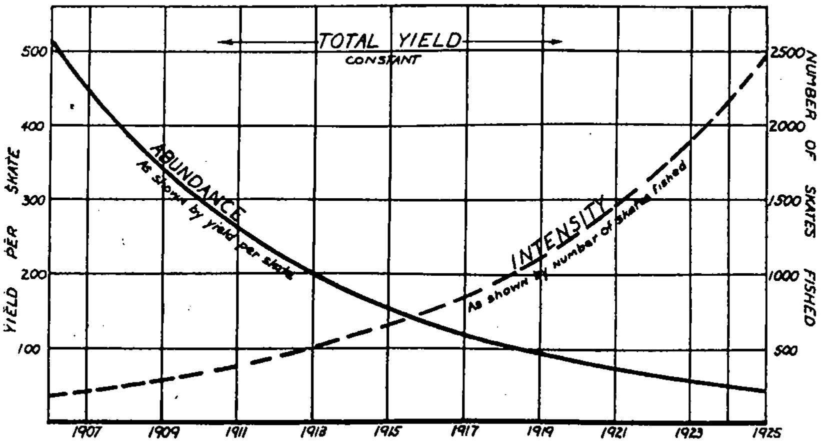

FIG. 18.—Hypothetical abundance in halibut fishery, showing various levels (left margin and unbroken line) and the numbers of skates required (right margin and broken line) to produce a fixed annual yield of 100,000 pounds

from an economic standpoint, justify the principal of making the public pay all it could. Would it be economically worth while to double the yield by fishing six times as much gear? Perhaps so; perhaps not.

	Case 1	Case 2
Abundance	40 pounds per skate	120 pounds per skate.
Total yield	40,000,000 pounds	20,000,000 pounds.
Intensity	1,000,000 skates	166,667 skates.

However, we have no such knowledge as to the course of events. The total yield might very well be the same in both cases, or even greater under restriction. Nor do we know what the final reaction of a species is to intensified fishing. That is a biological problem of first magnitude to which we will return.

As we have said, the great fisheries have been and are in a condition of constant increase of efficiency and intensity. This increase has been so consistent and continuous as to give ground for thought as to whether it will reach a limit, or as to what a terrific strain it may finally impose on our available species.

The total yield, however, has not increased correspondingly in the threatened fisheries, such as plaice and halibut, however much it may have in those formerly less used, or however much the yield may be affected by extension of banks. The question arises in my mind as to the result were this increase of efficiency and intensity to stop. Would the total yield thereupon enter a decline? It would seem to be doing so in the case of the halibut on the older grounds despite the increase in efficiency.

But speculation is rather useless as to the future of our great fisheries—we have no real records as yet to use. We must observe what fisheries we have before us, and we must recognize, in the *continuity* of the decline in abundance, a very real threat. We must never forget that there may be a lower limit of abundance beyond which the species may not be able to breed at all; that if there is no limit to efficiency and intensity there is no limit to the decline. And the whole vast future of our fisheries may proceed on a grossly wasteful and inefficient, as well as dangerous, course if we do not solve our problem. Nor will conservation ever be sane until based scientifically.

I might briefly summarize the points I wish to make, and then take them up in turn for discussion.

1. Our problem, as reviewed above, requires, first of all, adequate studies of yield, not merely total but per unit of gear or effort.

2. It then requires a study of the reaction of the species to fishing.

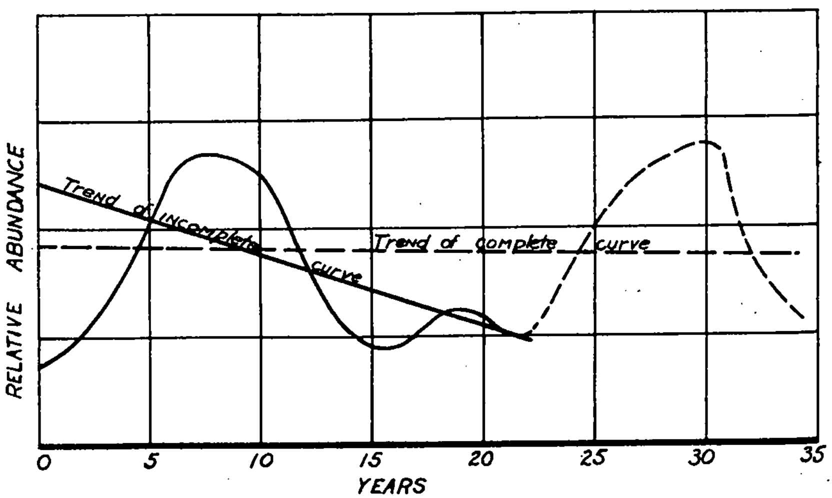

FIG. 14.—Hypothetical fluctuating abundance of a species of fish, with mathematically determined trends to show error that might arise from incomplete data

3. And, finally, our proposal to restore previous levels of abundance will require restrictive measures based on the biology of the species and the economics of the fishery.

The scientific investigation of marine fisheries has come to mean, to me, first of all, the establishment of adequate statistics of yield and abundance. This is not a simple problem. It requires accuracy, of course, but it also requires the discovery of some measure of abundance—as the yield per skate of 210 hooks in the halibut fishery. It implies, still more, the careful observation of the unit of gear for small changes, such as the use of small hooks instead of large, and the recording of the exact localities. But over and beyond this, it implies the study of the categories of fish taken, changes in which accompany and may exceed in value, to us, the changes in quantity. The study of these changes by means of age analyses, etc., is, of course, biology. How it can be separated from statistics is unknown to me.

Methods of sampling the catch are still in rudimentary shape. Once the data are at hand, there arise the difficulties of interpretation, and the scientific point of view becomes of exceeding value. To cite but one case as a warning: We have found in the herringlike fishes great fluctuations in abundance. These extend over a period of 10 years, perhaps. The result to our curve of abundance might possibly be thus (fig. 14):

Even to the nonmathematical eye it should be plain that the trend can not be determined until a great many years' records are available. In such fisheries, detection of a decline in abundance or in total yield may require more time than has elapsed since the beginning of the real fishery.

It seems, finally, that the separation of economic effects is difficult and occasionally impossible.

The biological problems involved in the study of the reaction of the species to intensive fishing revolve for us very largely around the possibility of greater resistance at lower levels of abundance. To illustrate: A highly respected English scientist postulates[5] that the more intense the fishery, the better condition it finds itself in. This reasoning is based on the sequence in events in the North Sea as a result of its closure and is, very briefly, a theory that under natural conditions the competition between adults and young starves the latter and vastly reduces their number and their rate of growth. When the banks are intensively fished, the removal of the adults allows the young to grow faster and survive in greater numbers, so that they replace all that the fishery takes. Unfortunately, it is impossible for us to ignore selection by the fishermen when both young and adults are available, and facts from other sources[6] indicate that as a result of the North Sea closure both young and adults increased in numbers. Furthermore, the young occupy "nursery areas." They do not inevitably compete with the adults, nor are the great mass of their competitors for food necessarily members of their own species. But I am not criticizing the paper; it is theory I am interested in, and Garstang's theory does at least present the possibility that an intensive fishery leads to a greater productivity at lower levels of abundance. He makes use of facts of growth, and should make use of facts of migration, to formulate his equation, for such it really is.

Another attempt is equally interesting. A Russian scientist[7] postulates that the *production of a surplus pound* of fish *requires thrice the nutriment that the maintenance* of a pound requires. The abundance of fish, under his theory, will fall until sufficient food supply is freed for use, so that the rate of reproduction (beyond that to maintain the stock existing each year) exceeds the demand by man. It is hard to understand, at least for me, but he does make an effort to expresss the problem of the increased resistance or increased productivity of a species, which he assumes exists at a low level of abundance. He believes the food supply to be definitely limited in amount and used largely by the plaice, as does Garstang, but fails to see that the rule he applies to the plaice might well apply equally to the animals it uses as food. The intensive use of the food supply by the plaice might lead to greater productivity of the said foods and the elimination of useless competitors, so that in the end it might not make any difference how many plaice existed—they would never run short of food, any more than mankind would run short of plaice.

However, the battle is fairly joined, as to the productivity of a species under various intensities of fishing. To me the only possible method of solution is the experimental one. But it is a great problem, indeed, and in its solution lies our sole hope of reducing the exploitation of our major marine resources to a logical basis.

In passing, I would like to call your attention to the biological importance of such studies. Mankind's demand on the fisheries is a type of adverse condition leading to greater mortality, very similar in many of its effects, perhaps, to the adverse conditions met by a species in nature. The power of survival exhibited by a species in contact with man seems to me to be that power that has enabled it to survive through the ages; and the record of evolution may be, in fact, the record of development of these powers.

Our analysis of the factors important to us may throw light upon the nature and methods of evolution.

Let us consider for a minute the facts brought to light in the study of dominant year classes in herring, sardines, and other fish. It might be supposed that the abundance from year to year would remain level; but our experience with sardines, herring, and Mr. Sette's mackerel, as well as locusts

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[5] Garstang, Walter: Plaice in the North Sea. London Times, Apr. 21, p. 15, and Apr. 26, p. 20; 1926.

[6] Heincke and Mielck: Schongebiete für die Scholle in der Nordsee. Berichte der Deutschen Wissenschaftlichen Kommission für Meeresforschung, neue Folge, Band 11, Heft 1.

[7] Baranov: On the question of the dynamics of the fishing industry. Bulletin of Fishery Economics, No. 8, Moscow, 1925.

and other animals, has shown this to be far from true. There very obviously is great variability in the conditions of survival, the yield varying widely from year to year, even in cultivated organisms. We have learned, indeed, that an organism must meet, in the course of its existence, periods of varying length in which adverse conditions of varying intensity prevail, causing great unequal infant mortality.

A species in the state of nature has existed throughout the ages. It has had to survive the most extreme of these periods in length and intensity. It is my thought that this variability in nature has played a major rôle in evolution and in the survival of species. Many characteristics of a living organism are of importance from this standpoint, and theoretically, at least, it is easy to conceive that the reproductive power of a species must have an excess beyond that required by a favorable or normal year.

I think of many characters of a species as adapted to meet the normal or ordinary emergencies of the annual cycle. The power of resisting freezing, which many spores have, is an example. These many characters must be developed far beyond the ordinary in order to meet the occasional extraordinary conditions. For our purposes, however, I am thinking mainly of those characters that serve to bridge the adverse periods of various durations. An animal, developing warmth of blood, is capable of surviving more than a year with less loss in numbers. So, too, the young are protected by the adults through the period of highest fatality, the protection in some cases lasting sufficiently long to bridge an ordinary long period of difficult years.

Foremost among survival characters one must place age. The halibut reaches a great age, as do the elephant and man. One inevitably thinks of the significance of this age as a survival factor of first magnitude. The loss of one year's spawning is but a fifteenth of the total loss for the life of an individual, and after a period of adverse years the adult is left to spawn anew.

But species vary widely in such characters as food, habits, age, fecundity or egg production—they meet the situation differently. Why can not we expect infinite variety in the reaction of survival characters to the strain imposed by man? The halibut is long-lived and comes to maturity at 12 years. Man's attack on the adults shortens greatly the average duration of life and seems to me to be undermining the very character upon which the halibut largely depends for its power of survival. May his fishing efforts not result in the inability of that species to meet and overcome some prolonged period of adversity? In that case it may disappear, entirely or over large areas. The reverse may be true of the herring—who knows? But at all events, it may be fair to think that we will have as many problems as there are species.

Perhaps, using the factors of age, food production, egg production, and migration, man may be able at some time to deduce some general law as to the productivity of a species and as to the value of characters contributing to this power of survival. The solution of such a problem may contribute vitally not merely to fisheries science but to biology. The power of survival is an essential part of the evolution of a species.

The most promising method of attack seems to me to be through experiment, carefully observed by statistical method. Under known biological conditions of age, migration, spawning, etc., certain results may be obtained. In time a general law may be framed to bring these into harmony, but until then, and as a means to such an end, we certainly must seek results experimentally.

So much for the second great problem of fisheries science. Our first was to obtain accurate methods of observation, our second to ascertain the method of reaction of the species to the strain. Our third must be to devise methods of protection.

After much thought concerning the halibut and other species, it seems to me that almost all protective measures are based upon the degree of migration existing. The reason for this is easy to see when the significance of a high degree of independence between banks is grasped. An isolated race of fish is depleted as a separate unit and must be rebuilt as a separate unit. With a homogenous, freely moving species the case must be just the reverse—it must be dealt with as a whole. Let us, then, set the study of migrations above all others when protective measures are discussed.

It is not necessary to review at length the means of such study. Tagging, the finding of racial characters, of differing growth rates, of finding physical traces in the individual of its past life history—all these are biological studies of great importance.

My purpose is not to emphasize to you the known methods of research. I wish, rather, to outline the great problems; and in regard to the nature of protective measures I find one of these great problems.

To begin with, if restriction is necessary, there are many types of it. Some species have been protected by saving the spawning adults, others by saving the immature. There is no cold scientific reasoning back of these measures. They are restrictive, they are expedient from an economic standpoint, they are popular, and hence they are those that it is advisable to impose. Once restriction is granted as necessary, and as either limited in area or general in application, the choice of restrictive measures becomes economic and political, not biological. I am not speaking of the salmon, of course, in which there is but one stage to restrict, but of marine fishes, many life stages of which are exploited. Restriction and regulation, however necessary, are not and can not as yet be based upon biological reasoning.

To illustrate, is there any biological reasoning that justifies the protection of halibut young? They are the most abundant members of the species. They are scarcely touched as yet. Many of those taken would die before maturity anyway. As a matter of fact, however, an economic reason justifies their protection—they are not worth as much for food, pound for pound.

I wish to suggest here, as a biologist, that the existing relative abundance of the various stages or ages of fish in nature is presumably that best fitted for the survival of a species. That is, if a species spawns 1,000,000 eggs, that habit has been acquired by a natural selection to meet the conditions of the environment. So with the young—their numbers are adapted to conditions to be met. But somewhere in the cycle between egg and adult must be a stage or stages in which there exists the reserve power of survival. Until we know, then, what characters affect this reserve power our restrictions and regulations may be more or less arbitrary.

There is only one sound biological principle that I can suggest. That is, that if mankind takes his toll before a period of great mortality, it must mean less to the species, proportionately, than if the toll were taken after such a period. That is, put concretely, if 1,000 pounds of fish exist, 100 pounds taken constitute only one-tenth; but if this 1,000 pounds pass through a period of mortality that reduces it to 500 pounds, and the toll then be taken, the toll of 100 pounds constitutes one-fifth instead of one-tenth. If to spawn and reproduce a species passes through such periods of intensified mortality, surely one would safely recommend that wherever possible man's toll be taken before these periods.

There is, of course, another thought—that where a species taken mostly as an adult declines in abundance it would be in order to protect the adult stage as the weakened link in the chain. But, of course, industry has its say there.

To sum up these remarks on methods of protection, I would like to think that I have impressed upon you the unscientific state of our present knowledge and the great need of earnest study of basic principles by biologists. In fact, some such remarks as these may apply to all three of the great problems I have touched upon—in determining the trend of the abundance there is need for careful study, in gauging the reaction of the species to the drain of our fisheries and to the results of protection the possibilities and principles are yet to be outlined, and in devising logical methods of protection the field of thought and discovery is wide open.

Looking back over that which I have thought and written, it seems to me that what stands out most clearly is the vast promise in this field of work for one desirous of thinking as he goes. The accomplishments in every essential phase of marine fisheries science seem to be almost *nil*—to have been sadly neglected, compared with what may some day be true. There is here vast opportunity awaiting some clear-minded thinker in biology; and in view of the uncertain knowledge of the basic necessities in marine fisheries conservation, no one taking that duty seriously can afford to expend his efforts aimlessly.

Mr. Higgins. Because I had the making of the plan, I took the liberty of preparing a paper myself, as a target for you to aim at, something to center our discussions on, something to carry in the back of our minds while we are going over each investigator's individual work—the policy of the Bureau of Fisheries in regard to biological investigations. I call them my own ideas; at least I wrote them down, but you will recognize, no doubt, a familiarity in what I have to say. I invite criticism; I invite discussion; and being a target, your sharpest shafts will be welcome.

THE POLICY OF THE BUREAU OF FISHERIES WITH REGARD TO BIOLOGICAL INVESTIGATIONS

By Elmer Higgins
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The first step toward the conservation of our aquatic resources, taken because of the well-defined conviction as to their imminent destruction, was made by Congress in 1871, when the United States Fish Commission was established. Spencer F. Baird, the first commissioner, outlined the duties imposed by Congress, as follows:[8] That it should be the duty of the commissioner "to prosecute" the necessary inquiries, "with the view of ascertaining whether any and what diminution in the number of food fishes of the coast and lakes of the United States has taken place; and, if so, to what causes the same is due; and also whether any and what protection, prohibitory or precautionary measures should be adopted * * *." Thereupon, numerous activities, which had been conducted by scattered agencies such as the United States National Museum, the State fish commissions, and private agencies, were stimulated and centralized by the amazing energy of Commissioner Baird and his associates. The United States Fish Commission (later the United States Bureau of Fisheries) has been, therefore, since its inception, essentially an investigative advisory organization, whose duty it is to discover the need for and devise the means of practical conservation work. The principal direction in which the expansion of original plans has occurred is in the development of fish-cultural operations, intended to prevent depletion or build up the fisheries that have been depleted, and in the administration of the fisheries of Alaska, including the fur-seal industry.

Due to the rosy promises of the newly discovered art of fish culture, Congress was induced to add to the duties of the fish commissioner, at the end of the first year of his service, the artificial propagation of fishes. Under the influence of Professor Baird, an admirable program was initiated and carried out vigorously for many years. Investigations in marine biology were fostered and encouraged. A great marine biological station was established on the Atlantic coast. Vessels and equipment for deep-sea explorations were procured and many extensive expeditions to distant seas undertaken. Physical and economic inventories of the fisheries were made, and technological investigations looking to the more adequate utilization of fishery products and the developing of new fishing areas were begun. It was in the field of fish culture, however, that the most evident progress was made. The principal activity of this most versatile first commissioner was directed toward the wholesale replenishment of supposedly depleted waters. So successful was fish culture in the United States that in 1880 the grand prize of the International Fisheries Exposition at Berlin was awarded to Professor Baird "as the first fish-culturist in the world."

The early attitude of the commission toward scientific work, which included the "systematic investigation of the waters of the United States and the biological and physical problems which they present," was admirably expressed by G. Brown Goode[9] in 1884 as follows:

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

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[8] The status of the U. S. Fish Commission in 1884. By G. Brown Goode. Appendix E, Report, United States Fish Commissioner for 1884 (1996), p. 1141.
[9] Idem, p. 1141.

All of this, you will admit, has a distinctly modern flavor, but he concludes[10] that in order to neutralize destructive tendencies in the fisheries it is necessary to do three things:

1. To preserve fish waters, especially those inland, as nearly as it may be possible in their normal condition.
2. To prevent wasteful or immoderate fishing.
3. To put into practice the art of fish breeding: (*a*) To aid in maintaining a natural supply; (*b*) to repair the effects of past improvidences; and (*c*) to increase the supply beyond its natural limits rapidly enough to meet the necessities of a constantly increasing population.

The difference between present-day opinions and those announced a half century ago will be given more consideration later, but the failure to emphasize and to analyze carefully the fact of depletion and to determine and remove its causes, particularly in the great shore and marine fisheries, or to recognize and take advantage of the natural fluctuation in the abundance of the fish supply in the sea, may be understood readily and condoned when it is remembered that 50 years ago our Nation was still young, that untouched natural resources awaited exploitation and development, and that the extent of present-day needs, with the resulting strain on the fisheries, was undreamed of. Furthermore, the great promise and the popular success of fish culture induced a complacent confidence, as it was believed that the control of the fish supply was within easy grasp. This confidence may be illustrated by Goode's words: "Here the fish culturist comes in with the proposition 'that it is cheaper to make fish so plenty by artificial means, that every fisherman may take all he can catch, than to enforce a code of protection laws.' The salmon rivers of the Pacific slope," he continues, "and the shad rivers of the East and the whitefish fisheries of the lakes are now so thoroughly under control by the fish-culturist that it is doubtful if any one will venture to contradict his assertion. The question now is whether he can extend his domain to other species."

How well founded was his faith in the all-effectiveness of fish culture in maintaining or restoring the fisheries in the face of all possible destructive influences may be seen by the fate of the three great fisheries that he chose as illustrations. Despite 55 years of artificial propagation, the Pacific salmon fishery has declined alarmingly, the pack in Puget Sound[11] in 1924 amounting to but 12 per cent of the peak production in 1913. The shad fisheries of the east coast have declined, on the whole, 74 per cent from 1896 to 1923, and now are totally destroyed in many of our rivers.[12] The whitefish fisheries of the lakes, despite an annual distribution of 409,000,000 eggs and fry per year,[13] have declined in yield from first place in 1880 to fourth place in 1922, with a yield only slightly greater than that of suckers.

These statements should not be construed as an attack on fish culture in general, for the success and utility of the artificial propagation of many species is proved so fully that blame or praise from me is unnecessary. The entire system should not be condemned because the too optimistic hopes of its early advocates have not been realized; and if present methods fail to produce reasonably expected results, a measure of the blame should fall on the aquatic biologist who neglects this phase of fishery science and on the fishery administrator who accepts hatchery records uncritically as proof of the real abundance of fish.

While the early years of the United States Fish Commission may be characterized as the era of fish-cultural development, the liberal policy with regard to scientific research resulted in the production of a rich and varied literature dealing with many phases of marine and aquatic biology, in which surveys and explorations, with the cataloguing and description of animals new to science, were most prominent. The type of biology popular during the first three decades of the commission's work is indicated by the fact that 71 per cent of papers on the biology of fisheries (13 per cent of all papers), in the document series, were devoted to systematic ichthyology, and papers on other marine

[10] Idem, p. 1148.

[11] Pacific Fisherman Year Book for 1925, p. 76.

[12] The total yield of the shad industry of the Atlantic coast, from records of the U. S. Bureau of Fisheries: 1880, 18,134,534 pounds; 1888, 35,685,714 pounds; 1896, 50,408,860 pounds; 1908, 25,938,500 pounds; 1919 to 1923, 13,286,948 pounds.

[13] The output of whitefish eggs and fry has been as follows: 1925, 172,970,000; 1924, 372,780,000; 1923, 537,546,000; 1922, 623,100,000; 1921, 420,450,000. Total, 2,126,846,000; average, 425,369,000. 1920, 390,365,000; 1919, 310,365,000; 1918, 484,032,000; 1917, 384,212,500; 1916, 391,155,000. Total, 1,960,129,000; average, 392,026,000. Ten-year total, 4,086,975,000; 10-year average, 408,698,000.

animals were almost equally devoted to taxonomy and morphology. While the fish-culturists produced relatively few publications during this period, their actions spoke louder than words, for the artificial propagation of nearly every animal of economic value, vertebrate and invertebrate, was undertaken; practical inventions of all manner of apparatus, from egg trays to fishways, were perfected; and extensive efforts at transplanting and acclimatization were made, with brilliant results in some cases.

Since 1900 the policy of the bureau has undergone a gradual change. Partly as a result of the maturing of this science, and partly because of the general trend in research in the universities throughout the country, investigators turned their interest from systematic ichthyology to the experimental branches, and papers on physiology, embryology and behavior, habits, or natural history of fishes appeared in increasing numbers. Indeed, papers on the taxonomy of fishes were reduced in number from 71 per cent to 28 per cent of those on biology of fishes (or from 13 per cent to 7 per cent of all documents published). Publications on fish propagation indicate an increasing interest in pond culture; and in the fisheries, less attention has been given to reconnaissance surveys and more to the economics and technology of the fishery industries.

This changing attitude is shown further by the interest displayed in the study of habits and behavior of fishes, which later has become expanded into studies of life history. As the publications in systematic ichthyology decreased in number, those on natural history of fishes increased, and even those papers dealing with fishery surveys have given more attention to the habits of the fishes considered.

It may be assumed, in the absence of evidence to the contrary, that this growing attention to studies on the life histories, with its many immediate practical bearings upon fisheries conservation, met with popular approval; for, beginning in 1908, the appropriations began to take a distinctly upward trend, although they had been virtually horizontal for several years previous. It was at this time that the brilliant researches of LeFevre and Curtis on the life history and artificial propagation of the fresh-water mussel were published; and marked progress in the understanding and control of oyster production, as initiated by the work of H. F. Moore, resulted in increased interest in practical problems of fishery development.

The increase in financial support continued steadily, with but a slight check, until in 1918 appropriations had increased 150 per cent over those in 1908. Beginning in 1918, however, a period of retrenchment, corresponding with post-war deflation, began, and resulted in an actual decline in total appropriations, reaching a low level in 1923.

It may be of interest to consider in a little more detail the support given to scientific investigations of the bureau, as indicated by congressional appropriations. Figure 15 is a historogram of the appropriations for scientific inquiry since 1894, in which salaries and miscellaneous expenses are indicated separately and together. It is very difficult, because of the method of accounting, to determine exactly the amount of money spent each year by this division on strictly scientific investigations, partly because of the fact that there has been extensive cooperation between the various divisions, partly because there has been an overlapping of activity, but particularly because the account of vessels for all purposes has been kept separate, and it is impossible to segregate that part spent on purely biological work. I have included the expenditures made on the steamer *Albatross* (not including extensive overhauling and repairs, and not including the pay of the Navy crew). The upper line, therefore, represents this additional amount and also an estimate of the cooperation afforded by the Alaska division, particularly on salmon investigations. The serious decline in total appropriations from 1920 to 1923 is thus apparent. It would appear that this curve of expenditures approaches some form of exponental curve, and that its rate of increase is, therefore, fairly uniform. This is more apparent if the curve before 1920 is considered. In order to show more clearly the rate of increase I have plotted these figures on a logarithm basis, as in Figure 16.

If my assumption is correct that the curve of expenditures is represented by the formula $y=ax^b$, the trend on the chart will be a straight line. Although there is some tendency to break about 1911, the curve apparently does fit a straight-line trend during the two decades from 1900 to 1920, and hence it may be concluded that the expansion of scientific investigations has progressed at a fairly consistent rate. It is undoubtedly a common conviction, which may have been fostered deliberately in some quarters, that the investigations of the Bureau of Fisheries have suffered serious curtailment for lack of support. By comparing the rate of increase in appropriations for fishery research with that of all other civil expenditures of the Government, it will be seen that prior to the great war the fisheries received proportionately greater support from year to year than did other governmental activities; but if it be assumed that it is proper to spend a definite proportion of the Nation's wealth upon the conservation of the fishery resources, then it would appear that investigation of the fisheries has suffered to some extent for the curve of total wealth of the Nation rises somewhat more rapidly. Of course, the activities of the Bureau of Fisheries are but a part of the total effort expended in the whole country upon fishery conservation, but inasmuch as the field of endeavor is still so vast, it is not unreasonable to look for a parallel development of total wealth and of Federal conservation effort. As a tremendous setback occurred following the

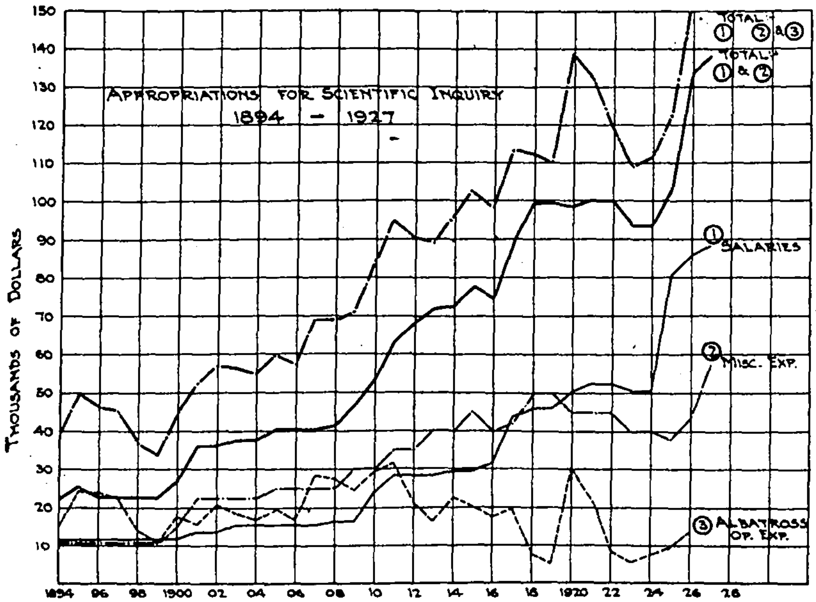

FIG. 15.—Expenditures for scientific inquiry of the bureaus, 1894 to 1926. Curve 1, appropriations for salaries of the scientific staff; 2, miscellaneous expenses; 3, operating expenses of the steamers *Albatross* and *Albatross II*, which are chargeable largely to scientific work. Total curves appear above and the upper one includes some additional expenditures made by the Alaska service in the interest of salmon research

war it is but natural to expect a proportionate increase in activity in the coming years, and if the trend is to be maintained the appropriations for scientific inquiry should reach approximately $275,000 by 1930.

In 1924, by an act of Congress of far-reaching importance, the salaries of the employees of the division of scientific inquiry, through the reclassification act, were increased approximately 60 per cent. By thus placing the standard of compensation at a level comparable to that in State universities, the employment of specialists adequately trained to produce worth-while contributions to the knowledge of fisheries conservation now is possible. Whether or not we are successful in carrying out this program of expansion depends upon the success of the scientific staff in producing results of the highest scientific standing and the utmost practical value. The promise of the future is rich, indeed.

Before reviewing the modern tendency in fishery investigations, particularly since 1920, consider the state of the fisheries of the country and the outstanding problems that they present. The total yield has continued to increase since the earliest survey in 1880, until the annual yield, including that of Alaska, exceeds 2,900,000,000 pounds, valued at more than $90,000,000. While it thus appears that the fisheries, on the whole, have prospered, there is convincing evidence that many of our great fisheries are suffering actual depletion. I need not dwell upon this fact, for it has been treated fully already to-day.

The condition of the fisheries is even more alarming, however, when we consider the possibility of future development. While it is true that the Ameri-

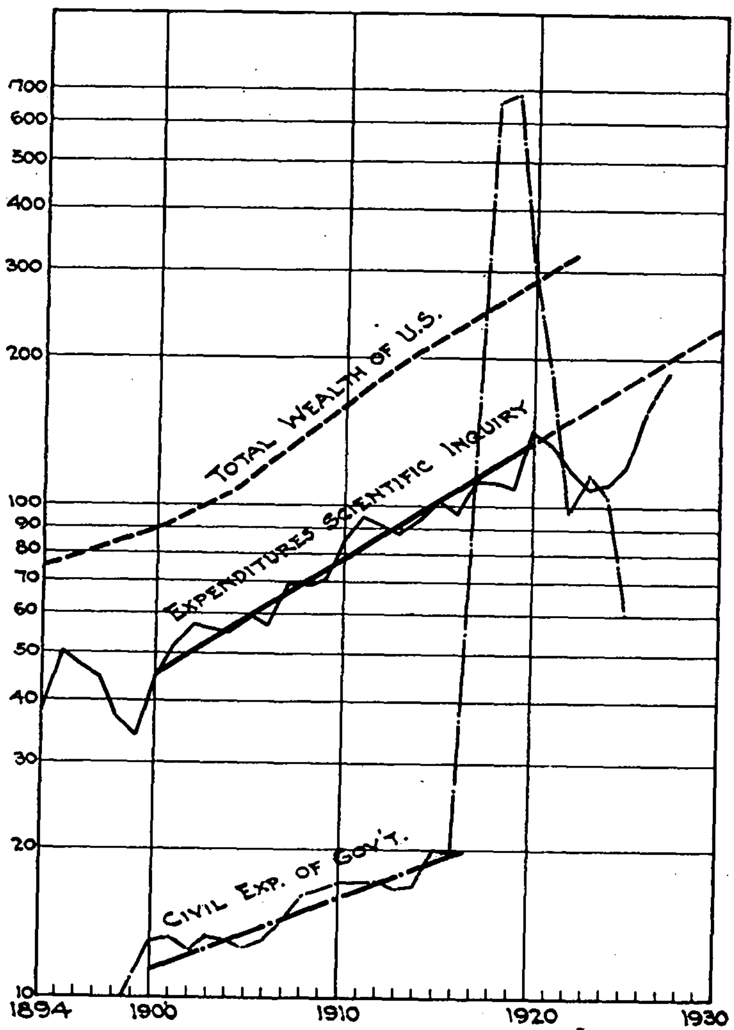

FIG. 16.—Expenditures for scientific inquiry of the bureau, compared with all civil expenditures of the Government and with national wealth (expressed as mantissas of the logarithms of dollars)

can Nation is not a fish-eating people, the great importance of sea food in the balanced dietary, recently demonstrated, makes the fisheries an indispensable source of healthful food. The increase in population of this country during the last decade exceeded that of any previous period and will, in all probability, continue to increase for many decades. Moreover, recent developments in refrigeration, preservation, and distribution of sea foods, together with improvements in marketing, compel the conviction that we are on the threshhold of an era of exploitation of both fresh and salt water fishes, the extent and intensity of which, on the basis of past experience, is beyond our ability to estimate. The one great outstanding problem of the fisheries, therefore, overshadowing all others in fundamental importance, is that of maintaining an abundant supply. The time has passed when our fishing grounds may be extended and new reserves drawn upon sufficient to meet the demand. The only hope of the future lies in the wise husbanding of our present resources.

It is, therefore, clearly the duty of the Bureau of Fisheries, in the fifty-seventh year of its activity, to return to the faith of the fathers and, in the words of Spencer F. Baird, to ascertain what diminution in the number of food fishes of the coast and lakes of the United States *has* taken place, to determine what are the causes of the same, and to suggest any measures that might serve to remedy the evil. An official of the Bureau of Fisheries has made the profound discovery, the honor for which I am sure he will share gladly with hundreds of codiscoverers, that the *real* cause of the deterioration of our fisheries is the lack of adequate regulation! This discovery is valuable as the basis for an excellent alibi, for the fisheries are the property of the States and are under their sole jurisdiction, hence the responsibility for the decline rests upon the State governments, which have permitted excessive destruction and wasteful methods of fishing to continue unabated. It means more than that, however. It epitomizes the changed attitude toward the all-sufficiency of fish culture in maintaining the fisheries.

Of course, the announcement of this discovery does nothing more than define the responsibility, for the lack of adequate regulations is the result of inadequate knowledge concerning the proper methods of conserving the fish supply and public apathy, in some localities, toward making use of the knowledge already had. In its rôle as advisor to the States, it is the duty of the bureau to determine the variations in the supply of commercial fishes and the factors that regulate their abundance, and to encourage the application of this knowledge to their protection and wise use. While fishes have been studied heretofore as individuals, they must now be studied as species or as natural units—populations that inhabit limited areas. A fisheries science must be developed comparable to the science of vital statistics—an idea advanced by Dr. Johan Hjort before the International Council for the Study of the Sea in 1907.[14] As he pointed out, the three most prominent factors affecting populations are birth rate, age distribution, and migration, and these must receive our first attention.

While an intimate knowledge of the life history of the commercial species of fish must always be the basis of every attempt at conservation, the husbandry of fish must depend upon other information, chief of which is an accurate knowledge of changes in the abundance of the fish stock. The fishery itself must be studied therefore, together with the effects of fishing effort upon the stock, in order to gauge the increase or decrease in available supply and to discover if these changes are due to natural causes over which man can hope to have but little control, or to overfishing, and therefore subject to regulations. Effective fish husbandry must further take into account the proper regulation of the fishery, so that the yield may reach its maximum without encroaching upon that reserve of spawning stock upon which the future must depend. Another phase of fish husbandry, and which applies to inland waters, is concerned with fish farming. Methods of propagation, of cultivation, and of management must be devised to supplement and increase the productivity of natural waters and to make fruitful the barren areas wherever possible.

To summarize: 1. The bureau must assume part of the responsibility for maintaining and building up the commercial fisheries, and its investigations must be directed toward that end.

2. It must actively encourage the States to do their part in gathering statistics and cooperating in investigations.

3. The bureau's investigations of commercial fisheries must include observing and describing the composition of the catch and the fluctuations in supply, as indicated by reliable criteria of abundance. Natural fluctuations must be distinguished from depletion resulting from man's activities.

4. The life histories, migrations, and ecological relations of the principal species must be worked out to explain the fluctuations in the fish stock and, if possible, to control or foretell their occurrence.

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[14] Rapports et Procés-verbaux, Vol. XX.

5. In those fisheries more directly under the control of man, such as river, smaller lake, and mollusk fisheries, the principles of aquiculture and the science of water farming must be developed.

6. These problems are so great, and the need of their early solution so urgent, that investigations into other phases of ichthyology, oceanography, limnology, physiology, zoogeography, and related branches of aquatic biology should not be undertaken independently, but only as they relate to a proper understanding of these immediate problems. This is not an attack on "pure science," but a plea for "purer" fishery science.

The rapid development of natural science in America fills one of the most brilliant pages in our history, yet our fisheries have declined, some of them have been destroyed perhaps beyond all hope of recovery, and all have failed to develop to their fullest state of usefulness. This willful disregard of the interest of posterity in the natural wealth entrusted to our keeping is a reproach upon the American system of democratic government and a challenge to American brains to devise the means for its protection. We must accept this challenge or merit the resentment and blame of the unborn future.

Mr. Higgins. It has been suggested that the remainder of the afternoon be devoted to free discussion of all of the problems that have been raised to-day, and I think it would be proper for us to discuss them as a group and then spend the rest of the afternoon in informal discussion in smaller groups.

Mr. Radcliffe. I think we should realize what a resource to this country the fisheries represent. A resource producing some 1,400,000 tons of products used for human food and products used in the arts and industries. Both Mr. Thompson and Mr. Higgins have emphasized the fact that we are at the beginning of an era of exploitation. I should like to give you some indication as to how far that is going on outside of our own borders, as well as within. With the falling off of the catch of the North Sea, immediately the European trawlers began to fish around Iceland. Now that those waters are showing the strain they have turned to Greenland. In 1924, the Norwegian Government sent a vessel to Davis Strait to determine something of the fisheries resources off Greenland. Last year between 30 and 40 European vessels went up there for the purpose of exploiting the fisheries. The present year, I understand, that activity has been continued.

The whole trend is to build larger vessels—vessels better equipped for exploiting fisheries of the whole globe. In our own country we have seen the advantages in the improved methods of merchandising fish, such as the development of filleting and brine-freezing—matters of that kind which are building up the industry.

One of the most alarming situations, in so far as our fisheries are concerned, has to do with the whale fishing. Heretofore it might have been possible to have exercised some measure of regulation over these fisheries. At the present time they are building vessels capable of operating on the high seas, taking the whale aboard the ship, manufacturing it into products that have a market value, without ever touching at any port, and then steaming to the port offering them the best prices for their products.

Mr. Scofield told you something of what is happening off the coast of California, where the concerns are anchoring outside the 3-mile limit. A vessel has been constructed recently in France, allegedly for the purpose of operating off the coast of Africa. This vessel has a refrigeration plant and storage for seven or eight hundred tons of frozen fish; eight retorts, part of which are for cooking lobsters and crawfish, some for the reduction of fish into oil and scrap; a storage tank that will hold 26,000 gallons of oil; another tank for holding 400 gallons of oil; and the statement has been made that if the African venture is not successful, they will turn to Greenland or even to our own North Atlantic banks.

The problems of the fisheries are no longer State or National, but international. How are you going to govern these things unless it is through international agreement? The trend and condition of a fishery can be ascertained only after long study and research. Take our own North Atlantic fishing banks; we do not know what the conditions are that obtain there. Next year we may have a "rum row" exploiting these fisheries in a manner unparalleled in our history, and the only way we can control these conditions is by a "round table" of international statesmen and diplomats to solve such international problems. The biologist must produce something that will show us where these fisheries are bound, and then pass it on in a form to be sold to the diplomats and statesmen for their use in order to get proper regulation.

I have the deepest sympathy for the fisherman. I think that too often we forget the conditions under which the individual fisherman operates. Our fishermen receive about $97,000,000 for their harvest. Less than $500 per fisherman. Think of them in the winter; two of them in a small dory, operating in the lanes of steamers, facing death, under all kinds of weather conditions. Nearly every week the papers in New England tell of some fishing vessel returning with at least one or two of the men missing from the crew. The men who operate under these conditions can not be expected to have a perspective that will enable them to say just what is best for the fishery as a whole.

Mr. Scofield. I would like to hear some one discuss a question I would like to bring up. I had more or less to say about the use of the sardine in California, outside of the 3-mile limit, for reduction purposes. I have been asked the question, "Why do we care if they use the sardine for reduction purposes, if our investigations have not shown that the sardine is decreasing in abundance in California?" The sardine is being guarded against exploitation by the reduction plants within the State, and I was going to suggest that as a topic. I think there are some here who might have something to say along that line.

Mr. Higgins. I think Mr. Thompson has thought on that question perhaps as much as any of us. I am going to ask his opinion.

Mr. Thompson. Mr. Sette showed on one of his graphs the enormous importance of the menhaden fisheries. That importance is entirely due to the expansion in the market for oils. I can see where the possible limit to expansion is—that is, a fishery that will take absolutely everything that the net brings in—and some time in the future we may find ourselves with a situation we can't very well control. I think Mr. Scofield's attitude in advocating the restriction of such fisheries as the sardine for fertilizer is a sound one as a general state policy. The danger is not so much what may happen to-day as it is allowing the growth of a great industry that can not be controlled when the time comes to control it.

Doctor Rich. I have always wondered why edible fats might not be as legitimate a use for a fishery as food alone. Might not the by-products serve just as great an amount of good as the actual food? Should all the fisheries, then, be reserved solely for the use of food, if they can be so reserved?

Mr. THOMPSON. Edible fats would reach the people in the form of fish; but to take one-tenth of the value of a fish, when you might possibly build up the use of the whole fish, I think would be a mistake.

Mr. SCOFIELD. We have one factor in California that is operating under a modification of the law which certain persons were able to bring about. They are making fish flour. The process is not very different from an ordinary reduction that is carried on in an ordinary reduction plant. The fish are run through by machinery. Then the product is ground and run through the mill, and the final product is fish flour. It is not much more expensive to produce than ordinary fish meal. About three-fifths or two-fifths of the product is bone and gross material which goes as fertilizer, anyway.

The law was also modified to permit the use of sardines for the oil, provided the oil be used for edible purposes. The company extracting the oil must refine it for use as human food. Two rather large concerns made use of that modification last year.

It seems to me that if the companies are permitted to take the sardine for the oil and use the oil as a food there will be no limit to their activities. It would be the same thing as permitting a reduction industry to take fish for fish meal or fertilizer; so we hope to have striken from the law the special privilege of taking fish to make oil.

If the supply is exhaustible (and we are not sure that it is not), I think our scheme should be to guard against the establishment of a reduction industry, and should be in favor of the use of the sardine or herring as human food. The use of the sardine, at least for canning, gives employment to a great many more people than if it were used solely for reduction purposes. As Mr. Thompson pointed out, the great danger is in permitting a great industry to be established which we will be unable later to curtail or to put out of business when we find that the resource that is being drawn up is not sufficient.

Mr. HIGGINS. Captain Wallace, what is your idea on this subject with reference to menhaden?

Captain WALLACE. The menhaden is not a food fish. It is used only for making fertilizer. There is this viewpoint in the manufacture of a fish like the menhaden into oil and fertilizer: There is being given to the country something that otherwise would not be utilized. The fertilizer that is being used on the farm is also of economic good to the country in rendering the land more productive.

Doctor GALTSOFF. I would like to ask a few questions about your paper, Mr. Higgins. It seems to me one important thing was missed entirely. I understand perfectly the fundamental ideas which show the necessity of statistical work, but it seems to me the statistics are sound only if we have a good biological understanding of these particular species. That is true for every type of biological work. Mathematics is all right, but there must be some biological background to which to apply the mathematical formulas. In a general way, the understanding of the biological background requires a perfect understanding of the organism—the understanding of its environment and its habits. I heard nothing about the study of its environment, which is absolutely necessary for understanding biological factors. One thing particularly refers to the environment in which our fish and other marine organisms live. That is the question of pollution.

Everybody who has had experience in the work of the Bureau of Fisheries knows that sooner or later, directly or indirectly, this question certainly is brought to his attention. The question of pollution has two aspects. One is sanitary, which I regard as outside the scope of the bureau. That is up to the health department, to determine whether the oyster we are eating is safe. The pollution kills the marine organisms or makes them unpalatable. In this way, certainly, it is a primary question for the Bureau of Fisheries to decide. The question of pollution is certainly complex. It is not a State affair. It very soon will be an international question. So far it is not, but maybe in 20 or 25 years, with the development of sea communication, it will be international. It seems to me the study of pollution, or the effect of pollution on marine organisms, certainly must be put on the program of the scientific investigation of the Bureau of Fisheries. If I am allowed to make this remark at present, I think we have no special laboratory, or agency, or organization to go into this situation, and so really the question is neglected.

We have found from our experience in the oyster division, say, that probably every third or fourth oyster comes directly in contact with pollution. Then there is a question of oysters along the Connecticut shores—the question of why the oysters become unpalatable, and so on—because of domestic sewage pollution, trade wastage, and oil pollution.

It probably requires the joint efforts of both the economist and the biologist. I wish only to call your attention to these facts, which probably are not known in a general way. I looked into the records of the New York Metropolitan Sewage Commission and found that New York discharges about 1,000,000,000 gallons of sewage daily into the water. The theory that this is carried out to the ocean is wrong. It just washes back and forth within 15 or 20 miles and stays right there. Notwithstanding the activity of the Public Health Service to secure strict enforcement of strict regulations with reference to oysters, we have the following situation: Last year we went to the localities that looked to be safe from any pollution. The request was to show to Georgia State officials the grounds suitable for oyster cultivation. The Public Health Service made a survey at the same time. I found, to my great disappointment, that all the best localities, the most suitable for the cultivation of the oyster, were condemned by the Public Health Service. It would take too long to discuss the reasons for condemnation, but I didn't think they were reasons to condemn, because I questioned the methods of this survey, which was made during the tremendous flood. But still there are certain areas in the South, far from obvious pollution, which can possibly be polluted and are not suitable for the production of oysters.

I saw, in the Gulf of Mexico, thousands of acres of grounds bearing good oysters that are entirely unpalatable. They are polluted by oil and acquire a little oily taste, which makes them absolutely unpalatable. Fish there also acquire this oily taste. So really this question becomes more and more serious. It may set aside entirely all the statistical investigations that are made on a certain section. There will be no scarcity or decrease in abundance of fish; simply, they will migrate in a different direction. They don't go into these polluted or semipolluted waters. This must be taken into consideration.

I think it will be absolutely necessary for the division of scientific inquiry to put this question of pollution on its program, from the point of view of conservation.

Mr. RADCLIFFE. It may be well to review very briefly the story of the bureau's attitude toward this question. I am in sympathy with Doctor Galtsoff's attitude. Some years ago the bureau sought an appropriation and failed to get it. About two years ago, after hearings that lasted several months, it was very evident that Congress was chary about taking away the rights of the States to handle these particular problems. There were, also two schools of thought—one favoring the War Department and the other the Department of Commerce for the study of these problems. The War Department won. When the act was passed finally, the War Department was given authority to put the law into effect, and we have been a little timid about stepping in. Sooner or later, however, we will have to enter that field.

Mr. HIGGINS. Doctor Koelz, do you see any signs of an international problem of pollution?

Doctor KOELZ. A little in Canada. The fishermen that were arraigned on the charge of catching small fish in Lake Erie pleaded that the Detroit River was killing them off anyway. That is about the only situation, because the other lakes are too wide to have a general bearing.

Mr. HIGGINS. It is your opinion that pollution is localized on the American side of the Great Lakes and is not present on the Canadian side?

Doctor KOELZ. The Canadian side has no cities at all. The pollution is relatively nothing on the Canadian side.

Mr. SETTE. Doctor Galtsoff has brought up the question of what good are statistics if we haven't the biological background, and I agree with him. However, I question the value of a biological background without statistics. Even pollution may enter the question. Our yield of anadromous fishes declined earlier and more rapidly than our other fishes, not saying anything about the abundance. We have taken fewer anadromous fish in recent years than we have in the past. That may very well be because they are subject to river conditions, which, in turn, are more influenced by pollution than the sea. The point I wish to make is that we couldn't even know we had a problem in pollution if we didn't know that the yield had declined in the rivers; and if you are going to attack any problem in fisheries you will have to know what the yield is, and, further, you will have to have a measuring stick of abundance based on the yield.

Inasmuch as our problems are on the conservation of the fisheries, we are faced continually with the questions of the yield, fluctuation in the yield, etc., which can not be taken up unless we know that there are fluctuations and what these fluctuations are; and so, even when deciding which species you are going to study, you must have statistics of the yield, and when you get into the study of them you must have continuous reference to statistics.

Being more or less responsible for the conduct of the statistical department of the bureau, I realize very fully that our statistics are woefully inadequate. In the first place, we have statistics only once in a while on any particular region—once in half a dozen years. We may hit the peak or trough of any fluctuation of any fishery, so that the picture is very rough, indeed, if not entirely valueless, for analysis of an investigational nature. If we could have annual statistics we would be so much better off, because we know at least where our peaks and troughs are, and the biologist investigating the fisheries would learn why those peaks and troughs occur.

It has been more or less definitely expressed as the policy of the Bureau of Fisheries that we should develop the matter of collecting statistics by the States. That discussion, I believe, has appeared in the last two commissioners' reports and also in the last two reports of the division of fishery industries, and I should like to ask the biologists of the Bureau of Fisheries to consider carefully what it means to have this policy go through. You will be driven constantly to the use of the facts brought out by the statistics, and unless you have them you are at a loss. They are just as necessary as to find the ages and rates of growth of your fish or the ecological factors. As you go to various parts of the country you have opportunity to come in contact with men in various industries, with State officials, and with various persons interested in fisheries; and I think it would help a great deal in advancing this feature if each one of you would be more or less of a missionary in educating people to an understanding of this vital necessity in our fisheries. Educate the public so that they will appreciate the necessity for statistics and will actually have enough interest to support a movement in this direction.

We, in this division, would always welcome suggestions from the biologists as to how we can best present statistical material. I don't know whether you noticed or not, but in the last report of this division, instead of showing the statistics of each county in the States for which we published statistics, we confined our presentation to State figures only. We did this for two reasons—for economy in publication and clarity in presentation. We discussed these particular changes before they were made. No one could decide whether or not it should be done, and we finally decided that the only way was to do it and see what objections would be raised. I just wish that everybody who has occasion to use any of these statistics would offer suggestions for improvement of presentation or improvement of collection, or for any additional statistics that it may be feasible to present in our annual publication.

REVIEW OF FISHERY INVESTIGATIONS CONDUCTED BY THE BUREAU OF FISHERIES

NORTH ATLANTIC FISHERIES

GENERAL REVIEW

By Dr. H. B. Bigelow

I didn't come here with any set speech, so shall say only a word of reminiscence about the North Atlantic investigations.

The life histories of the fish that support the great North Atlantic fisheries have been slighted in American waters—cod, haddock, pollock, mackerel, herring—and when it became possible to undertake such studies a few years ago the two problems that seemed to promise the most fertile field were the lives of the cod and mackerel.

The cod has been the backbone of the North Atlantic fisheries on this side of the Atlantic, and a good deal of attention has been paid to the life history of the cod on the other side of the Atlantic, so the basic facts of the cod's life history are well understood. Nothing, however, was known about the migrations of the codfish in American waters nor about what conditions favored years of high production (and so good fishing) or what hindered years of high production; and until some light was thrown on these questions it was obvious that the bureau never could outline any rational means of conservation if the fishery should show signs of depletion or tell the fishing interests how they could increase their catches if there was opportunity and if the fish market would take them.

The simplest problem to attack in the case of the cod was migration; and so, in 1923, the bureau started tagging codfish. Fortunately, the codfish proved to be a very favorable fish to tag. We have some codfish that have been tagged and recaptured twice, on which the tags look perfectly all right—the cod has been perfectly fit and happy and his rate of growth hasn't been set back. Consequently we have every reason to think that the cod returns are significant, even though many of the fish lose their tags.

Tagging has been carried on from 1923 up to date. During the first years the bureau was limited in the field that could be covered by the lack of a seaworthy ship. Those of you who have worked at sea know that on the high seas, often in winter, you must have a ship that is seaworthy if you want to do the job. Now the bureau has become possessed of a ship that is seaworthy; she can go anywhere; so this last year the bureau was able to spread its tagging operations to Georges Bank, and in the future there is no reason why such work can not be carried out anywhere on the offshore banks.

While the cod tagging has been going on, haddock and pollock have been tagged too, and data have gradually accumulated to show the migrations of these species as well. Mr. Schroeder has worked up the report on the migrations of the codfish which he will present to you shortly. As to the factors that control production, etc., a start was made two winters ago by the *Fish Hawk* in Massachusetts Bay. Very satisfying things came out as to the involuntary drifts of the eggs and larvæ. We knew previously from European experience that cod eggs and larvæ, like any other buoyant eggs, drift where the water takes them. And it does not follow because a lot of larvæ are found in one place that they were spawned there. Doctor Fish will tell you about this one actual start that has been made in the Massachusetts Bay region on that problem. Mr. Sette can tell you about the mackerel.

I might add that all the work carried on at sea has been accompanied constantly by an oceanographic program, yielding records of the temperature of the water, of the salinity of the water, and of the nature and abundance of the plankton, data which, when tied up with the production of eggs, may tell us what factors favor high years of production and what things go against it. We begin to suspect that it is not so much the physical character of the water. In fact, Doctor Leim's experiments on cod eggs show that the cod egg is almost foolproof. You can do almost anything to it and still it will hatch successfully. The great loss apparently comes after that, and we begin to suspect that it is the predatory members of the plankton that are chiefly to blame, combined with the scarcity of food for the larval fishes.

I think, perhaps, that this is sufficient introduction to the lines of attack. I might say that we also begin to see ahead the possibility of predicting whether, in any year, the stock of fish is going to be big or small—in the case of the mackerel, for instance, whether it is going to be worth while to go mackerel fishing or not. For years the mackerel fishery has been subject to tremendous fluctuations, the catch varying from practically none to hundreds of millions of pounds. Until these investigations started there was no way of envisaging at all whether these fluctuations reflected movements of the fish or whether they reflected actual fluctuations in the number of mackerel existing in the sea at the time. We are now in position to say that they do reflect actual fluctuations in the numbers of mackerel.

COD STUDIES

By W. C. Schroeder

My problem is concerned with the life histories of the cod, pollock, and haddock. The three species are found under much the same conditions, so that their combined study is practicable; but special attention has been given to the cod, and the data for this species are more complete than for the others. These are important food fishes, found on both sides of the North Atlantic, and are worth over $5,000,000 annually to our fisherman.

Migrations, rate of growth, and age with respect to size are the chief factors under consideration. Doctor and Mrs. Fish have been studying the drift of the eggs and larvæ, while I am interested chiefly in fish upward of 1¼ inches in length. It is at about this size that the cod takes to the bottom and the first scales appear.

We know very little about cod less than 10 inches in length or less than 2 years of age, and this is one of the gaps we are endeavoring to fill. Fish of this size appear to be scarce along our immediate shores, for repeated seining around Woods Hole and along the entire New England coast has produced but very few specimens. Offshore we have done a limited amount of dragging with beam trawls, otter trawls, and circular nets; but on smooth, sandy bottom we catch next to nothing, and on rocky bottom the fishing gear is nearly always damaged or lost. Last summer we were fortunate in making several good hauls on northeast and southwest Georges Bank, where the bottom was somewhat rocky, yet not enough so to destroy the gear. Among miscellaneous fishes, about a dozen cod and many haddock, 2 to 5 inches long, were caught. It seems logical to conclude, even on this meager evidence, that the habitat of very young cod includes all our offshore cod grounds. In changing from the pelagic to the demersal stage, those fish that happen to go down on or near rocky bottom ought to have a much better chance of survival than those that chance upon mud or sand, where they afford an easy prey for carnivorous fishes.

The smallest caught along our shores are usually more than 10 inches in length. The shore waters of Maine form a refuge for cod of 10 to 20 inches, and fish of these lengths are so abundant there that some sort of migration from offshore evidently takes place.

In an attempt to throw light on migrations, 41,000 fish were tagged from 1923 to 1926, of which 28,000 were cod, 5,000 were pollock, and 8,000 were haddock. Operations were carried out by the *Halcyon* up to 1925 and by the *Albatross II* during 1926. The fishing grounds comprised many localities from eastern Maine to southern Massachusetts, but most of the fishing has been centered off Mount Desert and on Nantucket Shoals.

All these fish were caught with hand lines and by the same method of fishing as is employed by commercial vessels. Generally we fished in water less than 25 fathoms in depth, for beyond this depth an increasing number of fish are unsuitable for tagging, owing to their sudden removal from the great pressure which exists on the bottom. In shallow water we lose from 5 to 10 per cent of our fish, due to injuries received when they are hooked, and in water as deep as 40 to 50 fathoms the losses due to pressure and hooking combined amount to from 15 to 20 per cent.

After a fish has been landed it is laid on a measuring board and a tag is clamped to the upper part of its tail near the base. A few scales are scraped from along the side below the first or second dorsal fin and the fish is then returned to the water. These operations require about 20 seconds per fish.

The scales and measurements are placed in books numbered the same as the tags.

A metal tag is used. Various metals were tried, none of them entirely unsatisfactory, but monel metal was adopted finally as being noncorroding and comparatively cheap in price.

One of the chief difficulties in using tags of any description is the effects of an irritation set up around the point of attachment. After several months, or more, many of the tags will pull through the softened tissue, out along the membrane of the tail, and be lost. It is estimated that 60 per cent of the tags are lost in this manner within the first year. The irritation of the tag does not appear to affect the physical condition of the fish except at the point of attachment, and in some cases the wound heals nicely.

About 1,700 tagged cod have been reported recaptured, of which 350 were taken by our vessels *Halcyon* and *Albatross*, most of them a month to a year after the fish were tagged. These latter records are of particular value, for with them it is possible to determine the rate of growth with reasonable accuracy and to note how this increased growth is registered on the scales. Locality records, the condition of the fish, and other data are more precise when we make our own recaptures.

The percentage of tag returns depends largely on the intensity of fishing and the locality of tagging, whether close to land, on a cod ground of restricted area, or offshore, where the grounds may be a thousand times as large. For example, as many as 20 to 35 per cent of the cod tagged on certain cruises have been recaptured off Mount Desert Island, Me.; whereas we have not yet received a single return from 1,000 cod tagged last August on Georges Bank, 150 miles from our shores.

The results of the tagging have several points of particular interest. According to tag returns it was found that cod east of Cape Ann, Mass., do not migrate south toward Cape Cod, except as stragglers; but quite a few Maine fish migrate east to Canadian waters. Of about 10,000 cod tagged east of Cape Ann, only 1 has been reported recaptured south of Cape Cod, and we caught that fish ourselves; and of nearly 18,000 tagged on Nantucket Shoals, we have only one reliable recapture record from as far east as Maine. Between Maine and southern Massachusetts we have tagged a few cod in Massachusetts Bay, and recaptures of these fish have been made both to the eastward and to the southward.

The most impressive cod migration that we have found occurs each fall from Nantucket Shoals to Rhode Island, Long Island, New Jersey, and Delaware. Our most southerly recapture record was off Cape Henlopen, Del., but we know that cod migrate as far south as North Carolina. Within the region west and south of Rhode Island virtually no cod are present in summer. In the fall the first cod appear off western Long Island and off New Jersey the last week of October. The first recaptures of our tagged fish have occurred each year in this region between October 27 and November 4, and the last during April. In Rhode Island waters cod are rather abundant from fall to spring, and a few fish remain over the summer, but not enough to support commercial fishing.

Speaking of all localities along the New England coast where we have tagged it was found that cod may remain for long periods in one immediate locality, sometimes for as long as 1 or 1½ years. We have tagged fish very close to buoys and lighthouses or other convenient marks and returned one year later to recapture the fish in exactly the same locality. Not only has this happened to individual fish, but small pods of cod have shown a tendency to remain intact for a considerable time. We have more than one record where nearly consecutive numbers were taken a year later in the same locality on the same day; and we have several records of consecutive numbers taken within a few minutes of each other several months after the tagging date.

Scale samples have been taken from all fish tagged since 1924, inclusive. When a fish was recaptured by our vessels it was again scaled, of course, and measured, The data obtained from these recaptures are of great importance for it is our only positive method of learning how growth is registered on the scales. The scales from these recaptured fish prove that an annulus is formed. What is usually called a zone of winter growth on the cod scale might better be termed "zone of retarded growth," for I have noted that the so-called "winter rings" begin to form as early as September and October.

Over 10,000 scales have been mounted, and of these about 10 per cent have been studied. Scale study has not been pushed vigorously because of an uncertainty existing as to the early growth. The long spawning period of the cod (from October to April) makes it particularly difficult to interpret the first year's growth. To assist in this all young cod, as well as pollock and haddock, are preserved.

According to scale growth, I find that cod from southern Massachusetts, of 1, 2, and 3 years of age, are about 7, 14, and 21 inches in length; and cod from eastern Maine are 6, 12, and 18 inches in length. After the third year, the increase in length becomes less with each added year. Our recapture records show that the actual increase in growth made during one year by tagged cod from Maine was about 4 inches from the third to the fourth year, the same from the fourth to the fifth, 3½ inches from the fifth to the sixth, and 2¾ inches from the sixth to the seventh year. Year classes, as determined by length frequencies, compare well with the lengths of the fish as calculated from the scales, at least up until the fourth year. Little can be done with the length frequencies of the older fish.

The cod problem is a complex one and it is necessary to study the fish in many localities and under varying conditions. In general, large fish are found offshore and small fish inshore. The smallest cod of 1,000 caught on Georges Bank last summer was 20 inches long; whereas, out of the same number of fish caught within a few miles of shore, it frequently happens that as many as 80 or 90 per cent are below 20 inches. Each cod ground affording differing physical conditions has its own peculiar stock of fish, and there appears to be no general intermingling of fish from the various banks. It is true that large numbers of spawning cod collect in the shore waters of New England throughout the winter, but I am not prepared to say at this time where they come from or where they go after spawning. A few of our tagged fish have been caught among these spawners, but only scattering records and not enough to indicate a migration from the tagging ground.

Cod can adjust themselves to diverse living conditions; or at least we find them *living* under differing conditions. Comparing eastern Maine with Nantucket Shoals, both of which places have a year-round cod population, the Maine fish seldom have a bottom-water temperature greater than 11° C., which has been considered the upper limit for the cod. Yet Nantucket cod withstand as much as 14½° C. Maine cod feed largely on small crustaceans, such as shrimp and small hermit crabs, whereas Nantucket fish usually are gorged with large Cancer crabs. Maine cod appear to grow more slowly than Nantucket cod. The only migration shown by Maine cod has been entirely to the eastward to the coasts of Nova Scotia. Nantucket cod, if they migrate, go west and south, or to the Chatham grounds a few miles to the northeast. Out of thousands of cod tagged in eastern Maine, from 65 to 75 per cent were less than 18 inches in length; while on Nantucket Shoals, up to 1925, the percentage of these small fish was one-fourth to one-half of 1 per cent.

Another problem arises from the fact that while cod of one locality may behave the same for a period of years, an abrupt change may then occur. Nantucket cod, as regards the stock of fish and their migrations, were much the same for the three years 1923 to 1925; but in 1926 we found the stability of the fish population had in some way become unbalanced. Whereas, fish from 22 to 32 inches in length largely predominated during the first three years, in 1926 we found this group in the minority and that a new stock of fish, of 14 to 20 inches, had taken their place. Where the larger fish went and from whence the smaller ones came we have not yet ascertained, but are waiting for our tag returns to give some indication of what happened.

The cod program must continue for some years before we can hope to give a comprehensive account of the fish's life history.

Doctor Rich. What is the age of the small fish that came in this year?

Mr. Schroeder. There was a combination of two or three year fish. The 2-year-olds were extremely scarce the previous three years, but in the fall of 1925 we noted a change. Some of these small fish came in the fall of 1925. The previous fall some indication was noted that the change was about to occur when the small fish comprised about 8 per cent of the total, instead of one-fourth or one-half of 1 per cent, and then we thought something would happen. If you fish on any offshore grounds you can get absolutely nothing out of length frequencies; it seems as though all the lengths are represented, so that we fish inshore and get enough of the small fish of 2 or 3 or possibly 4 year old size. We can not seem to get any of these sizes offshore.

Mr. THOMPSON. Did you analyze only the catches that you made yourself?

Mr. SCHROEDER. Yes.

Mr. THOMPSON. I then ask would the size of the hook make any difference in the class of fish caught?

Mr. SCHROEDER. It is true we did change the size of our hooks, but even then if young fish were present in any numbers at all you would expect to catch a few and the hooks are not so large that it was impossible to hook them at all. I have tried with one or two sizes; I have tried with smaller hooks and attempted to catch young fish, but have never succeeded.

Mr. THOMPSON. I am not familiar with the codfish or their fishing methods, but we might experiment with the dominant year classes. From my own experience with other fish, it is necessary to carry on a far more extensive analysis of catches—perhaps catches that were turned in by the fleet. You will find out, no doubt, that there are distinctive sizes in various parts of banks, so that before you could even attempt to demonstrate a dominant year class you would have to examine the commercial catch from all parts of the bank.

Mr. SCHROEDER. That would be preferable, but it was very hard to get all the fish that the commercial fishermen caught; usually this smaller size is almost worthless and the net return is so small they frequently throw them away so that it would be very hard to get any of the unselected catch. Furthermore, we usually fish 4, 5, 6, 7, or 8 hours, drifting all over, so that we have ample opportunity to cover a bank rather thoroughly. You may fish for an hour and catch nothing; then occasionally you catch fish 30 and 31 inches long; then you get no more of these big fish for 20 or 30 minutes; then another haul. We found, on Nantucket Shoals, that we would occasionally strike a body of other fish, and these would be smaller fish.

Mr. RADCLIFFE. Isn't it true that in recent years there has been a considerable increase in the intensity of fishing around that area—around Nantucket Shoals—and in the number of tags that have been taken from that area?

Mr. SCHROEDER. It has affected the cod more than the haddock.

Mr. RADCLIFFE. Is it possible that the increase in intensity of fishing has reduced the proportion of larger fish?

Mr. SCHROEDER. I really don't think so, because most of the fishing there is along the edge of the bank. Sometimes we do not see a commercial fisherman for two or three days around the grounds. Of course, they may be around when we are not there, but Nantucket Shoals has not been considered a particularly important cod ground in the last few years. Some years ago, in 1914, Nantucket Shoals and the Chatham grounds actually contributed more cod than all the other cod grounds along our coast.

Doctor BIGELOW. Speaking of the migration of the fish—you state that the fish migrated but were confined largely to individual banks. I do not get the connection between these two statements.

Mr. SCHROEDER. It is hard to see why the fish migrate, for we know some do and some do not. For example, if we tag 1,000 fish in eastern

Maine, perhaps 700 of these fish will stay at home until they are caught—they will be recaptured a week or a month, a year or two years later—but some of those fish, for reasons unknown, will start to migrate, and it is impossible to say why. The same thing happens to our Nantucket fish; some will migrate and others will stay on Nantucket Shoals. At first we thought the varied temperature was an important factor, and the coming of fall and winter would cause the fish to migrate to warmer waters; but we are mistaken in that, because the maximum temperature is not reached until late fall, and that is about the time the fish start to migrate west and south—when the weather is actually warmest. Unless they have an instinct which sends them on these migrations, I can not find any reason why they should migrate west and south.

Doctor GILBERT. Is the number of straggling fish great enough to indicate migration?

Mr. SCHROEDER. I really think it is. I think the reason the straggling fish are often recaptured is because the fishermen go to those banks were many of them migrate and catch the fish. Perhaps some go to places where no one fishes—places seldom visited by anyone.

Doctor GILBERT. About this different rate of growth in the southern and northern fish; did I understand you to attribute that to food rather than any racial habits?

Mr. SCHROEDER. It may be to food and temperature combined. I do not think it is racial habit. I really can not answer that question at this time, although I hope to at some later time. Unmistakably, southern fish do grow faster than northern fish.

PLANKTON INVESTIGATIONS

By DR. CHARLES J. FISH

The plankton investigations that form a part of the bureau's North Atlantic program have two basic objects:

1. To determine the relative value of the various cod "banks" as production centers, and to determine whether local production is sufficient to maintain the inshore stock along the New England coast or whether it is dependent for its supply upon immigration from the offshore spawning grounds.

2. To investigate the factors that cause success or failure in the annual production of young fish (high or low breeding years), as indicated by the variations in the catches of the various "age groups."

The results of extended investigations by Norwegians have shown the existence of an intimate relation between the fluctuations in the numerical value of the fish stock and the yield of the great fisheries. This makes it possible to determine the fluctuations in the renewal of the stock from year to year by determining the numerical value of the various age groups in the catches.

My problem is concerned with what causes these fluctuations from year to year in the supply of fish and where are the sources of supply. Obviously the fate of any group that has pelagic young is solely dependent upon the success or failure of the young to maintain themselves in the plankton. There must be ample food available, and the winds and tides must remain favorable at least until they reach the stage when benthonic life begins.

In European waters it has been shown that the actual quantity of eggs produced is often not in itself a factor sufficient to determine the numerical value of a year class. A rich spawning year may produce a year class poor in numbers, while a large year class may have its origin in a year when the spawning was at its lowest. This has been observed repeatedly in the water about Lofoten. However, it has also been determined that we must look to the early stages to find the conditions that determine the number of individuals in any year class. In discussing the cod, Hjort stated as early as 1914 that the numerical value of a year class apparently is determined at a very early stage and continues in approximately the same relation to that of the other year classes throughout the lifetime of the individual, and that such data as are available indicate that the most important determining stages are "the very earliest larvæ and young fry stages."

Therefore, if the numerical value of a year class is determined in the early stages, and the actual quantity of eggs produced is not necessarily the determining factor, then we must look to the pelagic eggs and fry for an explanation.

The cod-spawning areas along the New England coast fall into two natural groups—the inshore grounds and the offshore grounds. Because of the lack of a suitable ship, the former were selected for investigation first, with the field work centered in and about Massachusetts Bay. As a result of the investigations by Doctor Bigelow, there was available considerable information on the seasons of spawning, the seasonal variation in the plankton communities, and the general movements of the water in the Gulf of Maine. Drift-bottle experiments and observations on plankton distribution had established the existence of a definite southerly drift or set along the whole western margin of the gulf. This has long been known to the fishermen as the "so'west current." Fish eggs in progressively later stages of development have also been found as one approaches Cape Ann from the east. Again, the catches extending over a long period of years have shown that the bay itself harbors one of the largest inshore breeding centers—the Plymouth grounds.

The immediate problem involved a determination of the value of Massachusetts Bay as a production center and also as a nursery for the large numbers of eggs and larvæ that we had reason to believe were constantly being transported in as contributions from the spawning grounds to the east. Here the young fry could find ample food and be protected from the storms and ocean waves until large enough to care for themselves. It has even been suggested that this limited area might form one of the most important sources of supply for codfish on the whole Atlantic coast.

The work was to consist of an investigation of the Massachusetts and Ipswich Bay grounds, the conditions existing during the period of incubation of the eggs, the early life history, the food during this period, the enemies, and the distribution and migrations during the first year.

In November, 1924, 2 visits were made to the Plymouth grounds, and between December 3, 1924, and June 17, 1925, 14 cruises were made on the *Fish Hawk*, covering the area between Ipswich Bay and Provincetown. At 41 stations physical observations and net collections were made.

Charts based on the distribution of eggs in various stages of development show clearly the spawning center and the drift of the eggs, the greater proportion of late stages being taken about the Provincetown region. Drift bottles also substantiated the current movement as indicated by the eggs.

The results so far indicate that a very definite and constant counterclockwise drift carries all cod eggs spawned in Massachusetts Bay out before they hatch. Throughout the breeding season eggs were found in abundance, particularly about the Plymouth grounds, but the collections of the 14 cruises failed to yield a single young cod. Drift bottles took the same general course as the eggs, those not fetching up on the inner arm of the bay dividing after passing beyond Provincetown. A part of the latter completed the circle and appeared on the Nova Scotia coast, or, if they turned south, passing into the region about Nantucket. One apparently drifted farther to the eastward and was carried in the Gulf Stream to the beach of Lands End, Cornwall, England, where it was recovered on June 15, 1926.

Investigations carried on in Ipswich Bay, an important adjacent spawning ground to the north, yielded similar results, showing that here the eggs were carried out east or south, beyond Cape Ann, at even earlier stages than those of Massachusetts Bay.

We must therefore conclude that local production in Massachusetts Bay is not sufficient to maintain the inshore stock, and were it not for constant immigration from the outer waters the supply would soon be exhausted.

At the time, the lack of a suitable ship prevented an extension of the survey to the outer waters to determine the fate of the cod eggs after leaving the bay, the next logical step in the program. No doubt many of the eggs carried beyond the cape survive and perhaps help stock the outer banks, or else work back when the bottom stage is reached, or both. Perhaps the young bottom stages entering the shore waters south of Cape Cod with large schools of small pollock, each spring, represent survivors from the bay.

Unfortunately, it was not possible to continue the work long enough to determine whether the eggs that enter past Cape Ann hatch within the bay. Although of interest, I do not think this would alter the problem, because the same current that carried them in would transport them out again.

Various investigators have shown that the fry often are transported for tremendous distances, and the few that might reach their benthonic stage during the interval between Cape Ann and Provincetown probably would not affect seriously the natural economy of the area.

It is to be expected that some of the cod eggs drifting west from the Gulf of Maine will hatch before leaving Massachusetts Bay, and there is some evidence of this. Doctor Bigelow has found cod larvæ in the bay; and Mrs. Fish, in examining two 45-minute plankton hauls (top and bottom) made by Mr. Iselin 1 mile east by south of the Boston Lightship on June 5, 1926, found 122 cod larvæ, 4.5 to 9 millimeters in length, in the haul from 8 fathoms (temperature, 39.5° F. at 10 fathoms). No larvæ were found in the surface net, but an abundance of eggs was present in both.

Certain peculiar conditions were observed early in the bay. We saw very soon that the eggs were disappearing before they hatched. We took thousands of eggs on these trips at all stages of development, but never a young cod. Two results were obvious—either these eggs were being destroyed before they hatched or they were drifting out—so drift bottles were placed at various places in the bay and at the same time the eggs were plotted. The distribution of eggs at each station and the percentage of eggs at four stages of development were taken. Later, to avoid any confusion in distinguishing between early and late cleavage and to note any line of demarcation, we divided into cleavage and embryo stages and plotted them. That showed very definitely a movement from the Plymouth Banks around the inner arm of the bay. At some times it appeared that the eggs were following close to the lower island and in others they seemed to be drifting across to other stations. The drift bottles also indicated the same drift. Of those placed along the lower arm almost all were found five or six days later either along the inner arm or in Provincetown Harbor. Those that missed the top of Cape Cod went out and divided, part drifting southeast and part to the north. Those turning to the north followed the same general direction as the bottles placed by previous investigators. It seems that the rate of drift was somewhat slower—I believe about 4 miles a day. According to the records on the return trip they did not do much more than 1$\frac{7}{10}$ miles a day.

The records made by Doctor Bigelow on the movements of codfish and eggs in Massachusetts Bay give us every reason to believe that this may form a very important nursery, because the eggs may find protection and apparently ample food, the plankton communities being very rich; and it would probably be an ideal spot, not only for locally spawned cod eggs but for those passing along the whole coast of Maine to drift in and develop; and if our observations are repeated for another year they will, no doubt, show the same thing.

The solution of this problem should be sought along two lines. The eggs passing out of the bay should be followed. I have computed the rate of drift as indicated by the bottles and as indicated by the eggs. The eggs that spawned in the Gulf of Maine may drift into Massachusetts Bay and hatch. That would not seriously alter the problem, because the same current that brings them in would, no doubt, carry them out; and the few that reach the bottom in the interval might not seriously alter the general conclusions that very few remain there.

The other possibility is that a great many larvæ are destroyed in that region. In fact, some of the recent papers raise that question whether or not the larvæ are not all being destroyed in the early stages. It may be that a great many of them are being destroyed, but the cod investigation shows that the cod eggs have been hatching in the bay. The fact that so many of the pollock seem to exist there, at least for a time, indicates that they are not all wiped out.

That covers the work to date, except that there is one other little indication that at times large numbers of cod larvæ come into the bay. Some experiments were made after the conclusion of our work near the Boston Lightship by Mr. Iselin on June 5, and he found in one bottle, at 10 fathoms, 122 cod larvæ from 4 to 5.9 millimeters in length. Eggs were abundant in both bottles. We do know that some larvæ come in at certain times, but I do not think any of them remain long enough to be of any importance, because, obviously, the drift is a permanent thing.

MACKEREL

By O. E. Sette

The mackerel investigation was begun in June, 1925. Thus we have to date only a part of the field data for the 1925 season and all of the data for the 1926 season. All of the material collected is not yet analyzed, so that at best we can present at this date only a preliminary report on limited phases of the subject.

The first work was done during June and July at Woods Hole, Mass., where the pound-net fishermen were visited as often as possible and specimens of mackerel were secured in such quantities as could be handled in the laboratory. The particular object in this first work was to determine the technical methods suitable for this species. Large numbers of fish were measured, weighed, sex determined, scales and otoliths collected, and their condition of spawning maturity determined.

It was soon evident that the mackerel caught in the traps were generally much smaller in size than those taken by the offshore purse seiners, the trapped mackerel ranging between 20 and 30 centimeters in length, while from the market reports received from Boston it was evident that larger mackerel were taken by the purse-seine fishery.

In order to cover the purse-seine fishery we secured the services of Mr. Gregersen, who took data at Boston from August to the end of the season; and during 1926 we were fortunate in securing the services of Mr. Nesbit, who collected the material of the purse-seine and gill-net fisheries throughout the entire 1926 season. These data consisted of relatively accurate information on the time and locality of capture of each vessel's catch. Measurements were taken daily on 20 to 100 mackerel selected at random from each of as many catches as possible. Scales were taken from five mackerel, selected at random from each of as many catches as could be handled daily, and such other general notes on the fishery as might pertain to the problem. During the 1926 season 1,206 vessel skippers were interviewed, over 25,000 mackerel were measured, and scales were taken from about 3,500.

Before presenting any of the data it will be necessary to describe the fishery in general, using as a basis our experience during the 1926 season.

Mackerel first appeared at the Delaware capes shortly before the 15th of April and were caught progressively farther northward until in the latter part of May, when they were taken in the vicinity of Block Island. At this time the majority of the purse seiners left the southern fishery and outfitted for the so-called "Cape Shore" fishery—that is, along the coast of Nova Scotia—where they fished during the first two weeks in June, returning with fairly good trips of mackerel about the middle of June, when they again took up the fishery in the Gulf of Maine, from Nantucket Shoals to the coast of Maine. Here they continued to make good catches until the early part of October, when the landings tapered off in quantity, and continued to do so until the middle of December, when the season finally was concluded. Summarizing, there are four natural divisions of the season:

1. The southern fishery, extending from the middle of April to the first of June and catching mackerel south of Cape Cod.
2. The "cape shore" season, from June 1 to June 15, when most of the purse-seiners are operating off Nova Scotia.
3. The "summer fishery," extending from the middle of June to some time in October, with the fleet operating in the Gulf of Maine.
4. The "autumn" season, from October to December, when the catch becomes more uncertain and the season tapers to an end with the approach of winter.

These are the natural divisions recognized by the fisherman, and, as we shall see later, they seem to have biological significance.

Referring now to Figure 17, we may present a summary of our data on sizes of mackerel during 1925 and 1926. The 1926 graphs are shown by the solid-line curves, representing the frequency distribution of sizes of mackerel in the purse-seine catch. The base lines of the various distributions are plotted with ref-

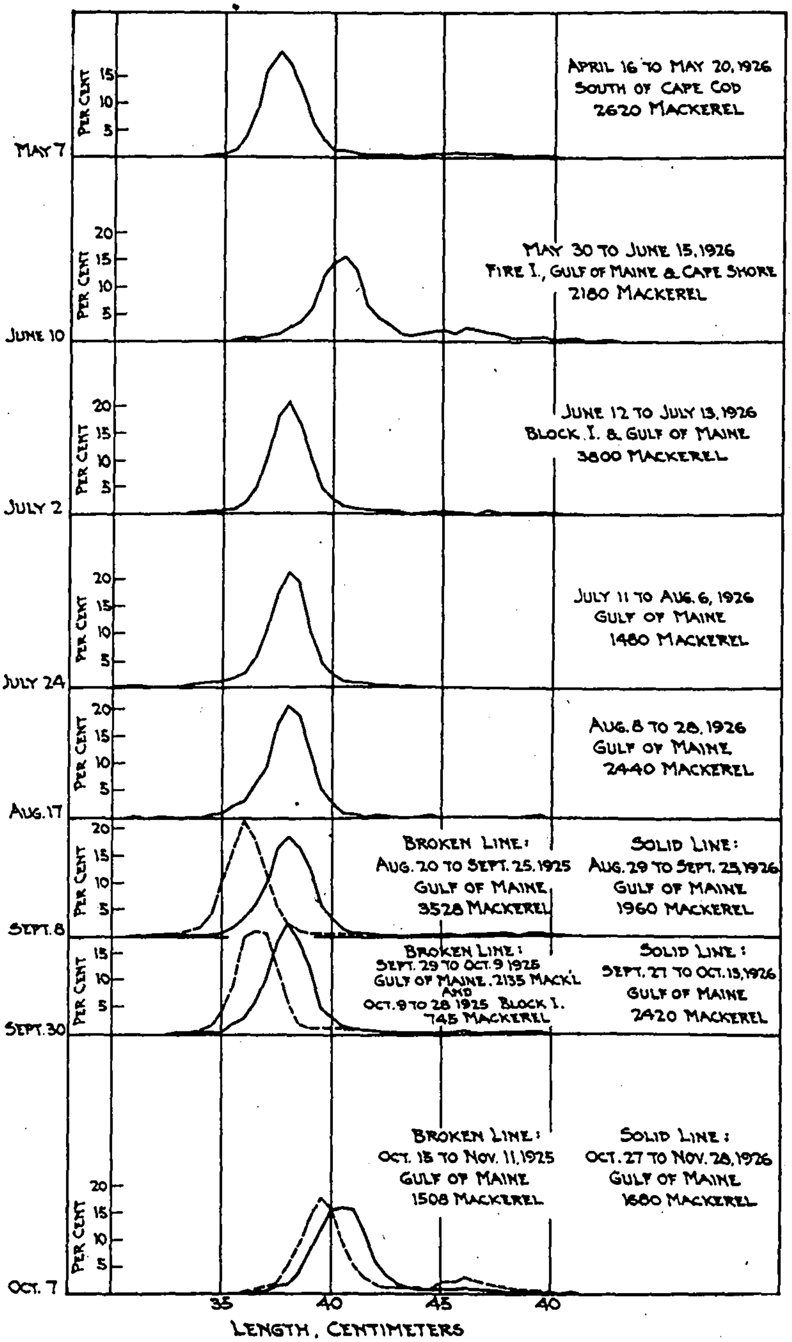

FIG. 17.—Frequency distributions of sizes (length from snout to middle rays of caudal fin) of mackerel during the seasons of 1925 and 1926

erence to the date that approximately represents the mid-point of the time interval during which the samples were taken, this mid-point being the date of the median sample of the series taken during the interval covered.

Disregarding for the moment the second and eighth frequency distributions, it should be noted that the sizes are grouped very uniformly around the mode at 37½ and 38 centimeters in the first and third to seventh distributions, respectively. Let us call the mackerel around this mode "medium sized." Turning now to the remaining two distributions (the second and eighth), we find the concentration of sizes represented by modes at 40½ centimeters, in position with lesser concentrations at 45 and 46 centimeters. Let us call these the "large" and "very large" mackerel. With these definitions in mind it is readily apparent from the graphs that medium-sized mackerel were caught in the southern fishery and during the summer New England fishery, while the large and very large-sized mackerel were caught during the cape shore season both along the coast of Nova Scotia and along the cost of New England by the few purse-seiners who remained in the New England fishery; and that, again, in autumn the large and very large mackerel appear in the catch off the New England coast. The full significance of these data on sizes can not be appreciated without a knowledge of the relative quantities of mackerel taken in the various portions of the season. We have not yet had time to analyze this feature in any accurate fashion, but we know that in general the quantities of fish caught during the southern fishery and the summer New England fishery were far greater than the quantities caught during the cape shore season and the autumn fishery, when the large and very large mackerel were present. With this in mind, it may readily be seen that the greatest bulk of the mackerel caught during the 1926 season were of medium size, and this may possibly be as high as 80 per cent of the total catch. We believe that it is highly significant that such a large portion of the catch was comprised of the medium-sized mackerel with the mode uniformly at 37½ and 38 centimeters.

Referring now to the 1925 curves, shown by the broken lines,[15] there are certain similarities and dissimilarities between the 1925 and 1926 data, which appear highly significant. From August 20 to October 28, 1925, corresponding to the latter part of the 1926 summer fishery, we have a similarly uniform group of sizes, the only difference being that the 1925 frequency curves have their mode at 36 and 36½ centimeters, as compared with 38 centimeters in 1926. Furthermore, the frequency curves during the 1925 autumn season apparently correspond to the large mackerel of the 1926 autumn season, with their modes at 39½ instead of 40½, as in 1926. It probably is not venturing too much to assume that the shift in the modes of the medium-sized mackerel from 36 centimeters in 1925 to 38 centimeters in 1926, may be due to growth, just as the shift from 39½ to 40½ centimeters in the large mackerel may also be due to growth. If so, it would appear that the stock of mackerel from which the bulk of our catch was taken in 1925 was of the same year class as that which formed the bulk of the catch in 1926.

If this progression in size from one year to the next represents the growth of a single year class from 36 to 38 centimeters, it is not unreasonable to suppose that in 1927 this year class would have grown so that its mode would be at 39½ centimeters and would then be of similar age and size to the large mackerel, with their mode at this length, in 1925. The 1925 large mackerel have progressed from 39½ to about 40½ centimeters in 1926. Considering these facts and assumptions, it is possible to trace, tentatively at least, the growth of the mackerel from 36 centimeters to 38 centimeters to 39½ centimeters and to 40½ centimeters in four successive years. These four points, when plotted in the fashion of the usual growth curve, present a contour that suggests that they really represent the growth of the species. With the addition of the 1927 data, these assumptions probably will be verified as facts. Meanwhile, it appears that our present catch of mackerel is based, for the most part, on a single year class, supplemented in small part by a year class of secondary importance two years older.

This theory will be tested further by the examination of scales and otoliths from mackerel collected during 1925 and 1926, and these collections will be continued in future years. Age determinations of these scales and otoliths will be made entirely independently of the data on lengths, and should afford an entirely independent corroboration of the year groups tentatively discussed in this presentation.

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[15] These have been plotted on base lines representing similar parts of the 1926 season.

Should our year-class theories be verified by subsequent study, we shall have an explanation of the tremendous fluctuations that occur in the American mackerel fishery; for if, in any one year, we depend mostly or wholly on mackerel of a single year class, it means that the stock of mackerel in the ocean is augmented principally by the offspring in unusual abundance in certain years, with one or a number of years intervening when very few young mackerel survive to enter the commercial fishery. Not only would the establishment of this fact explain the fluctuating abundance of mackerel, but it would also make possible the foretelling of years of abundance and years of scarcity, which would be a service of no little importance to the mackerel fishermen and fish dealers.

The establishment of this fact may also have tremendous importance in the conservation of the species. Each successful season leads fishermen to outfit in excessive numbers for the following season, and, having incurred heavy outlay in outfitting, they are obliged to continue even after it is evident that the season is a poor one. Were it known in advance that the season would be a failure, the fishermen would, in large part, turn their attention to other fisheries, avoiding a profitless investment in outfitting for the mackerel fishery and thus relieving the species of undue strain during critical periods in its survival.

In addition to the large secular fluctuations of the fishery, which may be traced to the dominant-age classes, there are the fluctuations within the season. These raise a number of questions of utmost importance to the fishing industry, questions that a greater knowledge of the biology and ecology of the species should answer. Why are mackerel caught abundantly on some days and not on others? What causes the appearance of mackerel at certain times at certain places? Why were the medium mackerel taken in the southern and summer fisheries, and why were the large and very large mackerel taken only during the cape shore and the autumn fisheries? In an attempt to answer these questions eventually we are compiling data of the catches and temperatures at various points along the coast; and as the contributions of the oceanographers provide additional knowledge of the physical and ecological conditions in the north Atlantic, we may ultimately be successful in understanding the causes of the intraseason fluctuations.

There are many other problems that also must be undertaken along with the major part of the investigation. These are being carried on in so far as our resources will permit. We have done some townetting for mackerel eggs and larvæ and have established the fact that in 1926 there was a great abundance of these forms in Massachusetts Bay. It is hoped to continue this work in order to correlate, if possible, the years of successful spawning with the years of subsequent successful commercial fishery. It is also necessary to know whether the stock of mackerel found along the American coast is a homogeneous population, or whether it is composed of several distinct races, which might individually be affected by unequal birth rates and thus produce differing size dominance in various regions. Tagging experiments, which might throw light on this point, were initiated in 1925, but due to the technical difficulties in finding a suitable tag these were discontinued for the time being without results that we can consider significant. It is hoped to develop a suitable tag and continue these experiments, and also to examine mackerel in the various regions from a morphological standpoint to determine whether racial characters are present. Meanwhile, our data are being collected in a manner that will permit of segregation according to such localities as may be designated for separate analysis in future migration and racial studies.

Doctor BIGELOW. I would like to ask one question—why the growth of the mackerel is so extraordinarily slow after they get to a considerable size?

Mr. SETTE. That we will have to ascertain.

Doctor BIGELOW. In fact it does not grow at all.

Mr. SETTE. The growth is very slow; but the material we had was not very extensive.

Captain WALLACE. Is the temperature of the water taken into consideration in the matter of scarcity?

Mr. Sette. That is another thing I have left out. Since last year, the Bureau of Fisheries has arranged with the Lighthouse Service to supply the temperatures to these light vessels, as far as they go.

Doctor Bigelow. You do not say anything about why the towing is so successful this year and whether there were a lot of eggs in the water.

Mr. Sette. We strained the water in Massachusetts Bay from about the middle of May to early in July, towing close to the bottom and at the surface, thus getting a large number of plankton samples. However, there was no one to look over the material, so I went at it myself; spent about six weeks over it and examined only a fraction of the material, covering approximately the collections from the middle of June and extending over two weeks. I identified, beyond reasonable question, an astounding number of mackerel eggs, and during the last days the larvæ appeared in numbers that were astonishing to me.

Doctor Bigelow. Certainly, only a handful of larvæ.

Mr. Sette. I got as many as 80 to 100 larvæ in one sample, and the eggs numbered tens of thousands.

STUDIES ON LARVAL FISHES

By Marie D. P. Fish

The spontaneous remarks of visitors to the laboratory, when they peer through the microscope at our work, are not always complimentary. It is a difficult task to convince many very practical persons that a tiny thread of fish life—often just a few millimeters in length—can truly be of such economic worth that a perfectly able-bodied man or woman is justified in spending time upon it. Fortunately, I do not have to apologize to this group!

It is a knowledge of that crucial period between the time when the adult fish is indicated merely by a few cells or an egg-confined embryo, until it ceases to be carried around passively by currents and tides, that gives us a key to the distribution of species, abundance, and the answer to many such questions, which we, as fisheries' investigators, are constantly asked to solve.

My general problem has been the identification, embryology, and distribution of the young of North Atlantic fishes. I place identification first, inasmuch as other problems are dependent, primarily, upon a determination of species. The work has consisted in the identification of all larval and young fishes collected by the various fisheries vessels in the region, a study of their early life history based on these records, supplemented wherever possible by artificial fertilization and development experiments in the laboratory. It has been our purpose to study the seasonal distribution of the species that occur in this region in relation to physical factors, and particularly in relation to the other organisms that occur with them in the sea. Much of this investigation has formed a part of the problem of the early life histories of the cod, haddock, and pollock now being carried on by Doctor Fish. A complete knowledge of the life histories of all fishes forms an essential part of the bureau's program in the North Atlantic. At the present time almost nothing is known concerning the early stages of many species, some of them commonly abundant.

As to methods, the surest way to identify a larva with an adult species is, of course, to secure a ripe male and female, fertilize the eggs artificially, and study the resultant developmental stages in the laboratory. Many of the commoner North Atlantic fishes have been studied in this way, and we have excellent descriptions and illustrations based upon the experiments. However, the possibility of keeping a larval fish alive for long after the yolk sac has been absorbed and the animal is actively feeding is very slight. We can not duplicate exactly their normal conditions of life in the laboratory, and, therefore, only early larval stages can be reared.

The chief source of our larval-fish material is the sea itself. Gaps often occur in our developmental records, for certain stages can not be found by ordinary collecting methods.

In collecting young fishes we employ nets of various kinds. Silk plankton nets, small 1-foot nets at the surface, and the ½-meter and 1-meter varieties are used commonly for eggs and larvae. The Petersen young-fish trawl, especially designed for postlarval and larger fishes, is very effective. In order to determine the exact depth of distribution, closing nets are necessary, of course, but our work rarely needs such fine differentiation. It is highly desirable to examine the specimens immediately, for preservatives are apt to shrink and distort the material and to change the color.

Although the larvæ of most fishes are totally unlike the adults, and at first glance offer no clue to their identification, there are a few characteristics that are permanent throughout all stages, from the embryo to the adult. Such a constant character is the number of vertebræ and, later, the number of fin rays. In the earliest stages, before the fins are distinguishable, the vertebral count is practically the only means of identification. There are certain peculiarities for such species, especially shape and pigment markings, which make them easily distinguishable subsequently, but the first identification is possible only by counting the vertebræ.

In some tiny specimens strong light will be sufficient to reveal the spinal column, but usually it is necessary to use stain, and in larger fishes to disect. Alizarin is used a great deal, as is new methylene blue. The fish is then cleared in clove oil, xylol, or oil of wintergreen, and mounted in balsam.

These methods have been applied to certain specific problems. In relation to the cod problem, I have cooperated with Doctor Fish in the identification, description, and measurement of all eggs and larvæ, computing percentages and charting results. This work has not been confined to the cod, haddock, and pollock, but has included all other species taken with them.

An unusual opportunity was afforded by the *Arcturus* oceonographical expedition for the study of larval fishes, their distribution over large areas in the Atlantic and Pacific Oceans, the embryology, food, and enemies, the determination of unknown forms as well as new stages of known species, and the conditions of life under which they exist in the open sea.

Throughout the cruise, larval and postlarval fishes were found distributed everywhere over the ocean, but the number of species and the actual abundance of specimens were strikingly different in the various regions investigated. From Bermuda, southward, in the Sargasso Sea area, every haul of the plankton nets and Petersen trawls yielded quantities of young fishes—often 10 to 20 species at a time. Although this part of the Atlantic had been subjected to heavy storms for some weeks past, the larval fishes seemed to thrive well, if we can judge from the number of uninjured specimens taken. It would appear, also from the collections here in a region that typifies conditions of the open sea, that a great many ocean fishes spend the early part of their lives at the surface. Of 41 species that I recorded and described in late February and early March, approximately 80 per cent were found always at the surface, 10 per cent at depths of 100 to 200 meters, and 10 per cent only in nets from below 1,000 meters.

The Pacific Ocean, in contrast with the Atlantic, although swarming with animal life, yielded noticeably few larval and postlarval fishes from March until the middle of June. Although every haul brought in a few larvæ, and the number of different species represented over the whole period was no less, the total number of specimens was much smaller than in the Atlantic during late February, March, and July.

On the *Arcturus* I worked out the embryology and early development of five species of flying fishes, some of them taken from nests of Sargassum weed. The unusual modification of the fins was found to be evident even in the egg. The eggs of 15 different species, of which the development was previously unknown, were hatched in the laboratory. At the completion of the expedition I had figured and described 161 species of larval and postlarval fishes, and further study of the collections undoubtedly will reveal many more. I was fortunate in obtaining and hatching the eggs of the burrfish, of Coryphæna, and even of *Mola mola*, the giant sunfish. Although this latter species may weigh almost a ton, as an adult, it starts life as an egg only 1 millimetter in diameter.

The *Albatross* made an extensive collection of tropical larval fishes, and through my work on the *Arcturus* I hope to be able to identify many of these.

A problem in which I have been interested since 1922 is the appearance and disappearance of tropical fish migrants at Woods Hole. The Gulf Stream, sweeping northward up our coast from the Gulf of Mexico, carries with it great quantities of floating gulfweed, *Sargassum baociferum*, under which numbers of little tropical forms feed and live. For some hundreds of miles they travel away from their normal home but surrounded by the same neighbors, the same conditions of temperature, and possibilities of food which they experienced in the region of the West Indies.

A first glance at a list of fishes, with their distribution areas, would astonish the observer. Dozens of species, known from Florida to Brazil, are recorded from just one northern region—the vicinity of Woods Hole, Mass. Why should this spot be favored with fishes alien to the rest of the coast between Cape Cod and the southernmost States? The explanation lies in the contour of our Atlantic seaboard. Below Cape Cod the coast line runs approximately north and south, except between New York City and Chatham, where it turns sharply and runs in an easterly direction. The Gulf Stream follows this curve, so that it lies due south of Marthas Vineyard. Thus the prevailing southerly winds of summer tend to speed the rate of northern movement of the stream south of New York, while north of this turning point their effect is to blow from its course the Sargassum weed, with its attendant fauna, into the shallow waters along the shore. In summer the broad belt of water between the Gulf Stream and the shore is sufficiently warmed so that any tropical forms that follow weed blown out of the Gulf Stream can survive. Records since 1893 seem to indicate that 12.5° C. is the minimum temperature for these species. When the temperature drops below this limit in the fall, all perish. I have recorded 92 subtropical species at Woods Hole (by "subtropical" I mean those species which our temperate waters have in common with the Tropics) and 70 species of truly tropical fishes. This group comprises those species having a definite range, which extends northward no farther than Florida or, in rare cases, to South Carolina. As nearly all of these visitors are either young or of small size, it is probable that they enter local waters only in company with the Sargassum weed.

The *Arcturus* oceanographical expedition was directly responsible for the discovery of the first American eel eggs known to science. We were at station 100, about 15 miles southwest of Bermuda, when a Petersen trawl brought up four specimens. After incubation for about seven days there emerged a tiny leptocephalus, 9 millimeters long, provided with great fanglike teeth. The method of identification was by counting the myomeres, which correspond in number to the vertebræ, and the specimen was found to have the correct number for the American eel. No other species had exactly this number, and others within 20 of the count had other specific differences that allow their elimination. The specimen had come, moreover, from the very place in the Atlantic designated by Johannus Schmidt to be the breeding ground of the American and European eels. Although Schmidt had never found an egg of either species in his 18 years of searching, he concluded that they must be in this region, since it was here that he found his smallest leptocephali. My paper on the American eel is in press now as a volume of Zoologica. The preliminary notice of the find appeared in Science two months ago.

NEW ENGLAND SALMONIDÆ

By Dr. William C. Kendall

As the chairman has indicated, my subject has been listed as "Salmonidæ of New England." My letter of advice concerning this conference was something to the effect that I should speak in reference to my work within the past year or so. While, in conformity with that advice, my major subject pertains to smelts, I should like to say a word about the salmon of New England, which from the sea ascend fresh-water rivers to spawn, and the so-called "landlocked" salmon, a permanent resident of inland lakes, both of which are propagated by the bureau.

The landlocked salmon has been variously regarded as a subspecies (*Salmo salar sebago*), a distinct species (*Salmo sebago*), and by some as structurally indistinguishable from the sea salmon (*Salmo salar*). Basing my conviction upon my own studies of the fish, I regard it as a distinct species. Further than that, there is some evidence that there may be different races in different waters, as for instance, in Grand Lake in Cumberland County, but I shall not try to prove it now, although the facts are important to fish culture.

The Bureau has been conducting tagging experiments with some of the Atlantic fishes. I should like to see such operations extended to the Atlantic salmon. A few years ago there was an unprecedented catch of young salmon ("smolts") in traps and pounds along a section of the Maine coast. The following year there was an abundance of "grilse"; later larger salmon were numerous; but last year (1926) the salmon catch was very small. For years the salmon catch on the coast of Maine has fluctuated, but until comparatively recent years salmon were taken only rarely in the outer Casco Bay region.

For many years the United States Fish Commission propagated the Penobscot salmon, and the Bureau of Fisheries has continued the operations to some extent. It seems to me that it would be worth while if the periodical appearances of salmon could be traced positively to the operations at Craigs Brook. Tagging adult salmon might be supplemented by marking some of the output of the hatchery.

Referring to my major subject: The smelt is a small species best known as a marine fish, which, like the salmon, ascends fresh-water streams (principally brooks) to spawn. As it appears in the market, it usually ranges from 5 to 7 inches in length, sometimes larger, sometimes smaller. Certain lakes contain "landlocked" varieties of smelt. My studies pertain to both the salt-water and fresh-water forms.

At one time the fishery for smelt was quite an important industry on the coast of New England and to some extent as far south as New Jersey; but it has greatly declined. It is a shore fishery still of some importance in Maine, and in value per pound the fish ranks with some of the commercially more important food fishes.

One of the objects of my work has been, by study of the biological and physical conditions affecting the supply, to endeavor to find some facts upon which regulatory measures designed to check the decline and possibly to improve the fishery might be based. While for many years the smelt fishery of Maine has declined gradually, that of New Brunswick, in the meantime, has undergone a remarkable growth, a great part of the products of which are shipped to the United States. Nearly 40 years ago the inspector of fisheries of that Province sounded an alarm concerning an imminent destruction of the fishery unless steps were taken to prevent it. Later regulatory laws were enacted, protecting the smelt in the breeding season and restricting the commercial fishery to two and one-half months in the winter.

In Maine there has never been any protection of the smelt while spawning in fresh water and they were caught at that time in great quantities, but not as a commercial fishery. Men and boys, from near and far, still visit the brooks and take all they can get almost every night during the breeding season. However, there is a close season for the commercial fishery during certain months in the year.

Maine has two independent commissions, one of which is the Inland Fish and Game Commission and the other the Sea and Shore Fisheries Commission, and each has its own laws and regulations. The general smelt law pertaining to the sea and shore fisheries prohibits the capture of smelts in tide water between the 31st of March and the 30th of September, inclusive. The Inland Fish and Game Commission's law allows the fish to be caught in fresh water, above tide water, for an indefinite period after April 1.

Before outlining the problem pertaining to the fresh-water smelt, first I will briefly describe some features of my work on the marine smelt, because of its bearing upon the situation just described and because it is the latest to engage my attention, although it simply supplements what I have done from time to time in years past.

In the last three years I have collected samples of the runs of smelts in the brooks during the breeding season of about a month in each year. My procedure was to visit the brook nightly, for the smelts run only after dark, on the ebb tide, beginning soon after high tide.

The size of the samples secured depended much upon the number of other fishers on the bank, which might be anywhere from 1 to 20 or more. The more smelters there were, the fewer fish would be caught by each. As high tide occurs about an hour later each night, of course my visits were succeedingly later. The following day the fish were measured and marked according to sex and scales were taken from each or from representative sizes for subsequent study. Three length measurements were taken—total length, length to fork of tail, and length to end of scales at base of tail—so that if any puzzling situation arose the use of one or the other dimension might remove the difficulty.

Inasmuch as the other dimensions, particularly that of the total length, are subject to more or less unavoidable variation, the most exact measurement is from the tip of the snout to the base of the tail. However, thus far I have used only the total length, which probably is correct enough for the immediate purpose. This measurement has been used in constructing length-frequency curves using class intervals with a range of 5 millimeters.

Inasmuch as a sample may not have represented the exact proportions of the various sizes of individuals composing a run, perhaps in a way it might be regarded as a selected lot. Yet in securing the sample it was a matter of "catch as catch can," so that when all the samples are considered as a whole the combination may be regarded as at least approximately representative. The combination of samples was made at the end of each season.

All the samples collected between April 1 and May 2, 1925, comprising 735 individuals, ranged in length from 130 to 270 millimeters. It is seen that the highest peak is reached in the 170–174 millimeter class interval. There is a fairly uniform curve from the 130–134 to the 190–194 class interval. Thence the number of individuals irregularly decreases, with hardly distinguishable peaks and troughs, to 270 millimeters.

As concerns the ages represented. it is difficult to judge where each year class begins and ends. It is clear that the youngest fish are comprised in the highest curve, but beyond that the matter becomes uncertain. To determine that point I resorted to the scales taken from the individuals composing each sample. As the age was determined by scale reading, that shown by each length of fish was jotted down opposite each class interval. By this method it was found that virtually all individuals up to the 185–189 class interval were 2 years old, but along here there was some overlapping by the next age group. The remainder were 4 and 5 years of age, but the 3 and 4 year age groups overlap a little, as was to be expected.

The graphs show that increase in age is accompanied by decrease in number of individuals.

To sum up: The determination of the ages of 1,254 individuals comprising the samples represented in the graphs for 1924, 1925, and 1926, reveal 1,057 2-year-olds, 152 3-year-olds, 38 4-year-olds, and 7 5-year-olds. It seems that the dominant year class is the 2-year-olds, which were to spawn for the first time.

The great majority of smelts that are marketed are of this class, also, although there is a greater proportion of older fish, which are sorted out and sold for a higher price. Thus, it appears that the smelt fishery depends largely upon 2-year fish.

From inspection of considerable material from three localities on the coast of Maine and from one in New Brunswick, I had thought that different geographical races might be represented by them and that proportional measurements, counts of fin rays, scales, and vertebræ might yield information on that point. Good-sized collections from each of the four localities were examined. Measurements of various dimensions were reduced to percentile proportions, and these, as well as the fin-ray counts, were each treated in the same manner as described in the case of total length. In other words, frequency curves were made. While some of the proportions showed possible racial differences, the amount of material was not sufficient to prove that the differences were not attributable to some other cause, as, for instance, dominance of a different year class, in one or another collection. Scales of these fish have been studied and they suggest that possibility.

Attention was also given to rate of growth of young smelts, but I had no extensive collections covering any one entire season. However, collections in several consecutive months, from May to March following, although not all in the same year, approximately indicate the rate of growth in the first year.

Recently hatched smelts average 5.15 millimeters total length on May 13. In March the range was from about 60 to about 90 millimeters, with the peak in the class interval of 75–79 millimeters. On August 16 the peak was in the 35–39 millimeter class interval; on October 14 in the 55–59 millimeter class interval; in December in the 65–69 class interval; shown by 126, 30, and 22 individuals, respectively.

That the curve may be affected by the facts that some of the months were not in the same year is indicated by another group, representing collections of November 4, 1907, and December 11, 1918. Here the class intervals are the individual lengths of the fish. The lengths range about the same, but the peak in the curve of the November fish (about at 73 millimeters) exceeds that of December (at about 68 millimeters) by 5 millimeters. As previously indicated, 2-year-old smelts may range from about 140 to 200 millimeters.

I have used so much time already that I will only briefly refer to the fresh-water smelt.

While the fresh-water smelt fishery is not extensive, and is localized, being almost wholly confined to Lake Champlain, the fish present several problems with which I have been engaged; but I will discuss only one of them at this time. This problem pertains to two apparently distinct size groups of smelts, which occur in the same lake. Other lakes apparently contain only one or the other size group. The difference in size is conspicuously manifest as the fish ascend inlets to spawn. In Sebago Lake, for example, the large form ranges in length from 8 or 9 inches up to 15 inches, or more, and averages, perhaps, around 12 or 14 inches. The maximum length of the small form is less than 6 inches and the average between 4 and 5 inches.

The principal question concerning these two forms is whether they represent distinct species, subspecies, or races, or not, or whether the small form is only the juvenile of the large form. There is some evidence that they are distinct. The breeding run of the large form occurs earlier than that of the small form. At Greenlake, Me., for example, where both sizes occur, the large form spawns in the last of March or early in April and the small form in May. The feeding habits and food of the two forms appear to differ. In Sebago Lake the large form has been found to subsist largely upon young smelts and the small form of smelt, while the small form eats Entomostraca almost exclusively.

The large form of Greenlake, transplanted in Michigan lakes, has become established in some of them, and, according to Creaser, no small form has been observed there. With considerable data on hand, an attempt was made to ascertain to what extent, if any, this evidence is supported by structural characters.

As in the case of the marine smelts, proportional measurements and counts were made in the same way. These show some differences. Thus, for example, the small form has a proportionately shorter head, the distance from the snout to end of maxillary is shorter, and it has more gill rakers than the larger smelt. A comparison of the probable errors of the means, made by Dr. Willis H. Rich, in each of these shows that they are unquestionably significant; but just what they signify is hard to say, as the apparently distinguishing structural characters of the small form may be those of the juveniles. It has not yet been observed, at least in my collections.

However, as a general rule the heads of the young fish are proportionally longer than those of older fish, and the reverse is the case in the instance in question. The large form is structurally more like the salt-water smelt, and the two have virtually the same number of gill rakers.

Comparison of the small form of fresh-water smelt with the salt-water smelts shows that in those particular characters they differ from one another in almost the same way that the small form differs from the large form; but scale readings show that the majority of the breeding small form are 2 years old, with a few 3-year-olds, while the smallest of the large form thus far examined are 3 years old.

There are other situations that complicate the problem, but those stated will suffice for the present.

The practical importance of a solution of the question lies in the fact that only the small form, with perhaps young of the large form, is eaten by larger food and game fishes. In stocking waters with salmon it has been customary to introduce smelts for salmon food in the same waters. If smelts are to be distributed thus for food for other fishes, the small form would be the better for the purpose, for in its relation to the young of some other fishes the large smelt is known to be a formidable predator in some waters. So, pending a positive solution of the problem, perhaps it would be as well to regard the two forms as distinct and to distribute only the small form; for if it is distinct the desired end would be attained, and if the form is simply a juvenile of the large form, the same results would follow as if the large form were distributed.

Mr. Radcliffe. I would like to ask Doctor Kendall a question. He called attention to the fact that there is no protection for smelt in the breeding season. Would it be possible to take smelt in any other season?

Doctor Kendall. That is when the commercial fisheries are carried on outside of the breeding season.

Mr. Radcliffe. Carried on outside the breeding season?

Doctor Kendall. About the middle of September or the first of October the season begins and continues until March.

Mr. RADCLIFFE. Is the catch of small smelt?

Doctor KENDALL. Six or seven inches long.

Doctor GILBERT. In fresh water?

Doctor KENDALL. There is no commercial fishing in fresh water.

Mr. RADCLIFFE. You are speaking of protection for the breeding smelt?

Doctor KENDALL. There is no protection in the breeding season. Great quantities of young smelt that have not attained 1 year of age are caught in the fisheries of Casco Bay, and I presume the same fisheries see that these little fellows, only a few inches long, are brought into the market when the larger smelts are not present in sufficient quantities. I went into Shores's grocery store one December and he had some smelts he was selling for 30 cents a pound. I bought a pound of them to examine. There were 41 smelts in that pound. In the same month, in Massachusetts, I bought 1½ pounds of smelts and paid 75 cents for them. There were just 10 smelts in the 1½ pounds. The small smelts certainly need protection.

SOUTH ATLANTIC AND GULF FISHERIES

WORK OF THE FISHERIES BIOLOGICAL STATION AT BEAUFORT, N. C.

By DR. S. F. HILDEBRAND

Of all living animals, none remind one quite so much of the giant, clumsy, lumbering reptiles of prehistoric times as do the turtles, tortoises, and terrapins. Some of these animals, such as the leather turtle and the loggerhead, still reach a very considerable size. The diamond-back, however, is small, for it seldom exceeds 7 inches in length when measured on the median line of the lower shell. In sluggishness and awkwardness it is quite the equal of its larger relatives, and ample evidence is available to show that this lowly creature, which nevertheless possesses meat that is unexcelled in flavor, is doomed to meet the fate of its ancient relatives unless man, who is its chief destroyer, becomes less destructive and, on the other hand, comes to its rescue by means of artificial culture. The rescuer and the perpetuator of the diamond-back terrapin has appeared in the form of the United States Bureau of Fisheries, assisted by the fish commission of North Carolina.

The work at Beaufort concerned with the propagation of the diamond-back, as stated in the last report of the commissioner, has definitely passed the experimental stages, and practical cultural operations have been begun, thanks to the aid given by the State of North Carolina.

There are on hand at the Beaufort station at the present time about 3,330 adult terrapins, consisting of 2,610 females and 720 males. The State has placed 1,760 adult animals there, consisting of 1,320 females and 440 males. All of the other breeding animals belong to the experimental lots of the bureau, and all of the last-mentioned animals, exclusive of about 370, have been grown in captivity.

About half of the animals belonging to the State were received too late for the last breeding season, and the others had not been in confinement long enough to become fully acclimated. Quite a few of the bureau's animals, included in the number previously given, are only just maturing. Reproduction, therefore, for the past season, considering the large number of adults on hand, was very low, as only about 4,360 young have been uncovered to date. Only 700 of these are the offspring of the animals owned by the State, all others coming from the experimental stock. It is expected that the hatch will be doubled next summer and that in another year it will climb to 12,000 or even 15,000, and that it will continue to climb as more of the bureau's animals mature and the State terrapins become better acclimated, and that a hatch of 25,000 to 30,000 will result by 1930.

Even the largest number mentioned is negligible as compared with the number that the fish culturist counts. Numbers hatched and liberated, however, may mean little or nothing; the number of animals that are liberated and survive to reach the dinner plate is what counts. It is here that we believe we have a very great advantage over the fish culturists, for we are able to keep the young animals, with comparatively little work and at small expense, until they have reached a length of 1½ to 2 inches, when they have definitely passed through the most critical stage of life. At this size they have developed a hard shell, are able to get about more rapidly, and they are no longer the utterly helpless creatures they were when first hatched. They no longer can be destroyed by mice, small birds, crabs, or small fish. We are able to bring the animals to this point within about six months, when winter fed, and within a year and six months if permitted to hibernate. The loss among these young animals seldom has exceeded 15 per cent, which is a lower mortality than commonly occurs among young chickens.

Furthermore, we have some evidence that a fair percentage of the animals liberated live and grow in the wild state, for of the comparatively few (consisting of only several hundred) individuals liberated at Beaufort each year, from 1914 to 1923, several have been recovered; and the rate of growth in these animals compared very favorably with those of the same age kept in captivity. It is believed, therefore, that the diamond-back terrapin cultural work along the lines now pursued at Beaufort promises to bear fruit from fifty to seventy-five if not one hundred fold.

When it was said that the work had passed the experimental stage it was not intended to leave the impression that experimentation had ceased. There is much to learn, and at least 10 definite sets of experiments, involving 21 lots of terrapins, are now under way. As time is less of an item in the life of a terrapin in North Carolina than to the proverbial hog in Louisiana, some of the experiments will have to run a long time before definite results may be expected. For example, several years ago, as the result of a conference with a geneticist of the Bureau of Animal Industry, a series of breeding experiments was planned, and the animals to be used were segregated in the spring of 1923. We have yet to wait another year before we can be sure that the offspring is from the particular males selected for the experiments. Then we will be obliged to wait at least six years longer for this offspring to mature and for the second generation.

The slow growth and the long time between generations naturally brings the question to mind: How long does a terrapin live? Or, what is its normal span of life? This is a question that does not yet admit of an answer, and I am not sure that we will live long enough to learn definitely, unless a genius should appear who can find a more reliable way of reading the age than by the growth rings on the carapace.

A lot of about 370 wild terrapins is on hand. The lot is composed of a few animals secured in 1902, others that were obtained in 1909, and the rest in 1912. Only about half a dozen of these animals have died during the many years they have been in confinement, and they were all adult breeding terrapin when secured. The only certain indication of old age of some of these animals is the smoothness of the shells, for the growth rings have disappeared, quite probably due to wear. For several years in succession egg production fell off, and just as we were becoming convinced that "old age" had overtaken them, this lot of old breeders came back last season with about the largest number of eggs and young ever produced. Consequently, we will have to guess again.

Other experiments consist of cross breeding two species of diamond-backs, comparison of rate of growth of hybrids with animals of pure blood, comparison of growth of the offspring of wild terrapins, that have been confined, with that of animals grown in captivity. Other experiments have to do with space requirements of the animals, the proportion of males to females necessary to insure fertility of the eggs, and the natural sex ratio. Among all the groups of animals that have been grown in captivity the males are very greatly in the minority. These lots, however, all consist of selected animals. Two unselected lots, each consisting of 300 terrapins, have now been set aside and will be retained until the sexes become distinguishable.

Winter feeding of young animals is being continued. One of the practical results derived from this work already has been referred to, for it was shown that a year's time may be saved in bringing the animals to a size at which it is thought safe to liberate them. Similarly, a year's time is saved in bringing the animals, when held in captivity, to sexual maturity and to marketable size. Our data indicate that a somewhat larger percentage of the animals survive when handled in this way, than if allowed to hibernate.

Necessity is the mother of invention. Similarly, many other things that are not inventions are learned when necessity knocks at the door. Last summer we were handicapped for suitable out-door space for young terrapins that had hibernated. It was decided finally to place them in the hothouse temporarily, as that place was vacant, the animals that had occupied it having been liberated. It was known, however, that the extreme heat from the glass roof would kill them unless some protection were provided. This was accomplished by coating the glass heavily with lime and by placing a board lengthwise over each tank, providing at least some shade at all times. This situation proved so successful that the animals were left there until they had to be taken out to make space for a new brood. Better growth than usual resulted, and the death rate was considerably lower. It is planned to repeat the experiment.

I have already stated that time is no item in the life of a terrapin. Therefore the year's growth gained by feeding the young the first winter probably is of no great importance when the animals are to be liberated. In practical terrapin farming this is of value, as the turn-over is shortened. The house that we have at Beaufort is large enough only for experimental purposes. At the present time we have crowded the animals very closely in some of the tanks and are holding as many as 100 to 125 in compartments scarcely 2 feet square. This is much closer crowding than has even been thought permissible. It is too early to know what the result will be. I can say only that so far the crowded animals appear to be getting along just as well as the less crowded ones. Under the largely "overcrowded" conditions, space was found for only about 2,500 animals. This number, within a few years, will be only as a drop in a bucket when compared with the large number of young that will be hatched. I am not prepared, at this time, to recommend the construction of a larger house, because I have not had time to study carefully all the data on hand relative to the difference in the death rate among the winter-fed animals, as compared with the hibernating stock. Deaths undoubtedly are fewer among the winter-fed animals, but how great the difference is can be determined only after an analysis of the extensive data is completed. This is what I regard as important, rather than the year's growth gained through winter feeding.

All the results concerning winter feeding through the years 1911 to 1925 are clouded by one factor—namely, heat. During all these years the house has been heated by means of a stove. It is utterly impossible to supply uniform and even heat all over the house at all times with a stove. Almost invariably, and largely without regard to the treatment given or the kind of food supplied, the greatest amount of growth has taken place among the terrapins nearest the stove, and the least growth has occurred in those farthest removed from the heat. This appears to show that a uniformly high temperature is highly desirable. The diamond-back is a cold-blooded animal, and without doubt digestion stops when the body temperature falls below a certain degree, as has been shown, experimentally, to be the case in a fresh-water relative. When digestion stops, it follows that growth also ceases. The interpretation of the results of virtually all of the many experiments performed in winter feeding is difficult, as it is impossible to know how much to charge to the important factor—heat—and how much to the treatment given, food supplied, and to other factors. A better heating plant is absolutely essential for the conduct of further experimental work in winter feeding.

Very extensive data on diamond-back terrapin culture that have not been analyzed properly have been accumulated at Beaufort. The working up of these data is the job immediately in hand.

FISH IN RELATION TO MOSQUITO CONTROL

We have heard much about the use of fish during the past few days. One important use has not been mentioned, however. I am referring to the employment of fish for the control of mosquito breeding. I am thoroughly convinced that fish are so important in this connection that many regions now occupied by man would be entirely uninhabitable were it not for the degree of mosquito control provided by fish. Such prosperous cities as Wilmington, N. C., and Savannah, Ga., for example, would never have been built had it not been for the measure of mosquito control provided by fish. I am as sure of that as I am of anything. Yet when fish are spoken of, few people think of these animals in that connection. In fact, it is only very recently that the value of fish as agents for mosquito control has been known. How unusual it is to think of fish in this connection I can best illustrate by telling you of a little incident that happened a few years ago in a Southern State. I called on a State health officer, and while there a reporter came in and said to the officer, "Do you have anything for me to-day?" The officer said "Yes," and gave him the following: "Mr. Hildebrand, of the United States Bureau of Fisheries, is here conferring with the State health officer and the sanitary engineers as to the best use to make of fish for malaria control." The evening paper printed this item of news with the following headline: "Eat more fish, best way to prevent malaria."

The use of fish for mosquito control is well established in the South. Of course, different situations are met in nearly every locality, and certainly they differ among localities. In some of these a very high degree of control is brought about by the fish alone (seldom 100 per cent control results); in other environments the degree of control is lower. Intelligence must be exercised in the use of fish for mosquito control, just as in using drainage, oil, or Paris green for controlling mosquito breeding.

I was asked several years ago by a Kiwanis Club in a southern city to talk to them on the use of fish for mosquito control. During my talk I made the statement that top minnows first were used for this purpose on a large scale in 1918—that is, during the war. My statement was challenged by an engineer present, who informed us that his company used the fish on a very large scale as early as 1913. I was obliged to admit that I knew nothing of this early work. However, I made diligent inquiry later, and I learned that this power company had received, presumably through the Bureau of Entomology, half a dozen cans of Gambusia from Louisiana to plant in an artificial lake almost on the Atlantic border, which had an area of several thousand acres. The fish certainly were given a wide range and a very large scale of work to do, but that obviously was not what I meant, nor was that intelligent employment.

Several Southern States now have regulations requiring the establishment of ponds on or near the area to be flooded for the purpose of propagating Gambusia, not by the hundred or even thousands, but by the millions. Such a regulation is not difficult to enforce, for the power companies have suffered such heavy losses from damage suits brought by people living in the vicinity of newly flooded areas, who have claimed damages because they suffered greatly from malaria. Consequently, the companies have learned their lesson and they are most anxious to do what they can to prevent malaria. The propagation of the minnows, particularly under artificial feeding, even in new ponds, has been very successful, and the results derived by way of mosquito control have been good. Of course, other methods of control, too, have to be used frequently in newly impounded waters. The little fish, if plentiful enough, will destroy the wiggle-tails if they can get them. Frequently, however, floating débris is so thick and so abundant in newly flooded areas that aid must be given.

Recently, upon the suggestion of a United States Public Health Service officer, I addressed a series of letters to 14 State health officers who are doing mosquito-control work for the purpose of controlling malaria, making inquiry relative to the use of fish (Gambusia) for malaria control. One State replied that the fish had been tried and found entirely unreliable and their use no longer was recommended. Another replied that other methods of control so far had appeared preferable for the very limited amount of work done in that State. However, plans were being made to use the fish in new work planned for next season. The other 12 all replied that they considered the fish very useful and depended upon them a great deal.

Sufficient investigations have been made in the South to have determined that Gambusia is the one fish to rely upon, as it is a natural mosquito eater. We are less fortunate, however, in the North. I wish to bring to your attention the crying need for further investigations of this problem in the northern waters, where Gambusia does not occur naturally. Prof. J. Percy Moore made a good beginning when he studied this problem briefly in the vicinity of Philadelphia and New York City. However, the study should be carried on much further; it should be done more thoroughly and it should be carried to other localities. The need for such a study has been impressed upon me very strongly during the past fall, when a great many inquiries relative to the use of fish for mosquito control were referred to me by various public health officials as well as private citizens. Of course, under the circumstances definite recommendations are impossible.

We have been telling these people that Gambusia could not be used. Now I learn that this fish has lived and multiplied for several years in certain ponds in a suburb of Chicago. This introduction was made from southern Illinois. Possibly a cold-resisting strain of Gambusia has been found, and it may be possible to use Gambusia in northern waters. In any event, the matter seems worthy of further study.

Doctor HILDEBRAND. I would like to add just a few words on some other work we are doing at Beaufort. Mr. Towers will present a paper dealing with the pigfish. We have followed the development of the egg and the young of the large anchovy, and we have taken up a third species of which we have the egg, but are not certain we have the egg linked with the right fish. We think it is the young sheepshead.

When we went to Beaufort we finished quite a bit of work already on hand. We had a collection of fish from Mississippi and from the Gulf of Venezuela. I had prepared some notes on Gambusia and have just completed the paper. We shall get all of these things out of the way and will then confine ourselves to the local fauna. No extensive work has been done at the station heretofore in the winter time, but we have undertaken some investigation to find out what lives in the deeper waters there in the winter.

We got many of the younger food fishes there until we had some very cold weather during the holiday season. Thereafter we got practically nothing, showing that these fish at least leave the harbor in the winter.

Doctor GILBERT. Do you remember when the Gambusia was taken to the Hawaiian Islands? That was very successful.

Doctor HILDEBRAND. Yes; I understand it was. It has been introduced since in the Philippine Islands and has found its way to southern China and Japan, Italy, and Spain. A shipment was sent to the West Indies recently.

Doctor RICH. Was a shipment sent to Palestine?

Doctor HILDEBRAND. Yes. It got across successfully, but the fish are not doing well. They have too many enemies. They still have a brood stock, but it isn't multiplying.

Mr. HIGGINS. The proposal for extending the work on mosquito-eating fish to the Northern States should properly be brought before the advisory committee when it considers plans for the future. I want to ask now about the success of your towing operations for eggs and larvæ of fishes in both inside and outside waters.

Doctor HILDEBRAND. That work has not been carried on long enough to have yielded results. The weather has been so bad lately that very few trips have been made. We have had a season of rough weather, with high winds and it has been almost impossible to do anything. I think only two trips had been made when I left Beaufort, but the work is being continued.

EMBRYOLOGY OF THE PIGFISH

By IRVING L. TOWERS

As is probably already well known, the pigfish (*Orthopristis chrysopterus*) is one of the important food fishes of the Beaufort region. A study of its feeding habits and life history, especially during the early stages of its life, has been commenced with a view to obtaining further information concerning the type of environment best suited to its needs, the rate of growth, the character of its food, and also the outlines of its embryology.

A plentiful supply of eggs of the pigfish was secured last May with a tow net in the channel between Pivers Island and the mainland; and as this is within 100 yards of the laboratory, the eggs could be examined with the loss of but little time.

Towings made shortly after dusk yielded the best results in furnishing eggs in the early stages, it being evident that spawning takes place principally at this time of the day. The eggs are comparatively large, being nearly 1 millimeter in diameter; they are semitransparent and contain one large oil globule.

Cleavage of the germinal disk takes place rapidly, so that the 2-cell stage is reached within half an hour, the 4-cell stage at 45 minutes, and the 8-cell stage at 1½ hours after fertilization. After 24 hours several features of the embryo pigfish are discernible, including the snout and eyes, with the dorso-ventrally flattened body, consisting of about 30 somites, extending around about one-half of the inner circumference of the egg. At 36 hours the embryo has assumed a more cylindrical form and has grown so as to encircle almost completely the inner circumference of the egg. The heart and the auditory vesicles are quite evident. During this process the yolk, of course, has decreased in bulk, so that at this stage it is perhaps only two-thirds its original size.

The period of incubation in this species is about 48 hours. Upon emerging, however, the young is considerably handicapped by the large elliptical yolk sac, which is equal to one-half the total length of the larva. The young pigfish, nevertheless, is quite active at this stage.

At about 2½ days after hatching, or at 4½ days after the egg was fertilized, the young pigfish had attained a length of 3 millimeters, the pectoral fins had appeared, and several characteristic chromatophores were evident. The yolk was virtually absorbed, with the exception of the oil globule, which was less than one-half its original size. The median finfold extended from the nape completely around the body, terminating at the throat.

The young, up to this stage of 3 millimeters in length, had developed in a glass dish in the laboratory, but due to some unknown cause several lots of fry expired upon attaining this size and none was carried to the next stage in the laboratory. The next stage available for study had attained a total length of 7 millimeters. These presented a considerably altered appearance, when compared with the preceding stage; the continuous median finfold had disappeared and was replaced by distinct dorsal, caudal, and anal fins, all with fairly distinct rays. This stage, however, scarcely resembled the adult in a single feature, the profile being concave, with the pineal fontanelle quite evident. Young of this class were found to frequent the more protected shoals around Pivers Island, where protection was provided by a close marginal growth of sedges.

This stage, represented by the concave profile, is very transitory, as fry only a few millimeters longer have a notably convex profile and the pineal vestige has entirely disappeared. The fins in these young pigfish of 11 millimeters retained virtually the same form as those of the preceding stage, with the exception that the spinous portion of the dorsal had commenced to make its appearance in the form of several tubercles somewhat anterior to the soft dorsal, which was already formed through a modification of the original median finfold.

In fish having a length of 15 millimeters the spinous dorsal is well developed, but there is a noticeable interval between it and the soft dorsal, although in mature fish these fins are joined. Scales have not yet been developed; the myomeres are quite distinct.

Young 1 inch in length may be recognized easily as pigfish, differing from the adult form principally in having enlarged eyes and a broad lateral stripe.

The ingested material in 100 young, ranging from 10 to 93 millimeters in standard length, was examined for the purpose of gaining some idea as to the progressive change in diet as the fish increase in size. Young of from 10 to 11 millimeters in standard length were the smallest in which the stomach contents could be identified definitely. Several of such fish had taken a few very small copepods. These minute crustaceans continue to be taken in considerably increasing amounts until the fish attains a length of approximately 30 millimeters, when chætopods are taken, after which the copepod becomes less evident and seldom is found in specimens over 60 millimeters in length. Other small crustaceans, including Gammarus, ostracods, and Mysis, supplement the copepods in the diet during these early stages; and even the larger sizes, up to

90 millimeters, continued to utilize Gammarus. Minute periwinkles appear to be taken also whenever they are available, as several fish 1 inch in length contained over 100 of these small mollusks. Chætopods, which are first utilized when the pigfish is a little over 1 inch in length, increase in frequency, forming the major part of the diet for all fish from 30 to 90 millimeters in length. The study has not yet been continued on fish of greater sizes.

Doctor BIGELOW. May I ask Mr. Towers whether he has made any determinations as to the age which the pigfish reaches?

Mr. TOWERS. They average between 4 and 5 inches in length. I haven't any idea as to the maximum age.

Doctor BIGELOW. There was some indication that they were rather a short-lived fish.

MULLET

By ELMER HIGGINS

For the sake of completeness, the mullet investigations have been included in this program. I shall take but a short time tc outline the problems presented by the mullet fishery, without giving detailed data in support of the observations made or the conclusions that may be drawn. The work is still in a preliminary stage, due to various circumstances, although many field data have been collected. Much of the credit for this work belongs to several assistants who worked with me.

The mullet fishery of the South Atlantic States is one of the most important sources of sea food in that region. The mullet occupies the same position in the South that the codfish occupies in the North. It is eaten fresh and salted in great quantities, and in the latter condition is a staple food of the poorer people from New Orleans to Norfolk. The gray mullet (*Mugil cephalus*) ranges from New England to Brazil, but the important centers of production are in North Carolina (which produces from 1,000,000 to 6,000,000 pounds annually) and Florida (with an annual yield of 30,000,000 to 40,000,000 pounds). While two species of mullet occur in the commercial catch, the silver mullet (*Mugil curema*) is practically negligible, and for that reason attention has been paid solely to the gray mullet.

The conviction that the mullet is suffering depletion in the Southern States has been growing among the fishermen and others for many years. While it is difficult to demonstrate a heavy decline in the yield in Florida, the total yield in North Carolina unodubtedly has fallen off to a marked degree. The maximum yield in that State was reached in 1902, when 6,750,000 pounds were landed; and from that year until 1918 the trend, as shown by statistics collected by the bureau, has been constantly downward, until the total catch in 1923 reached the minimum of 1,250,000 pounds. The yield in Florida since 1890 has been generally upward, although great fluctuations have occurred. It is apparent from the figures of the various sections of the coast that the fishery in Florida is composed of several units, and hence is subject to independent variations in yield. In general, the trend of the yield on the east coast and on the southern section of the west coast has been upward, but the trend of the yield on the western extension of the Florida coast has been downward since 1897. Here, again, however, the statistics have been quite inadequate for detailed examination, and as they are taken at such infrequent intervals they may, indeed, be misleading. Nevertheless, the popular idea is firmly fixed, particularly in North Carolina, that depletion is occurring. This notion is based partly on the declining yield and partly on the fact that grossly wasteful and destructive methods have been practiced in the fisheries. For example, for many years it was the practice to seine great quantities of very small mullet for use as fertilizer, either spreading them directly on the fields or sending them to the menhaden reduction plants. Both purse seines at sea, and haul seines in the rivers and estuaries, were employed. The popular opinion is supported still further by the fact that formerly the bulk of the yield consisted of fish in spawning condition, and in some places the roe fish, too large to market profitably, were taken solely for the roe, which has sold, when dried, for as much as $1 per pound.

Because of the importance of the fishery, the growing interest in conservation, and the popular belief in depletion, supported by statistical evidence and the personal experience and testimony of old fishermen, the problem of conserving the mullet fishery is considered acute in North Carolina, and has, therefore, received first attention in that State. As a basis for effective regulation of the fishery, observations on the life history of the mullet have been undertaken, and I shall outline for you briefly what is known from popular knowledge and from my own observations of the habits of this species.

Only two brief papers on the biology of the fish have appeared in America, and recently some observations on rates of growth and similar facts concerning an allied species have been published in Egypt; but it is surprising how little attention has been paid to the mullet, despite the fact that it has been cultivated in foreign countries for ages.

The mullet is a shore species, living in rivers and estuaries where an abundant growth of eel grass on muddy bottoms is found. In North Carolina the mullet scatter over the tide flats of the extensive brackish and salt-water sounds, feeding largely on the bottom mud and its contained organic matter. During the autumn months the scattering individuals congregate in schools and migrate from the sounds to the open sea. It is at this time that the commercial fishery takes toll of the migrating schools, which are packed so densely that many thousands of pounds are landed at a single haul of the beach seine; such as, for example, a single haul made at Beaufort in October, 1926, which yielded 62,000 pounds. The schools are composed of fish singularly uniform in size, usually of a single age class, although in the larger fish several ages undoubtedly are mingled. The early fall runs, beginning in August, usually are composed of the younger fish—the 0 class—with occasional schools of the 1-year-old fish. In September the usual runs are of 1-year-old fish, known as "fat mullet," because the abdominal cavity is filled with rolls of white, fatty tissue. Following these come the older fish, or roe mullet, which dominate the fishery after the middle of October. Virtually all of the mullet have left the sounds by early November, and it is at this time that spawning is believed to occur in the mouths of estuaries and in the open sea. The fish apparently do not remain in the open sea during the winter. The schools are observed traveling southward and entering the inlets again, and it is known that many of them either remain in the sounds or return during the late fall, for occasional catches are made during the cold winter months farther up the rivers in fresh water.

These fall migrations always accompany a change in weather, marked by falling temperature and northerly winds. Fishermen believe that the schools run before the wind out of the sounds, for they have been observed to return to the sounds if the wind suddenly shifts to the southward. Inasmuch as the younger fish take part in this migration, it can scarcely be considered a spawning migration; but as it comes at the time of the year when the eggs reach maximum observed maturity, there may be close relationship between the two phenomena. At present no spawning fish have been observed, nor have the eggs been taken in tow nets, but it is believed that proper means will reveal the presence of eggs in the open sea. As the fish with evidently mature eggs are taken on their seaward migration at this time of year, spawning may be said to occur during November and December; and it is likely that the spawning season is of limited duration, as the eggs are of approximately the same development throughout the ovaries of the fish, and as the young appear the following spring in very uniform size groups.

The larval stages of development of the mullet are unknown, but juvenile fish appear in the sounds about Beaufort in early February, when they are from 18 to 25 millimeters in length. Fish smaller than this size are seen rarely, but the group increases in abundance and the larger members of it become more numerous during the latter part of April, and by May even the smaller sizes show distinct growth. It is during April that the so-called "metamorphosis" occurs. The fish that formerly were silvery become pigmented over the dorsal areas. They are also said to change from surface or midwater plankton foods to the bottom foods, and distinct growth in scales can be observed. The circuli on the scales, which in the juvenile condition are transverse, now begin to grow in a more nearly concentric form, inclosing the juvenile scale so as to show a typical winter check. Scales from collections of these small fish made during early March had no marginal circuli, but a collection taken on March 24, 1925, contained three fish with one or two marginal circuli. Another collection, on March 30, contained a few in this condition; but by the middle of April the scales from all the collections of fish of this size group showed varying numbers of marginal circuli inclosing the so-called "juvenile scale." The mean length of this size group increases rapidly in May and maximum growth occurs during June and July. In the latter part of the summer the growth rate apparently falls off somewhat, but the exact figure has not been determined because of the admixture of another class of fish known as "cape mullet."

The next larger size group, which is found in the sounds during the winter and spring months, ranges from 110 to 180 or 190 millimeters in body length. The mean size does not increase until the middle of April, when growth is observed in this group, also. By the end of April spring growth has begun in this group, and the same formation of a winter check (by the inclosing of the scale by concentric circuli) is noted. At this time the fish bear on their scales a distinct winter check, which in every way is comparable to the check inclosing the so-called "juvenile scale." It is the second winter mark, therefore, and is formed when the fish is approximately 17 months of age. I have called all the fish up to this time the 0 group, and those after the formation of this winter ring, at a size of approximately 150 millimeters, the 1 group. The 1 group grows rapidly during May and at a maximum rate during June and July. By August these fish have reached a modal size of 265 millimeters body length and then appear in the commercial fishery as small mullet. In September they are mixed with the smaller fish of the next older year group, when they are termed "fat mullet." They are also taken in reduced quantities during October and November when mingled with the spawning fish.

These fish are considered resident in the vicinity of Beaufort, N. C. They are present in the sounds throughout the year, and the observed progress of the modal size is so constant that there can be little doubt of the real identity of this class of fish. In late August, or sometimes in September and October, another class of fish, known as "cape mullet," appears in the sounds. They are caught in greatest abundance by the menhaden purse-seine vessels while at sea in the vicinity of Cape Lookout before they enter Beaufort Inlet. They are taken in considerable quantities, also, by haul seines situated on the beaches inside the inlet, and southwestward along Bogue Bank. These cape mullet are distinguished chiefly by size, which ranges somewhat larger than the local 0 class in the fall and considerably larger than the 0 class in the early spring—that is, from 140 to 200 millimeters, with a modal length in September of 180 millimeters. They are also of the 0 class—that is, they bear only the juvenile winter mark on the scales. When last seen in October, however, they are nearly 50 millimeters larger than the 0 class in the early spring, and hence form a group that lies between the sizes of the local 0 group and the local 1 group. According to popular belief, they come from the north and are occasionally referred to as Virginia mullet. They certainly enter Beaufort Inlet from the sea, and are most abundant in the ocean outside the sounds. Their origin and the part they play in supporting the stock in this region are still a problem.

North Carolina fishermen believe that the migrating schools of mullet that leave the sounds in the fall proceed southward along the coast, always swimming, as they say "with their right eyes to the beach," and proceed to Florida. As dense schools are seen leaving the sounds in the fall and none are observed returning in the spring, the fishermen believe that the mullet remain in Florida and never return to North Carolina. This view, in part, is supported by Jacot, who made a brief investigation of the mullet at Beaufort during 1914–15. He believed that the mullet migrated to Florida in a leisurely fashion, feeding as they went, but that they returned in the spring singly, making a continuous voyage, and that the strain of this travel caused the formation of the winter check. His idea, however, was not supported by observations, and we have shown that the winter check is not formed by migration but by normal spring growth, which begins when the water warms to about 20° C.

This idea as to the one-way migration to Florida has had serious effect in opposing any regulation of the fishery in the interest of conservation, for the fishermen argue that if the mullet are not caught in North Carolina they will be lost to the State and will be caught in Florida. We therefore determined to examine the evidence of such migrations and whether or not the stock of mullet in North Carolina and Florida consists of a single intermingling population. Two methods of study were employed—the first by searching for morphological characters that might serve to prove the identity or the segregation of stocks in both States, and the second by tagging the fish. Numerous measurements were made of physical proportions of Florida and North Carolina fish, and it was found that the ratio of head length to body length of fish of the same size from the two localities was distinctly different. The same was true of the length of snout and eye, but the width of the interorbital was the same in both localities, as was also the position of the fins and the number of vertebræ. These measurements show that body proportions of Florida and North Carolina fish are different to a degree of high statistical significance, and it therefore indicates the segregation of the stock and the lack of extensive intermingling.

While such evidence, if sufficiently extensive, would be convincing, it was determined to make the proofs more satisfactory through tagging experiments. Accordingly, approximately 5,000 fish were tagged in the vicinity of Beaufort during 1925. A reward was offered for tagged fish, and 36 fish were returned. Early recoveries were from fish moving northward from Beaufort into the sounds, away from the ocean; during midsummer (August and September), recoveries were from the vicinity of Beaufort or to the southward and seaward; but from December to March occasional recoveries were made in the fresh-water rivers northward and inland from Beaufort, or in the same situations to the southward. The most southerly recapture was from near Georgetown, S. C., not more than 170 miles from the place of liberation.

During 1926 an additional 1,000 mullet were tagged, with almost identical returns, except that a larger proportion was recaptured. Thirty-seven were returned—three from the northern section of the South Carolina coast and all the others from North Carolina waters. It seems certain, therefore, that any decline in the North Carolina fishery can only be due to local conditions, and any restriction of the commercial fishery would result in benefit to the local stock of fish.

The question of regulation of the fishery is extremely difficult, even if it were proved that overfishing is the cause of the shortage of the supply. Natural fluctuation in the abundance and composition of the stock may be extremely important. The State collects no records suitable for the study of these changes, but our limited observations show that great variation occurs from year to year. For example, in 1925 we collected records of the landings from all of the dealers in Carteret County, where the majority of mullet are landed. The total yield did not greatly exceed 750,000 pounds. A high percentage of these were roe mullet; that is, fish 2 or 3 years of age. The younger fish were relatively scarce, and cape mullet were present only in moderate quantities. In 1926, however, a canvass of the State showed a yield of approximately 5,000,000 pounds, which contained a surprising amount of the first-class and of cape mullets. Repeated catches of 40 to 50 tons each were made by menhaden vessels, and these consisted entirely of cape mullet. In 1925 the examination of the market landings indicated that after October 10 all of the fish taken were roe mullets. The proposal was made that closed seasons be established after about October 15, which would reduce the season's catch only about 25 per cent but would result in saving more than half of the total number of spawning fish taken that year. During 1926, however, such a closure would have curtailed the total yield considerably more, and the number of spawning fish protected would have been insignificant.

Since the spawning fish are taken almost exclusively in haul seines and gill nets within the sounds it may be possible to protect them without restricting the sea fishery for cape mullet. On the other hand, free exploitation of the cape mullet may have serious influence on the supply of fish if it proves true that the cape mullet are not a distinct stock but are merely members of a rapidly growing group of North Carolina fish. It is anticipated that evidence on the subject will be secured through the detailed study of the large collection of scales now on hand, and it is hoped that means for collecting more accurate statistics in North Carolina can be instituted in order to study the variation in abundance of fish in the sea. If the press of administrative duties in this office permits, I shall look forward to rounding up many of these problems during the coming year.

TEXAS FISHERIES

By J. C. Pearson

The condition of the marine fisheries of Texas has produced a curious frame of mind among fishing interests of that State. While many insist that the peak of production has been passed long ago and that the fisheries are in a state of sad depletion, others maintain that the peak has not even been reached and that the fisheries are in a state of arrested development.

The fact that strong opposition has arisen in Texas against the modern type of fishing gear stands out clearly, however. As is usually the case this opposition comes from two main sources—from the commercial fishermen, who use less costly and less effective gear (in this case hooks and lines), and from the sportsmen, through legislation enacted for the alleged purpose of conservation.

During the summer of 1925, Mr. Higgins and Mr. Lord, of the United States Bureau of Fisheries, attempted to secure data relative to existing conditions, and this information is embodied in a preliminary report on the marine fisheries of Texas, a publication just off the Government press. In this report the authors stressed the need for more exact knowledge of the biology of the important food fishes of Texas before rational conservation needs could be realized.

It has been my privilege to conduct studies on the life histories of the leading food fish since last April. Our plans originally called for a study of the fishery itself, with careful emphasis laid on the size and age composition of the catch. This was found to be impracticable, as nearly all net fishing in the vicinity of Corpus Christi had been stopped by legal restrictions that closed various waters to net fishermen.

The Texas game, fish, and oyster commission is cooperating admirably with us and has furnished, for the field work, a boat and fishing crew to operate our collecting gear, which includes various types of seines, trawls, and townets. All work up to the present date has been confined to the vicinity of Corpus Christi, a region always considered one of the best commercial fishing areas along the Gulf coast.

Most progress has been made in understanding the life history of the redfish, *Sciænops ocellatus*. Spawning has been discovered as taking place in the Gulf of Mexico in the late fall. The young have been secured in incredible numbers in the Gulf Passes, on their way to inside waters. The young redfish, on reaching inside waters, grow at a remarkable rate and when a year old have attained an average total length of 35 centimeters and a weight of more than 1½ pounds. They enter the commercial catch when they reach this size and probably are most valuable to the trade, although it is believed that the fish does not commence to spawn until its fourth or fifth year.

The second fish of commercial importance in Texas, and also an important fish of the Atlantic coast, is the spotted trout, *Cynoscion nebulosus*. This species has a spawning season that extends from March to September, with the heaviest spawning probably taking place in April and May. Ripe fish have been secured throughout the inside bays, and the taking of larval and young trout from 9 millimeters in length up seems to indicate that the trout spawn in the inside waters, although heavy spawning may take place in the vicinity of the passes that lead to the open Gulf. Larval trout never have been secured in Gulf waters.

The third fish to receive special attention is the black drum, *Pogonias cromis*. This is the most abundant food fish in Texas. Collections of young from 7 millimeters up together with the occurrence of spawning fish in the inside shallow bays, indicate that spawning takes place here. The spawning season seems to be from February to May, although fish have been found in a ripe condition in August. Spawning occurs as early as the second year.

The preceding bits of information will give you an idea of what the bureau is striving for in Texas waters. Our plans have been extended recently to include a systematic study of all fishes along the coast of Texas, with Mr. Ginsburg in charge of this work.

A plain-spoken Texas philosopher once said to me: "There ain't no fish here, they're all conserved." What did he actually mean? Did he mean that the fisheries of Texas actually are disappearing because of man's unselfish desire to conserve, or rather, preserve the unborn fish for his unborn great-grandchildren? No; the man was honest, and he really suggested the evil fact that all conservation might not be in good faith. That conservation was merely a cloak for personal desires to be satisfied. With the alarming decrease in Texas marine fisheries in spite of virtual prohibition of all forms of modern fishing gear, does not the suggestion of that old philosopher bring to your minds a new idea? Might it not be true that conservation of natural resources is exceedingly profitable for the present generation? Certainly the tourists to Yellowstone Park bring more to the State of Wyoming than the sale of lumber from the park ever would. Does it not pay to conserve these trees? Do not the tourists to Niagara Falls bring more wealth to that section than the commercial utilization of the water power would? Hence the movement to protect Niagara Falls against utilization by electric-power concerns.

In Texas we have a powerful sportsmen's organization, whose self-appointed duty is the guardianship of the remains of the fish life. They have decided that every Texas citizen should have the privilege of visiting coastal waters and of fishing therein. But there is no fun in fishing when you can't catch fish. There is only one thing to do, and that is to conserve the poor fish by preventing their being caught in wholesale quantities. It is easy just to close all suitable water against commercial fishermen, and this, gentlemen, has been done in Texas.

We have an interesting economic problem before us. Would it not be of far greater economic value to Texas to encourage these thousands of sportsmen to follow a pastime that leads to the building of pleasure resorts, to the creation of many new occupations, and to the great advancement in real estate values rather than to allow a relatively small commercial fishery to interfere, at least in a psychological way, with the highly profitable trade of "soaking suckers?" That is a question that should interest some of you. Mr. Holmes suggested to me yesterday that a similar situation exists in Oregon in regard to the razor clam. The economic value of nonprofessional clam diggers in the community is apparently greater than that of the clams themselves.

How are we to distinguish true conservation from the vast amount of propaganda that pours forth from professional conservationists? You know they exist. They have demoralized the marine fisheries of the largest State in the Union; and, I understand, have caused trouble elsewhere. From a purely present-day economic standpoint they may be correct in their ideas. It is necessary that thought and attention be given to the problem.

Mr. Holmes. It might be well for me to qualify the example in Oregon that Mr. Pearson mentioned. I think the conditions there are somewhat different than those he related in Texas. There probably is more justification for the experiment and the tourists' attitude in trying to conserve the razor clam for their use; it could not support a very large industry, whereas it does bring in a very large number of tourists from every part of the country.

Mr. Sette. I would like to know whether the expansion of the commercial fisheries in Texas is really incompatible with equal enjoyment of the sportsmen's privileges in those waters. I do not see how it necessarily follows that you need to stop commercial fishing entirely if restrictions are sufficient to perpetuate the stock of fish. It should be possible to urge some reasonable degree of regulation, which would permit both factions to enjoy their occupation or sport.

Mr. Pearson. I pointed out that the sportsmen were not alone responsible for the decadent state of commercial fishing. There is a class of "poor" fishermen, who can afford only a few hooks, who at times make from $30 to $50 a day with hook and line, and they also oppose net fishing.

Mr. Radcliffe. I should like to make a few comments on the South Atlantic investigations. I think you are all impressed with the great diversity of the work in which the bureau is concerned in this region, including terrapin farming and stocking with fish to destroy mosquito larvæ.

I do not know whether it was modesty on the part of our chairman in not calling for comment on his paper on the mullet. I want to call attention to one point: In Doctor Bigelow's region, when you speak of fish you mean cod; when you come down to the South Atlantic and the Gulf, you mean mullet. The mullet is the important fish of the South. If it ever is marketed extensively outside of that area and others learn what a good fish it is, there won't be any left for the southerners to consume. The mullet fishery represents a highly important field for scientific investigation.

Doctor GALTSOFF. I wish to take this opportunity to point out briefly the extreme scientific interest in the study of the Gulf of Mexico. What I am going to mention may not be a job for the Bureau of Fisheries directly, because the relatively small importance of the fisheries there wouldn't justify prolonged scientific investigations, but I wish to call attention to the interesting oceanography in the Gulf of Mexico and its unexplored area. There is virtually nothing written on the Gulf of Mexico, except by Agassiz in his report of the Blake expedition. I searched the literature and couldn't find anything on plankton organisms, bottom forms, etc. At present, probably all shore fisheries are confined to the inshore products because of the currents outside of the lagoons, which make a boundary between the inshore waters and the Gulf itself. Because of the velocity of the currents the fishing is rather difficult. This should attract the attention of the oceanographer; the origin of the Gulf Stream lies in the Gulf of Mexico.

Mr. PEARSON. In my talk I merely wanted to point out how ineffectual any scientific work would be in a State like Texas if public opinion is not converted to believe in real conservation. This is illustrated by the results of work we did in North Carolina, where we recommended a closed season. The commission first voted to have a two months' closed season put in operation at once. Then the fishermen got together, the commission got scared, and there were no regulations; so the work practically has gone to waste.

Mr. THOMPSON. In connection with the fact that conservation has run wild in Texas, it might be interesting to say something about the fisheries of California and the scientific work there. I believe Mr. Scofield will agree that the scientific work upon the fisheries has as greatly restrained unwise conservation as it has helped wise conservation.

Mr. RADCLIFFE. What is the length of the coast line of Texas, roughly?

Mr. PEARSON. About 400 miles. The catch of food fishes is about 5,000,000 pounds.

Mr. RADCLIFFE. They must have a very poor fish supply out there, or else their commercial operations are having a very serious effect upon the supply that is there.

Mr. HIGGINS. The question of conservation in Texas is a little more serious than in some of the other States, because they have no offshore fishery. I wouldn't consider the snapper a Texas fish, although they do land some snappers. They depend upon three species almost entirely. No fishery can develop greatly if dependent upon such a small number of species; and these are shore fish, easily taken, and therefore subject more readily to depletion than are the pelagic species. I think the situation in Texas is not as hopeless as Mr. Pearson suggested, however. So far as the illustration that Mr. Pearson gave goes, the investigation in North Carolina showed a tremendous loss of immature fish. It is true that the fishery commission did not feel that they had public sentiment behind them so strongly that they could actually force a closed season. Yet the sentiment of the board was in favor of restriction, and they actually did pass some restriction on the fishing season. They have now about

10 days' protection, which is about one-fifth as much as they really need. I think sentiment will develop, and the work we do, whether it results in immediate regulation or not, will be appreciated later.

SCALLOPS

By J. S. Gutsell

The present scallop investigations, carried on chiefly at the Beaufort laboratory, were begun in the summer of 1925 at the request of the Fisheries Commission Board of North Carolina. The request was prompted by the great depletion of this valuable fishery.

The bay scallop fishery occupies an important place among the fishery industries of the State and is an extremely important one among those of Carteret County, to which it is confined. Of recent years it has approximated, in financial importance, the oyster industry of the entire State, with an annual value of nearly $250,000—an important item in the prosperity of the community.

The bay scallop had been studied previously by various investigators, particularly by Ritter, in Rhode Island, and Belding, in Massachusetts, with somewhat conflicting results as to growth and length of life. Belding's studies appear more convincing and his ideas have received wide acceptance. According to him, the life of the scallop is somewhat as follows: Spawning in early summer, growth to a considerable size before the first winter, the formation of a distinct winter ring, growth during the second summer to marketable size, and death before the next summer. Belding also studied spawning and embryology. He obtained fertilization by induced spawning but did not have much success with artificial fertilization nor succeed in rearing beyond a very early shell stage. The embryology seems to have been worked out well by him. He found no evidence of scallop migration. Drew has studied the sea scallop and various European workers the European forms. Of special interest are Dakin's memoir and Von Uexkull's study on Tonus.

I began these scallop studies with a general acceptance of Belding's views, but with a mind open for differences due to the different conditions prevailing (particularly climatic differences), and with the hope of extending our understanding and particularly of finding facts of immediate application to the local scallop fishery.

During the summer of 1924, a survey by the Fisheries Commission Board revealed an unusually great and widespread abundance of scallops. A later survey, following unprecedentedly heavy rains, showed almost complete mortality, except over unaffected areas in lower Bogue Sound. The scallop fishery, active from December 1 to 15 and from January 1 to April 15, confirmed these findings revealing scallops in great abundance, where found at all. Although direct evidence is lacking, there seems to be no reason to doubt that water-freshening from abnormal rains over the watersheds caused the mortality.

The first step in the investigation was to look for scallops. Dredging surveys revealed scallops in appreciable but not great numbers in one small area only, and that far from the laboratory. The area of recent abundance was extremely depleted. Fortunately, careful raking in the dense aquatic vegetation of the flats at the laboratory revealed scallops in considerable abundance. These flats then became and have remained the principal work ground. Surveys have been made from time to time over formerly productive areas. Recently it was determined to try, in addition, an area chosen because of the small size attained by the scallops.

The scallop is a hermaphroditic lamellibranch, possessed of the power to swim (for a short distance at a time), which inhabits shallow, grassy areas in decidedly salty water. Points chosen for special study were spawning, early life history and distribution, rate of growth, and age attained. Spawning is being studied by observation of gonadal conditions (both gross and histological) and by attempts at induced spawning and artificial fertilization. It has been learned that spawning occurs at least from spring to early winter. It has not been learned what are the governing factors, or definitely if there is a predominating or principal spawning time. Indirect evidence seems to point to the fall as the principal time, but this may be due to incompleteness. This is of possible importance for regulation of the open season. Attempts at artificial fertilization have failed in all cases to yield developing eggs. Attemps at induced spawnings may be considered to have been unsuccessful, except on three occasions. On two of these development proceeded only to few cell stages. On the third attempt embryos developed well and large numbers of shelled larvæ were obtained. These grew beyond the latest stage studied by Belding, but not beyond the straight-hinge stage. They were measured, sketched, and supposedly preserved, but, like the extensive but incomplete embryological material, came through in very poor condition. It was thought that these and the prodissoconch shell on small postlarvæ would make the recognition of larval scallops a reasonably simple matter. However, very few straight-hinge larvæ like these have been found, and no larger forms that could be surely connected with them. Until recently no postlarvæ have been found that showed the prodissoconch shell at all clearly. Little progress, therefore, has been made in this direction. However, perhaps it is worthy of note that the larval stage is thought to be of brief duration, for the egg is decidedly larger than that of *Ostrea virginica* and the larva attains a much smaller size, only (about 0.18 millimeters in extreme length).

Growth rate and age are very important, from a practical standpoint, and are not so elusive as spawning and some other problems that confront the investigator. They have received special attention. Data compared have been entirely from Pivers Island scallops. At first, collections of 50 were made once a week. Later this was changed to 100 twice a month—a more satisfactory arrangement. Data thus secured are regarded as quite satisfactory, except at the two ends of the series of collections.

In January, 1926, at my recommendation, the scallop season was opened. Contrary to my recommendation, no exemption was made of flats at Pivers Island (the laboratory) and in the last three days of the season they were denuded almost completely of scallops, thus ruining all chances of obtaining satisfactory disappearance data. Data for small stages also were deficient. For quite a while no small scallops were seen; thereafter, until recently, only scattering numbers were found (except that a moderate size was attained in the spring of 1926). Yet the crop this year is comparable with that of last year.

Various methods of collecting material were tried. Fine nets were dragged through the grass, grass was collected and rinsed in water, and the water was screened—no scallops. After long searching, some were found attached to grass. Next, spreading and drying the grass on newspapers was tried with considerable success, but still with uncertain results. This fall, in desperation it was determined to rake up much larger quantities of "grass," a washtub full being chosen. Although this represents a greater amount of labor in the collecting than would be imagined, and some day's work in subsequent study, it has been adhered to with increasingly satisfactory results. I feel that if the Pivers Island flats do not fail me, satisfactory growth (and death) data may be expected by another year, and with them a good understanding of the spawning season. Of course, unless there is a great deal of improvement on the depleted areas, the data inevitably will suffer from extreme localization. Tagging experiments to obtain information as to growth, longevity, and spawning time are being tried on a small scale.

The growth data taken for mid-month periods are presented in a series of graphs (fig. 18), which, with sufficient clearness, show two year classes and indicate growth to market size in not much over a year. A normal fall growing period is indicated by the special graph for 1925 and by data for 1926.

Doctor GILBERT. What is the extreme age of the scallop?

Mr. GUTSELL. I don't know. Belding's idea was about 2 years. He found a few spawning a second time. He found very plain year marks on the shell. Presumably because in the South there is winter growth, I didn't find anything that I could be sure of in the way of rings at this stage. Sometimes there would be three or four rings on a small scallop, one just as plain as the other. For a period of about three months (September to November) there is practically no growth. That is based on averages. This was also very plain by inspection of new growth in the fall. This year it was somewhat the same, but not so definite. What the explanation for the lack of growth in the fall is, I have no idea. It doesn't seem to have anything to do with spawning or anything else.

PACIFIC COAST FISHERIES

GENERAL REVIEW—THE INTERNATIONAL PACIFIC SALMON INVESTIGATION FEDERATION

By Dr. Willis H. Rich

As a very brief introduction to the outline of the salmon investigations, it might be well to give you a little idea of what we have in the way of salmon on the west coast.

There are five species, ranging widely from the coast of southern California up into the Arctic Ocean. The most valuable species, from the commercial

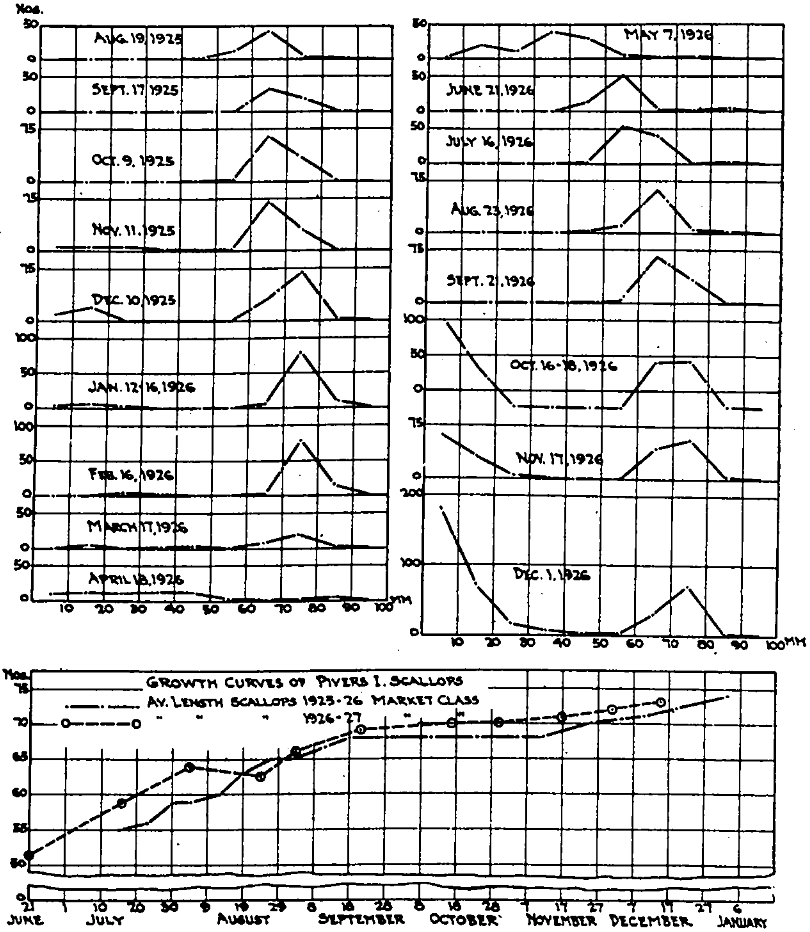

Fig. 18.—Length frequency curves (above) and growth curves (below) of scallops from Piver's Island, N. C.

standpoint, is the red salmon, and we have also the chinook salmon, the silver salmon, the chum, and the pink. In addition to these species of real Pacific salmon, there is a large, anadromous trout, or salmon, of the genus Salmo, closely related to the Atlantic salmon and with similar habits. This is known as the "steelhead trout." These fish are all anadromous, spawning in fresh water, the young going out to the ocean, remaining there for varying lengths of time, and returning to fresh water to spawn.

The habits, in so far as the life in fresh water and the life in the ocean are concerned, are quite different in the various species. The simplest type of life history is that of the pink salmon. The fish spawn in fresh water, the young go out to the ocean as soon as they emerge from the gravel and remain out there until they are 2 years old, when they return to fresh water to spawn. We have an invariable habit here—the fish always being 2 years old and having spent the greater portion of that time in the ocean.

The chum has, perhaps, the next most complicated life history. It has the same habit as the pink in going down to the ocean as soon as it emerges from the gravel, but it does not invariably return at 2 years of age, but at anywhere from 2 to 5, or possibly 6 years.

The silver salmon presents a still different variation. It remains, almost invariably, in fresh water for one year and then goes out to the ocean. It remains there for two years, returning as a 3-year-old fish. There are some variations from that, but the silver salmon, on the whole, is a 3-year fish.

There remain the red salmon and the chinook. The red salmon, with very few exceptions, remains in fresh water for at least 1 year but anywhere from 1 to 4, and then migrates to the ocean. It remains in the ocean for from 1 to 3 or 4 years and then returns. It varies in age, at the time of its return from 3 years (or possibly 2) to 7 years. The predominating age varies in different streams. In the Fraser River the predominating age is 4 years. In the Karluk River the predominating age is 5 years.

The chinook salmon presents other complications and ranges in age, at the time of maturity, from 2 to 7 or 8 years, the same as the red salmon, but, especially toward the southern portion of its range, has a marked tendency to migrate some time during its first year. It may migrate seaward immediately after emerging from the gravel, or, on the other hand, it may remain in until it is 1 year old or more. Spawning takes place in the fall. Many of the salmon do not migrate until the second spring following spawning, when they are approximately 18 months old, counting from the time the eggs were laid. In the Columbia River, particularly, which is the most important chinook-salmon stream on the west coast, the time of seaward migration is very variable and one may find seaward migrants in the lower portion of the Columbia River in almost every month of the year.

There are two well-known features of the life history of the salmon that have molded our conception of the need of conservation measures to a very marked extent. One of these is the fact that the salmon invariably die after spawning. That is a matter beyond question. The second, and most important, is the fact that the fish almost invariably return to the stream from which they came as little fish. In other words, what is known as the "parent-stream theory" is more than a theory; it is unquestionably a fair statement of fact. As a result of this habit, there has become established in all of the streams, and even in the tributaries of the larger streams of the coast, races of salmon. These may not always be distinguishable by physical characteristics (in fact, they resemble one another in everything, so far as any structural peculiarities or general habits are concerned), but we have every reason to believe that even in those cases where there is no possibility of distinguishing there are races, or incipient races, or something of that sort—self-perpetuating colonies of salmon in all of the separate streams and presumably in all of the main tributaries. We have considerable experimental evidence to support this, resulting from an extensive series of marking experiments and the evidence derived from scale examinations; and there is evidence, which has never been very carefully sought but which could undoubtedly be worked out in considerable detail, of structural differences.

The present problems of the salmon fishery are rather different from those of many of the other fisheries of which we have heard during the past two days. We know fairly well the general features of the life history of the salmon. We have methods whereby we can get any particular detail in the life history of any of the races or groups of races of salmon, if we want it—such as the age at maturity, the migration routes, and things of that sort. We have many data and methods well worked out whereby we can secure any particular item that we may happen to need. Furthermore, we have fairly reliable statistical records of the catches over rather long periods. In some places the statistical records are not as reliable as they should be; but in other places, particularly in some of the more important salmon-spawning areas in Alaska, the records are fairly good, and we feel that we are now in a position where we can begin to make a study of the causes of fluctuations in abundance. We can now undertake not merely a study of the fluctuations in abundance, determining their existence, extent, and nature, but an investigation of some of the causes of these fluctuations, and a considerable part of our present program is directed along that line, although not exclusively.

A couple of years ago the United States and Canada and the fish commissions of the west coast organized a group known as the International Pacific Salmon Investigation Federation, for the purpose of coordinating the work of the salmon investigations. The State of California, the Canadian authorities, and the Bureau of Fisheries were each working on salmon investigations. This federation was for the purpose of coordinating these various efforts.

At the last meeting of this federation, a program was presented and was accepted by the executive committee of the federation which will give you, very briefly, about as good an outline as I can present of the work that is being undertaken and projected. With your permission, I shall simply read this report.

The subcommittee wishes first to express its belief that the primary purpose of any program of research should be to produce the essential knowledge needed for the proper and scientific administration of the salmon fisheries. Our desire is to conserve effectively the great salmon resources of the North Pacific, and our conception of such conservation involves the utilization of the resources to the fullest extent compatible with their perpetuation. We would like to be able to say definitely how many salmon it would be possible to take from a given region and still leave sufficient for spawning purposes so that the supply will continue year after year at a high level. It has been brought out repeatedly at both of the previous meetings of this committee, that the central idea about which we should build our program is the production of the maximum yield obtainable from this fishery; and by the maximum yield is meant the greatest production of fish that may be taken for commercial purposes without affecting the future supply. To provide adequately for this we must know: (1) What natural fluctuations in the abundance of salmon occur; (2) the causes of these fluctuations, particularly the immediate causes, though the ultimate causes should finally be known; (3) the intensity with which the commercial fishery is conducted and its effect on the future supply; and (4) the relative value of various measures that may be used to prevent depletion and to build up runs already depleted. With these fundamental requirements in mind, the following program is presented:

COLLECTION OF ADEQUATE AND UNIFORM STATISTICS

These are of fundamental importance and should include not only data that will show the trend of the yield of each stream or fishing area, but the trend of the fishing effort. Reliable statistics are indispensable to a determination of the fluctuations in abundance, and without these all our other efforts can be of little value. It is recommended that a separate subcommittee be appointed to consider the reliability of the present statistics and to suggest desired changes, either in the content, manner of collection, or manner of presentation.

TAGGING EXPERIMENTS

The tagging experiments conducted in the past have been productive of a great deal of valuable information relative to the oceanic migrations of the salmon and bearing on the relationship existing between the salmon found in various regions. This should be continued until we understand, with considerable thoroughness, these features of the distribution of the salmon along the coast. Such data are essential to the proper interpretation of the statistics, and only in this way can be know the true yield of a given stream or region. (The importance of such data is well known in the results obtained from the tagging along the Alaska Peninsula, through which it was determined that the fish caught in the Ikatan–Shumagin Island district were largely from the productive streams of Bristol Bay.)

SCALE ANALYSES OF THE ADULT RUNS

This is essential to any understanding of the causes, either immediate or ultimate, responsible for the fluctuations in abundance, and likewise will provide the necessary data on which may be based prophecies of future runs. By this means only can we determine the productivity of each brood year, the relative effects of heavy and light seedings of the spawning beds, the effect of various methods of artificial propagation, and of modifications in the intensity of fishing, etc. Such studies are being carried out already on a number of the more important salmon streams, and it is important that they be extended to others. They must be continued indefinitely as long as any salmon research is being conducted.

STUDY OF THE ADULT RETURNS FROM KNOWN ESCAPEMENTS TO THE SPAWNING GROUNDS

This line of investigation must be carried out on specially selected streams where the production can be accurately determined. The number of fish taken each year in the commercial fishery must be known, as well as the number of fish ascending to the spawning grounds. In this way the effect of variations in the spawning escapement may be worked out, as well as the natural fluctuations in production, from a given escapement.

Such studies are now being conducted on the Karluk and Chignik Rivers and at Alitak in Alaska, and at Cultus Lake in British Columbia. These must be continued at least until the more fundamental factors affecting the fluctuations in production have been determined. It will be impossible to conduct such studies on all salmon streams, especially on such large rivers as the Fraser and the Columbia; but it is believed that important principles may be discovered by the intensive studies on these selected streams, which will be of universal application.

STREAM SURVEYS OF THE SPAWNING GROUNDS

These, as conducted on the Fraser, Rivers Inlet, Skeena, and the Nass Rivers by Mr. Babcock, and in the Bristol Bay region by Mr. Winn, and others, are valuable as a substitute for escapement counts, where these last are impossible. They provide a fairly satisfactory measure of the escapement and the extent to which the spawning grounds are seeded.

STUDY OF THE PRODUCTION OF SEAWARD MIGRANTS FROM KNOWN ESCAPEMENTS OF PARENT FISH

This is being done by actual counting at Cultus Lake, in British Columbia, and the Bureau of Fisheries is attempting to get some measure of the number of seaward migrants at Karluk through marking experiments. It is important as a means for determining whether the greatest fluctuations in mortality occur during the fresh-water life or in the ocean, and will also serve as a measure of the results of conservation measures (such as artificial propagation) applied during the life in fresh water.

EFFICIENCY OF VARIOUS METHODS OF ARTIFICIAL PROPAGATION, AS COMPARED WITH NATURAL PROPAGATION

This line of investigation is one of the most practical and is designed to improve the present methods of fish culture. Intensive experiments are being conducted by the Biological Board of Canada, and extensive marking experiments have been conducted by the Bureau of Fisheries and the States on the Columbia, Klamath, and Sacramento Rivers. Not the least important phase of this work is the study of the differences in the efficiency of natural propagation under varying conditions. Very few reliable data on this point are available, and a united effort should be made to discover the facts.

EFFECT OF TRANSPLANTATION

This is of very great practical importance on account of its bearing on the possibility of restoring depleted runs by artificial propagation. Experiments designed to test the effect of transplantation on the return of salmon to the tributaries of a large system are being conducted by the California Fish and Game Commission on the Klamath River. Some of the marking experiments conducted on the Columbia River will touch this problem, and others are planned in British Columbia.

IMPROVEMENT OF SPAWNING AREAS AND OVERCOMING OF OBSTACLES, NATURAL AND ARTIFICIAL, TO THE ASCENT OF SPAWNING SALMON AND TO THE DESCENT OF THE SEAWARD MIGRANTS

Under this heading by far the most important question is that pertaining to the possibility of providing efficient passageways for both adult and young salmon over high dams. It is imperative that a solution to this problem be reached in the near future, if possible, else the salmon runs in some of our more important streams will be destroyed, or at least reduced to a point where commercial fishing will be unprofitable. It is recommended that a subcommittee be appointed to consider the advisability of making a complete study of this whole question.

THE LIFE HISTORY IN FRESH WATER, WITH PARTICULAR ATTENTION TO THE FACTORS AFFECTING SURVIVAL DURING THIS PERIOD OF THE SALMON'S LIFE

If we are to control, to any extent, the survival of young salmon in fresh water, it is essential that we know the causes of the fluctuations in the rate of mortality. It is important that we know the optimum conditions for the development of the eggs and young and the effect of variations in weather, water stages, temperature, chemical composition of the water, abundance of food, abundance of enemies, etc. This includes, necessarily, a study of the rate of development of the eggs, the growth and habits of the young, and allied problems. In addition to their bearing on the problems of natural propagation these questions also have to do with the problems of fish culture, and in that respect are of immediate practical value.

LIFE HISTORY IN THE OCEAN

Although many of these problems will be difficult of solution and must be deferred indefinitely, it is important, for the sake of completeness, that they be included in the program. The questions of the optimum conditions for survival in the ocean, habits, food, enemies, distribution, factors affecting migrations, factors affecting the onset of sexual maturity, etc., are all important to a thorough understanding of the fluctuations in mortality rates during the life in the ocean; but since they are not, apparently, subject to any control by man, these problems do not appear to this committee to be of prime practical importance.

STUDY OF THE EFFECT OF SEA FISHING

It is generally believed that trolling and purse seining for salmon in the ocean, as at present conducted, is destructive, especially of immature fish. Various details necessary for intelligent control of this fishery should be worked out in each locality. From the tagging of troll-caught fish we will ultimately learn the interrelations of the fish caught at different places along the coast; and we should know, in addition, certain details for each fishing locality, such as the percentage of immature fish taken at different times during the year, the loss due to fish hooked but not landed, etc.

It is recognized that many of the fundamental facts of the life history of the salmon are fairly well known; in this respect we are fortunate in having a good foundation on which to build. We have good methods for tagging, marking the young fish, and for making scale readings, and these may be applied to the working out of many of the details that will be required. Many minor details can be and are being studied in connection with some of the larger problems mentioned, but it has not been thought necessary or desirable to bring forward at this time too many of the details.

Not all of the items in this program can be undertaken immediately, but it is hoped that ultimately the program, in its entirety, may be accomplished. We wish to emphasize, however, the importance of selecting the more important practical problems for first attention. These practical problems may not be the most interesting or the most fundamental, but may be urgently required as a basis for immediate administrative action, without which serious and perhaps irreparable damage to the salmon runs may results.

We have been conducting special studies on the salmon stock in Bristol Bay, Alaska. Bristol Bay is the greatest red-salmon producing area of its size in the world. There are a number of large streams, each heading in large lakes, one (Iliamna) being nearly 100 miles long. There are other lakes above Iliamna, connected with it by rivers. Spawning of the red salmon almost invariably takes place in these lakes, where the young remain for a year or two. At one time there were 30 or 40 canneries in this region. The production is upwards of 1,000,000 cases a year. The question was whether the fish taken in this fishery were of local origin or from somewhere else. Of the fish we took, we found that a considerable percentage belonged in Bristol Bay. That naturally threw a light upon the conservation problem there.

That is an outline of the general program. I, as you know, have been out of the work for some time and have only very recently gotten back into it, so I shall ask Doctor Gilbert to tell you more about the work that actually has been accomplished on the west coast recently and for which he mainly has been responsible. Doctor Gilbert, as you know, is the leader, I might almost say the originator, of fisheries research in this country, and I presume there are a great many of us here to-day who would not be here if it were not for the work Doctor Gilbert has done.

SALMON

By Dr. C. H. Gilbert

I shall speak briefly on the work we are attempting to accomplish in the Kodiak region, to which Doctor Rich has referred—a region that lies south of the Alaskan Peninsula and is the site of an important salmon fishery.

Among the multifarious duties that devolve on the Bureau of Fisheries there are no others, I venture to say, that are so exacting and entail such heavy responsibilities as the administration of the salmon fisheries of Alaska. In 1924, recognizing the precarious condition of these fisheries, Congress passed a bill that granted extraordinary powers to the Secretary of Commerce to enable him to control the fisheries of Alaska and prevent their further depletion. The powers thus granted made it possible to limit the fishing in any district to whatever extent seemed necessary, or to close it to fishing entirely for a term of years, if serious depletion already had taken place. The kind and extent of fishing could be prescribed in any area, and, in general, such regulations imposed as would prevent the disastrous effects of overfishing or would restore the yield in such districts as had suffered already. The entire responsibility for maintaining the yield of this most important salmon fishery was thus placed squarely on the Secretary of Commerce, and through him on the Bureau of Fisheries.

No one except those who have been directly concerned with the administration of these fisheries can appreciate the complexity of the problems and the inherent difficulties of the task. There are five different species of salmon of commercial value in Alaska, each species presenting a series of problems distinct from all the others. Furthermore, each of the almost innumerable streams of Alaska has, for each of these five species, its individual colony of spawning fish, which must have independent protection. The fishery is based exclusively on the spawning run, on the fish which, at maturity, are seeking their native stream for purposes of propagation; and it is obvious that the future of each stream depends on there being provided, each year, an adequate spawning escapement from the membership of its own colony. Regulations must be devised and enforced, which will so hold the fishing in check that enough of the salmon bound for each stream may escape the nets, to serve as parents for a future generation. Failure to accomplish this for any year will make serious inroads on the salmon supply when the inadequate progeny of that year shall have matured and themselves comprise the spawning run of the year.

It must be remembered that when these administrative problems were imposed on the Bureau of Fisheries a very extensive fishery was already established. Millions of dollars were invested, many thousands of men depended on it for their livelihood, and the products of the fishery formed an important food supply for domestic consumption and in foreign commerce. This industry had developed in entire indifference to the future. With each year all the salmon were caught that could be caught to commercial advantage, with no concern as to the size of spawning reserves. The inevitable consequence had been partial depletion, in varying degree, throughout the coasts and streams of Alaska. The damage already done involved not only the current year. Salmon of the different species mature at different ages, from 2 to 7 years, and the progeny of the inadequate brood years of the past were already in existence and must form our sole dependence for salmon runs extending over a term of years.

Had it been feasible to abolish the industry out of hand, increased spawning of all species in every stream would have resulted immediately, and rapid improvement could have been predicted confidently. But nothing approaching this simple solution was possible. A gradual curtailment of fishery operations was all that could be hoped for, which would occasion as little harm as possible to the fishery and at the same time insure progressively larger spawning reserves. It was a new experiment in fisheries conservation, the exact results of which could not be foretold. Regulations to insure the desired result called for the establishment of a delicate balance between commercial catch and spawning reserve. The effect of the regulations must be made the subject of careful analysis in each district, and modifications made from year to year, as experience should dictate. The pressure of this responsibility has been so great that Commissioner O'Malley has felt constrained to take the field each year in person, and has found full scope for his intimate knowledge of the Alaska situation and his wide practical experience of the fisheries.

As Doctor Rich has pointed out, the scientific staff of the bureau fortunately had made substantial progress in working out the life histories of the salmon before these heavy responsibilities devolved upon the bureau. A firm basis for conservation measures was thus at hand. But with the assumption of new duties toward the salmon, the demand for increased knowledge was at once experienced, and some of the unexplored regions took on a sudden and pressing importance. Among these unsolved problems, and the most urgent of them, was the question of how large a spawning reserve could be considered adequate in any stream, or, stated in different form, how large a yield can normally be expected from any given number of spawning fish. No even approximate answer to this problem was at hand, and yet the bureau found itself suddenly confronted with the duty of providing an "adequate spawning reserve" in each of the streams of Alaska. It is to throw light on this all-important subject that the Karluk and Chignik experiments have been devised.

The urgent necessity for this investigation had been appreciated even prior to 1924, and a beginning had been made before that date. The difficulties of the problem were seen clearly. The normal or average yield from a given number of spawning salmon could be expected to vary more or less widely for the same species in different streams, and would surely vary extensively for different species even in the same stream. Furthermore, a certain amount of variation could be anticipated between one year and another for the same species in the same stream.

The final yield from a given number of spawning fish would depend on percentage of successful spawning, percentage of escape from destructive physical agencies, from diseases, and from predatory enemies; and these, with other destructive factors, would vary with the species, with the stream, and with the season. It could confidently be expected that certain seasons, in a given stream, would be more favorable than others, and it might well happen that a smaller spawning reserve in a favorable year would produce a larger ultimate run than would be produced by a much larger spawning reserve in a year less propitious. These fluctuations, due to natural causes, are independent of the size of the spawning colony and form one of the greatest obstacles to a scientific administration of the fisheries. Through them, even the fact of depletion becomes difficult of detection, and the trend of the fishery can be determined only through observations extending over a considerable period of time. They make difficult, also, the solution of our special problem here considered, and will produce such a variation in our results, from year to year, as will yield us nothing more than an average expectation on which to base our procedure. Even this, however, will be invaluable. We shall have established what is a normal or average expectation of yield from a given number of spawning fish in the stream in question, and we shall have a basis for exact determination of the full swing of the pendulum of natural fluctuations in the yield of these colonies, a basis that heretofore has been lacking.

We selected as our species the red salmon of Alaska (*Oncorhynchus nerka*)—the most valuable species, commercially, and the one concerning the life history of which the most is known. It develops spawning runs in such streams only as have one or more available lakes in their course, and spawns almost exclusively along the gravelly shores of the lakes or in their tributary streams. The young, after hatching, seek the deeper waters of the lake and live there for varying periods before they enter on their downward migration to the sea.

In selecting streams for our experiments, it was necessary to find such as admit annually of a complete census of the run, including that portion that is taken commercially, as well as the portion that escapes the fishermen and ascends to the spawning grounds. Such streams are difficult to find, for usually at some portion of their spawning migration the mature fish mingle with those bound for other rivers and are there the subject of an important fishery. It is impossible to segregate the different races involved in such a fishery, and the commercial part of the yield is therefore left in doubt. Fortunately, in the Karluk River, on Kodiak Island, and in the Chignik River, on the southern slope of the Alaska Peninsula, we have two important red-salmon streams, the runs to which are substantially free from capture until they reach the vicinity of their respective mouths, where the fisheries are located. These two streams have been selected for our experiments. Agents of the bureau collect daily statistics of the commercial catch, and the spawning escapement is ascertained at counting weirs, one of which is operated in each of these rivers. The Karluk weir has been maintained yearly since 1921, and the Chignik weir since 1922.

Such a weir consists essentially of a picket fence extending entirely across the river, with a number of adjustable gates, through which the ascending salmon are permitted to pass, virtually in single file. Employees of the bureau are stationed at these gates day after day throughout the season and count the fish as they pass through. The run in the Karluk River begins in May and continues uninterruptedly into October. During this long period the watchmen are constantly on duty, shutting the gates during the darker hours of the night or for limited periods in the daytime when the run is slack; but otherwise, in wind and rain and the searching cold of the Alaska summer, they stand on the weir and count the salmon streaming through the gates. Although the run is constantly in progress during the summer months, the numbers that pass on different days varies widely, from a few hundred on some days to over 100,000 on others. The magnitude of the task becomes apparent when it is considered that in the season of 1926 over 2,500,000 red salmon were counted through the Karluk weir.

If all the progeny of a given year matured at the same age and returned in the spawning run of a single year, our problem would be a relatively simple one. Unfortunately, this is far from being the case. They may mature at any age from 3 to 7 years and return mingled in widely varying proportions with salmon of different age derived from other brood years. To ascertain the yield of any single year's spawning, therefore, it becomes necessary to analyze the runs of all the different years in which the progeny may appear. The first year the Karluk weir was in operation was 1921, when about 1,500,000 spawners ascended the river to the lake. Part of these returned as 3-year fish in 1924, as 4-year fish in 1925, and as 5-year fish in 1926. Others may be expected as 6-year fish in 1927 and as 7-year fish in 1928.

Completely to ascertain the yield from one year's spawning in the Karluk necessitates, therefore, the full analysis of the runs of five consecutive years, in each of which we ascertain the proportion of the fish of each age present in the run, and ther actual number. As the runs are not homogenous throughout the season, but vary from time to time in the proportion of fish of different age, it becomes necessary to take adequate samples at frequent intervals. An employee of the bureau who is stationed on the Karluk fishing grounds takes therefrom a sample of scales from 100 to 120 salmon on every available day during the fishing season. The number thus obtained for investigation during the season of 1926 was in the neighborhood of 9,000. Data of length and weight and sex are obtained for each fish, and from the scale analysis we learn the length of early residence in the lake and the age at maturity. Complete analyses thus have been secured of the runs of 1924, 1925, and 1926; and we have learned from these that while, as has been stated, the total range of age at maturity is from 3 years to 7, the great majority of the Karluk red salmon mature at the age of 5. The average of 5-year fish for the three years mentioned is approximately 80 per cent. Now, the 5-year fish from the 1921 spawning matured in 1926, so, although we do not as yet have complete returns from that spawning, we are now in possession of figures that make possible a fairly reliable estimate. This is of special interest as furnishing the first information we have ever had concerning the returns from a known number of salmon spawning under natural conditions.

The spawning reserve of the Karluk in 1921 consisted approximately of 1,500,000 salmon. The run in 1926, over 80 per cent of which was derived from the 1921 spawning, consisted of over 4,500,000 fish. The final figures will not vary widely from these and will thus show an increase of approximately 3 to 1. The significance of these figures we are not now in position to estimate. How wide the oscillation in productiveness is from year to year, due to natural fluctuations, we do not know. Neither can we tell whether the ratio of 3 to 1 lies nearer the maximum yield of the more favorable years or nearer the minimum, or whether it most nearly approximates the mean. Some light on this problem may be expected in 1927 and in succeeding years. As it happens, the spawning escapements to the Karluk varied widely during the first few years of the operation of the weir. With 1,500,000 in 1921, less than 500,000 in 1922, over 670,000 in 1923, and over 750,000 in 1924, we shall have presented to us a series of runs representing returns from spawning colonies of widely different sizes. If the 3 to 1 ratio observed as between 1926 and 1921 is substantially reaffirmed as between 1927 and 1922, the 1927 Karluk run will be of such small size as to yield little if any surplus to the fishery there located.

These disquieting facts have been communicated by the bureau by way of warning to the companies concerned, coupled with the qualifying statement that in the present early stage of our investigations our experience is too limited to serve as the basis for confident prediction. If the ratio of return in 1927 should prove much higher than in 1926, a satisfactory run might result, despite the very limited spawning of 1922. The result will be observed with the greatest interest. Whatever it may be, it will add materially to our present knowledge. With each successive Karluk year, further additions will be made. In 1927 we shall have similar returns from the Chignik, to be followed by an unbroken series also from that river. In the near future, therefore, we should have ascertained how close a correlation exists between the size of a spawning colony and the extent of the run that it produces.

Mr. Sette. With reference to this 50 per cent escapement, isn't it reasonable to suppose that at times the natural run, due to natural causes, might be much below the usual number, and by allowing a 50 per cent escapement of this natural run you would have much less than the necessary amount to produce a normal run in subsequent years? If the normal run amounted to 5,000,000, and in an off year you got only 1,000,000, would not the fluctuations be continued by having merely a 500,000 escapement in that year, as compared with a normal escapement of 2,500,000 in a normal year? Would it not be possible, by having a fixed escapement for any certain river, to control to some extent the natural fluctuations?

Doctor Gilbert. That point is one that occurred to us at the beginning of our Karluk experiment. It must be apparent to you that on some years we got not only one-half of the total run, but the entire run.

We proceeded to deal with that situation in a modest way. We did not know at the time what the total run of the Karluk River was. We did not know what the ordinary escapement was. We did set, in the case of the Karluk and Chignik Rivers, an arbitrary number. The number that we fixed at that time was 1,000,000. That is the minimum on the Karluk River to permit of a commercial fishery. The same thing is true on the Chignik. We may find later that the minimum that we have set is entirely too small to answer our needs.

In 1922, the second year of our operations on the Karluk River, before this provision had been adopted only 500,000 fish proceeded to the spawning grounds. We expect returns from those fish next year.

The following year, 1923, about 670,000 fish went to the spawning grounds.

Mr. RADCLIFFE. I would like to stress the tremendous economic importance of this work. The world production of solmon in 1924 was about 1,000,000,000 pounds. Of that, the United States produced 520,000,000 pounds and British Columbia 197,000,000 pounds; or, the combined production on our North Pacific coast was seven-tenths of the world production.

The production of salmon in the North Atlantic is very small—less than 1 per cent.

This tremendous salmon-canning industry started in the States. As the fishery became depleted, the canneries moved northward. They are at the outpost of that industry. Either the industry must be maintained where it now exists, or we shall have to do without salmon, unless, perhaps, we can look to the southern seas.

Doctor Gilbert mentioned the fact that the scientist in the North is on trial. I sometimes wonder if it wouldn't be a good thing if more of us were on trial.

Mr. THOMPSON. Doctor Gilbert is in somewhat the same position that we are in the case of the halibut. The North Pacific seems to have been chosen as a ground to try the biologist. The great problems he has met and his statement of them apply very aptly to the halibut. I think that as I gain in experience with the marine fisheries, it is impressed upon me more and more that the fundamental problems to be met are very much the same, and that as the biologist is brought to face the facts in other regions, he will have to come to the same conclusion. I think those statements of fundamentals in the salmon problem, stated perhaps a little bit differently, would apply to a great many other fisheries.

We have in the inshore fisheries quite a problem as to the relative rate of fertility of the young and older stages. That has become of considerable importance in such fish as herring and halibut. The salmon goes to sea in its second year and remains for 4, 5, or 6 years. There is an interlude of sea life, and there is no way of getting at the mortality then.

I am interested to observe that there is a definite correlation between the spawning runs in the case of the Fraser River and the returns to that river. The fluctuations in the sea have not been so great nor so marked as to destroy that correlation between the spawning run and spawning return. During the sea life of the salmon the fluctuations in mortality are not sufficient (in the case, at least, of the Fraser River) to destroy the correlation.

That last statement regarding the general correlation and the fact that there is very little destruction in the sea, is another interesting aspect. If a very small number of fish returned in any particular year there would be two possibilities—either that they had not been successful in their early natural history, or else that there had been some destruction out in the open sea. That makes possible, I should think, a very interesting study of the needs of the young fish.

Doctor GILBERT. As regards this matter of destruction in the sea, we must not minimize the amount that occurs. There is always a very great destruction. The best evidence we have comes from our experiments with marked fish. Doctor Rich has been foremost in this investigation, and for many years we have marked large numbers of fish so that they could be recognized on their return, and the ratio of return to the number marked (assuming that the marking has not caused any injurious effect on the young fish) will give a fair evidence of the destruction in the sea.

Doctor RICH. I think the work of marking will be handled by Mr. Holmes. He has been taking charge of that work on the Columbia River, and I think he has that all in hand.

Doctor GILBERT. With reference to the amount of destruction that occurs to fish on entering the sea from the Karluk River, we believe we have some very favorable results in that respect. The majority of fish remain until their third year, when they proceed to sea. They are somewhere between 5 and 8 inches long, and we believe are fairly well able to take care of themselves. At the same time, I shall be very agreeably surprised if we find, on the completion of our investigation in the Karluk River (which Doctor Rich now has in progress, he having marked some 47,000 fish on their way to sea last year), we have a return of more than 10 or 15 per cent of these fish. So that destruction in the sea is not negligible, and the fact that it has not, in all cases, succeeded in destroying the correlation between the spawning and the final returns, merely shows that there are fluctuations in spawning which may not easily be overcome by destruction in the sea.

I may emphasize, at this point, our experience in the Fraser River. In this river we had had, from time immemorial, a very extensive run every fourth year and small runs in the intervening three years. In the fourth year there was very heavy spawning, for some unknown reason. Far back, beyond historical times, the four-year cycle became a fixed feature in the fishery of that stream, but by a very unfortunate occurrence in one of those fourth years the run was checked. The fish were not permitted to reach their spawning grounds, and the peak run in the fourth year was lost entirely and never was recovered.

I must call your attention to the fact that the pink salmon, or the humpbacked salmon, is a 2-year fish, as Doctor Rich has said, and we have alternate cycles almost universally throughout the range of the pink salmon. Every other year is a successful year. There is no overlapping of groups. We do not have 3, 4, 5, 6, or 7 year fish to help breach over the results of unsuccessful spawnings; so when an unsuccessful spawning occurs, two years thereafter there can not be a large run. Sometimes, when a successful spawning occurs, unfortunately, a large run does not occur two years thereafter. It is possible to undo the effects of a large spawning and not possible to overdo the effects of a small spawning.

Mr. THOMPSON. Is it your opinion that the large mortality in migrating to sea has in very many cases destroyed those 2-year and 4-year cycles? Are these cycles not evidence, rather, of the stability of that correlation?

Doctor GILBERT. So far as that is concerned, I am ignorant at this time. The correlation will be between the commercial catch of a given year and the returns 4, 5, or 6 years thereafter. The correlation will have to be between the spawning escapement and the adult return. Unfortunately, prior to the present era, we have no statistics except those for the commercial catch. It may very well be in a given region that the commercial catch has a definite relation to the spawning escapement. In Bristol Bay the fishing is conducted exclusively by gill nets operated from small boats. If the season is very stormy the small boats can not operate freely and we will have a very much larger percentage of fish escaping than we have in a season of good weather in which it will be possible to fish every day. You can see that our correlations are based on very inadequate data.

Doctor DAVIS. In regard to the marking experiments, we thought it would be very desirable to mark the young trout last summer. We cut off the fins, etc., and in practically every case within two months they had almost grown out again.

Doctor GILBERT. If you had consulted with Doctor Rich before you attempted that experiment I think you might have had better results. We had this same experience. The known power of regeneration of fins was a difficult factor to deal with until we ascertained that if you cut deep enough below the articulation of the rays with the underlying structures no regeneration will occur. You may cut the caudal fin off one-half inch from the base and that entire fin will regenerate. I took a harness punch and made circular cuts in the fin. They also filled up completely. There was nothing to show that this had been done except some pigment markings. If you will cut deep enough, you will find that no regeneration will occur.

Mr. BOWER. I have had something to do, more particularly in an administrative way, with the Alaska fisheries for more than 15 years, and I think I am in position to pay tribute to the excellent results that have been gained by Doctor Gilbert and Doctor Rich and others in solving the problems that confronted us when we sought to protect and conserve the salmon fisheries in Alaska. I can not use too high terms in indorsing the work that has been accomplished.

Perhaps the record should be made to show the extent of the fisheries of Alaska commercially. Employment is given at present to approximately 25,000 men. There is an investment of about $60,000,000, and the products, annually, are valued at substantially $40,000,000. That gives some idea of the extent of the industry with which we are dealing. Prior to the enactment of the law of 1924, to which Doctor Gilbert made reference, we dealt with the fisheries of Alaska as best we could under the law of 1906. We realized its inadequacies, but we used the limit of authority given by it in conserving the fisheries of Alaska. Nevertheless, serious depletion occurred in many places. The law of 1924 gave us the authority we needed to say when, where, and how fishing might be practiced. It seems not inappropriate for me to mention one or two of the results, in a practical way, of that new law and the regulations promulgated by the Secretary of Commerce.

The outstanding practical achievement is the return of the pink salmon to Alaska waters in the season of 1926. I think the regulations of 1924 may be given full credit for this result, for the reason that the pink salmon is a 2-year fish, and the fish that escaped in 1924 by virtue of the department's regulations produced, in 1926, the largest run of pink salmon in the history of Alaska. The commercial catch was more than 1,000,000 cases in excess of the largest previous catch in the history of the Territory. That is a direct tribute to the scientific work that has been done, because the regulations are based chiefly upon the results of science.

The other thing I want to mention is that we have a commissioner of fisheries who has courage, foresight, and ability to deal with this situation. Doctor Gilbert spoke of the dilemna with which we are confronted. The commissioner knows only too well the troubles that visit us, from an administrative standpoint, in dealing with this problem. Sometimes our best friends are after us with the sharpest sticks. I want to pay the highest tribute to the commissioner of fisheries in his administration of these fisheries. It is an inspiration to work with him and for him in such an undertaking.

Doctor Rich. I wonder if we might not hear from Mr. O'Malley on some of the experience he has had recently in regulating the salmon fishery of Alaska.

Mr. O'Malley. Possibly Doctor Gilbert could tell it better than I can. Looking back on the catch and the escapement in Karluk in 1922, and comparing them with 1926, there seems to be a three to one ratio—three fish this year for every one that spawned then. At that time Doctor Gilbert called my attention to the fact that with such a small escapement it might be a good plan to close the fishery this coming year and let the fish have a chance to rehabilitate themselves. Doctor Gilbert also pointed out to me the small percentage of grilse noted in this past season, which might indicate that we need not expect a successful run in 1927. In fairness to the three companies operating there, we thought it best to close up shop, leave the run untouched, and accept the suggestions that came from the scientific investigators. However, there were local needs to be considered, for the natives are dependent for their livelihood upon work furnished by these three companies. Therefore, the department followed a more moderate course. It was thought better to warn the companies of an impending poor season and let them make their preparations accordingly, on a small scale. We have left the regulations as they were last year and notified the companies what we consider the run may be next year; we don't say positively it will be poor, but we have every reason to believe that it will be. As a result of this warning, I believe the companies will consolidate and operate on a small basis. If we are able to make predictions successfully regarding the size of runs it will save the industry millions of dollars. What we hope to do later on is to be able to forecast, with some degree of accuracy, what will happen in the future.

We have a problem confronting us in Bristol Bay, where there have been poor runs for several seasons. I think that if we can forecast with some accuracy what the next season's run will be, the people in Bristol Bay will be willing to forego a season's operations in order to take care of the run and give it an opportunity to rehabilitate itself. There is considerably more spirit of cooperation now than we had in the summer of 1924. I wondered then whether it was better to let the industry drift another year and make excuses to Congress or to take aggressive action.

I have just received the following telegram, which I shall read to you:

SOUTH BELLINGHAM, WASH.,
January 6, 1927.

HENRY O'MALLEY.
United States Commissioner of Fisheries,
Washington, D. C.

After going into records of Bering River very carefully we are convinced that in the interest of conservation of fish this section should get all escapement possible this season. It is always our desire to cooperate with the bureau in matters of this kind and it will be agreeable to us not to operate this plant during 1927, if you will issue an order closing the Bering River district. It is our sincere belief that this should be done, and we therefore believe it our duty to recommend it to you.

PACIFIC AMERICAN FISHERIES.

If we can get more people into that attitude, there is some hope for progress.

Doctor GILBERT. Since the question has arisen as to the amount of doubt in our prediction for the next year, I wish simply to state the nature of that doubt: What is the relation between variations in natural production, due to causes which we have not been able to identify, and the spawning reserve? We know what the spawning reserve was, the commercial run, we know in any year what a given spawning produced, but we have not been able to ascertain to what extent spawning reserves will vary in their productiveness. In other words, is it possible that a spawning reserve of one-third million may, under extraordinary conditions, produce a larger run of fish than is ordinarily expected?

Mr. BOWER. I want you to know that the splendid cooperation of the trade is due, in a large measure, to Mr. O'Malley's bringing diverse interests together. I am confident that the future of the salmon industry of Alaska is absolutely safe under the regulations of the Secretary of Commerce.

COLUMBIA RIVER SALMON

By H. B. HOLMES

As one of the most important means of studying the life histories of salmon, the Bureau of Fisheries, in cooperation with the Oregon Fish Commission, has conducted, during the past 10 years, an extensive series of marking experiments. In these experiments young, artificially reared salmon have been marked by removing certain of their fins and then have been liberated into the streams on which the various hatcheries are situated. The marked individuals have been identified by the absence of the fins when they were caught upon their return to fresh water to spawn. By means of these complete records of individual fish, our knowledge of the biology of the species and the success of various hatchery practices has been increased materially.

Twenty-six experiments, involving over 1,000,000 fingerlings, have been conducted. As a result of these markings, over 7,000 adult fish have been recovered, and additional returns from some of the experiments are to be expected during future years.

The collection of the data from the returning adults has proved to be a difficult matter. Some representative of the Bureau of Fisheries has spent the greater part of each season in the commercial fishing district, but it has been necessary to depend, for the greater part, upon the assistance of fishermen, cannery employees, and hatchery men for these data. The majority of the returns have come as a result of the payment of rewards for records of recoveries.

Two species of salmon have been marked—the chinook salmon (*Oncorhynchus tschawytscha*) and the sockeye salmon (*Oncorhynchus nerka*). The experiments with sockeye salmon will be considered first.

A thorough understanding of the sockeye marking experiments will require a knowledge of the history of the Columbia River fishery for *Oncorhynchus nerka*, which is known there as "blueback salmon."[16] In the early years of the fishery this species contributed an important part of the pack. For the five years, 1890 to 1894, it supplied an average of 43,000 cases. With the exception of a large pack in 1898, there was a rapid decline until the low level of less than 6,000 cases was reached in 1907. For the five years, 1904 to 1908, the average pack was about 9,000 cases—less than one-fifth of that of the period 15 years earlier.

In 1905 the Oregon Fish Commission made an effort to rebuild the run by artificial propagation and built a hatchery for that purpose on the Wallowa River. For some unknown reason, no bluebacks were intercepted by the racks at that station. Having failed in this undertaking, and knowing of no other tributary in which spawning bluebacks might be found, the Oregon Fish Commission called upon outside sources for a stock of eggs. In 1910 they received a shipment of 1,500,000 sockeye eggs from Alaska. Similar shipments of Alaska sockeye eggs were obtained each following year.

In the years in which the imported sockeyes should have reached maturity, none entered the tributaries in which they had been liberated, and there was some question as to the success of their propagation. It was suggested by some that the fish had returned to the Columbia River but not to the particular tributaries in which they had been liberated, the supposition being that in this case they would have been mistaken for native bluebacks. Other persons, who were not convinced of the truth of the "parent stream" theory, suggested that the fish might have entered some other river system for spawning.

The marking experiments with sockeye salmon were undertaken primarily to determine these points. The first experiment consisted of a marking of 50,000 yearlings, which were liberated in a tributary of the Columbia River in March, 1916. Adult fish from this experiment returned to the Columbia in 1918 and 1919, when they were in their fourth and fifth years. Authentic records of about 100 of them were reported from the commercial fishery. This number is of little significance, however, as no rewards were offered at that time, and as a result the reported returns are known to have represented only a small part of the actual recoveries.

The most interesting fact coming from this experiment was that these Alaska sockeyes differ sufficiently from the native bluebacks as to make it possible to distinguish the two classes of fish from each other by appearance only. This suggested the question of why these fish had not been observed in the Columbia River during the preceding four years when results of the propagation of the sockeyes should have been obtained. The only logical answer to this question was that the propagation had not been successful. The confidence in this answer was strengthened when it was observed that the fingerlings in former years had been liberated at a much earlier age. More conclusive evidence was obtained by a second marking. In this experiment the marked fingerlings were liberated during the fall of their first year, instead of being held until the spring of their second year, as in the first experiment. Not one return was obtained from this marking. It is evident, then, that under the conditions that prevail at these Columbia River hatcheries, success with sockeyes obtains only when the fingerlings are held until the spring of their second year—until their normal time of seaward migration. These results might be presented as evidence of the necessity of carefully checking the success of hatchery operations. In this instance it has been shown that success does not necessarily result from the liberation of large and vigorous fingerlings.

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[16] As a matter of convenience, the term "blueback" will be used in referring to the fish native to the Columbia River, and the term "sockeye" will be used in speaking of the imported fish. Both are of the species *Oncorhynchus nerka*.

The quantitative results of rearing sockeyes to the yearling stage have been shown best by three later experiments, in which rewards were paid for records of recoveries. The reported returns from these experiments represent 1.4, 2.5, and 4.8 per cent of the number liberated. The last two percentages represent only the 4-year-olds, which were recovered during the past season; additional returns from these experiments are to be expected in 1927.

The returns have been expressed in relation to the number of yearlings liberated, because the data of the mortality in the hatchery are not sufficiently accurate (in most cases, at least) to be of value. In one case, comparatively accurate records of the entire history of the fish are available. In round numbers, the history is as follows: Starting with 100,000 eggs, 50,000 yearlings remained at the time of marking in February of the second year; 2,400 adults were caught in the commercial fishery when they returned in their fourth year; and an additional 100 4-year-olds passed through the commercial fishery and returned to the hatchery at which they had been liberated. From this 100 fish, 150,000 eggs were taken. The cycle ends, then, with a stock of eggs one-half greater than the number with which it started. The total number of adults recovered represents 2½ per cent of the number of eggs required to produce them.

A return of 2½ per cent may, at first thought, seem very small, but the impression is quite different when the fact is taken into consideration that each female sockeye produces two or three thousand eggs. The return in this experiment was at least 30 fish to each parent fish. Hatchery operations that provide a return to the commercial fishery of 30 fish from each parent and a spawning escapement sufficient to double the stock in two generations must be considered as successful.

The artificial propagation concerned in this particular experiment has been underrated in several ways. The quoted returns represent only the 4-year-olds. The 5-year-olds will return next season. The spawners did not all return to the place of liberation; only those that did have been considered here. It must be pointed out, however, that this experiment has been more successful than any other in producing returns. Similar practices may or may not produce equal returns.

Possibly the most valuable contributions to be added to our knowledge by these experiments are in regard to the habits, instincts, and racial peculiarities of the fish. One of the racial peculiarities is that of storing fat in the flesh. Chemical analyses of canned salmon have shown that the blueback of the Columbia stores a greater quantity of fat than does any other representative of the species, the flesh being about 16 per cent fat. In Alaska this species has from 5 per cent to 10 per cent of fat, the average being 7 per cent, or less than half that of the Columbia River blueback. The question in regard to the imported sockeyes was: Is the quantity of fat stored determined by heredity or by environment? The former has been found to be the case. The imported sockeyes, although presumably living under the same conditions as the native bluebacks, still store much less oil than do the bluebacks. Samples of a second generation of sockeyes in the Columbia are now available. The samples have not been analyzed as yet, but from general observation the fat content does not seem to have been changed by the longer residence in the Columbia. Interest in this character lies in the fact that the value of the canned product varies directly with the quantity of fat. The imported fish, therefore, are greatly inferior to the native bluebacks.

Among the instincts of salmon the homing instinct has been of most concern. The fact that salmon return to spawn in the river system from which they entered the ocean is substantiated by a wealth of data from other sources. It will be sufficient merely to mention here that no fish marked on the Columbia has been recovered in any other river system. We shall be concerned here with a more exacting analysis of the homing instinct—the return to a particular tributary. The sockeye-marking experiments are not especially satisfactory for this consideration, because they involve transplanted fish and because the tributaries in which the fingerlings were liberated have not offered favorable conditions for the return of the adult fish. Nevertheless, there has been a distinct tendency on the part of the fish to return to the place of liberation. What straying has occurred has been mainly to the tributaries in the vicinity of the one in which the fingerlings were liberated. In one experiment, however, none of the adult fish returned to the place of liberation. This instance is of much interest to practical fish culturists. The hatchery at which the fish were reared was constructed primarily for the propagation of sockeyes. It purposely was situated on a tributary in which native bluebacks formerly spawned, and an effort was made to simulate further natural conditions. The marking experiment conducted at that station resulted in the recovery of 2,500 adults in the commercial fishery, but none returned to the hatchery stream. Why they did not return to the place of liberation or where they did go is not known. There may be some significance to the fact that this particular race of sockeyes, in their native river in Alaska, has a migration route of only a few miles from the ocean to the spawning grounds, whereas the station at which they were liberated on the Columbia is approximately 500 miles from the ocean. The instinct to return to the place of liberation may have been present, but the fish may have been physically unable to make such a long migration. The small amount of fat stored by them may have been insufficient to supply the energy necessary for the long migration without food. The importance of this feature of the homing instinct lies in the fact that a hatchery can not become permanent in its operations unless it can produce its own breeding stock. Eggs can not be introduced indefinitely from some other locality.

The chinook marking experiments are too numerous and too varied in nature to be discussed in detail at this time. Only the most general conclusions will be given. From the standpoint of the number of returns, the chinook experiments have been far less successful than those with the sockeye salmon. The reported recoveries have varied from 1 out of each 50,000 fingerlings liberated to 1 out of each 300. The reported recoveries are not as representative of the actual number of returns as in the case of the sockeye experiments, but this discrepancy will not account for the great difference in the returns from the two species. The reasons for the difference in the returns is unknown. One of the chinook experiments was identical in every detail with one of the sockeye experiments. The fish were even reared together in the same pond, and the same mark was used on both species, but the return of the chinooks was only one-sixth as great as that of the sockeyes. It is hoped that future experiments, which have been designed to involve a greater variety of hatchery practices, may give better returns and point the way to more successful hatchery operations.

As with the sockeyes, the question of the quality of the flesh has been an important one. The chinooks of the Columbia vary in quality from a maximum for which canners are willing to pay to 13 cents per pound to a minimum for which they can pay only 2 cents. An effort has been made to determine if this character is hereditary or if it can be changed by changing the environment of the fish through artificial propagation. The results are not conclusive as yet, but the indications are that, as with sockeyes, the quality of the flesh is determined by heredity.

The homing instinct has been found to be the same with chinooks as with sockeyes. They instinctively return to the tributary in which they spend the early part of their life, whether this is their native tributary or one into which they were introduced. Their migration may be altered, however, by unfavorable conditions.

Another feature of the spawning migration that has been found to be hereditary is the time of year when the fish leave the ocean. Chinooks enter the Columbia during every month of the year, but fish having the same ancestry are to be found only during a definite and regular part of each season.

The knowledge of the nature of these two features of the spawning migration has thrown doubt upon the advisability of indiscriminately transferring the eggs from one tributary to another. If under natural conditions all or nearly all of the salmon return to spawn in their home tributary, it would follow that each tributary supports a separate colony or race of salmon. As a result, there would be a constant interbreeding between fish of the same colony and an absence of cross breeding between different colonies. This would lead to the development of racial differences through which the fish would become adapted to the conditions that prevail in their home tributary. We have found that character (of starting the spawning migration at a definite period) to be among these racial differences. If, then, the progeny of any race are transferred to a tributary in which different conditions prevail, the resulting adult fish may not be able to adjust themselves to the new conditions, and as a result they may not be able to deposit their eggs. Several marking experiments have indicated that this is possible. These experiments were with a race of chinooks that normally spawns at a considerable distance from the ocean and that starts its upriver migration three or four months before spawning time.

Fingerlings from this race were introduced into a creek that empties into the Columbia only a short distance from the ocean. When the resulting adult fish returned to the Columbia they lingered for a short time at the mouth of the creek but finally continued on up the main Columbia, with no definite destination before them. Whether or not they succeeded in spawning, we do not know.

As a converse experiment the progeny of chinooks, which normally leave the ocean late in the season and make only a short migration, were reared and liberated at a distance of several hundred miles from the ocean. The fish in these experiments have not yet reached maturity.

The opportunity offered by these experiments to secure scales of salmon of known age and life history has not been overlooked. It is hardly necessary now to present evidence of the validity of salmon-scale reading in general. It is pleasing, however, to find that without exception our interpretation of the scales has agreed with the known age of the fish.

The study of the chinook scales has clarified our understanding of many perplexing variations that are found in the scale history of the first year's growth.

Doctor Rich. The rather striking difference between the results obtained from the marking of the sockeye salmon in the Columbia River and the marking of the chinook salmon is worthy of an explanation. There are a number of reasons why we could not expect as great returns from the marking of the chinook salmon as were received from the marking of the sockeye. In the first place, they have different feeding habits in the ocean. The sockeyes are plankton feeders, and the chinooks feed on smaller fishes. The distinct difference in feeding habits is a factor presumably of some importance. In the majority of cases the chinook salmon have spent
a greater actual mortality to take place with the chinook.
to the difficulties of ocean life for a longer time. The result is that while the mortality might not be at the same rate, one would expect
a greater actual mortality to take place with the chinook.

Probably the most important fact that makes the difference in returns is that the sockeyes in the Columbia River are so different from the other fish that are running at the same time that they are separated and counted separately, so that much less difficulty is experienced in getting the returns from the sockeye. When there may be 30 or 40 tons of chinook salmon on the floor they will have a few hundred pounds of the sockeyes, and it is much easier for the men in the canneries to pick out these and get their dollar reward than it is to pick out the comparatively few marked chinook salmon that may be mingled with this great mass of other unmarked fish.

Mr. Bower. It has occurred to me that the Columbia River is one of the outstanding examples of the effects of fish-cultural work. Something that Mr. Holmes said leads me to suspect that he thinks the Columbia River is on trial in that respect. May I ask whether he thinks the work is a success on that stream?

Mr. Holmes. That is rather difficult. Practices differ so, and our experiments have covered such a small part of the work that the results may be so different that I would hesitate to give any opinion. I may say that from what I know of salmon culture, I really think the Columbia River hatcheries are at the top. The particular experiment with sockeyes in the Columbia shows that since we put our figures on the basis of the percentage of returns from the number of fish liberated, our reported returns were 1.4 per cent, the next were 2.5 per cent, and the third were 4.8 per cent. As Doctor Rich has pointed out, the conditions that determined the number, or rather the percentage, of return have not been particularly favorable. They have varied in different years. In the first experiment the men were not aware of just how we wanted our returns. Butchering is done by the Chinese. We have an element there that makes it difficult to get results. We require rather detailed data regarding the size of the fish, time and place of capture, etc., and many of them felt that it wasn't worth while. One of my greatest tasks has been to devise ways and means of getting these returns in. I have been able to pick out one man in the cannery to look after things. After the butcher threw the fish out we gave him part of the reward and the picked man did the rest. Probably we have been getting better returns in recent years than before. I think the last experiment may represent conditions as they are. The several experiments are conducted with every condition identical, the only difference being in the fins that are removed and the variation in practice of the particular hatchery. The fish will return in the same year, at the same time, and at the same age. It is with experiments of this nature that we hope to have greater success in the future.

ALASKA HERRING

By George A. Rounsefell

The aim of this investigation has been to determine the following with regard to the Alaska herring, *Clupea pallasii*: First, whether or not depletion is occurring, either generally or locally; second, whether the fluctuations in abundance are due to natural causes or to overfishing, and the extent to which they can be foretold; and third, what protective measures are necessary to maintain an adequate future supply of herring.

The first problem to be attacked was that with respect to the homogeneity of the species. If the herring were a homogeneous population, migrating freely up and down the narrow coastal banks, the problem would take an entirely different aspect than if the herring were local; depletion, to occur, would have to be widespread; regulations, to be effective, would have to consider that fishing in one locality affected every other locality. On the other hand, if each locality supported a local race it would be possible for the supply in one area to be reduced greatly without affecting the supply elsewhere.

In order to determine whether or not there are such local races, we have made a study of the racial peculiarities. We have measured from the tip of the snout to the end of the occipital bone, to the end of the opercular bone, and to the insertions of the dorsal and anal fins, and have calculated what proportion of the body length each of these measurements is. Counts have been made of the number of dorsal and anal fin rays and of the vertebræ. These characteristics have been compared for several localities with illuminating results.

The total range of the vertebral count is from 45 to 57; the localities that differ the most (California and the Shumagin Islands) overlap so slightly that each overlaps only on the count of 53 and the difference between their means is 3.9, with a probable error of 0.06, making a difference of sixty-five times the probable error. The number of vertebræ tends to increase as one goes northward and westward from San Francisco Bay, up through British Columbia and southeastern Alaska, and across the gulf to central Alaska, and even continues to increase as one goes southwestward to the Shumagin Islands. However, it is a very surprising thing that a sample from Golovin Bay, Norton Sound, showed a decrease in number, so that it was about the same mean as Old Harbor.

The ratio between head length and body length seems to show the opposite tendency, the heads being much longer in southeastern Alaska than farther to the westward, the averages of 25 centimeters body length for fish from southeastern Alaska and Russian Harbor showing a difference of roughly 2 per cent, or a difference in actual head length of 5 millimeters.

The dorsal and anal fin-ray counts also show significant differences, although less pronounced than those of the vertebræ.

These differences may be hereditary or due to environment. If these structural differences are due to environment, they are probably fixed at a very early stage of development—in fact, before the embryo leaves the egg. Any intermingling between the herring of different localities after these characters became fixed would cause all of these differences to vanish. The question might arise as to whether each locality was contributing to the others through the drift of eggs during the early embryonic period, before the characters had become fixed. The eggs themselves, however, are attached securely to the seaweed and eel grass, and so are not subjected to drift. These facts would seem to preclude the possibility that the population of one region contributes very extensively to that of another, and to show that the fishery is not drawing upon any great offshore body of herring.

The problem now is to refine the analysis to a point where it can be determined if differences occur between closely adjacent localities. This will necessitate a careful examination of larger numbers in order to arrive closer to the true meaning of the distribution of each character, and to obtain an accurate measure of the variation to be found between samples.

Supposing that, through a careful study of these characters, the differences give indications of the relative independence of the different grounds; the question still remains as to the reason for the changes in abundance. Are these changes natural or due to overfishing?

Great natural fluctuations in abundance occur in both the European herring and the California sardine, due to the presence of dominant age groups. Such a phenomenon may be one cause of the great fluctuations in the abundance of the Alaska herring. To determine this point, samples are being taken for length-frequency studies, and the ages are read from the scales.

The length-frequency distributions of herring taken in July in Prince William Sound for the past three years have been studied. These studies show a forward progression of the modes that may be caused by dominant age groups. This is also suggested by the last year's collections, in which the 5-year-olds are subordinate to both the 4 and 6 year olds.

In order to make certain as to this point, it will be necessary to collect data for a few years and note the changes in the position of the size modes. The collection of data of this sort presents some difficulties. There is question as to the size of samples and the frequency with which they must be taken in order to follow the changes in the run. As soon as the opportunity offers of obtaining samples for a complete season in one locality, a study will be made to determine how often samples must be taken and how large they must be in order to secure an adequate representation of the population.

If regulation is necessary, either because of overfishing or reckless use, there must be, necessarily, some knowledge on which to base it. What conditions should the fish be in when used? At what time do they spawn, and when do they reach a suitable condition for packing? At what age do the herring spawn? These and many similar problems are being investigated.

The only data obtained on the age at maturity were taken from beach-seined samples at Halibut Cove. No 2-year-olds were mature; out of twenty-five 3-year-olds, 13, or 52 per cent, were mature; out of twenty-four 4-year-olds, 20 or 83 per cent, were mature; all of the 5-year-olds were mature.

Weights were taken to follow the changes in the weight of herring of any given length, as an index to the condition in the various localities and at different seasons. Owing to the unusual scarcity of herring it was not possible to follow this throughout the season in one locality. The results show principally the need of data throughout the season in one locality, but they have some value.

In order to have a standard of comparison, we have shown the relation between the weight and the length by using a condition factor obtained by the formula—K equals one hundred times the weight, divided by the cube of the length. It is expected that besides a difference throughout the season and between localities, there will also be an annual variation, not only in the time when a certain condition is reached but probably also in the maximum condition attained.

Taking herring of 255 millimeters body length a couple of weeks previous to spawning, at Halibut Cove in April, when the herring contained no fat but about 25 per cent of their weight was contained in the ripe gonads, the condition factor was 1.35. During the period from June 25 to July 2, in Prince William Sound at Elrington Pass, the smaller herring were in good condition and contained an abundance of belly fat, but the larger herring in the same samples contained very little fat and were rather thin, the condition factor at 255 millimeters body length being then 1.42. In the female gonads from one to half a dozen ripe eggs often were found, and the male gonads had blood clots, and both the female and male gonads were flabby. All of these facts tend to show that it was probably not long since they had spawned. In Red Fox Bay, Shuyak Straits, from July 15 to August 5, the herring were in the very best of condition and the factor at 255 millimeters was 1.57. In Kachemak Bay, from August 19 to August 30, the herring were also in fine condition, the gonads weighing only from 1 to 5 per cent of the total weight and the belly still containing much fat, the condition factor was 1.56. In Eshamy Bay, Prince William Sound, from September 12 to 20, the herring were all rather thin, with only a trace of belly fat, and their condition factor at 255 millimeters was 1.34. A few were too thin to salt.

Mr. RADCLIFFE. I want to raise a question. There is considerable discussion as to how far it is desirable to use herring for commercial purposes, or whether we should use the herring at all. The herring is one of the best food-conversion plants that we have. Would it not be better to let members of the herring family stay in the water and furnish food for other fishes which are considered of greater economic importance?

Mr. ROUNSEFELL. That is a question that is very hard to answer—as to the conversion of food products. The salmon fisherman looks with disfavor upon the extensive use of herring in reduction plants because they believe that is why the pink salmon is becoming more scarce.

Mr. BOWER. I assume you take it that herring is just as important for a reduction plant as for food.

Mr. ROUNSEFELL. In southern Alaska very few of the herring are used for food. Some years ago the Franklin Packing Co. canned a great many herring and lost a great deal of money. Herring in southern Alaska are not good for anything but reduction into meal and fertilizer. Farther north they are given the "Scotch cure"—salted and used for food.

THE RAZOR CLAM

By DR. F. W. WEYMOUTH

[Read by Dr. W. H. Rich]

The razor clam is of wide distribution on the Pacific coast and is found in great abundance. It shares with the oyster and abalone the foremost place among edible shellfish in this region. In 1924, the value of canned razor clams was more than $863,000—about equal to all other shellfish together.

The habitat of the razor clam is strictly limited to broad, sandy beaches. They are accessible to diggers, and, due to their high value, are subject to such intensive fishing that many of the beds are evidently depleted. Information that will enable us to follow the abundance of the razor clam, detect signs of depletion, and point the way to intelligent protective measures is being sought. The wide distribution, under varied conditions, of this single species presents unique opportunity to follow certain biological problems of importance, which also have a direct bearing on the protection of the species.

As long as the industry retains its present value, certain facts should be gathered annually and made available for future comparison and for an index to the condition of the beds. A general survey of the industry, including the intensity of digging, area being exploited, and the size and age of clams in the catch, is essential. Observation of the spawning and the abundance of the resulting set gives an index to the future supply of clams. The relation of the set to number and age of the spawners, as shown by the commercial catch, should also be followed out.

Study of the rate of growth of clams from Oceano and Crescent City, Calif., Warrenton, Oreg., Copalis, Wash., Graham Island, British Columbia, and important beds in Alaska are being completed. Observations on the spawning and other natural-history features are being made as opportunity offers. The abundance of the set on any bed determines the amount of digging that it will support, and efforts are being made to determine the success of each spawning.

The work has been carried on continuously since 1923. Special attention has been given to the beds most in need of protection. The ring method of age determination has been found to apply to this form. By the use of it, the course of growth for the more important beds and the age and size of sexual maturity have been determined. The relation of water temperature to the time of spawning has been studied on the Washington beach, as records from Alaska are difficult to obtain.

OYSTERS

GENERAL REVIEW—OYSTER SURVEYS AND EXPERIMENTAL PHYSIOLOGY

By Dr. P. S. Galtsoff

The purpose of the oyster investigations is to discover the method by which the production of oysters can be increased and better oysters can be produced. It sounds like a very simple problem; but, as you know, those problems that appear to be the simplest are often the most difficult for scientists. The solution of the problem requires a perfect knowledge of the organism and of the conditions under which it propagates itself and grows. This involves a study of the physiology of the organism and of the ecological conditions existing in the sounds, bays, and other bodies of water where the oyster grows in abundance. Thus, the investigation of the oyster fishery covers a great variety of physiological and hydrobiological problems. Geographically, this work extends from Cape Cod to the Gulf of Mexico.

I shall begin my review with the description of some physiological experiments that have been carried out during the past summer at Woods Hole. The first question that appears to be a very important one is that of the feeding of the oyster. Many attempts have been made by various investigators to determine the manner of feeding, but no accurate method has been evolved as yet. At the present stage of science no real progress can be expected unless a quantitative method is developed. We know, in a general way, that the oyster feeds on plankton carried in by the current produced by the gills. The first thing in this problem is to find out how much water is carried in and how many organisms are caught by the gills. The feeding of the oyster consists in three distinct phenomena: (1) Opening and closing of the shell, caused by the contraction of the adductor muscle; (2) production of currents by the ciliary epithelium; and (3) swallowing of the microorganisms caught by the gills. Only the two first phenomena so far have been studied.

The closing and opening of the shell were studied with a recording apparatus, which registers automatically every motion of the shell. The records show that on an average the oyster keeps its shell open for about 20 hours a day.

To study the currents produced by the gill epithelium a new method has been developed which enables us to determine accurately the amount of water that has passed through the oyster and to measure the pressure developed inside the gill cavity. It is also possible to collect the water that has passed through the gills and analyze it. Inasmuch as this method has been described in Science, I shall not enter into the details. It reaches its maximum (about 4 liters per hour) at 25° C. and slows down with the decrease of temperature. Below 7° C. no current is produced, though the cilia are still beating. This is entirely in accordance with the theory of hibernation developed by the bacteriologists who found that in winter, oysters taken from the polluted beds show a very low *Bacterium coli* score, while in summer the *B. coli* score of oysters taken from the same beds is very high.

By using my method, the water discharged from the gills can be collected and analyzed easily. Counting the microplankton in the tank water and in the discharged water, I found that more than 99.5 per cent of diatoms and dinoflagellates are caught by the gills. Water, after having passed the gills, contains almost nothing but mucus. With the cooperation of Doctor Pease's laboratory, I was able to make a few experiments to determine whether the bacteria are caught by the gills or if they pass through them freely. The following results were obtained: Water containing 27,000 *B. coli* per cubic centimeter contained, after passing through, 24,000 per cubic centimeter; another experiment gave 16,000 and 11,000, and 9,000 and 7,000, respectively. These results indicate that a great many bacteria are able to pass through the gills.

The next important physiological question is the spawning of the oyster. Literature on the oyster contains many descriptions of the spawning habits of the oyster, but no real study of the phenomenon has been made as yet. The experiments were performed last summer with the oysters attached to the kymograph and kept in the tank where temperature, oxygen content, and pH were kept constant. The results of the experiments show that both male and female oysters can be induced to spawn by increasing the temperature of water in which they are kept. The kymograph records show that the spawning reactions of the male and female are different; in the first case the shell is kept open and the sperm flows in a continuous stream with the outgoing current of water; in the second case the rhythmical contractions of the adductor muscle cause the closing and opening of the shell. However, there is an additional factor that is responsible for the spawning of the female oyster. At a constant temperature the female can be induced to spawn by adding a small amount of sperm to the water. As the kymograph records show, the reaction lasts from 15 minutes to several hours, after which the oyster becomes insensitive to the subsequent addition of sperm. The sensitivity is restored, however, after two or three days. There is a certain minimum dose of sperm that produces the reaction. Two or three doses, each of which is less than a minimum dose, produce no reaction, though the total amount of sperm added is larger than the minimum dose. The oyster becomes immune, however, but comes back to normal condition after two or three days.

The results of this experiment have several practical applications: First, it shows that in order to obtain a successful spawning on the oyster grounds the oysters should lie rather densely, but not be scattered over the bottom; second, that when the temperature of water is low and the oysters do not spawn, they can be induced to spawn by adding sperm to the water. The latter experiment was tried in Milford by Mr. Prytherch and was successful.

Leaving the field of physiological research, we have to turn to some other work, namely, the study of the conditions under which the oyster grows. Investigations have been carried out during the last two years on Cape Cod, Long Island Sound, and the coastal waters of South Carolina, Georgia, and Texas; at present we are conducting investigations in Mississippi Sound, Miss., and Pamlico Sound, N. C. The purpose of these investigations, made at the request of the State authorities or representatives of the industry, is to answer the practical questions: How and where to plant oysters and how to utilize the natural oyster reefs and beds; how to grow better oysters? I am not going into the details of all the phases of this work, but I wish to make a general review of the conditions existing in the waters of the North Atlantic, South Atlantic, and the Gulf of Mexico.

The chief problem in the North Atlantic is the production of seed oysters. Set is getting scarce, and the production of a good set is the key to success in oyster culture. Extensive investigations and experiments on the behavior of oyster larvæ were made in northern waters. Last year artificial spat collectors were developed and tested in Great South Bay, Milford, Wareham, and Wellfleet. Instead of scattering oyster shells over the bottom, they were put into crates built of lath and planted over the various bottoms. Mr. Prytherch will describe the results of this experiment; it will suffice to tell at present that by this method the productivity of a given area of sea bottom can be increased from seven to ten times; and, besides, bottoms not suitable for ordinary planting, as, for instance, mud flats or sandy bars, can be utilized. In the southern waters the setting is so abundant that every object is covered with spat. This creates overcrowded conditions and results in the formation of oyster reefs or beds consisting in so-called "coon" oysters of a very little market value. Fortunately, in these waters setting seldom occurs below low-water mark, so that oysters planted there are not crowded out by successive generations and develop into a well-shaped product. The practical method of oyster culture in these waters is to obtain seed oysters on brush, then to transplant them into deep water. This method has been tried on a small scale in Georgia and has proved successful.

The study of the enemies of the oyster is of great importance. Out of many organisms that prey on oysters, the drill is the most dangerous and the most difficult one to combat. In certain localities, over 70 per cent of the oysters are destroyed by the drill. So far we have no efficient method with which to combat this pest and know very little about the organism itself. We have decided, therefore, to include the investigation of the drill in our program. Doctor Federighi is conducting this investigation in Norfolk, Va., and will tell us about his plans and experiences.

COLLECTOR EXPERIMENTS

By H. F. Prytherch

As a foundation of this discussion I would like to describe conditions in the industry. On these we base all practical experiments and our study of the biology and environment of the oyster. The oyster industry in Connecticut represents the greatest development in the production of aquicultural crops. Here, we have man increasing production over nature by putting into operation his own methods and appliances. In some areas in Connecticut where oysters were formerly very prolific, to-day you can not find an oyster under any circumstances. From experimental plantings it was found that grounds out in deep water—30 or 40 feet deep—were suited to growing oysters. When they began transplanting oysters from inshore regions to these beds they occasionally got a crop of seed oysters, which led to the extensive practice of planting shells in deep water for seed collection. In a short time this practice failed to supply the industry, as conditions there are unsuitable for obtaining a yearly crop of seed oysters, because deep water in Connecticut is not the natural environment chosen by the oyster. It's choice has been the bays, harbors, and inshore regions, where food is more abundant and general conditions are more favorable. Milford Harbor was formerly a very prolific oyster-growing region, but practically no oysters were growing there when I first began studying; in fact, in 1925 we established two spawning beds in the harbor and put out several types of collectors. One type planted on the mud flats was birch brush; another type was glazed tile; and the third consisted in putting shells in baskets to see if oyster larvæ would go in there and attach to the old shells. The results of the first summer's work were unusually good. A good set formed on the brush and was obtained on the tiles also. The wire baskets, however, were the most practical and the best collectors of all. In 1925 the shells in these baskets were found to contain about 15,000 spat, so it was decided in the following year to carry on more extensive basket operations. In examining the baskets set out in 1925 we found that the larvæ had not penetrated into the center of the basket; so the following year we developed a triangular crate, which was stronger, cheaper to build, and gave much less distance for the oyster larvæ to penetrate. We found, at Milford Harbor, in putting out these crates, that oyster larvæ penetrated into the very center of the containers. The baskets put out in 1926 collected about 2.000 oyster larvæ, and though this was a smaller number than was collected in 1925, it was, at the same time, a good commercial crop. The difference in the quantity can be traced to conditions on the spawning grounds.

In experiments made with the crates in Massachusetts we found that the oyster larvæ attached only to the shells in the outer portion of the crate. In this case, scallop shells were used, which are smaller than the shells used at Milford Harbor, with the result that the oyster larvæ did not have the same chance of penetration. Controlled natural propagation has enabled us to use or restore these valuable inshore areas and utilize them for obtaining a maximum production of seed oysters. Conditions in this area are suitable, not only for seed collection, but also, for growing adult oysters.

There has been considerable comment lately with reference to artificial propagation as it applies to the oyster. I would like to discuss this phase a little, as I experimented with it for three years and understand the problems it presents. The fact that artificial propagation can be carried out successfully under laboratory conditions does not warrant conclusions that this method will be commercially practicable for the industry. However, I do not think that it will be possible ever to develop a method of artificial propagation that will produce in 10 years the amount of seed oysters that we produced in one summer in Milford Harbor. For example, in addition to the set on the crates, brush, etc., we collected over 100 bushels of seed oysters from a gravel bar in the harbor, averaging from 20,000 to 30,000 seed oysters to the bushel. That was only in an experimental way. To do that with any type of apparatus would be an enormous task. Another thing with regard to artificial propagation is that it invariably succeeds when natural propagation succeeds and fails to produce results when results are needed most.

In order to carry on the experiments with the collectors it was necessary that we have wider knowledge of oyster larvæ and their behavior. For instance, in Milford Harbor, and in experiments carried out in Long Island Sound over a period of several years, we were able to collect the oyster larvæ when they were 2 days old, but could not find any trace of them again until they were within a day or two of setting. They are quite active a few days before setting, so that we were able to find many of them in this stage of development. In 1925, when Milford Harbor had been stocked and when spawning was known to have occurred, attempts were made to collect larvæ so as to determine their size and relative abundance. We were unable to find any except the smallest straight-hinge larvæ, and so we decided to take a sample of bottom mud or sand and see if we could find any trace of them there. In these samples we found quite a number of the larvæ in the intermediate stages of development, for which we had been searching for many years.

It is evident that the oyster larvæ in Milford Harbor spend a great deal of time lying on the bottom, and, in that particular body of water, conditions are such as to influence their behavior in this respect. The important point is that it gives us some knowledge as to the behavior of the oyster larvæ previous to the time of setting.

In bodies of water where conditions are more quiet we found the oyster larvæ throughout all stages swimming around in the water. In Milford Harbor the strong tidal currents make it necessary for them to protect themselves from being carried away, so they have developed this habit of settling to the bottom. To increase our knowledge of currents in Long Island Sound, we released 500 drift bottles. Some of the bottles made journeys of 50 miles in 5 to 12 days, and the majority moved great distances from places where they were placed originally. From the drift-bottle records it is obvious that if the oyster larvæ did not adapt themselves in this way to combat the currents they would be carried far away from the spawning beds, and oyster-cultural work would be even more difficult than it is at present.

Another great problem that has confronted us has been the peculiar attachment of the oyster spat in definite zones. In South Carolina and Georgia we found that setting occurred from low-water mark nearly to high-water mark; in Connecticut from the bottom of the channel to a point about 2 feet above low-water mark; and in South Bay, Long Island, from the bottom to the surface of the water. In South Carolina waters it was observed that the greatest intensity of the set occurred at a point midway between high and low water. Milford Harbor had its greatest intensity occurring at the level of low, slack water.

From experiments at Milford Harbor it was found that the predominating factor that controlled the attachment of the oyster larvæ was the velocity of the tide. The time at which the greatest attachment occurred was when the tidal velocity was practically 0. The tides in Milford Harbor are such that the oyster larvæ are unable to attach after the tide has reached a point about 2 feet above low water. At this point the tidal currents have developed a velocity of 10 centimeters per second, preventing the oyster larvæ from attaching themselves to any object. The type of tidal current in South Carolina and Georgia waters is different from that of Long Island Sound, with the result that the zone of attachment is different also. Of what significance is this knowledge to the industry? In South Carolina, though we found the oysters attached above low-water mark only, we knew that their absence below would not indicate necessarily that they could not live there, and so we took advantage of this condition by planting the seed oysters on beds below low-water mark, where successive generations are unable to attach and crowd them out.

Doctor Galtsoff mentioned the effects of sperm on producing spawning in the oyster. In Milford Harbor water temperatures were high during the first part of July, but the oysters refused to spawn; so on July 15 I stripped some oysters and released the spawn over the beds with the result that the spawning occurred and spread over the entire spawning bed. This method was also carried out in Long Island Sound on the oyster grounds. The oysters were ripe and well filled with spawn and it was decided that no harm would be done by stripping them to induce the others to spawn. Five bushels were stripped and the product pumped down to the oyster bed. The oystermen that owned this particular bed said they got a splendid set, but we are not claiming that we produced it.

Another question that is always interesting and important is the value of the scientific work to the industry. From my observations made in the vicinity of Milford Harbor over a period of years we accumulated some knowledge as to the condition of the oysters each year and the hydrographic conditions on the beds in Long Island Sound. I found favorable conditions for a set in some of the inshore regions in 1925 and advised the oystermen to plant their shells as early as possible. The oystermen plant from July 15 to August 15 usually. This year they got their shells out as rapidly as possible, with the result that they were able to secure the early set on July 27 out in the deep-water regions which ordinarily would not appear until the middle of August. The best crop of seed oysters since 1914 was obtained that year.

Mr. Prytherch. I have here a few exhibits to be passed around. Here is some brush with oysters attached, which was planted in 1925 in Milford Harbor. The brush disintegrates or is destroyed by shipworms, with the result that the oysters attached to it break apart or can be separated as single specimens, whereas when they are collected on shells the oysters continually crowd each other as they increase in size.

Doctor Fish. I would like to ask Doctor Galtsoff a question regarding the food of the oyster. You stated that 99 per cent of the forms contained in the water are taken in by the oyster. Does this mean 99 per cent of the larger forms, or of the total?

Doctor Galtsoff. That really means of the the microplankton. The water used was taken out of the tank where the oysters are kept. Dinoflagellates and diatoms were the principal organisms present. I collected one liter of water after it had passed through the gills, and after examination it was found to contain nothing but mucus. All these small forms constitute the food of the oyster. There is some question as to how all these things are taken into the stomach and consumed. I am going to study more carefully next year what kind of food the oyster takes in. We know at the present time that the oyster has the ability to select its food according to its size. It may be that it can select its food according to the kind of food desired. It may be that some of the diatoms are rejected. An important consideration is, what propels the food particles to the mouth cavity and then separates them—rejecting some and accepting others. We have found a method by which we can measure the amount of food passing into the mouth cavity. We must find out if everything is consumed or if something is rejected, and what part of the food is desirable. I know of one large oyster bed—15 by 6 miles—in which none of the oysters are of value. They are very dark and can not be marketed, probably due to lack of food. When we know exactly what the oyster needs for its food, we can avoid this. We may supply some artificial food, as is done in France; but first it is necessary that we know the type of food as well as the quantity required by the oyster.

Doctor Fish. I was wondering if possibly out of the total amount of food there was a minimum below which no use was made by the oyster.

Doctor Galtsoff. Possibly that is the case. We have no positive evidence; in our experiments we found nothing to confirm this fact. It seems to me that every organism about 2 microns in diameter can pass through the gills easily.

Mr. THOMPSON. I would like to ask about the drills. Has anyone any idea as to how fast they grow? It seems to me that if the rate of growth is very slow, and they move very little, it might be possible to exterminate them.

Doctor FEDERIGHI. The rate of growth is one of the problems that will be taken up this spring when the drill begins to spawn.

Mr. PRYTHERCH. Our observations at Milford Harbor indicate that the adult drills cover the shells with their capsules. They hatch at about the same time that the oyster does. It seems that these little yellow drills are just large enough to keep pace with the growing oyster. In Milford Harbor we found 60 of these tiny drills that had drilled something like 120 of the smaller oysters in one small area.

Mr. THOMPSON. If that is true, I should think you could study the problem of growth simply by a study of the length.

Mr. PRYTHERCH. We very likely could, although we find all sizes in the sounds.

Mr. GUTSELL. I would like to ask another question with regard to the oyster. As I understand it, the stimulation of the female to spawn is produced through the addition of sperm. Does that occur in the case of those that are unripe as well as those that are ripe?

Doctor GALTSOFF. Oh, yes. The difference is that if the female is not quite ripe the reaction may last for 10 or 12 hours. This reaction has been recorded by a slow-going kymograph. In one case the reaction recorded required six hours.

Mr. RADCLIFFE. Is my understanding correct, Doctor Galtsoff, that the artificial stimulus to spawning might be used in Long Island Sound in certain seasons when there is no natural spawning? Might it be possible to produce spawning in years when otherwise no spawning would occur?

Doctor GALTSOFF. Probably Long Island Sound is quite a good locality. I certainly believe that it could be done in Great South Bay and that the artificial impulse to spawn can be made of practical use.

Mr. THOMPSON. I would suggest that one of the best places to test that would be in California.

OYSTER-DRILL CONTROL

By DR. HENRY FEDERIGHI

Any remarks that I might make must be, necessarily, fragmentary. I have been working on the problem for a little less than three months, and most of that time has been spent in getting a laboratory ready, playing the part of carpenter, plumber, etc.—everything but a biologist. Recently I started the experimental work.

The oyster "drill" is a very important pest in the oyster industry. It is known that the drills have caused tremendous losses to the oyster business, but until recently the oyster drill had not entered the Chesapeake Bay—one of the largest centers of the oyster industry. The old literature contains some data on the drill. The older workers who made surveys would recommend that something be done to control the oyster drill. They found the drill in this locality and that locality. Florida is especially fortunate in having a specific drill of its own. The work is just beginning, of course, and so not much has been done on the problem. The only work I know of is that done by a man in the fisheries here—one named Pope—who, in 1911, made some experiments at Woods Hole. He worked especially on the reaction of the organism to various food substances—oysters and clams. He placed the drills and some oysters, opened or unopened, in a tank. The drill invariably would migrate toward the oyster, whether the oyster was or was not opened, and proceed to eat it. This is about all we know about the oyster drill.

Of course, my talk is going to be about what I want to do instead of what I have done. I therefore believe it would be better at first to give a plan of the problem as I see it. The problem is very complex—in fact, the more you think of it, the more complex it becomes. The whole problem could be divided into two or three separate problems. The first thing to know is something about the anatomy of the organism, because structure is nothing but crystallized function. It is necessary to know something about the structure in order to know something about the behavior. The second thing is to state the natural history of the organism. By that I mean the fertilization, spawning, growth, migration, if any, and its distribution, etc. The third problem relates to the reactions of the organism to experimental conditions; that is, supplementing the field work with work in the laboratory—experiments in which we know most of the conditions and in which conditions can be controlled, so that under the same conditions we shall be able to predict the reaction. Doctor Galtsoff called attention to that—that ecology must be supplemented by laboratory experiments in order to understand the behavior of the organism. Then the last problem—to find a method of controlling the organism. It seems very probable that if something is known about the natural history of the drill, some way of getting rid of it will suggest itself. The organism must have some bad habit. I am interested in getting rid of the organism or in reducing its numbers to such an extent that it will be negligible. As the work progresses, new problems will arise, and some of the intended work will be neglected for more important work; but I believe the plan must go forward to obtain results. The work has been going on for 10 weeks. It is being conducted at Craney Island, a United States Public Health Service quarantine station. They have given me two rooms; one is heated and the other is not. The first part of the work consisted in equipping a laboratory and an aquarium room.

The oyster drill is a small gastropod, whose average length is about 1 inch. Larger ones occur, but only rarely. It is found everywhere where marine bivalves are found. It is distributed along the whole Atlantic coast. Up until two or three years ago the "drill" was almost unknown in the more inland waters (Chesapeake Bay). Recently it has invaded the more inland oyster beds and has caused great losses. From actual count, some beds have suffered a depletion of almost 80 per cent. In one bed, which contains 45,000 bushels, over 50 per cent of the oysters have been killed. It is a very serious problem. Between pollution and the oyster drill the oystermen are greatly worried.

The biological work so far consists of a preliminary survey of the situation in Chesapeake Bay and the neighboring rivers. The work has only just been started, and I have not enough data from which to derive any conclusion. I can say only that the work is in progress and that something can be learned from this work already. The survey includes the following factors: The abundance of the drills; whether or not egg cases are present; the salinity; and whether or not any oysters have been killed in that area. Of course, some observations are not very accurate—for instance, the presence of egg cases. I do not know whether the eggs were put there by the drill themselves or whether the egg cases were carried there from other areas.

Salinity is a very important factor. If you talk to the oystermen, they say: "What we want is about two weeks of good hard rain that will freshen the waters." It is believed that this would so reduce the salinity as to kill the drills.

Experiments on migration were attempted, but before I say anything about this I want to say something about the reactions of the organism within the laboratory. I have collected several hundreds of the organisms and have kept them in tanks in the laboratory. These animals were carefully watched while in the laboratory, and it was observed that the drills showed no activity. They seem to be in a state of hibernation, if there is such a thing. This was rather puzzling at first, and still is. This condition was thought to be due to the temperature of the laboratory. The running sea water was preheated by means of a small kerosene lamp. In that way I raised the temperature, but the organisms still refused to show activity. I then tried to see whether starved "drills" would respond to oyster and clam meals. No responses were obtained. Newly collected drills gave the same results. Migration experiments will be conducted to determine whether the drills are inactive in the field.

Some work was done also on the phototropism of the organ.sm, but no results were obtained. That is the extent of the work at the present time. I hope that as it becomes warmer more work will be done and more results will be obtained.

FISHERIES OF THE GREAT LAKES

GENERAL REVIEW

By Dr. Walter Koelz

The Great Lakes are a unique series of water bodies that have been formed by the blocking of ancient valleys. They have a very complicated history—now they were separated, now intimately joined. They have emptied through the Mississippi, the St. Lawrence, the Mohawk; they have even been flooded, in part, by the ocean, and all within relatively recent geological ages—that is, some 25,000 years.

The total area of the five lakes is in the neighborhood of 100,000 square miles. Lake Superior is the largest and deepest. The greatest depth is about 1,000 feet. Lake Ontario is the smallest and Lake Erie the shallowest, being less than 100 feet deep over most of its area. The lakes are what limnologists call first-class lakes. Their waters are very deep, very pure, and very cold, and few plants, except algæ, grow in them. Their economy is probably so different from that of small and shallow lakes that principles derived from a study of the smaller lakes may not be applied to the culture of the Great Lakes. In spite of the apparent sterility of their waters, the fish production has been high. The total annual yield of the commercial fisheries has averaged around 150,000,000 pounds. The productivity of the individual lakes, however, is not equal, due to the varied conditions that obtain in them. Lake Superior and Lake Ontario are the poorest, averaging 500 and 650 pounds per square mile per year; Huron comes next, with 800; Michigan has 1,100; and Lake Erie has far exceeded the others combined, with about 6,000. These relative figures do not reflect the effects of depletion (it is assumed that depletion has been relatively equal in all), and the inequality of the figures undoubtedly is a reflection of the unequal productive capacity of the various bodies of water. Favorable conditions for fish do not depend alone on humidity, as many people, including scientists, seem to think, but on bottom conditions, temperatures, etc.; and the fishermen know well that there are hundreds of square miles in the lakes that produce noth:ng.

Of the grand total of 150,000,000 pounds, about one-half consists of species of Coregoninæ—the whitefishes and lake herrings. These fish occur throughout the boreal regions and are among the world's most important fresh-water fishes. Wherever they occur, however, it has been very difficult to define the limits of a species, so that it is not known, even approximately, how many species there are in the world, or, in fact, in any region. This has been no less true in the Great Lakes. Where other fishes are separable by color, number of fin rays, vertebræ, scales, proportions, etc., the various species of these fish are alike in all these characters.

It is necessary obviously to determine what forms occur and to define these forms before anything can be done to conserve the fisheries that they sustain. This uninteresting undertaking of describing the physical differences of species is what the average worker understands as systematics. Systematic workers are in more or less disrepute among the workers in practical science, and it is more or less just that they should be. Too many of our systematists have failed to realize that describing and naming species or subspecies or races is not an end, but only a beginning, and that no one should or may safely name or describe any form until he is acquainted with the important facts of its life history and that of its relatives.

My work on the Great Lakes, then, has of necessity attempted to correlate differences in structure with differences in habits. It is of no biological significance that a human being should find that a fish is very unlike another fish, if the fish feel intimately acquainted with each other and are able to spawn together; nor does it alter matters if fish and fish are exactly alike, so far as I can see, if they have totally different physiological reactions and never spawn together. The Great Lakes whitefishes illustrate, abundantly, both kinds of phenomena. The lake herring in most of the lakes exist in two forms—one very elongate and terete in form, with a body depth of one-fifth its length, and the other with a short, much compressed body, with a body depth of one-third the length. Both forms may spawn together. About 10 specific names have been given to this single species in the Great Lakes.

In Lake Superior two species resemble each other so closely that they can be distinguished only by the value of the fraction, which for numerator has the sum of head depth and base of the anal fin and for denominator the sum of the maxillary and snout; and even these values, for the two species, are not exclusive. The fish are, nevertheless, very distinct in their habits. One spawns in September in deep water; the other in November along the shores. So much for structures.

Even the habits of the various races of a species may not be alike in different areas. One species in Lake Michigan spawns in May, while in Lake Ontario its representatives, which can not be distinguished from their brethren in Lake Michigan, spawn in January. Even in a restricted locality, one school of the true whitefish may spawn on one reef in October while another reef, a few miles away, may not be visited by spawning fish until December.

Where such variability exists, members of a species may differ more from one another than from individuals of other species; two species may be almost exactly alike in their structural features and the breeding habits of races of the same species are entirely different.

I would not have you believe, however, that the situation remains so obscure and confused that no one but me will ever be able to identify the Great Lakes whitefishes. I have been able to send descriptions of desired species to various fishermen and have received in return collections of the fish I wanted. It must be apparent, also, that it is possible to describe the fishes in simple terms, for no fisherman would attempt to interpret the descriptive formulas that systematic ichthyologists have found necessary to employ in portraying a species.

The coregonids, like most of the other Great Lakes fish, are taken by the fishermen with gill nets and traps. Most of them have been the object of commercial fisheries for more than 50 years. Until their numbers were so seriously depleted that it became apparent that some protection must be granted, fishing was unrestricted. The fishermen were allowed to catch fish of any size, in any quantity, at any time. Even after protective laws were put on the statute books, usually they were not enforced immediately. In late years some kind of minimum-mesh laws have been enacted and usually enforced, and in some places one species—the whitefish—has been more or less protected in the spawning season. These fish thus have sustained an almost unrestricted fishery, whose effects have been tempered only by the "law" of supply and demand. Fortunately, the supply has, until recently, exceeded the demand. In 1925, however, the impossible, the incredible, happened. The herring of Lake Erie, suddenly and without warning, gave out. Where in 1924 the fish could be caught by the ton, in 1925 only stray individuals could be found, though dozens of boats, with miles of nets, set virtually from top to bottom in the lake, undertook the search. In 1926 the fish still failed to appear. A fishery that annually yielded as many high-class fish as could be sold (around 25,000,000 pounds, about one-sixth of the Great Lakes total yield) was no more.

It has been mentioned before at these meetings that though the Great Lakes yield has been maintained at about a constant figure, it has been achieved only by the capture of undesirable species to replace the choice ones that have become rare. The Great Lakes have now no more unexploited species, except the shiners that throng the shores, and the loss of one-sixth of the production of the choicest fish marks the last chapter in the history of a once important industry. The herrings everywhere in other lakes have been sought to fill this gap in production. These species probably never have been collectively numerous enough to supply so great a quantity of produce, and in their seriously depleted condition the intensive fishery to which they are consequently subjected must unavoidably exterminate them also. One species is already extinct in all but one of the lakes. It follows, further, that the demand for species of fish other than coregonides will increase as they decline, and the fishery for these species must then become still more intensive, with possibly catastrophic consequences.

The most significant lesson that depletion has taught in the Great Lakes is that species once reduced never recover. Furthermore, it is not clear how the blackfin, or the Erie herring, could ever have become exterminated with the employment of as large a mesh as was used to take them.

Theoretically, it should be quite all right to carry on a fishery that takes only the largest fish, especially when those fish already have spawned several times before their capture. We have indications that there is a delicate balance in the economy of gregarious species, which is adversely affected by great reduction in their numbers.

Besides "catching out" the fish, the waters in many once very productive areas have been made unfit for fish by the increased dumping of pollution from industrial sources. It almost comes to the condition that the fishermen sometimes charge that the fish are bound to be poisoned, anyway, and they might as well catch them as soon as possible.

As discouraging as it is that the fish are being exterminated and the waters polluted (and here I want to repeat that I am not an alarmist; the facts are plain and point to an unavoidable conclusion), it is demoralizing to realize that nothing is being done about it. No less than nine governments are administering conservation legislation, and it goes without saying that no two have the same idea! Some, in fact, have no idea at all! Control of these fisheries must be coordinated, and this clearly is possible only through a centralized body. As the waters are international, this body must be international in character.

The problems that confront other fisheries, confront the conservationist on the Great Lakes—we want to know more about the life histories of our species; we want to know whether artificial propagation does any good; we want adequate statistics; in short, we want to know everything about them, but, most of all, we want regulation of the quality and the quantity of the apparatus, or no fish will remain for us to investigate.

LIFE HISTORIES OF THE COREGONINÆ

By Dr. John Van Oosten

When the life-history studies of the coregonines of the Great Lakes were begun in 1921 the scale method of study had not been applied to these species of fish. Since then two short preliminary papers have appeared—one on the whitefish of Lake Erie and one on the herring of that lake—in which the scale method was employed. During the past six years I have accumulated many data on, and a large amount of scale material of, the lake herring, whitefish, blackfin, and several species of chubs. The chubs have been studied little. The work has been confined chiefly to the lake herring and to the whitefish of Lake Huron.

The problem, as I saw it at the beginning of the study on the lake herring, involved three questions: 1. Are the structural characters of the herring scales so clearly recognizable as to permit their study by the scale method? 2. If the characters are thus recognizable, are the fundamental assumptions underlying the scale method warranted in the lake herring? 3. If the scale method is valid, what does its application to the lake herring show concerning its life history and the fishery of it?

It is apparent at once, to those who are familiar with scale work, that the scope of the above problem is very broad indeed. I am convinced, however, that such a broad scope was entirely warranted. Too many life-history papers, based on the scale method, are written without any regard to the validity of the method, in so far as the particular species involved is concerned. It is repeatedly asserted by scale investigators that assumptions that are valid for one species are not necessarily valid for others. Further, for no one species of fish have all the assumptions of the scale method been verified, nor have these assumptions been tested critically in the wild, fresh-water fishes of this country. Most of the theoretical work has been done on the marine fishes—salmon, herring, and plaice.

The major assumptions whose validity was considered in my studies involved the constancy in the number and the identity of the scales throughout life, the growth relations between the scales and the body, and the relation between the formation of the annuli and the increments of time. Nearly 4,000 specimens, collected at the same place for four consecutive years, were employed for this study.

The various phases of the scale theory can not be considered at this time, but I would like to mention briefly two of my conclusions which affect the scale method as it is generally applied to-day. First, my data show that the computations of length, based on the diameters of scales, are more accurate than those based on the anterior radius, the dimension now universally employed. All my computed data on the growth of the coregonines are based, therefore, on diameter measurements. Second, the so-called "Lee's phenomenon of apparent change in growth rate," a characteristic of the computations of length of virtually all species of fish for which calculations have been made, is due to perfectly natural events in the life history of the lake herring, and no corrections for it should be made. Briefly, Lee "phenomenon" is this: When we compare the calculated lengths derived from the scales of the various age groups of a collection, or of a year class, with one another, we find that for corresponding years the lengths computed from the scales of old fish are, nearly always, lower than those calculated from the scales of young fish; that is, the amount of calculated growth at corresponding ages increases regularly as the scales used are taken from fish of younger age groups. Thus, if the first year's growth increment is calculated from the scales of a 6-year fish, it is less than if calculated from scales of a younger fish. This is true, even though the fish belong to the same year class, that is, hatched in the same year and grown up under the same environmental conditions.

It is now generally believed that Lee's "phenomenon" is caused by the fact that scales do not begin their development until the fish has grown to a certain length. The growth history of the early part of the first year of life is not registered on the scales, therefore. This, if ignored, presumably introduces an error into the computations of length, which are based on the assumption that the entire history of the growth of the body of a fish is registered faithfully in its scales. On the basis of this belief, certain investigators apply a corrective formula to their computations of length.

My herring data, however, show that this corrective formula does not eliminate the "phenomenon," although it does become less pronounced; and that the length values, after having been corrected by this formula, appear to be too high for the early years of life. Further, the discussion shows that the corrective formula does not take into consideration the rapid growth of the scale, as compared with that of the body, especially the rapid growth occurring immediately after the scale appears during the first year of life. The effect of this relatively rapid scale growth upon the calculated lengths is exactly the opposite of that produced by the late appearance of the scale, and the former neutralizes or counterbalances (at least, in part) the latter.

Finally, the data show that the "phenomenon" not only characterizes the computed lengths but also the direct measurement of the scale diameters. That is, if we measure the annular diameters (the diameters included in the annuli) of the scales of the several age groups, of a year class, or of a sample, we find that for corresponding years these diameters in the scales of the old fish average less in length than those in the scales of the young fish—corresponding diameters decrease progressively with age. Obviously, tardy scale formation can not be a factor of the "phenomenon" found in the direct measurements of scale diameters, inasmuch as in them no computations are involved.

I may state, incidentally, that in the lake herring, Lee's "phenomenon" may be explained best as the result of four natural events in the life history. They are, briefly, as follows: 1. The late-maturing fish of a year class are the more slowly growing individuals of their year class. 2. The scale grows relatively faster than the body. 3. Sexual maturation retards the rate of growth. 4. A compensation in growth occurs—that is, fish that grow slowly during the earliest years of life grow rapidly during the later years of life, and vice versa. Lee's "phenomenon" is a natural event—it should be present in the herring calculations of length and no correction should be made for it.

In general, I found that the assumptions underlying the scale method were valid in the lake herring, and that the method may, therefore, be applied with confidence in a study of the life history of this species. The natural history of the lake herring is, briefly, as follows:

Lake herring may be taken at almost every port on Lake Huron. Saginaw Bay ranks first in the herring industry of this lake, while Alpena ranks second. Herring are taken in either pound or gill nets (in trap nets rarely) in the fall and spring of the year (the big catches are made in the fall during the spawning run). After June, most adult herring have moved out of the shallow water.

The herring occasionally take their food from the bottom, though they are typical pelagic feeders, subsisting principally on the plankton forms.

They spawn chiefly in November in shallow water (3 to 8 fathoms), preferably on a sandy or gravelly bottom. Very little is known about the young herring and many special efforts to obtain them have met with failure. As the herring generally have not been kept separate in the statistical reports, no definite information concerning their relative abundance is available at present.

The eggs of the herring deposited in the fall sometimes hatch in the early spring, probably April. During the first year the young herring grow very rapidly. On the average, they reach a length of 5 inches in the first year, 7.3 inches in the second year, 8.6 inches in the third year, 9.3 inches in the fourth year, 9.6 inches in the fifth, 10.2 inches in the sixth, and 10.8 inches in the seventh year; or, in terms of increments, they grow, during each year of life, beginning with the first year, 5, 2.3, 1.3, 0.7, 0.3, and 0.6 inches, respectively. If the length at the end of the seventh year is taken as 100 per cent, then the percentage of total growth completed at the end of the first year is 46.4, the end of the second year 67.5, at the end of the third year 79.6, at the end of the fourth year 85.8, at the end of the fifth year 89.1, and at the end of the sixth year 94.2. The herring complete nearly 50 per cent of their growth in length during the first year of life. Males and females grow at identical rates.

The growth history, in terms of weight, is as follows: At the end of the second year the herring weigh about 3.53 ounces; at the end of third, 5.03 ounces; at the end of fourth, 5.61 ounces; at the end of fifth, 6.18 ounces; and at the end of the sixth year, 7.78 ounces. In the third year the herring gain 1.5 ounces in weight; in the fourth, 0.58 ounce; in the fifth, 0.57 ounce; and in the sixth year, 1.6 ounces. If the total weight at the end of the sixth year is taken as 100 per cent, then the percentage of total weight attained at the end of each preceding year is as follows: Year second, 45.4; year third, 64.7; year fourth, 72.1; and year fifth, 79.4. The females weigh slightly more than the males at corresponding ages, but this presumably is due to the slightly greater weight of the partly developed female sex organs. In comparison with length, the rate of the proportional total-weight increase is small during the first years of life, for while more than three-fourths of the total length reached by the species is attained at the end of the third year, more than five years are required for a similar increase in weight. In this connection, it may be of interest to know that Gilbert's law of compensation in growth also applied to the lake herring. That is, it is found that, on the average, the big yearlings of a year class were the big fish of that year class in all succeeding years of life, but that the differences between the small and large yearlings diminished in each year of age—that is, the small yearlings were rapid growers, the large yearlings slow growers.

We do not know where the herring stay during the first two or three years of life. They do not appear in the commercial catches until their third year, when many attain sexual maturity. Very few second-year fish are taken in the commercial catches (0.2 to 0.8 per cent). Likewise few eighth-year fish are taken (0 to 0.4 per cent). The percentage of seventh-year fish present varied from 9 to 1.8 per cent; that of the sixth-year herring from 1.8 to 9.9 per cent. The commercial catches are almost entirely composed of third, fourth, and fifth year fish, these age groups comprising 87.2 to 97.4 per cent of the entire catch. In 1921 the fourth and fifth year fish formed the bulk of the sample—72.9 per cent of the total. In the three succeeding years (1922, 1923, and 1924) the third and fourth year fish predominated, representing 78.4 to 84.8 per cent of the sample. In each year the fourth age group was the largest, its individuals comprising 42.8 to 58.3 per cent of the total catch. I found that a shift occurred in the age composition; the percentage of third-year fish increased each year during the period 1921–1923 (14.3 to 32.8 per cent), and then remained stationary in 1924 (32.7 per cent). This general increase occurred at the expense of the third-year fish mainly, which each year became progressively less abundant (30.1 to 19 to 17.3 to 11.8 per cent).

In many species the commercial catches are dominated by one particular year class for two or more consecutive years. This does not occur in the lake herring. Each year class drops off rapidly in the years following the year of its dominance, which, as shown above, was the fourth. Every year a new year class predominates in the commercial catches.

In general, the males and females are equally abundant. Of 2,950 herring, 49.5 per cent were males and 50.5 per cent females. The relative abundance of each sex does vary, however, during the course of the spawning run; the males are more numerous than the females early in the season but less numerous late in the season.

For a long time I was puzzled by the peculiar growth history of the Saginaw Bay herring. Both actual and calculated measurements of length showed that these herring were becoming progressively larger at corresponding ages each successive year. Analyzing the growth data, I found that this increased growth rate began suddenly in 1919 and involved fish 3 years of age, or younger, only. This accelerated growth rate continued in the years 1920, 1921, and 1922. During this period, 1919–1922 the second and third year fish did not increase their growth rate but simply maintained the rate attained in 1919. The first-year fish, however, grew more rapidly each successive year. There was a progressive increase in the size of the first-year fish each successive year in the period 1919–1922. The data show further that in each of the years 1915 to 1918, inclusive, the rate of growth was relatively low for herring 3 years of age and younger, and that higher rates prevailed before 1915. The growth rates prevailing among the herring of Saginaw Bay before 1915, were in some way inhibited during the period 1915–1918, and restored or partly restored in 1919. It is shown that the alteration in the rates of growth was due primarily to some local changes in the environment of Saginaw Bay.

That the third year and younger fish only were affected is explained on the basis that only these age groups grow while in Saginaw Bay. The first year fish spawned in the bay presumably spend most of the first year in the bay, while the older fish spend only the early part of the growing season there; but if all fish older than 1 year were subject to the same environment, why, then, did the second and third year fish show an alteration in growth rate, while the fourth-year and older fish did not? This is explained on the basis that (1) the younger herring commence the new year's growth earlier in the spring than the older fish, and (2) that, as the annual growth becomes progressively less with age, slight alterations in growth rate can not be detected as readily in the average measurements of the older fish as in those of the younger.

The question then presented itself: What controlling factors operated in Saginaw Bay during the period 1915–1918 that were absent in the open lake? Did these factors exist, also, before the period 1915–1918, and were they absent or reduced subsequent to it? The following natural factors were considered: Temperature, sunshine, and fishing intensity. It was concluded that these factors did not control the unusual growth rates of the Saginaw Bay herring. A fourth factor proved to be, in all probability, the effective one, viz, the temporary chemical pollution of Saginaw Bay during the World War. In the spring of 1915 the Dow Chemical Co., of Midland, began to pour large amounts of paradichlorbenzol (a useless by-product) into the Saginaw River. This pollution became so severe that many of the fish in the Bay became tainted to such an extent that they could not be sold or used for food. This chemical pollution continued to taint the fish until the spring of 1918. So far as we know, 1919 was the first after 1915 in which the waters of the bay were entirely free from the Dow chemical pollution. It is seen, then, that the period 1915–1918, during which dichlorbenzol wastes polluted the bay, is precisely that during which the growth rate of the herring was retarded. Further, it was shown that the presence of this pollution explained all the facts in the growth history of the herring, and no known fact was inconsistent with this explanation.

The loss to the fisheries during 1915–1918 must have been considerable. Not only did the fishermen lose through the nonsalability of part of their products, but also through the deleterious effect of the pollution upon the growth rate of the fishes. The indirect loss occasioned by the latter factor is commonly disregarded as of little consequence, not only by the general public but by the fishermen themselves. This attitude can be accounted for by the fact that in most cases the magnitude of these indirect losses must be left to the imagination or be stated in terms of description instead of dollars and cents. In order to stress as emphatically as possible the importance of the indirect effect of pollution upon fish life and industry, I have computed roughly, from my growth data and herring statistics, the indirect financial losses suffered by the herring industry of Saginaw Bay during the affected period, 1917–1923:

Year	Pounds	Value	Year	Pounds	Value
1917	869, 124	$26, 074	1922	113, 648	$3, 409
1918	1, 332, 909	39, 987	1923	3, 191	96
1919	1, 317, 995	39, 540			
1920	628, 907	20, 754	Total	4, 450, 224	136, 685
1921	184, 450	6, 825			

Not only were the herring affected by the pollution, but presumably also the pickerel, perch, suckers, carp, and all other species of fish that grow in Saginaw Bay; and the total damage done to these species involved much greater financial losses than those of the herring, for they yield the bulk of the commercial catches of the bay and possess an average value greater than that of the herring. The significance of a pollution such as described here is seen in the fact that the herring industry was still affected in 1923—five years after the pollution ceased.

Finally, this study shows that from the point of view of the commercial fisheries, it is not profitable to allow the herring, at their present rate of growth, to become much older than four years, as they increase slowly in weight after the third year. Further, relatively few third-year fish should be taken. This will permit most of the herring to spawn once, and some twice, as virtually all the individuals of a year class reach sexual maturity in their third or fourth year of life.

If present conditions remain constant, the herring fishery does not appear to be in any immediate danger of extermination, in spite of the fact that no closed season exists for this species. This, no doubt is due partly to the fact that the intensive fishing is carried on during the spawning run when mature fish only are taken. Many of the immature second, third, and fourth year fish are thus unmolested. Further, many of the mature third-year fish escape the nets and therefore have a chance to spawn twice. But the handwriting is appearing on the wall. That the herring fishing is very intense is attested by the paucity of old individuals in the catch and by the shifting in the age composition. Relatively very few fourth-year herring escape the nets to comprise, a year later, the fifth-year group. The data show that commercial fishing is so intense that a year class is practically wiped out during its year of dominance—the fourth. Briefly stated, the history of the majority of individuals of a year class seems to be as follows: They are spawned in the fall, hatched in the spring, grow as immature fish for two or three years, attain sexual maturity in the third or fourth year, and are captured by the fishermen before or during their fifth year. Each year class is depleted rapidly in the year of its dominance.

Captain WALLACE. With regard to the pollution of the Great Lakes, I wonder if any account is being taken of the ashes that are dumped overboard by the steamers that have used the Great Lakes for a number of years. I have heard fisherman say that the quantity of ashes dumped overboard in Lake Erie and Lake Michigan must have some effect on the vegetable growth at the bottom.

Doctor VAN OOSTEN. There is no effect, as far as I know.

Captain WALLACE. I was wondering if it had been taken into account with regard to pollution?

Doctor VAN OOSTEN. Yes; it has been considered in regard to pollution.

Doctor FISH. For the most part vessels follow more or less definite routes, and the accumulation of ashes would be more or less along these routes. I should think that the bottom accumulation would be in the greater depths of water, where the only plant or animal life to be found would be the diatoms gotten in the open waters.

Doctor VAN OOSTEN. The places where the growth of plants is thickest are near the waters edge, and this water probably would not be affected by the ashes. The places where these ashes are dumped may not be the vital places of plant production.

Mr. RADCLIFFE. Is it not true that these cinders, etc., do shift around on the bottom on the spawning areas and are actually destructive of eggs and young fish?

Doctor VAN OOSTEN. There is no question but what anything that sinks to the bottom becomes deleterious to spawning. There are a great many species that never come off of the bottom at all—they get their food and all there.

Mr. THOMPSON. Mr. Scofield and I were asking each other why these herring in Lake Erie disappeared as suddenly as they did. In my talk on the first day I mentioned the fact that fishes might be adapted to meeting the emergencies of adverse periods, and that in the case of some species a certain minimum number might be required in order to survive. If you reduce the members of this species, you might go on for years with the supply perpetuating itself; but, on the other hand, an emergency might arise and your species would not be equal to the occasion and would disappear. It seems to me that that is not merely a theoretical condition but a practical one. If you reduce the abundance of a species so far, some day an emergency will arise which your species can not meet. This disappearance of the lake fisheries might possibly represent just such a case.

Doctor KOELZ. That is nothing new biologically. The same thing has happened in the case of the bison. There have been similar cases in Europe.

Doctor BIGELOW. It seems to me that it is also necessary to take into consideration the fact that more than one species of fish has suddenly become abundant in certain areas, as well as disappeared. In the nineties the bluefish became very abundant in New England. No one wanted it. Large catches were made because they could not prevent the fish from getting into their weirs. This sudden increase in supply has occurred a great many times, apparently without the aid of fishery agencies. I think that this point should be taken into account.

FISHERIES OF THE MISSISSIPPI RIVER

GENERAL REVIEW—WORK OF THE FISHERIES BIOLOGICAL STATION AT FAIRPORT, IOWA

By THOMAS K. CHAMBERLAIN

The work of the bureau for 1926, carried out through the Fairport fisheries biological station, may be divided into four main groups of investigations: (1) Mussel investigations; (2) pond studies; (3) a river-pollution investigation that was only partly bureau work; and (4) a study of the influences of the Keokuk Dam upon the fish and mussel populations of the Mississippi River above and below the dam, especially in relation to their migrations.

This last is a resumption of an old investigation begun by Doctor Coker some years ago and which is now taken up again. Naturally, it covers a field wider than Keokuk Dam. It is hoped to make this the beginning of a general study of the influence upon fish populations of impounding waters and constructing dams. In this connection, the statement made by Doctor Rich, that a means was being developed to permit salmon to pass dams, may be of interest. Keokuk Dam has no fishway. Fish wishing to go above the dam are expected to use the lock.

Of the mussel work, that done by Doctor Ellis, of the University of Missouri, who has worked at Fairport several summers, unquestionably is the most important performed at Fairport during the past year. No doubt all are sufficiently acquainted with the life history of the commercial fresh-water mussel to know of the parasitic stage on the gills of fish, which the embryo mussels, or glochidia, must undergo in order to complete their development into mature mussels. During the past summer Doctor Ellis completed the preparation of a nutrient solution that serves as well as the living fish as a medium of completing this development.

Of course there is no use in painting too rosy pictures of what this may mean eventually, but there is no question but that this discovery will assist greatly in the work of propagating mussels. I believe that present methods of mussel propagation are of much value, however. As you may know, the millions of fish that the bureau's rescue crews save annually from the slowly drying pools and sloughs along the Mississippi, where they are left by high water, are inoculated with glochidia and released. However, there is no control of these fish after they are released. We have no reason to believe that any very large proportion of the young mussels are dropped by their hosts in localities where they will survive, nor that they will escape their enemies, and passing destructive physical conditions during the first 10 days or 2 weeks of their free state—an extremely critical period in their life. However, button manufacturers and many others are convinced that the marked increase in abundance of the more valuable shells in certain areas is due to the bureau's activity.

The culture of mussels in troughs at Fairport has been going on for years in a small way by inoculating fish and permitting them to drop the young mussels in troughs, where they may be cared for through the first season of their growth. The number of glochidia that may be cared for by one fish is limited, however, making it quite an elaborate operation to obtain many mussels that way. Inoculating the maximum load of glochidia upon a fish also is a strain upon the fish. The mortality among the fish used in the trough culture of mussels has been heavy, and there is reason to believe that to a less extent it is heavy among the inoculated rescued fish also.

Doctor Ellis's work, at one stroke, does away with the necessity of inoculating rescued fish, and at the same time permits planting young mussels in large numbers upon mussel beds, where they may do best, and at an age when they have passed the early critical period.

While Doctor Ellis is confident that the main work is done, it is necessary for him to develop a bactericide that may render glochidia free of bacteria when placed in the nutrient solution, but which will not injure the glochidia. It is necessary that the glochidia be sterile when placed in the solution, otherwise bacteria that may be present will increase sufficiently rapidly to destroy the glochidia before metamorphosis is quite complete. Doctor Ellis expects to complete this work this coming summer.

Doctor Ellis also undertook for the bureau some work on the life history of the two species of gar found at Fairport, in connection with a study of the life history of the yellow sandshell (the most valuable of all fresh-water mussel shells), which is parasitic upon the gar. Bearing in mind Doctor Ellis's nutrient solution this fact may not be important, but for a better understanding of the yellow sandshell it has seemed best to study the habits of the gars.

The trough culture of mussels was continued at the station on a small scale during the past summer. Some new ideas were tried, which it is believed may be used to advantage in Doctor Ellis's system as that is developed. The juvenile mussels obtained were planted in certain Virginia waters by H. O. Hesen, who had charge of an investigation of the results of previous plantings of commercial mussels in these waters. No indications that these mussels were becoming established were obtained.

As a result of correspondence between the bureau and the game and fish commission of Arkansas, a cooperative plan was made for a survey of the mussel-producing waters of Arkansas, with a view to working out a satisfactory open and closed system for areas of mussel waters. A previous system failed because the areas were too large.

Ample proof had been obtained that Doctor Coker's plan of dividing mussel waters into unit lengths and closing every other unit, with the understanding that at the end of given periods the open and closed sections should be alternated, was highly efficient for conserving mussel resources. Both the bureau and the commission, therefore, were anxious that a workable plan embodying these features should be put into effect in Arkansas. I was sent to Arkansas in May, and with members of the commission covered virtually all of the mussel waters of the State in about three months. Points that would serve as divisions between open and closed sections were studied carefully and a plan finally was worked out and presented to the commission. As recommended, the plan was first published in State newspapers and criticisms requested. As the result of suggestions some minor changes were made and the plan goes into effect in February, 1927.

The station has been making a series of surveys of certain mussel areas in the upper Mississippi waters, especially Lake Pepin, a widened portion of the Mississippi lying between Minnesota and Wisconsin. It was intended that these surveys should give an adequate idea of the extent of the mussel resources of these areas and indication of any trends in the supply. Up to the present time no entirely satisfactory method for making these surveys has been developed.

It was a little late in the summer when I reached the northern waters for the survey. The few good days were spent in attempting to develop a system that would compare favorably in accuracy with the surveys of Pacific coast clams made by Doctor Weymouth. Apparently, in Lake Pepin at least, going down in a diving helmet and removing all mussels from units of the lake bottom to a depth of 6 or 8 inches is the most accurate method. I am not sure as yet just how practical it is, as I did not get entirely accustomed to working in the helmet we had, but I am planning to continue this work next summer.

As regards the river-pollution investigation, Mr. Wiebe, who did the work under the direction of Doctor Van Oosten, will speak for himself. It is hoped that similar work will continue. Pollution in the Mississippi is as serious as in many eastern waters.

Of the miscellaneous work of the station I want to mention that in addition to the pond investigation, which will be described by Doctor Davis and Mr. Lord, the station carried on considerable fish-cultural operations as a side line and does its part in carrying out the policy of the bureau in assisting local fish and game clubs with their problems.

Doctor Rich. I want to explain further in regard to this matter of providing fishways for dams on the west coast. The problem is rather complicated there, as Mr. Scofield can testify. What they are trying to do is to devise means for getting salmon over high dams—much higher than this one at Keokuk. The power companies, of course, are very anxious to have this thing solved, so that they can go ahead in the building of innumerable dams without interfering with the conservation of fish. The device that was tried out, and which was successful to a certain degree, was advertised widely in one of the engineering journals as solving the difficulty; but apparently the only people who had confidence in the success of this apparatus were those who devised the apparatus. However, I don't think this equipment would be applicable to the Mississippi River dams.

Mr. Higgins. About a year ago the States of Minnesota and Wisconsin became greatly agitated over the pollution of the Mississippi River, and a committee from the State legislatures was appointed jointly, an appropriation was made by the States for carrying on this work, the various State health departments were brought into investigation, the United States Public Health Service was appealed to for assistance, and assistance from the Department of Commerce also was requested. The aid of the Bureau of Fisheries was offered by Secretary Hoover, and at the last moment funds were allotted for conducting an investigation on the pollution of fishes. I might say that last June the report was to be prepared and presented to the State legislatures for appropriate action on January 1, so you can see the scope of the work was necessarily very much restricted. Mr. Wiebe has made as thorough a study of the survey as time permitted and has made a report, which will be forwarded to the State legislatures.

MISSISSIPPI RIVER POLLUTION

By A. H. Wiebe

I shall speak on the biological survey of the upper Mississippi River. The object of the survey was to determine if pollution from the Twin Cities—Minneapolis and St. Paul—is a factor in destroying life in this section of the river. The work of the survey was divided into three phases: (1) Determination of the absence or presence of fish; (2) a study of the bottom fauna; and (3) a study of the plankton organisms. The part of the river studied extends from just above Minneapolis to just above Winona. Winona is about 110 miles below St. Paul.

The sampling stations on the Mississippi River were so distributed that data were obtained (*a*) before any sewage had entered, (*b*) after all the Minneapolis sewage had entered, (*c*) again after all the St. Paul sewage had entered, and one tributary, the Minnesota River, had entered the Mississippi River, (*d*) after the South St. Paul sewage has been added, and (*e*) at various distances below these points, where most of the sewage is added. In order to obtain comparative data from unpolluted streams, samples were taken from the Minnesota, St. Croix, Cannon, and Chippewa Rivers also.

To give you some idea of conditions in the Mississippi River below the Twin Cities, I might mention the fact that all the domestic sewage and trade waste from the cities (joint population approximately 650,000) is dumped into the river without having been treated previously. In addition to this, some 7 or 8 miles below St. Paul are the packing plants of Swift and Armour, so situated that all of their sewage goes into the river. The packing interests, of course, claim that they utilize everything except the squeal. If that is true, the squeal must have some extremely obnoxious qualities.

Within the Minneapolis area conditions are aggravated further by the Ford power dam, situated just below the city. This dam causes the settling out of most of the solid materials in the Minneapolis sewage. The city engineer claims that there already exists a 12-foot layer of sludge behind the dam, and that this deposit is increasing at the rate of 12 inches a year.

As the time is rather limited, I shall not attempt to give a detailed discussion of the survey but shall confine myself to a brief statement.

The determinations of dissolved oxygen made by Mr. Crohurst, who is in charge of the sanitary survey that is being made by the United States Public Health Service, show that for the month of August the amount of dissolved oxygen just below Minneapolis was 0.67 parts per million; just below St. Paul it was 0.87 parts per million; about 3 miles below the packing plants of Swift and Armour it was 0.51 parts per million; and at Hastings, about 36 miles below St. Paul, it was 0.39 parts per million. At Red Wing, at the head of Lake Pepin, the average for the month was 2.25 parts per million; but even here there were 11 days during the month when the dissolved oxygen was less than 2 parts per million. In the Mississippi River above Minneapolis the average for the month was 6.59 parts per million. At the lower end of Lake Pepin it was 5.37 parts per million, and at Winona 5 99 parts per million. For the tributaries—the Minnesota, St. Croix, Cannon, and Chippewa Rivers—the amounts of dissolved oxygen were 5.70, 7.10, 7.43, and 6.26 parts per million, respectively.

The bottom fauna of the Mississippi River above Minneapolis is dominated by clean-water species: May-fly nymphs, caddis-fly larvæ, planaria, and the larvæ of Simulium. In the metropolitan area and below it, as far down the river as Hastings, the bottom fauna is dominated by sludge worms (Tubificidæ). In one instance the number of sludge worms per square yard exceeded 300,000.

Red Wing marks a transition in the condition of the Mississippi River. This is shown by the decrease in the number of sludge worms and the increase in Mollusca and leeches; also by the presence of large numbers of Hyalella and a few specimens of Asellus in August and a few dragon-fly nymphs and caddis-fly larvæ in September.

At Winona, May-fly nymphs are found again along the shore. This may be taken as a sign that the river has been purified sufficiently to support the life of clean-water species.

The data on dissolved oxygen and the bottom fauna show that the upper Mississippi River is grossly polluted from within the metropolitan area and down to the head of Lake Pepin. Lake Pepin acts as a settling basin. At the lower end of the lake and at Winona the waters of the river are greatly improved. Such being the case and knowing that the tributaries are not polluted, the conclusion that the pollution of the Mississippi River is due to the sewage from the Twin Cities seems warranted.

The study of the plankton shows apparently nothing, as far as pollution is concerned. Variations in the amount and character of the plankton occur, but these variations are not sufficient to warrant the conclusions that they are due to pollution; they probably are seasonal variations.

Game fish and other small fish were abundant in the Mississippi River above Minneapolis and in the tributaries—the Minnesota and the St. Croix

Rivers. Above Minneapolis, 1,500 to 2,000 wall-eyed pike were taken in one seine haul. No seining was done in the Chippewa River or in the Mississippi River at the foot of Lake Pepin and at Winona, but the game wardens at these places reported that game fish were abundant.

No seine hauls were made in the Mississippi River just below Minneapolis, but the data on dissolved oxygen and bottom fauna make it seem very doubtful that any fish could exist there. Thirteen seine hauls made in the Mississippi River between St. Paul and Prescott yielded nothing except one stickleback. This was taken a short distance below the mouth of the Minnesota River.

The absence of fish is correlated with the presence of tolerant or pollutional bottom-dwelling animals and low concentrations of dissolved oxygen. Thompson, who worked on the oxygen requirements of fishes in the Illinois River, claims that even two parts per million of dissolved oxygen are not sufficient to support fish life. The results of oxygen determinations that I have mention are far below two parts per million.

I give below a table to show the relationship between the amount of dissolved oxygen, average number of fish per seine haul, and the number of species at stations 1 to 8.

Station	1	2	3	4	5	6	7	8
Parts per million of dissolved oxygen	6.59	6.08	0.67	5.70	0.87	0.51	0.39	7.10
Average number of fish per seine haul	1,000	750	------	330	⅛	0	0	330
Number of species	14	19	------	24	1	0	0	17

NOTE.—Stations 5, 6, and 7 include all hauls (13 in number) made in the Mississippi River between St. Paul and Prescott. Station 1 is above Minneapolis, 2 is just within the metropolitan area, 8 just below Minneapolis, 4 is on the Minnesota River, and 8 on the St. Croix River.

The results of the survey, which I have presented here very briefly, seem to point to the conclusion that the absence of fish in the upper Mississippi River from below the Twin Cities to Prescott is due to the pollution caused by dumping sewage from the Twin Cities into the river.

AQUICULTURE

GENERAL REVIEW—PATHOLOGY AND EXPERIMENTAL FISH CULTURE

By DR. H. S. DAVIS

The problems that have been under discussion at this conference, with few exceptions, have been confined to the so-called commercial fishes. To my mind, the game fishes are in many ways fully as important as those that form the basis of the extensive marine and fresh-water fisheries. True, from the monetary standpoint they are not to be compared with the more abundant commercial species, but the importance of the game fishes in connection with the life and health of the Nation far transcends their market value. In evaluating the relative importance of these fishes, statistics are of little avail. In the first place, we have very few statistics on the catch of the game fishes; and even if we had, they would be of little value as a criterion of their relative importance. Can you place a monetary value on the dozen trout or the couple of fine bass that are the concrete rewards of a day spent on a woodland stream or the more open waters of a beautiful lake?

Not only do the standards by which we must gauge the relative importance of these fishes differ, but the scientific problems they present are in many cases quite different from those that characterize the commercial fishes. Inasmuch as the game fishes are predominantly fishes of our inland streams and smaller lakes, they are more susceptible to the influence of man, either for good or ill. Anyone who goes angling for trout or bass in these degenerate days does not require a knowledge of statistical methods to determine that the fisheries are depleted and that overfishing is a fact and not a theory. There is no doubt that the situation in many localities is a most critical one; and while the causes are fairly well understood, it may not be easy, in any particular instance, to lay one's finger on the most important factor involved in the depletion. But it is not my purpose to consider the causes of this depletion, but rather the corrective measures that must be enforced if our game fishes are not to suffer the fate of the passenger pigeon and the dodo.

For various reasons, the bureau's efforts in this direction are confined at present to the artificial propagation and rearing of the more desirable game fishes. While it is obvious that the scope of this work should be enlarged and broadened, owing to the limited time at my disposal I shall confine my remarks to the problems that are at present under investigation or are to be taken up in the near future.

Necessarily, the program we have adopted has been dictated largely by expediency, and no one realizes more clearly than I that from the strictly scientific standpoint it has many serious defects. In outlining the work that we are attempting to carry on the primary purpose has been to render the greatest possible assistance to the fish-culturists in their efforts to increase the efficiency of the hatcheries. That there is urgent need of improvement in fish-cultural practices is obvious to anyone who is familiar with the work of the hatcheries. This statement is not intended as a criticism of present-day fish-cultural methods, but rather to emphasize the fact that, owing primarily to our ignorance regarding many of the factors involved, our hatcheries are not getting the results that can reasonably be expected of them. This fact has recently led Doctor Knight, of the Biological Board of Canada, to advocate the elimination of the hatcheries, although I have not as yet been able to obtain a clear idea of just what he proposes to substitute in their place.

The work in trout culture, which we are now carrying on, is the direct outgrowth of the work carried on several years ago on the diseases of the young fish. It did not take us long to decide that if we were to get anywhere regarding their control it would be necessary to consider many factors that relate to the diseases. Control measures must be from a prophylactic standpoint rather than therapeutic. As the food appeared to be one of the most immediate factors indirectly concerned in the outbreak of certain diseases, it was decided to study that phase of the problem. Feeding experiments were started in the summer of 1923 at the Manchester (Iowa) hatchery. The following year the experiments were continued at the White Sulphur Springs (W. Va.) hatchery. While we learned a great deal from our experiments, we found that if we were to get the best results it would be necessary to establish a station where we would have complete control of the fish and where the production of fish for planting was of secondary importance. We were able finally to establish a hatchery for this purpose at Holden, Vt. I suspect that Mr. Leach was willing, because it was a hatchery with a past, and a very shady past at that. There are advantages and disadvantages to this hatchery. In the past there has been a heavy mortality early in the spring and also during the summer. However, it also has some advantages. Anyone can raise fish where there are no troubles at all. We feel that it is a distinct advantage to have a hatchery all our own, so that we can continue our experiments indefinitely and where we will not be obliged to confine our work to young fish, as would be necessary if the work were taken up at a regular fishery station.

Mr. James will tell you of the details of the feeding experiments later on. I might say that we have been trying the various kinds of food in use at hatcheries. We have been determining the efficiency, relative value, etc., of these foods for trout of different species, and we have positive evidence that the same kind of food is not always equally good for all species of trout. Each species must be considered by itself. At the Holden station we have been able to carry on feeding experiments with all except the brown trout. I have recently received an inquiry from a leading fish-culturist regarding food for brown trout, but could not be of much assistance to him, as we have not been able to experiment with this species. Of course, this food problem can be carried on almost indefinitely, because there are large numbers of foods that are in common use, and each hatchery has its pet foods which it thinks are far superior to every other. For a single species of trout there are certain foods that are much better than others. One thing definitely certain is that no artificial foods (such as liver, heart, and foods of that type) are equal to the natural food. One line of experimentation that we are working with now is concerned with the possibility of producing some natural food that can be used to supplement the artificial foods on which these fish must depend for economic reasons.

Turning from the feeding experiments, I might touch briefly upon the diseases in hatcheries. This is a problem that will always be very important. When you consider that it is absolutely necessary to crowd these fish together in comparatively small areas, you will see that the opportunity for the spreading of various diseases, which under natural conditions usually cause little injury, becomes an important factor. The most serious disease we have to deal with in the case of the young fingerling is caused by a protozoan—a flagellate—which in certain stages of the life cycle attacks the epithelial lining of the intestine and causes extensive destruction of the epithelial walls. Death of the host quickly follows. In another stage it lives as a free-swimming flagellate in the lumen of the intestine. In this stage it causes very serious effects. The host first becomes emaciated, growth is stunted, and it gradually becomes weaker and weaker, and eventually may die. I have often wondered how they could stand such a severe infestation without showing more serious effects than they do. Sometimes the entire contents of the intestine appear as a writhing mass of these organisms.

Last summer at the Holden station we discovered two new diseases—one a gill disease, due to bacteria, which appear on the surface of the gill. The long filamentous bacteria are found lying side by side in a continuous layer, so as to form a film over the gills. As a result of the irritation produced by the bacteria, the epithelial membrance becomes thickened and the adjoining filaments may fuse into a common mass. Of course, as a result of this thickening of the epithelium and the bacterial film covering the gills, the intake of oxygen through the gills is interferred with seriously, even if there are no other detrimental effects. The disease may cause heavy mortality. It has been found that it can be controlled easily by using a solution of copper sulphate, which is very effective in many diseases of this character.

The other disease to which I have referred affects only the fins. This, again, is probably a bacterial disease, though our investigations in this case are not so far advanced. It probably can be controlled by copper sulphate solution, as in the case of the disease that attacks the gills. One of the great difficulties in studying diseases at hatcheries is that usually we do not find out about them until they are far advanced. By the time the mortalities become heavy enough to attract the attention of the fish-culturists the diseases are so far advanced that most of the fish die. We should be able to recognize these diseases in the early stages. I think we can make better progress in controlling these diseases by thorough study of them at Holden than by relying on reports received from superintendents of the hatcheries. I might also say in this connection that it is our purpose at this hatchery not to run it in a purely experimental manner. What we hope to do is to conduct it in much the same way as is followed at the other hatcheries—crowd the fish, etc. We are developing a practical hatchery, with thousands of fish, such as we have in various Federal and State hatcheries. In this way (reproducing hatchery conditions) we shall get a picture of what goes on at the hatcheries throughout the country.

Another line of investigation is the method of handling the fish. We have not attempted much in this field, other than to carry on some experiments as to the effects of light on fish. Results indicate that it is better to protect young trout from exposure to direct sunlight. Mr. James will tell you more about this experiment.

Another problem on which we are just beginning is that of selective breeding. The more I think of it, the more I wonder why it was not taken up long ago. There are great possibilities in this direction. The Japanese and Chinese have been doing it for some time with goldfish. There is no doubt but that trout that have been reared in the hatchery for several generations are often more adaptable to hatchery conditions than are the wild fish, and that undoubtedly is due to more or less selective breeding, which is inseparable from ordinary hatchery practices. We are confining our breeding experiments to brook trout. What we are trying to do is to get a strain of trout that will grow rapidly and mature early, producing the maximum number of eggs. Later on, we hope to extend the work to other species.

Another problem that we are attempting to investigate, but on which we have not made much progress, is to determine the survival of the fish from the hatchery when planted in streams. This can be correlated closely with another problem—the best age at which to plant trout. This is a perennial problem that has been cropping up for years. No two fish-culturists have the same idea on the subject. The questions revolve around this one point—what is the proper size or age at which to plant trout? As I see it, it is purely a business problem and perhaps can be expressed in another way; that is, how can you produce 1,000 fish in a stream, above the legal size, with the least expense? Perhaps by planting 10,000 fry, or 5,000 fingerlings, or so on—who knows? It is a problem that has direct economic bearing on the conduct of the hatchery. It is an expensive proposition to rear trout to the larger sizes. The mortality is heavy. Food costs are large. The expense of planting these fish is heavy. The tendency in the East is to plant larger and larger fish, because they believe (and I think there is some ground for that belief) that the larger the fish, the better the results that you get. Whether this is sound from a purely economic standpoint, I do not know. In some places they are planting trout 8 and 12 inches long, and the angler comes along the next day and catches them.

I shall now pass to pond culture, which is quite a different problem, in many phases, from that of trout, because the methods used are necessarily very different. Pondfishes are such fishes as the bluegill sunfish, the bass, and the crappie. We must produce spawning grounds and allow them to live under normal conditions. Natural conditions are desirable if we are to get as many fry and fingerlings as possible. Experimental pond work has been taken up only very recently. Last year the Fairport station had 21 ponds, the facilities of which were devoted to experimental purposes. Mr. Lord, who has been conducting these experiments, will give more details. I want to state, very briefly, the general program on which we are working. One of the first problems, and one that I consider of major importance, is the production of food for these fish. So far, we have not attempted to use artificial food. I think we will modify this when we have gone a little further into our operations. What we are trying to do is to produce the maximum amount of fish flesh per acre. We must use much the same methods that the agriculturist uses in producing crops on land. As you are probably aware, it has been found that we can produce as much flesh food, per acre of water, as we can on land, and possibly can do even better than that. Our pond experiments in the production of food revolve around fertility. Of course, this brings up the problem of the best fertilizer, the time when it should be applied, and so on. There are a multitude of problems, all of which we know comparatively little about. In connection with this problem is the study of forage fishes. By forage fishes we mean small fishes, such as minnows, on which the game fish feed. This is an immensely important problem and one on which very little has been done. During the past year we have been working with a number of species of fish at the Fairport laboratory and we have obtained some very encouraging results. I think there are great possibilities in the development of the use of forage fishes in pond culture.

Then, of course, just as in the case of the trout, we are undertaking investigations of parasites and diseases of these fish. These problems are not so serious as in the case of the trout, because the fish are not so crowded, but they will probably become more so in the near future. Already we have gotten quite a bit of publicity with regard to the parasites that occur in bass. One important parasite is a tapeworm, known as *Proteocephalus ambloplites*, which occurs in the bass. The adult stage does not do much harm, but the invasion of the parasite in the larval stage produces serious results, for it migrates into the connective tissues. It seems to have a special liking for the gonads, both in the male and the female. The result is that the fish are virtually sterile. They may appear to be all right in every respect, but they do not produce young. This parasite was first found in hatchery fish at the Neosho (Mo.) station, and since then has been found to be quite widespread. It probably was introduced into our hatcheries in fish shipped from Lake Erie. This illustrates one of the handicaps under which the fish-culturist is laboring because it is necessary, in order to get a supply of fish for the hatcheries, to ship them very long distances. Lake Erie was a common source of supply for the smallmouth bass, particularly, and as a result this parasite has been introduced widely throughout the country. This parasite probably is the most serious enemy with which we have to deal, in connection with bass, at the present time. Here, again, we are planning to start some selective breeding experiments. This work will involve difficulties that are not present in the case of the trout because the pondfishes are not so closely under our control. I believe, however, that it is going to be possible to produce superior strains of fish, which will be better adapted to hatchery conditions. Furthermore, more attention should be paid to the strains of wild fish that we are introducing into our hatcheries. If possible, we should use only superior strains of wild fish in building up a brood stock.

Another problem that we are intending to undertake this year is to look into the advisability of using fish in pond-cultural work which have not yet been utilized for this purpose. There is an urgent demand for a fish that grows rapidly and which will adapt itself to conditions existing in small ponds. The bluegill sunfish is the best that we have for this purpose at the present time. The yellow perch is very good and has some possibilities. However, certain objections have been raised to the use of the yellow perch for this purpose.

Still another problem which, I think, offers possibilities is that of utilizing two or more types of food by having more than one species of fish in the same pond at the same time. The hatcheries throughout the country usually have only one species of fish to the pond. It is possible that two or more species could be utilized in the same pond, and we could get a greater poundage from our ponds in that way. This involves the utilization of all food in the pond. We are approaching this from two angles—by the introduction of forage fishes and by the use of two or more ecologically dissimilar species of food fishes. We can introduce one type that feeds on the bottom material and another that feeds on the plankton. In the past it has been a matter of utilizing one food while others were allowed virtually to go to waste. It seems to me that if we once know the practicable combination, we can utilize all these various sources of food and thus get a much larger yield.

Doctor VAN OOSTEN. The black bass taken in commercial seines are retained in live boxes until collected by the State. Shortly thereafter a white film covers the fish. I have seen as many as 25 to 50 per cent of those fish with white coatings over the eyes. What do you think is the cause

Doctor DAVIS. Does it spread to various parts of the head?

Doctor VAN OOSTEN. No.

Doctor DAVIS. It might be a bacterial infection.

Doctor VAN OOSTEN. These are in Lake Erie.

Doctor DAVIS. That is the only thing I can think of at the present time. It would be rather remarkable that this is confined only to the eyes. It would seem that the fins would become infected if it is the species I have in mind. There was found, of course, recently a number of worms in the eyes. In fact, they have taken several hundred out of the eyes of a single fish, but I think this would hardly be found in this case.

TROUT CULTURE AT THE HOLDEN EXPERIMENTAL STATION

By M. C. JAMES

Virtually all of our work bearing on the scientific aspects of fish culture must be done at the hatcheries themselves. Formerly we were forced to move to one or the other of the bureau's stations, shipping equipment back and forth and making the best of the facilities afforded for undertaking the investigations. While every possible cooperation was offered by those in charge of the stations, their first object was the production of fish, and our efforts sometimes involved the destruction of fish and required space and necessitated changes that might reduce production materially. The net result was a failure to achieve the fullest results from the scientific work. Consequently the opportunity to secure from the division of fish culture a going trout hatchery, to be under our control with no obligations for the production of fish for distribution, was welcomed. The Holden (Vt.) substation was turned over to us in 1925. It probably is the only trout hatchery in the country to be devoted solely to scientific investigations of fish-cultural problems.

Parenthetically I may say that within the last few days there has appeared in the latest issue of the Scientific Monthly an article, by Dr. Nathan Fasten, which sets forth, far more concisely than I could hope to, the exact nature of these fish-cultural problems. He cites 12 separate phases, and I am tempted to refer to a few of the more important ones as an exact definition of the purposes of our work in this field.

Returning to the Holden station, it is sufficient to say that there is a 40-trough hatchery building with a room serving as a combination office and laboratory, and necessary outbuildings. There is an excellent water supply—both spring and brook. Of outside pond and raceway facilities there are none.

and the supplying of these deficiencies by the construction of 9 pools and 285 feet of raceways during the last two years has accounted for much of the time spent there and for the somewhat limited output of a strictly scientific nature.

A few words as to the conduct of such an enterprise may be permissible. It is probable that the keeping of exact, easily analyzed data and records on every condition occurring in the ordinary State or Government hatchery would bring to light information that would surprise the keepers. Such information as is generally recorded is fragmentary, unsystematic, and frequently an approximate expression of personal judgment. The fish records cover the lots as groups, and analysis of diverse conditions is impossible. At the Holden station it is a cardinal principle that every factor having any bearing on the fish must be recorded. A card filing system has been begun to give ready information on the history and status of virtually every fish on hand. These are cross indexed so that the fish in any trough or pond can be traced back to their origin with all deviations from normalcy exposed; or any particular lot of fry or eggs can be followed through to the final disposal of the last survivor.

Routine records are kept of losses, temperature, where changes are occurring, growth (if desired), diet, etc. Any unusual manifestation in any lot is noted as to time and place; this has proved to be of value in checking up in the case of a subsequent outbreak of disease. In fact, such a plan will give, in time, a mass of information, from the ordinary routine of the hatchery, that will be as valuable as any to be gained from formal experiments. It may be stated that with 6 species on hand from a dozen or more different sources, distributed among 10 ponds and 15 raceway compartments, as well as 40 troughs, a season's haul of notes can well be described as voluminous.

The feeding experiments cited at the beginning are part of a series initiated four years ago and carried on at other hatcheries. Based, at the start, on a belief that some of the many difficulties besetting the rearing of trout might reasonably be expected to have their origin, to some degree, in the diets of artificial culture, the assumption of vitamin deficiency was entertained. First attempts to improve such a condition (if it existed) by the enrichment of various foods with substances of high vitamin value, like cod-liver oil and yeast, were not highly successful. The most encouraging results were obtained in the augmentation of the diet of rainbow trout with vitamin A from cod-liver oil and vitamin B from yeast and natural sources. A short time later, investigations by other workers brought out the fact that liver, heart, etc., were much richer in vitamins than had been suspected. Less emphasis has been placed on this branch of the work of late; it has been developed that under some circumstances a vitamin enrichment of the diet of rainbow trout, by means of cod-liver oil, has been of some benefit, but our experiments have consistently shown the reverse to be true in the case of brook trout.

The more recent work (that of the past season) was devoted to determining the effects of various diets on a serious disease that prevails at Holden; to determining the relative values of the common diets of present practice (beef heart and liver and sheep liver); and to the development of three new products to supplement the meat diets. Beef liver was found to be apparently better, as regards lower mortality and increased growth, when compared with the other meats mentioned. The superiority is more marked, of course, where fish are to be reared to large size rather than planted as early fingerlings. The new products utilized were soy-bean oil meal, a dried shrimp, and a clam meal. It is widespread practice among fish-culturists to feed their larger fish a mixture of fresh meat with a large proportion of a cheaper meal cereal, such as middlings or a low-grade flour. There is a serious doubt that the carbohydrate of these materials enters into the nutrition of trout very extensively, and the purpose of the products mentioned above was to obtain the roughage values obtained from cereals, and at the same time feed a high protein ration to further growth and condition, and at the same time supplant part of the expensive meat. It can be said that experiments on a small scale have shown no objectionable features in these substances, with some promise of real benefit in the case of the clam meal, and their use will be continued in a more practical way.

The procedure and technique of these feeding experiments do not appear to have the complexity that would warrant the application of the term "scientific." The simple process of feeding one lot of fish a certain diet and another lot a different diet, and observing their reactions, growth, and mortality, would not seem to require a highly specialized training or a broad erudition. This is true; but at the same time it must be recalled that our present knowledge of vitamins has been gained from a multitude of experiments no more complicated than this. The work with fish enjoys certain advantages and suffers certain handicaps, in comparison with the vitamin investigations in higher animals. From a statistical standpoint, the results gained from experiment with a lot of 1,000 fish are worth more than those gained from a single individual or 5 or 10 rats or pigeons. At the same time, the vitamin investigators have a "standard rat" to work with, as well as uniform specimens of pigeons, etc., and they exercise almost complete control over the environmental conditions in which their animals exist. There is no such thing as a "standard trout," and the great fluctuation in the growth rate of fingerlings, the frequency and severity of epidemics, the changes in water conditions, the cannibalism, the inability to keep an accurate check on food consumption, combine to furnish the fish dietitian with food for thought for his idle moments.

Concerning the subject of fish breeding, I can offer little more than a prospectus at present. Briefly, this is merely the application of the universally known principles of selection of parent stock for desirable qualities, such as man practices wherever he is rearing animal or vegetable life for his use. Strangly enough, application of these simple principles has been merely rudimentary. At all hatcheries there has been, consciously or unconsciously, a selection of the future brood stock from the better grade of breeders, but the practice has been spasmodic, applied to large groups chiefly, little accurate check of results has been kept, and selection for specific qualities has been largely ignored. The commercial dealers probably have accomplished the most in this field, and while their efforts and achievements have been commendable, the need for immediate monetary profits necessarily has circumscribed their efforts.

We have been forestalled, in our plans to inaugurate a program of scientific selective breeding, by an undertaking at the New Jersey State hatchery. Doctor Embody, of Cornell University, is directing this project. Briefly, they now have a fourth generation of selected brook trout. The original stock consisted of survivors from a large number of hatchery fish that had been subjected to all the vicissitudes of ordinary hatchery life, including a serious epidemic. Enough remained to permit the work to proceed on a similar basis for the succeeding generations. Summarized, they have cut down the mortality, at the July fingerling stage, from 98 per cent to 30.8 per cent in the 1925 generation. At the same time, the average length at this age has increased from 2 to 3½ to 4 inches. Thus, the primary selection was exclusively for disease-resisting characters, and this has been adhered to throughout, although rapid growth has entered into the selection from the later generations as a secondary character. This has been accomplished by what is really mass selection with no attention paid to individual qualities. Incidentally, I know of no publication, save the report of this work, that treats of the selective breeding of trout, except in a cursory way, and that sets forth a definite program and describes the results of that program in a definite, reliable, and comparable manner.

As stated, efforts in this field at the Holden station are chiefly aspiration. This fall we took eggs from a lot of brook trout that have shown rapid growth and early sexual maturity. This is the first yield of eggs from these fish, and we will be in position soon to determine whether this precocity has a definite influence on the vitality of the eggs or fry. This has been mass selection, as the early-maturing character was common to all the fish that spawned, and no other outstanding differences existed. We also have one lot of this year's fingerlings, which exhibits the disease-resisting character to a greater degree than does the general hatchery stock. These probably will not yield eggs in any quantity until 1928. There is also on hand a lot of this year's fingerlings, which has exhibited splendid growth, and these will be depended upon as parents of a strain that emphasizes this quality. As for individual selection, we have this year taken eggs from five or six females that showed desirable qualities in the way of color, form, and production of a large number of eggs. These eggs will be segregated, of course, and the lots will continue to be handled thus until maturity. The fish spawned from individually selected stock are marked by numbered tags for future recognition, and the best males are selected for pairing with these fish whenever enough of the latter are ripe. However, extensive attempts to establish pedigreed stock will be deferred until the general strains have become well established.

This limited experience has demonstrated already that the demands of this sort of work, as regards time, effort, and space, are heavy and that the wisdom of having a hatchery devoted exclusively to this type of investigation is unquestionable. It is evident that the selective breeding experiments will require several years in the immediate future that will be barren of results; but the ultimate outcome will be of fundamental value. If it is not already evident. I should state in closing that all of the work at the Holden station is extremely practical and has as its aim the immediate application of all discoveries to the improvement of fish cultural practice.

POND CULTURE

By Russell F. Lord

Doctor Davis already has given an idea of the program we have initiated in the past summer at the Fairport biological station. Although fishponds may be small, pond culture is a large subject, notwithstanding. Many elementary and practical questions concerning the propagation of our pondfishes have not yet been answered satisfactorily. Here are some examples:

What is the best number of fish to rear in a pond of certain size?

Should adults and young be raised together, or should young fish be removed to rearing ponds?

If the latter, at what stage in their development and by what method?

Should species be isolated in separate ponds?

If this is not necessary, what species can be raised together best?

Is the use of fertilizer practical?

If so, what kind of fertilizer should be used, in what amounts, when should it be applied, and for what reasons?

Questions thus pile up; questions as to the best varieties of aquatic vegetation, questions concerning the relation of aquatic vegetation to plankton and other natural food, questions as to the use of forage minnows—in short, a great problem of ecological relationship.

Various experimental data, from 22 ponds, are being collected at Fairport in an attempt to answer these questions. Not a single conclusion has been reached so far as to any of these. They could not possibly be settled in a short time. Indications, however, are numerous.

One phase of these experiments consists of systematic observations on each pond, in which records of the amounts of net plankton and nanoplankton per unit volume of water, water temperature records (surface and bottom twice daily), pH determinations, turbidity readings, and chemical determinations of dissolved oxygen are being secured and filed. A check has been made on the rates of growth of different species in the different ponds, also. Commercial fertilizer has been applied for varying periods and in varying amounts for certain series of ponds.

This is the briefest possible review of this phase of the work and does not attempt to go into any of the details. On the forage minnows, however, I shall spend a little more time. Perhaps if I tell you some of the things contained in a more or less complete report on one of the species experimented with, it will give you an idea of how the work has been carried on.

It was planned to experiment with various minnows in the hope of finding several species that would be suitable as forage fish in the bass ponds. The golden shiner (*Abramis crysoleucus*) and the black-head minnow (*Pimephales promelas*) were the only two suitable species that could be secured in numbers sufficient for practical experiments. Work was done also with the common goldfish.

Pond No. B 13, of 1,482 square feet (0.034 acre), was used as the rearing pond for the black-head minnows. This small pond had been wintered dry. On April 23, 4½ pounds of fertilizer were placed in it and the water turned in. On June 5, 4½ pounds of fertilizer also were placed in it, and then from June 19 to August 30, inclusive, 2 pounds of fertilizer were applied at approximately five-day intervals.

On May 1 the pond was stocked with 72 adult black-head minnows. On May 15, 19 more were introduced, bringing the total up to 91 adults for the pond. These fish were secured in the sloughs of the Mississippi and Cedar Rivers. The pond was watched carefully for the first signs of spawning.

On May 21 a piece of floating wood was found in the pond with many hundred closely arranged eggs adhering to the under surface. The movements of well-developed embryos could be seen through the shells. A sample of these eggs was taken to the laboratory and more closely examined. Hatching began in the afternoon and was still in progress on May 22. Almost all of the emerging fry, however, were weak and dying, and before night all that had hatched, as well as the unhatched eggs, were all dead in the jar of water in which they had been placed. Fortunately, the nesting habits of this fish made detailed observations possible.

After the discovery of the first eggs on the floating wood, several boards, about 3 by 10 inches in size, were placed along the banks of the pond, about 8 inches under the surface. It was thus easy to take up each board for examination and then replace it in the soft pond bank. These nest boards were given numbers, and daily observations were made. During the season it was possible to examine 20 nests; and several other nests, out of reach on the under surface of the various pipe and platform supports, were indicated by the actions of guarding fish. The last eggs were observed on August 6. The following data was secured from observations on the 20 nests mentioned above:

Time of first appearance of eggs to first eggs eyed, average four days.
Time of first appearance of eggs to first eggs hatched, average six days.
Time of first appearance of eggs to total eggs hatched, average nine days.

The eggs of the blackhead minnow thus required a period of six days (at the temperatures given for the pond) from the time of their first appearance to the time of hatching. The eggs were not, however, all placed upon a nest board at once, but sometimes in as many as four successive lots. It was found that the eggs eyed and hatched in the exact order of their appearance upon the nest boards. No attempt was made to see if all the eggs on a certain nest were from a single female. Two fish, however, were all that ever were seen near a nest at the same time.

The habits of adult blackhead minnows were especially interesting. One or both of the parent fish were always seen near the nest board. Usually they kept immediately under the eggs and were very active, moving fins, tail, and body constantly. The male fish was the more aggressive, and when attempts were made to catch various males with a dip net, they would swim under, over, and around it, but refused to be frightened away from the nest permanently. When two fish were present, the female kept quietly under the nest board, at the shore end, and always returned to her position.

Thus, the protective instinct seems to be highly developed in these minnows For example, on May 28 two males were found fighting vigorously. The scene of action was close to the nest of the larger fish, which had been observed often enough to be recognized easily, and hostilities evidently began when the smaller male discovered the loss of his entire nest and went in search of it. This nest had been removed to another pond to see if the eggs would hatch without parental protection. The male on guard at nest D, however, resented the inquiring stranger and was quick to defend his own eggs. The two fighting males had a firm grip on each other's jaws and were shaking their heads and bodies strongly. As they approached the surface of the pond both fish were scooped up with one dip of the net and examined. Both were male *Pimephales promelas*. The color was deep black, especially about the head, with two large bands of gold from the belly part way up the sides, and a third, smaller patch of gold near the belly side of the peduncle. Tubercles were prominent on the snout. Both of these fish were returned, uninjured, to the pond.

On other occasions the guarding males would nibble at investigating fingers whenever a nest board was touched. They appeared to become more fearless as the hatching time approached. This display of aggressiveness seemed to be essential, as many times water beetles and water bugs, both adults and larvæ, were taken in the act of destroying the eggs on some nest board. In fact, when nests were transferred to other ponds where these beetles were abundant, it was necessary to protect them with fine wire screen.

The growth of fingerlings also was noted with interest. A large sample of blackhead minnow fingerling was measured on August 17. As the spawning had been more or less continuous from May 21 to August 6, it was not surprising to find the fish varying in size from 8 to 40 millimeters. Most of the larger fingerlings easily avoided the small hand seine that was used in the collecting, but the fish caught indicated a fairly even distribution, from the very smallest to those in the 40-millimeter class. The actual body lengths and the distribution for these lengths follow:

Body length, millimeters	Total number of fish at this length	Body length millimeters	Total number of fish at this length
8	1	17	7
9	5	18	4
10	11	19	1
11	4	20	4
12	5	21	1
13	4	24	1
14	4	25	4
15	14	35	1
16	7	40	1

As to plankton, samples of net plankton were collected from May 8 to September 15, inclusive. The May samples showed the highest concentration of the season, and even this was very low in comparison to most of the other ponds. The supply of net plankton continued to be very scarce throughout the summer. This was not surprising, considering the great number of young fish so small a pond was supporting.

Nanoplankton was collected from July 31 to September 15, inclusive. The amount of nanoplankton was several times that of the net.

There was a good supply of aquatic plants in this pond. Potamogeton was abundant at one end of the pond and submerged Ceratophyllum and Elodea also were common. A jellylike blue-green algæ that floated on the surface on hot days also was very abundant. A scum of the "jelly" had to be removed from the surface of the pond on two occasions. Other algæ (filamentous forms) also was abundant, but no attempt was made to study the algæ of this pond in any detail. Aphanizomenon, so abundant in other ponds, was not present in B 13.

The miscellaneous records taken at regular intervals include water temperature, pH, turbidity, and oxygen content.

Pond No. B 13 was drained on October 14 and the fish were removed. The minnows were first culled by allowing the smaller fish to pass through the meshes of a net that retained the larger. Four hundred and fifty-eight large minnows were thus separated and counted. Only one fish of this entire lot was clearly an adult. The rest of the minnows were very uniform in size and were no larger than blackhead fingerlings hatched in the first week of June. The smaller fish ranged from 12 to 41 millimeters in body length at a weight of 500 fish to 3 ounces. The larger minnows were not weighed, but in comparison to D 8 bass fingerlings, these minnows would easily average 7 ounces to 100 fish. There were 6,500 of the smaller minnows. Production for the pond was 6,500 small fingerlings at 39 ounces, 367 large fingerlings (458 less the original 91) at 25.69 ounces (estimated), 6,867 total fingerling production, weighing 64.69 ounces.

Production per acre was computed at 201,971 fingerlings of all sizes weighing approximately 119 pounds (smaller minnows at 71 pounds 11 ounces and larger minnows at 47 pounds 4 ounces).

What are the possibilities of this minnow as a forage fish for bass? Of course, a single summer's observations of the life history and general habits are not sufficient for exact conclusions, but the present observations do indicate that it is a valuable fish. The following facts are cited:

1. After a size of 25 to 30 millimeters was reached, the fish were observed feeding on algæ to a great extent.

2. The species was prolific, having increased in numbers about seventy-five times by the end of the summer.

3. It spawned on boards placed for the purpose, and thus its distribution to other ponds was made easy.

4. The spawning season was of long duration. This would supply both small and large bass with a supply of fish food throughout the growing season.

5. It appeared to be relished by the game fish.

A few trials made during the summer showed that bass and crappie readily took to these minnows as food. A large nest of eggs in hatching condition were placed in a crappie pond on June 24. When the pond was drained on September 21 there was a survival of only 4 minnows out of hundreds that must have hatched. The crappie from this pond were reported to be in better condition than in other years, and we might conclude that the minnows were somewhat responsible for this.

Another nest placed in bass-rearing pond No. E 1 had no survivors; and from 1,000 fingerling black-heads (estimated) placed in another pond, none were recovered in the fall.

The present conclusion is that this species will be of value in pond culture. Its superiority or inferiority to other forage minnows must be determined, however, by more experiments.

Good results also were obtained with the goldfish and golden shiners. In fact, the success met with the latter species was the factor that brought our production of bass fingerlings per acre up to an average of 5,000 fish.

In the rearing ponds where golden shiners were used in numbers the production of bass fingerlings was over 6,000 per acre.

As each of the 22 ponds must be taken up in this same way, we have so far collected a large number of miscellaneous data. It is evident that our work must be continued systematically and new experiments instigated as rapidly as possible. It is now necessary to make a thorough study of our material in an effort to establish correct interpretation and correlation.

Mr. Nesbit. Mr. Lord mentioned that he had in mind a number of other investigations. We must realize that he had just one summer for all this work. There are one or two points that seem to me rather significant—regarding the efficiency of different depths in the various ponds used. In this connection I may say that the idea in fertilizing ponds, in addition to what food might already be supplied, is that you modify the growth of the organisms; but it seems to me that you should get the actual value of the sunlight effect on the organism you are trying to rear.

In the days when I was a botanist, I recall that the University of Nebraska was carrying on studies in the sand lakes of Nebraska on the sunlight at different levels in the water. The outstanding fact developed was that the ray of sunlight that affected the organism most did not penetrate far below the surface. It seems to me that in deeper ponds you would have to use more fertilizer, and fertilizer costs money. On the other hand, if you reduce the depth of the pond you would have conditions that may be unfavorable for the fish, so, of course, some sort of balance would have to be reached. I might add that in my own experience in rearing algæ the amount of sunlight seemed to have a remarkable effect on the species.

Mr. Lord. We had not considered that in this summer's work. The ponds are not very deep and when we applied fertilizer we just scattered it along the edges of the pond. Of course, a complete analysis of the result of using the fertilizer has not been undertaken. We have been endeavoring to cover a great deal of ground to get practical results as soon as possible.

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PROPAGATION AND DISTRIBUTION OF FOOD FISHES, FISCAL YEAR 1927 [1]

By Glen C. Leach, *Assistant in Charge, Division of Fish Culture*

CONTENTS

[1] Appendix VIII to the Report of the U. S. Commissioner of Fisheries for 1927. B. F. Doc. No. 1033.

Part 2.—Distribution of Fish and Fish Eggs

INTRODUCTION

With changing conditions in many streams throughout the United States it has become increasingly difficult to maintain the supply of fish by natural reproduction, and artificial propagation and stocking of waters are being depended upon more and more, with the result that the demand for fish for this purpose is considerably greater than existing facilities of the bureau can satisfy. The bureau has striven to meet this increased demand by enlisting the aid of other agencies. Its cooperative efforts have included the development of the plan suggested by Secretary Hoover of inducing sportsmen's clubs and individuals to operate fish nurseries or rearing ponds; the greater interchange of facilities and aid between Federal and State fisheries authorities; and the advising of individuals and organizations as to the best means for developing their water resources.

During the past year more than 50 cooperative fish nurseries were established and many requests were received to inspect sites to determine their suitability for such purpose. The bureau has cooperated with virtually every State in which the fisheries authorities are interested in a comprehensive plan of fish stocking. Finally, by correspondence, the distribution of publications, and by actual inspection of many areas proposed for fish-cultural use the bureau has rendered aid to individuals and organizations interested in conserving and increasing the fish supply.

The earlier conception of the functions of the fish-cultural division of the bureau was that of an agency for introducing a brood stock of fish in barren waters and for substituting new and more desirable species in waters that already supported fish life. The planting of a brood stock that, when protected, would replenish the waters by its natural increase was considered adequate. Nowadays it is not expected that natural reproduction will offset the drain in the more thickly populated and heavily fished regions, and it is understood that if fish are to be taken from the waters they must first be placed there. This refers especially to the game species, whose production and distribution are the most difficult and expensive part of the bureau's fish-cultural work.

During 1927 more than 6,000,000,000 eggs of the cod, haddock, pollock, and winter flounder were collected; over 500,000,000 eggs of the whitefish and cisco were handled; a similar number of pike-perch eggs was taken; and the number of eggs collected from the various species of Pacific salmons amounted to over 100,000,000. Such operations represent a waste or by-product recovery in the truest sense of the word, as, particularly in the case of the marine species, the fishes of the Great Lakes, and the shad, the eggs would be lost otherwise in marketing the parent fish.

Inasmuch as the commercial species listed above are released largely in the egg or fry stage, the unit cost of producing them is low. Certain species, such as the shad and salmon, can be reared to the fingerling size successfully, and the question arises as to whether the greater expenditure required for such a plan would not be justified by the greater benefits derived. Wherever possible without occasioning too great a demand upon its funds, the bureau is endeavoring to make this its policy. When the public comes to realize that there is a unit cost in the hatchery production of fish, just as there is in the production of agricultural or manufactured goods, the prospects of producing enough fish to meet the needs of the Nation will be better. It costs more to rear fingerlings than fry, and the States and the Federal Government can not keep pace with the Nation's requirements.

Part 1.—FISH PRODUCTION: PROPAGATION AND RESCUE WORK

SPECIES OF FISHES HANDLED

During the fiscal year 1927 the fish-cultural work of the bureau involved the handling of 43 species of fish, as follows:

CATFISHES (SILURIDÆ):
- Catfishes (Ictalurus sp. and Leptops sp.).
- Horned pout (*Ameiurus nebulosus*).

SUCKERS (CATOSTOMIDÆ): Buffalo fish (Ictiobus sp.).

CARP (CYPRINIDÆ):
- Common carp (*Cyprinus carpio*).
- Goldfish (*Carassius auratus*).

SHAD AND HERRING (CLUPEIDÆ):
- Shad (*Alosa sapidissima*).
- Glut herring (*Pomolobus æstivalis*).

SALMONS, TROUTS, AND WHITEFISHES (SALMONIDÆ):
- Common whitefishes (Coregonus sp.)
- Cisco (Argyrosomus artedi).
- Chub (Leucicthys sp.).
- Chinook, king, or quinnat salmon (*Oncorhynchus tschawytscha*).
- Chum salmon (*Oncorhynchus keta*).
- Humpback salmon, pink salmon (*Oncorhynchus gorbuscha*).
- Silver salmon, coho salmon (*Oncorhynchus kisutch*).
- Sockeye, blueback, or red salmon (*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 (*Cristivomer namaycush*).
- Brook trout (*Salvelinus fontinalis*).

SMELTS (ARGENTINIDÆ): American smelt (*Osmerus mordax*).

GRAYLINGS (THYMALLIDÆ): Montana grayling (*Thymallus montanus*).

PIKES (ESOCIDÆ): Common pickerel (*Esox lucius*).

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*).
- Common sunfish (*Eupomotis gibbosus*).

PERCHES (PERCIDÆ):
- Pike perch (*Stizostedion vitreum*).
- Yellow perch, ringed perch (*Perca flavescens*).

DRUMS (SCIÆNIDÆ): Fresh-water drum, lake sheepshead (*Aplodinotus grunniens*).

CODS (GADIDÆ):
- Cod (*Gadus callarias*).
- Haddock (*Melanogrammus æglifinus*).
- Pollock (*Pollachius virens*).

FLOUNDERS (PLEURONECTIDÆ): Winter flounder, American flatfish (*Pseudopleuronectes americanus*).

COOPERATION WITH STATES, OTHER FEDERAL AGENCIES, AND FOREIGN GOVERNMENTS

Much duplication of effort was avoided during 1927, and great benefit resulted from a thorough cooperation with every State that interested itself in the conservation of its fisheries. Hatcheries were conducted jointly with Pennsylvania, Louisiana, and Florida, and eggs were incubated for the States of West Virginia, Missouri, North Carolina, South Dakota, and Washington. A list of the eggs assigned to the various States is given later in this report. The incubation and distribution of these eggs resulted in a marked saving to the bureau. In addition to such interchanges, the bureau gave advice and in some cases furnished the services of its experienced employees to solve fisheries problems affecting the States. The bureau's program was aided materially by the permission granted by some of the States to collect brood fish in their waters. Ohio, New York, and Maine were particularly accommodating in this respect.

Connections with the Forest Service of the Department of Agriculture have been mutually beneficial. This agency is interested in keeping the streams of the forest reserves well stocked and has distributed all fish that could be supplied for such waters. Many barren lakes in the West have been placed on a productive basis in this way. The Forest Service is now taking steps to rear fish and is providing sites for bass and trout hatcheries. Such sites have been inspected in the Unaka and Ouachita National Forests in Arkansas.

The continued operation of the Yellowstone and Glacier Park hatcheries is evidence of the maintenance of former cooperative relations with the park service.

Wherever possible, the bureau has acceded to the requests of foreign governments for American species of fish. A list of such shipments made during the past fiscal year appears later in this report.

FISH NURSERIES

During the fiscal year 55 cooperative nurseries in 12 States were operated for the production of fingerling fish. Pennsylvania leads in such work with 15 establishments. The nurseries range in size from single units having a capacity of several hundred thousand (such as the one at Barneveld, N. Y., which really constitutes a substation of the Cape Vincent (N. Y.) station) to small plants capable of holding only 10,000 or 15,000 fish. The bureau furnished approximately 2,500,000 fish to these nurseries during the year. The fish are to be fed and cared for by the nursery owners and will be released when from 6 to 18 months of age. The bureau reserves the right to claim half of the output for filling applications for fish received from persons living in the vicinity of the nurseries, and the rest belong to the nurserymen for disposal in waters in which they may be interested.

At present seven projects are being actively developed to receive fish at a later date; a number sufficient to bring the total to about 75 are under consideration; and from the requests for future inspections that are being received there is every indication that next year will see 100 or more of these private cooperative fish nurseries in operation. Basing estimates on the rearing capacity of the average hatchery, it is safe to say that the adoption of the Hoover plan for cooperation in rearing fish already has provided rearing facilities equivalent to three new hatcheries. The cost to private organizations

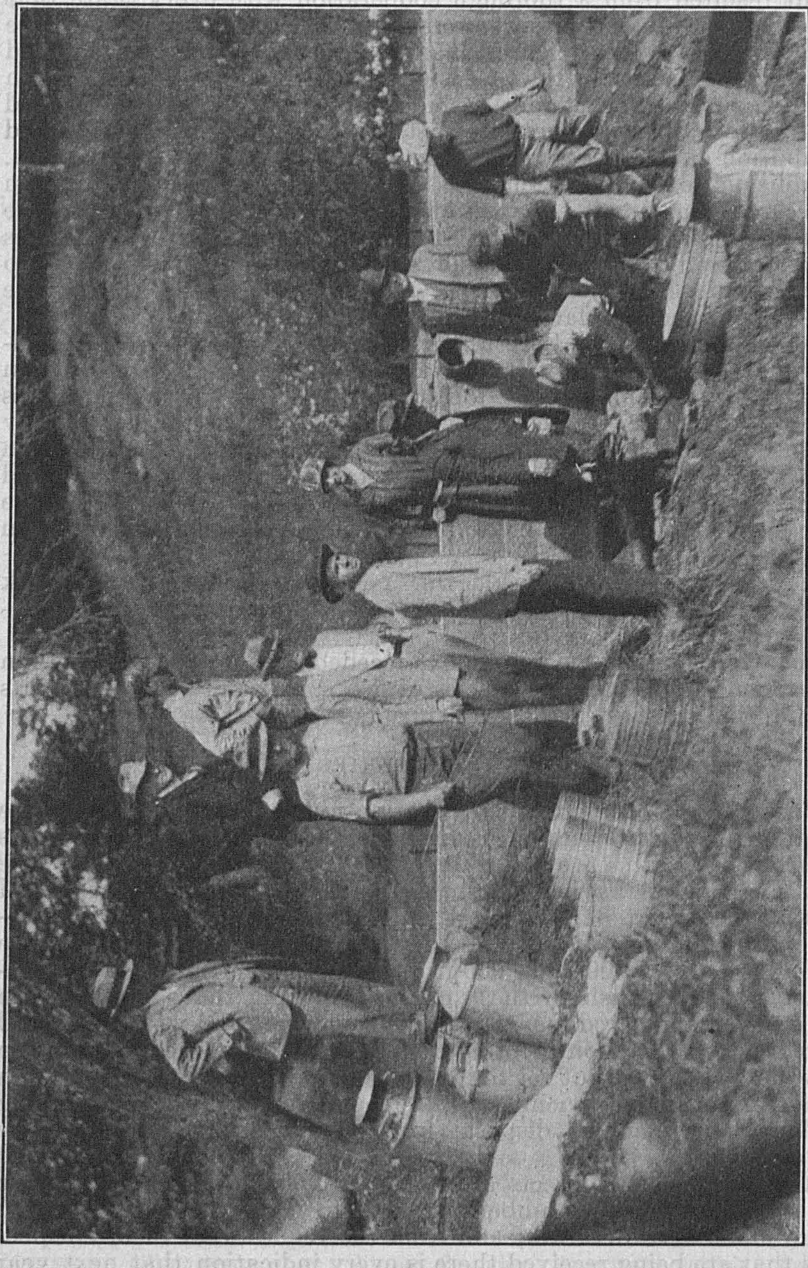

FIG. 1.—Applicants receiving fish at Meyersdale (Pa.) cooperative fish nursery

of developing and maintaining cooperative nurseries varies greatly, but in general the expenditures for units of average size have not exceeded $1,000.

The advantages that lie in having the sportsman himself raise the fish so that he may catch them later are (1) that he will receive a larger assignment than ordinarily would be made on a regular application; (2) fish frequently larger than the legal size limit are planted; (3) the fish are immediately at hand, so that distribution can be made without the confusion and hurry incident to receiving fish from a messenger; and (4) it is possible to exercise greater care in planting the stock. The chief advantage is that under the nursery plan an organization will have a carload of fish in October, whereas otherwise it would receive only a few cans of small fish in the spring from one of the bureau's hatcheries. The bureau gains (1) by having its distribution costs cut through handling a large proportion of its fish in the spring as advanced fry or small fingerlings; (2) by being able to utilize all its rearing facilities for the production of fingerlings to meet demands from sections where no nurseries have been established; and (3) by arousing the interest of the public and awakening it to a realization of the necessity for further stocking of waters and of the difficulties that limit the production of fish.

Commercial fishermen are becoming convinced of the value of rearing pools and of the necessity for their adopting this means of increasing their business. The Alpena (Mich.) station has undertaken the rearing of lake trout in cooperation with an organization of fishermen in a near-by town. Several of the States also have made private fish nurseries an important part of their programs. The plan has become well established, the initial difficulties have been overcome, and the advantages have been made evident. There remains the task of standardizing the practices and procedure and expanding the plan to cover territory not yet included.

OUTPUT

There were distributed to applicants during the past fiscal year or returned to original waters 6,481,073,000 eggs, fry, fingerling, and larger fish, in spite of the fact that a larger percentage than usual of the 1927 hatch is being held over for distribution as fingerlings in 1928. Of the above number, 190,502,000 were distributed as fingerlings, a decrease of 108,792,700 as compared with last year's figures, and of which 1.9 per cent were purely game species, particularly trouts and pondfishes. The remainder were species that are the basis of the commercial fishery, although they may also be considered game fishes in certain respects.

Summary, by species, of the output of fish and fish eggs during the fiscal year ended June 30, 1927

Species	Eggs	Fry	Fingerlings	Total
Catfish			27,101,000	27,101,000
Buffalo fish		2,850,000	6,120,000	8,970,000
Carp		18,500,000	17,264,700	35,764,700
Chub		240,000		240,000
Shad		21,579,000		21,579,000
Glut herring		2,000,000		2,000,000
Whitefish	7,087,000	146,060,000		153,147,000
Cisco	5,200,000	108,040,000		113,240,000
Chinook salmon	9,112,000	266,000	31,084,800	40,462,800
Chum salmon		17,964,000		17,964,000
Silver salmon	148,000	5,154,000	1,645,000	6,947,000
Sockeye salmon	125,000	12,030,000	36,919,000	49,074,000
Humpback salmon		3,544,000	30,000	3,574,000
Steelhead salmon	1,240,000		951,000	2,191,000
Atlantic salmon	200,000		1,229,000	1,429,000
Landlocked salmon	194,000	55,000	641,000	890,000
Rainbow trout	4,473,000	539,000	5,018,200	10,030,200
Black-spotted trout	6,968,000		7,751,700	14,719,700
Loch Leven trout	5,958,000	158,000	3,409,300	9,525,300
Lake trout	1,564,000	24,976,000	922,500	27,462,500
Brook trout	1,305,000	2,609,000	10,644,200	14,558,200
Grayling		1,800,000		1,800,000
Smelt	11,125,000	4,175,000		15,300,000
Pike and pickerel			361,500	361,500
Crappie			17,516,000	17,516,000
Largemouth black bass		904,000	1,260,200	2,164,200
Smallmouth black bass		688,000	239,200	927,200
Rock bass			54,600	54,600
Warmouth bass			7,400	7,400
Sunfish			15,144,900	15,144,900
Pike perch	48,100,000	134,510,000		182,610,000
Yellow perch	12,000,000	193,753,000	1,251,800	207,004,800
White perch			900	900
White bass			17,200	17,200
Fresh-water drum			27,700	27,700
Cod	1,049,668,000	265,314,000		1,314,982,000
Haddock	315,387,000	63,894,000		379,281,000
Pollock		638,749,000		638,749,000
Winter flounder	43,604,000	3,096,762,000		3,140,366,000
Miscellaneous fishes			3,889,200	3,889,200
Total	1,523,458,000	4,767,113,000	190,502,000	6,481,073,000

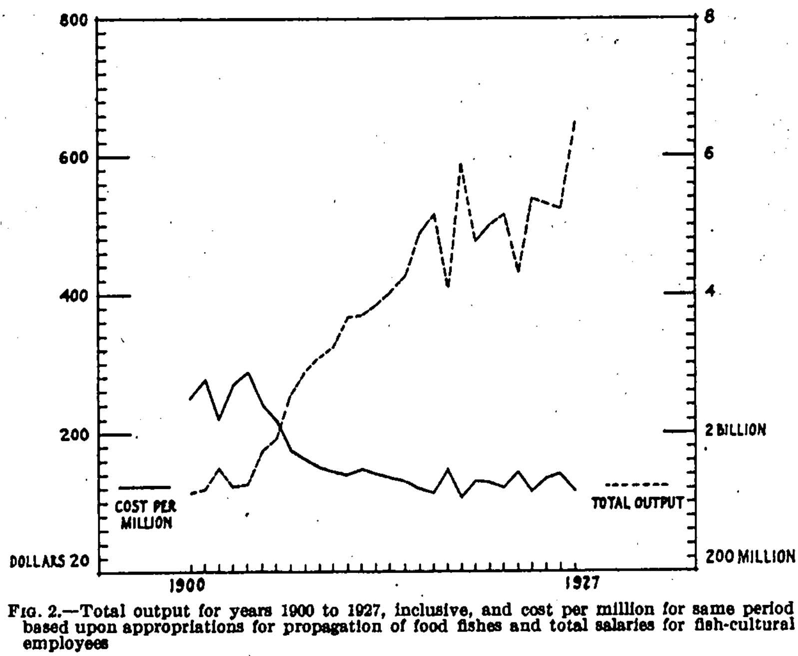

FIG. 2.—Total output for years 1900 to 1927, inclusive, and cost per million for same period based upon appropriations for propagation of food fishes and total salaries for fish-cultural employees

Assignments of fish eggs to State and Territorial fish commissions, fiscal year 1927

State and species	Number	State and species	Number
Colorado: Rainbow trout	100,000	North Carolina:	
Connecticut: Lake trout	50,000	Lake trout	20,000
Hawaii:		Loch Leven trout	100,000
Chinook salmon	26,000	Rainbow trout	186,000
Rainbow trout	25,000	Oregon:	
Idaho: Landlocked salmon	25,000	Black-spotted trout	500,000
Illinois:		Chinook salmon	8,986,000
Loch Leven trout	50,000	Pennsylvania:	
Pike perch	40,600,000	Cisco	5,000,000
Rainbow trout	42,000	Lake trout	50,000
Silver salmon	100,000	Whitefish	3,000,000
Iowa: Rainbow trout	68,000	South Dakota:	
Maine: Lake trout	300,000	Brook trout	500,000
Maryland: Rainbow trout	61,000	Loch Leven trout	500,000
Massachusetts:		Utah:	
Pike perch	500,000	Brook trout	804,000
Rainbow trout	25,000	Lake trout	50,000
Minnesota:		Rainbow trout	229,000
Lake trout	200,000	Steelhead salmon	25,000
Loch Leven trout	500,000	Vermont:	
Missouri:		Lake trout	100,000
Loch Leven trout	100,000	Landlocked salmon	25,000
Yellow perch	6,300,000	Loch Leven trout	100,000
Montana:		Washington: Black-spotted trout	2,425,000
Black-spotted trout	300,000	West Virginia: Loch Leven trout	201,000
Loch Leven trout	2,473,000	Wyoming:	
Rainbow trout	150,000	Lake trout	250,000
Whitefish	2,000,000	Loch Leven trout	500,000
Yellow perch	3,900,000	Rainbow trout	600,000
New Hampshire: Pike perch	1,000,000		
New Mexico: Loch Leven trout	909,000	Total	84,588,000
New York:			
Black-spotted trout	18,000		
Lake trout	515,000		
Steelhead salmon	100,000		

Shipments of fish and fish eggs to foreign countries, fiscal year 1927

Country and species	Number of eggs	Number of fish
Canada: Rainbow trout	26,000	19,500
Costa Rica: Rainbow trout	50,000	
Italy: Rainbow trout	50,000	
Japan:		
Rainbow trout	51,000	
Whitefish	2,000,000	
Switzerland: Rainbow trout	50,000	
Total	2,227,000	19,500

EGG COLLECTIONS

A large output of fish is the result, of course, of a large take of eggs. However, there is considerable discrepancy between the number of eggs handled and the number of fish obtained from them, as inevitably losses will occur during hatching and rearing. The quantity of eggs collected from hatchery brood fish (principally trout) is regular and dependable, but if wild fish must be depended on for the supply of eggs, the number that will be obtained will be uncertain. Weather conditions influence the extent of the fishing, and unlooked-for events may affect the abundance of fish or their readiness to spawn. As the following tabulation will show, declines in the take of certain species are more than offset by gains in other groups, but it is more desirable that the output of shad, for instance, be increased 1,000,000 than that a decline in the abundance of shad be offset by an increase of 100,000,000 in some other species, such as the cod.

Comparison of egg collections, fiscal years 1927 and 1926

Species	1927	1926	Species	1927	1926
Buffalo fish	3,000,000	128,100,000	Black-spotted trout	4,176,000	19,906,000
Carp	24,750,000	76,500,000	Loch Leven trout	15,426,000	12,792,200
Shad	23,104,000	9,625,000	Brown trout		93,000
Glut herring	5,160,000	123,840,000	Lake trout	73,241,290	56,601,500
Whitefish	219,023,000	252,599,000	Brook trout	20,762,290	13,517,020
Cisco	243,870,000	163,700,000	Smelt	9,250,000	
Chub	400,000		Mackerel		2,330,000
Chinook salmon	60,649,600	67,837,000	Pike perch	570,980,000	576,155,000
Chum salmon	24,557,000	18,860,000	Yellow perch	221,595,000	142,930,000
Humpback salmon	4,212,000	2,019,000	Cod	1,427,912,000	1,221,743,000
Silver salmon	6,334,000	8,520,000	Haddock	423,637,000	170,091,000
Sockeye salmon	64,606,800	59,481,490	Pollock	1,048,534,000	698,579,000
Steelhead salmon	3,859,000	6,473,600	Winter flounder	3,434,777,000	2,631,766,000
Landlocked salmon	773,700	923,450			
Rainbow trout	16,921,650	13,470,430	Total	7,951,511,330	6,478,453,290

Much of the work of obtaining eggs is carried on in the field at temporary substations. These are provided with the equipment necessary for collection work only, and few of them are maintained as plants for incubating eggs. Transfer of eyed eggs to the main stations as soon as the season closes is necessitated by the need for economy. The development of new fields of this type and the securing of more eggs from those already in operation are probably the chief hope for a greater output of fish, inasmuch as the supply of eggs from other sources is limited.

Egg-collecting stations

Station	Period of operation	Species handled
Baker Lake, Wash.: Brinnon, Wash	Nov. 18–Jan. 17	Chum salmon.
Boothbay Harbor, Me.:		
Casco Bay, Me	Mar. 1–Apr. 30	Winter flounder.
Ebenecook Harbor, Me	do	Do.
Friendship Harbor, Me	do	Do.
Georges Island Harbor, Me	do	Do.
Gulf of Maine, Me	May 3–June 18	Cod.
Johns Bay, Me	Mar. 1–Apr. 30	Winter flounder.
Linekins Bay, Me	do	Do.
Little River, Me	do	Do.
Mill Cove, Me	do	Do.
Muscongus Sound, Me	do	Do.
Pig Cove, Me	do	Do.
Port Clyde Harbor, Me	do	Do.
Sheepscot River and tributaries, Me	do	Do.
Townsend Gut, Me	do	Do.
West Harbor, Me	do	Do.
Bozeman, Mont.: Mystic Lake, Mont	July 1–Aug. 12	Rainbow and black-spotted trout.
Cape Vincent, N. Y.:		
Amherst Island, Ontario	Oct. 13–Nov. 1	Lake trout.
Bowmanville, Ontario	Oct. 28–Nov. 9	Whitefish.
Brighton, Ontario	do	Do.
Chaumont Bay, N. Y	Nov. 4–Dec. 1	Whitefish and cisco.
Cobourg, Ontario	Oct. 28–Nov. 9	Whitefish.
Consecon, Ontario	Nov. 10–Dec. 1	Cisco.
Fair Haven Bay, N. Y	Nov. 12–Dec. 1	Do.
Indian Point, Ontario	Oct. 13–Nov. 9	Lake trout and whitefish.
Pigeon Island, Ontario	Oct. 13–Nov. 1	Lake trout.
Port Hope, Ontario	Oct. 28–Nov. 9	Whitefish.
Simcoe Island, Ontario	Oct. 13–Nov. 15	Lake trout and whitefish.
Sodus Bay, N. Y	Nov. 12–Nov. 29	Cisco.
Wellers Bay, Ontario	Nov. 10–Nov. 20	Do.
Clackamas, Oreg.:		
Lemhi River, Idaho	Aug. 16–Sept. 4	Chinook salmon.
Upper Clackamas, Oreg	Aug. 29–Oct. 15	Do.
Wind River, Wash	Aug. 23–Oct. 20	Do.
Craig Brook, Me.:		
Craig Pond, Me	Oct. 20–Nov. 18	Brook trout.
Toddy Pond, Me	Oct. 20–Nov. 20	Landlocked salmon.

Egg-collecting stations—Continued

Station	Period of operation	Species handled
Duluth, Minn.:		
Agate Harbor, Mich	Sept. 30-Oct. 27	Lake trout.
Bemidji, Minn	Apr. 15-May 7	Pike perch.
Big Traverse Bay, Mich	Oct. 17-Oct. 27	Lake trout.
Copper Harbor, Mich	Sept. 30-Oct. 27	Do.
Grand Marais, Mich	Oct. 17-Nov. 5	Do.
Huron Island, Mich	Oct. 16-Oct. 31	Do.
Isle Royale, Mich	Oct. 15-Nov. 15	Lake trout and whitefish.
Keystone, Mich	Oct. 10-Oct. 26	Lake trout.
Manitou Island, Mich	Oct. 16-Oct. 27	Do.
Marquette, Mich	Oct. 16-Nov. 4	Do.
Munising, Mich	Oct. 16-Nov. 28	Lake trout and whitefish.
Point Abbey, Mich	Oct. 17-Oct. 27	Lake trout.
Portage Entry, Mich	Oct. 17-Nov. 2	Do.
Portage Lake Canal, Mich	Oct. 13-Nov. 3	Do.
Gloucester, Mass.:		
Boars Head, N. H	March to May	Cod.
Marblehead, Mass	February and March	Do.
Plymouth, Mass	November to May	Cod and pollock.
Rockport, Mass	do	Cod, pollock, and haddock.
Leadville, Colo.:		
Baker Lake, Colo	May 11-May 21	Rainbow trout.
Bolts Lakes, Colo	Apr. 25-May 10	Do.
Engelbrecht Lakes, Colo	Sept. 13-Nov. 18	Brook trout.
Hosselkus Lakes, Colo	Nov. 11-Dec. 8	Do.
Mount Massive Club Lakes, Colo	Oct. 21-Dec. 6	Do.
Do	May 5-May 31	Rainbow and blackspotted trout.
Red Feather Lakes, Colo	Apr. 1-May 12	Rainbow trout.
Turquoise Lake, Colo	Oct. 20-Dec. 10	Brook and Loch Leven trout.
Wurts Lake, Colo	Sept. 24-Nov. 18	Brook trout.
Nashua, N. H.: Lebanon, N. H	Apr. 5-May 20	Rainbow trout.
Northville, Mich.:		
Beaver Island, Mich	Oct. 25-Nov. 25	Lake trout and whitefish.
Boyne River, Mich	Apr. 11-Apr. 30	Rainbow trout.
Cheboygan, Mich	Oct. 19-Oct. 30	Lake trout.
Cross Village, Mich	Nov. 1-Nov. 20	Whitefish.
East Tawas, Mich	Nov. 16	Lake trout.
Epoufette, Mich	Nov. 3-Nov. 25	Whitefish.
Huron Beach, Mich	Oct. 27-Dec. 7	Do.
Leland, Mich	Nov. 5-Nov. 22	Lake trout.
Manistique, Mich	Oct. 25-Nov. 21	Do.
Naubinway, Mich	Nov. 1-Nov. 28	Whitefish.
Northport, Mich	Nov. 5-Nov. 22	Lake trout.
Oscoda, Mich	Nov. 3-Nov. 7	Do.
Presque Isle, Mich	Oct. 24-Nov. 2	Do.
Rockport, Mich	Oct. 26-Nov. 6	Do.
Rogers City, Mich	Nov. 5-Nov. 6	Do.
St. Ignace, Mich	Oct. 22-Nov. 4	Do.
Put in Bay, Ohio:		
Catawba Island, Ohio	Nov. 7-Nov. 30	Whitefish.
Middle Bass, Ohio	Nov. 6-Nov. 29	Do.
Do	Apr. 28-May 6	Yellow perch.
North Bass, Ohio	Nov. 6-Nov. 30	Whitefish.
Do	Apr. 10-Apr. 26	Pike perch.
Port Clinton, Ohio	Nov. 7-Dec. 2	Whitefish.
Do	Apr. 6-May 8	Pike perch and yellow perch.
Do	May 31-June 27	Carp.
Toledo, Ohio	Nov. 9-Nov. 27	Whitefish.
Do	Apr. 7-May 8	Pike perch.
St. Johnsbury, Vt.: Lake Dunmore, Vt	Oct. 27-Nov. 5	Lake trout.
Saratoga, Wyo.:		
Big Creek Lakes, Wyo	Sept. 8-Nov. 8	Brook trout.
Lost, Sage, and Canon Creeks, Wyo	Mar. 22-June 22	Rainbow trout.
Springville, Utah:		
Fish Lake, Utah	Oct. 20-Nov. 24	Brook trout.
Do	Mar. 29-May 28	Rainbow trout.
Salem Lake, Utah	Mar. 7-Mar. 26	Do.
Woods Hole, Mass.: Waquoit, Mass	Jan. 6-Mar. 14	Winter flounder.

FISH-RESCUE WORK

The aggregate number of fish handled in the rescue work in all fields failed by a wide margin to meet the figures of the previous year, when over 149,000,000 were salvaged. However, the bureau's crews can not take care of all the fish that may be stranded in a normal year, and when water conditions are such that rescue work is limited it really signifies that the fish are being preserved without the intervention of outside agencies. When such a situation prevails, as was the case during the fiscal year 1927, the funds of the division of fish culture may be applied to actual propagation work without detriment to the actual conservation of fish life in the Mississippi. The State of Wisconsin has continued to operate in some of the most prolific breeding areas, and to avoid duplication of effort the bureau has withdrawn from such territory.

The diversion of fish away from the parental waters was negligible. Less than 1 per cent of the fish rescued were shipped to fill applications, although the demand for fish in carload lots is insistent. It is the intention to make the work on the Mississippi River rescue work in the truest sense of the word, admitting no possibility of depletion by excessive withdrawal of fish from their sources of origin.

Appended are tables showing the disposition of fish according to species and a summary by stations. More detailed tabulation appears in the statistics of output of the individual stations.

Number and disposition of fish rescued, fiscal year 1927

Locality and species	Delivered to applicants	Restored to original waters	Total number of fish rescued
Homer, Minn.:			
Buffalo fish		5,935	5,935
Carp		2,918,650	2,918,650
Catfish	7,600	2,192,585	2,200,185
Crappie	23,100	3,910,000	3,933,100
Fresh-water drum		10,830	10,830
Largemouth black bass	25,230	95,740	120,970
Pike and pickerel		88,390	88,390
Sunfish	1,510	2,079,020	2,080,530
White bass		1,630	1,630
Yellow perch	40,700	892,005	932,705
Miscellaneous		546,795	546,795
Total	98,140	12,741,580	12,839,720
La Crosse, Wis.:			
Buffalo fish		130,200	130,200
Carp		1,766,000	1,766,000
Catfish		1,884,000	1,884,000
Crappie		992,000	992,000
Largemouth black bass	11,975	5,250	17,225
Pike and pickerel		64,650	64,650
Sunfish		795,200	795,200
White bass		900	900
Yellow perch	1,660	153,610	155,270
Miscellaneous		764,260	764,260
Total	13,635	6,556,070	6,569,705
Lynxville, Wis.:			
Buffalo fish		21,200	21,200
Carp		1,039,100	1,039,100
Catfish	7,820	4,341,580	4,349,400
Crappie		1,260,000	1,260,000
Fresh-water drum		500	500
Largemouth black bass	5,425	8,975	14,400
Pike and pickerel		8,100	8,100
Sunfish		1,105,000	1,105,000
White bass		3,900	3,900
Yellow perch		30,850	30,850
Miscellaneous		336,150	336,150
Total	13,245	8,155,355	8,168,600
Marquette, Iowa:			
Buffalo fish		1,908,700	1,908,700
Carp		4,176,800	4,176,800
Catfish		13,144,000	13,144,000
Crappie		7,400,300	7,400,300
Largemouth black bass	25,495	15,450	40,945
Pike and pickerel		127,350	127,350

Number and disposition of fish rescued, fiscal year 1927—Continued

Locality and species	Delivered to applicants	Restored to original waters	Total number of fish rescued
Marquette, Iowa—Continued.			
Sunfish		7,430,000	7,430,000
White bass		6,955	6,955
Yellow perch		125,550	125,550
Total	25,495	34,335,105	34,360,600
Bellevue, Iowa:			
Buffalo fish		3,744,000	3,744,000
Carp		6,064,000	6,064,000
Catfish	1,000	3,576,200	3,577,200
Crappie		1,051,615	1,051,615
Largemouth black bass	670	1,255	1,925
Pike and pickerel		72,900	72,900
Sunfish	500	1,763,775	1,764,275
White bass		3,800	3,800
Yellow perch		250	250
Miscellaneous		1,585,000	1,585,000
Total	2,170	17,862,795	17,864,965
Rock Island, Ill.:			
Buffalo fish		222,000	222,000
Carp		1,300,000	1,300,000
Catfish		1,900,000	1,900,000
Crappie		2,545,000	2,545,000
Largemouth black bass		1,530	1,530
Pike and pickerel		100	100
Sunfish		344,000	344,000
Yellow perch		10,000	10,000
Miscellaneous		657,000	657,000
Total		6,979,630	6,979,630
Simmesport, La.:			
Buffalo fish		88,000	88,000
Catfish		35,700	35,700
Crappie	1,840	249,900	251,740
Fresh-water drum		16,350	16,350
Largemouth black bass	2,350	235	2,585
Sunfish	13,675	919,325	933,000
Total	17,865	1,309,510	1,327,375
All stations:			
Buffalo fish		6,120,035	6,120,035
Carp		17,264,550	17,264,550
Catfish	16,420	27,074,065	27,090,485
Crappie	24,940	17,408,815	17,433,755
Fresh-water drum		27,680	27,680
Largemouth black bass	71,145	128,435	199,580
Pike and pickerel		361,490	361,490
Sunfish	15,685	14,436,320	14,452,005
White bass		17,185	17,185
Yellow perch	42,360	1,212,265	1,254,625
Miscellaneous		3,889,205	3,889,205
Total	170,550	87,940,045	88,110,595
Summary, by stations:			
Homer, Minn	98,140	12,741,580	12,839,720
La Crosse, Wis	13,635	6,556,070	6,569,705
Lynxville, Wis	13,245	8,155,355	8,168,600
Marquette, Iowa	25,495	34,335,105	34,360,600
Bellevue, Iowa	2,170	17,862,795	17,864,965
Rock Island, Ill		6,979,630	6,979,630
Simmesport, La	17,865	1,309,510	1,327,375
Total	170,550	87,940,045	88,110,595

PRODUCTION OF STATIONS AND SUBSTATIONS

The output of fish previously cited for the year 1927 was the product of 38 main stations and 35 subsidiary plants operated in conjunction with them. This represents an increase of 3 substations over last year. The above figures do not include the numerous field

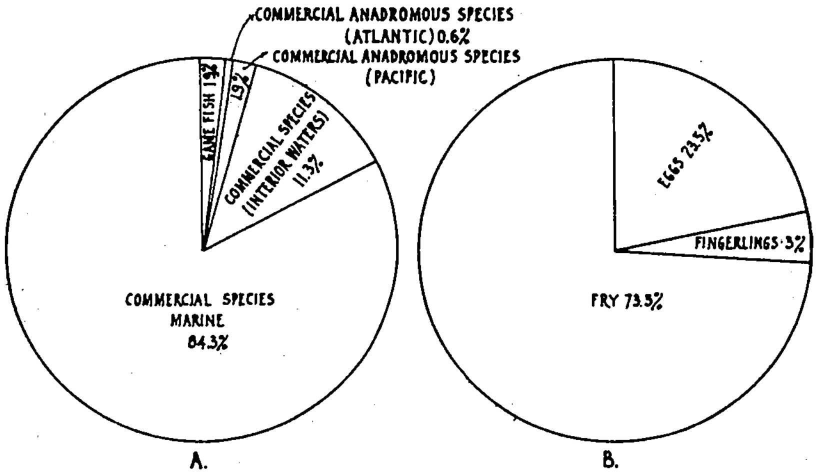

FIG. 3.—*A* shows percentage composition of various groups in total output and *B* shows percentage composition of different stages in total output

collecting stations but refer specifically to plants equipped for the incubation or rearing of fish. The stations and substations and their respective outputs are listed below:

Stations and substations operated and output of each, fiscal year 1927

[Asterisk (*) denotes transfer of eggs. See table, p. 701]

Stations, substations, and species	Eggs	Fry	Fingerlings, yearlings, and adults	Total [1]
Afognak, Alaska:				
Humpback salmon	(*)		30,000	30,000
Sockeye salmon			14,400,000	14,400,000
Steelhead salmon	790,000			700,000
Baird, Calif.: Chinook salmon			1,545,000	1,545,000
Battle Creek, Calif.—Chinook salmon			4,585,000	4,585,000
Mill Creek, Calif.—Chinook salmon	(*)		3,175,000	3,175,000
Baker Lake, Wash.: Sockeye salmon		6,730,000	995,700	7,725,700
Birdsview, Wash.—				
Carp			20	20
Chinook salmon		266,000	611,000	877,000
Silver salmon	* 100,000	2,504,000	485,500	3,089,500
Sockeye salmon	125,000			125,000
Steelhead salmon	200,000		715,600	915,600
Duckabush, Wash.—				
Chinook salmon			494,200	494,200
Chum salmon		10,763,000		10,763,000
Silver salmon			128,600	128,600
Steelhead salmon			60,100	60,100
Quilcene, Wash.—				
Chinook salmon			491,600	491,600
Chum salmon		7,203,000		7,203,000
Humpback salmon		3,544,000		3,544,000
Silver salmon		300,000	383,500	683,500
Steelhead salmon			44,000	44,000
Sultan, Wash.—				
Chinook salmon	26,000		351,000	377,000
Silver salmon		2,053,000		2,053,000
Berkshire trout hatchery, Mass.:				
Brook trout			298,600	298,600
Lake trout			5,600	5,600
Rainbow trout			45,800	45,800
Boothbay Harbor, Me.:				
Cod	213,470,000			213,470,000
Winter flounder		2,203,109,000		2,203,109,000
Bozeman, Mont.:				
Black-spotted trout			582,800	582,800
Brook trout			342,600	342,600
Loch Leven trout	* 2,184,000		17,000	2,201,000
Rainbow trout			529,200	529,200

[1] Lost in transit, 918,080.

Stations and substations operated and output of each, fiscal year 1927—Continued

Stations, substations, and species	Eggs	Fry	Fingerlings, yearlings, and adults	Total
Bozeman, Mont.—Continued.				
Glacier Park, Mont.—Black-spotted trout			1,526,600	1,526,600
Meadow Creek, Mont—				
Black-spotted trout			1,392,000	1,392,000
Grayling		1,800,000		1,800,000
Loch Leven trout	*3,774,000		2,313,000	6,087,000
Rainbow trout	*175,000		621,000	796,000
Mystic Lake, Mont.—				
Black-spotted trout			248,000	248,000
Rainbow trout	50,000			50,000
Cape Vincent, N. Y.:				
Largemouth black bass			17,250	17,250
Brook trout		1,010,000	401,840	1,411,840
Cisco	*5,200,000	105,960,000		111,160,000
Lake trout	*39,000	1,531,000	7,200	1,577,200
Loch Leven trout		1,000		1,000
Rainbow trout		39,000	16,900	55,900
Smallmouth black bass			4,920	4,920
Whitefish	87,000	37,800,000		37,887,000
Swanton, Vt.—				
Pike perch	*2,500,000	19,110,000		21,610,000
Yellow perch		10,560,000		10,560,000
Central Station, Washington, D. C.:				
Largemouth black bass			290	290
Brook trout			185,900	185,900
Catfish			300	300
Cisco		2,080,000		2,080,000
Rainbow trout		30,000	208,850	238,850
Silver salmon		12,000	5,600	17,600
Sunfish			1,900	1,900
Yellow perch			270	270
Bryans Point, Md.—				
Shad		20,979,300		20,979,300
Yellow perch		168,192,800		168,192,800
Lakeland, Md.—				
Largemouth black bass			13,320	13,320
Crappie			8,160	8,160
Sunfish			8,650	8,650
Clackamas, Oreg.:				
Black-spotted trout			98,000	98,000
Brook trout	(*)		251,300	251,000
Chinook salmon			2,872,000	2,872,000
Rainbow trout			90,800	90,800
Steelhead salmon	(*)		10,000	10,000
Applegate, Oreg.—				
Silver salmon			640,900	640,900
Steelhead salmon	*250,000			250,000
Big White Salmon, Wash.—				
Brook trout			37,000	37,000
Chinook salmon	*2,941,000		7,781,000	10,722,000
Little White Salmon, Wash.—Chinook salmon	*6,145,000			6,145,000
Rogue River, Oreg.—				
Chinook salmon			1,300,000	1,300,000
Silver salmon	48,000			48,000
Salmon, Idaho—				
Chinook salmon			7,879,000	7,879,000
Rainbow trout			224,400	224,400
Cold Springs, Ga.:				
Largemouth black bass		196,800	106,850	303,650
Catfish			1,030	1,030
Sunfish			160,180	160,180
Craig Brook, Me.:				
Atlantic salmon	200,000		1,229,000	1,429,000
Brook trout	(*)	140,000	1,150,130	1,290,130
Landlocked salmon	*194,000	50,000	337,560	581,560
Smallmouth black bass			30	30
Smelt	1,875,000	4,175,000		6,050,000
White perch			900	900
Grand Lake Stream, Me.—				
Brook trout			46,000	46,000
Landlocked salmon			289,420	289,420
Green Lake, Me.—Smelt	*9,250,000			9,250,000
Duluth, Minn.:				
Brook trout			204,000	204,000
Lake trout	*550,000	9,100,000	321,000	9,971,000
Pike perch		18,450,000		18,450,000
Whitefish		1,880,000		1,880,000

Stations and substations operated and output of each, fiscal year 1927—Continued

Stations, substations, and species	Eggs	Fry	Fingerlings, yearlings, and adults	Total
Edenton, N. C.:				
Largemouth black bass		39,500	49,050	88,550
Glut herring		2,000,000		2,000,000
Shad		600,000		600,000
Sunfish			4,540	4,540
Warmouth bass			400	400
Erwin, Tenn.:				
Largemouth black bass			43,890	43,890
Brook trout			137,250	137,250
Rainbow trout	56,000		218,100	274,100
Rock bass			16,050	16,050
Smallmouth black bass			50	50
Sunfish			12,550	12,550
Fairport, Iowa:				
Largemouth black bass			5,780	5,780
Carp			140	140
Catfish			80	80
Sunfish			20,130	20,130
Gloucester, Mass.:				
Cod	708,005,000	158,583,000		866,588,000
Haddock	315,387,000	63,894,000		379,281,000
Pollock		638,779,000		638,779,000
Winter flounder		170,718,000		170,718,000
Homer, Minn.:				
Largemouth black bass			120,970	120,970
Buffalo fish			5,940	5,940
Carp			2,918,650	2,918,65
Catfish			2,200,190	2,200,190
Crappie			3,933,100	3,933,100
Fresh-water drum			10,830	10,830
Pike and pickerel			88,390	88,390
Sunfish			2,080,110	2,080,110
White bass			1,630	1,630
Yellow perch			932,700	932,700
Miscellaneous			546,800	546,800
La Crosse, Wis.:				
Largemouth black bass			17,220	17,220
Brook trout			496,050	496,050
Buffalo fish			130,200	130,200
Carp			1,766,000	1,766,000
Catfish			1,884,000	1,884,000
Crappie			992,000	992,000
Loch Leven trout			229,900	229,900
Pike and pickerel			64,650	64,650
Rainbow trout			219,400	219,400
Sunfish			795,200	795,200
White bass			900	900
Yellow perch			155,270	155,270
Miscellaneous			764,260	764,260
Bellevue, Iowa:				
Largemouth black bass			1,930	1,930
Buffalo fish			3,744,000	3,744,000
Carp			6,064,000	6,064,000
Catfish			3,577,200	3,577,200
Crappie			1,051,620	1,051,620
Pike and pickerel			72,900	72,900
Sunfish			1,764,270	1,764,270
White bass			8,800	3,800
Yellow perch			250	250
Miscellaneous			1,[illegible]5,000	1,585,000
Lynxville, Wis.—				
Largemouth black bass			14,400	14,400
Buffalo fish			21,200	21,200
Carp			1,039,100	1,039,100
Catfish			4,349,400	4,349,400
Crappie			1,260,000	1,260,000
Fresh-water drum			500	500
Pike and pickerel			8,100	8,100
Sunfish			1,105,000	1,105,000
White bass			3,900	3,900
Yellow perch			30,850	30,850
Miscellaneous			336,150	336,150
Marquette, Iowa—				
Largemouth black bass			40,940	40,940
Buffalo fish			1,908,700	1,908,700
Carp			4,176,800	4,176,800
Catfish			13,144,000	13,144,000
Crappie			7,400,300	7,400,300
Pike and pickerel			127,350	127,350
Sunfish			7,430,000	7,430,000
White bass			6,960	6,960
Yellow perch			125,550	125,550

Stations and substations operated and output of each, fiscal year 1927—Continued

Stations, substations, and species	Eggs	Fry	Fingerlings, yearlings, and adults	Total
La Crosse, Wis.—Continued.				
Plaquemine, La.—Buffalo fish		2,850,000		2,850,000
Rock Island, Ill.—				
Largemouth black bass			1,530	1,530
Buffalo fish			222,000	222,000
Carp			1,300,000	1,300,000
Catfish			1,900,000	1,900,000
Crappie			2,545,000	2,545,000
Pike and pickerel			100	100
Sunfish			344,000	344,000
Yellow perch			10,000	10,000
Miscellaneous			657,000	657,000
Simmesport, La.—				
Largemouth black bass			2,590	2,590
Buffalo fish			88,000	88,000
Catfish			35,700	35,700
Crappie			251,740	251,740
Fresh-water drum			16,350	16,350
Sunfish			933,000	933,000
Yellowstone, Wyo.—Black-spotted trout	*6,968,000		3,232,000	10,200,000
Leadville, Colo.:				
Black-spotted trout			355,250	355,250
Brook trout	(*)		1,986,000	1,986,000
Lake trout			28,750	28,750
Rainbow trout			193,750	193,750
Steelhead salmon			48,800	48,800
Louisville, Ky.:				
Largemouth black bass			5,100	5,100
Lake trout		8,000		8,000
Rock bass			2,900	2,900
Smallmouth black bass		501,000	5,900	506,900
Sunfish			5,700	5,700
Mammoth Spring, Ark.:				
Largemouth black bass			104,170	104,170
Rainbow trout			42,000	42,000
Rock bass			18,550	18,550
Smallmouth black bass			133,750	133,750
Sunfish			44,600	44,600
Manchester, Iowa:				
Largemouth black bass			80	80
Brook trout			605,100	605,100
Loch Leven trout			34,000	34,000
Rainbow trout	*110,000		201,300	311,300
Smallmouth black bass			3,150	3,150
Sunfish			180	180
Nashua, N. H.:				
Brook trout			339,400	339,400
Catfish			8,700	8,700
Landlocked salmon			14,000	14,000
Loch Leven trout			14,000	14,000
Rainbow trout			2,250	2,250
Smallmouth black bass		32,000		32,000
Neosho, Mo.:				
Largemouth black bass			17,710	17,710
Crappie			1,890	1,890
Loch Leven trout			15,700	15,700
Rainbow trout	444,000		145,560	589,560
Rock bass			5,600	5,600
Sunfish			18,370	18,370
Bourbon, Mo.—				
Rainbow trout	*1,349,000		73,500	1,422,500
Langdon, Kans.—				
Largemouth black bass			34,670	34,670
Crappie			5,010	5,010
Sunfish			27,230	27,230
Northville, Mich.:				
Largemouth black bass			1,050	1,050
Brook trout			516,900	516,900
Rainbow trout			144,100	144,100
Smallmouth black bass		126,000	51,650	177,650
Sunfish			600	600
Alpena, Mich.—				
Brook trout			18,000	18,000
Lake trout		20,000	545,500	565,500
Pike perch	*5,000,000	19,050,000		24,050,000
Smallmouth black bass			37,500	37,500
Whitefish		6,500,000		6,500,000
Charlevoix, Mich.—				
Chub		240,000		240,000
Lake trout	975,000	15,000,000		15,975,000
Whitefish		20,000,000		20,000,000
Turtle Lake, Mich.—Brook trout			22,450	22,450

Stations and substations operated and output of each, fiscal year 1927—Continued

Stations, substations, and species	Eggs	Fry	Fingerlings, yearlings, and adults	Total
Orangeburg, S. C.:				
Largemouth black bass		64,300	197,150	261,450
Catfish			30	30
Crappie			190	190
Sunfish			31,780	31,780
Warmouth bass			500	500
Put in Bay, Ohio:				
Carp		18,500,000		18,500,000
Pike perch	40,600,000	78,000,000		118,600,000
Smallmouth black bass			550	550
Whitefish	7,000,000	79,880,000		86,880,000
Yellow perch	12,000,000	15,000,000		27,000,000
Quinault, Wash.:				
Silver salmon		285,400		285,400
Sockeye salmon	(*)	5,300,000	1,672,470	6,972,470
St. Johnsbury, Vt.:				
Brook trout		1,185,000	8,210	1,193,210
Lake trout		37,000		37,000
Landlocked salmon		5,000		5,000
Loch Leven trout		58,000	9,930	67,930
Steelhead salmon			17,460	17,460
Holden, Vt.—				
Brook trout			5,280	5,280
Lake trout			14,400	14,400
Steelhead salmon			5,000	5,000
York Pond, N. H.—Brook trout	(*)	46,000	3,940	49,940
San Marcos, Tex.:				
Largemouth black bass			163,760	163,760
Crappie			48,190	48,190
Rock bass			500	500
Sunfish			26,570	26,570
Warmouth bass			1,230	1,230
Medina Lake, Tex.—Largemouth black bass			8,720	8,720
New Braunfels, Tex.—				
Largemouth black bass			30,110	30,110
Crappie			18,750	18,750
Sunfish			24,940	24,940
Saratoga, Wyo.:				
Black-spotted trout			280,000	280,000
Brook trout		228,000	721,000	949,000
Loch Leven trout		99,000	185,100	284,100
Rainbow trout	1,459,000	470,400	113,500	2,042,900
Spearfish, S. Dak.:				
Brook trout			[1] 698,660	698,660
Loch Leven trout			176,750	176,750
Rainbow trout			113,060	113,060
Steelhead salmon			50,000	50,000
Springville, Utah:				
Black-spotted trout			42,000	42,000
Brook trout	*1,304,000		523,300	1,827,300
Rainbow trout	*410,000		873,750	1,283,750
Tupelo, Miss.:				
Largemouth black bass		518,000	119,850	637,850
Catfish			380	380
Crappie			20	20
Sunfish			313,200	313,200
Warmouth bass			5,300	5,300
White Sulphur Springs, W. Va.:				
Largemouth black bass			134,500	134,500
Brook trout	700		[2] 831,800	832,500
Loch Leven trout			413,900	413,900
Rainbow trout	*421,000		786,390	1,207,390
Rock bass			7,910	7,910
Sunfish			300	300
Woods Hole, Mass.:				
Cod	128,193,000	106,731,000		234,924,000
Winter flounder	43,604,000	722,935,000		766,539,000
Wytheville, Va.:				
Largemouth black bass		85,000	7,360	92,360
Brook trout			104,900	104,900
Catfish			40	40
Rainbow trout			197,800	197,800
Rock bass			3,100	3,100
Smallmouth black bass		29,000	1,730	30,730
Sunfish			300	300
Yes Bay, Alaska: Sockeye salmon			19,851,090	19,851,090

[1] In addition to 234,000 fingerling brook trout turned over to the State of South Dakota in cooperative work.

[2] In addition to 715,000 fingerling brook trout turned over to the State of West Virginia in cooperative work.

TRANSFER OF EGGS BETWEEN STATIONS

To illustrate that the various stations operated by the bureau are not independent units but are interlocking, there is given a list of the numbers and species of eggs transferred between stations. The object of such transfers is to maintain the widest possible distribution of the various species at a minimum cost and to relieve the pressure on those stations that take eggs in excess of their capacity to incubate them.

Transfer of eggs between stations, fiscal year 1927

Species	Number of eggs	From—	To—
Black-spotted trout	450,000	Yellowstone Park, Wyo	Leadville, Colo.
Brook trout	115,000	Clackamas, Oreg	Little White Salmon, Wash.
	115,000	do	Big White Salmon, Wash.
	100,000	Craig Brook, Me	Grand Lake Stream, Me.
	250,000	Leadville, Colo	Nashua, N. H.
	250,000	do	White Sulphur Springs, W. Va.
	500,000	do	Bozeman, Mont.
	100,000	York Pond, N. H	Holden, Vt.
	125,000	do	St. Johnsbury, Vt.
	259,000	Springville, Utah	Spearfish, S. Dak.
	506,000	do	Clackamas, Oreg.
Chinook salmon	882,000	Mill Creek, Calif	Baird, Calif.
	963,000	do	Battle Creek, Calif.
	988,000	Big White Salmon, Wash	Clackamas, Oreg.
	3,000,000	Little White Salmon, Wash	Salmon, Idaho.
	990,000	do	Clackamas, Oreg.
	2,050,000	do	Puget Sound Stations, Wash.
	230,000	Upper Clackamas, Oreg	Clackamas, Oreg.
	750,000	Wind River, Wash	Little White Salmon, Wash.
Cisco	2,000,000	Cape Vincent, N. Y	Central Station, Washington, D. C.
Humpback salmon	3,617,900	Afognak, Alaska	Puget Sound Stations, Wash.
Lake trout	15,000	Cape Vincent, N. Y	Berkshire trout hatchery, Mass.
	15,000	Duluth, Minn	Louisville, Ky.
	50,000	do	Leadville, Colo.
Landlocked salmon	162,400	Green Lake, Me	Craig Brook, Me.
	25,000	Craig Brook, Me	St. Johnsbury, Vt.
	25,000	do	Nashua, N. H.
	200,000	Grand Lake Stream, Me	Craig Brook, Me.
Loch Leven trout	75,000	Bozeman, Mont	St. Johnsbury, Vt.
	250,000	Meadow Creek, Mont	La Crosse, Wis.
	25,200	do	Neosho, Mo.
	25,200	do	Cape Vincent, N. Y.
	25,200	do	Erwin, Tenn.
	20,000	do	Alpena, Mich.
Pike perch	1,000,000	Swanton, Vt	Central Station, Washington, D. C.
	1,000,000	Alpena, Mich	Do.
Rainbow trout	25,100	Meadow Creek, Mont	Manchester, Iowa.
	20,000	do	Neosho, Mo.
	1,301,000	do	Bozeman, Mont.
	40,000	do	Wytheville, Va.
	33,000	Manchester, Iowa	La Crosse, Wis.
	200,000	Bourbon, Mo	Do.
	50,000	do	Mammoth Spring, Ark.
	397,000	Springville, Utah	Leadville, Colo.
	50,000	White Sulphur Springs, W. Va	Central Station, Washington, D. C.
	133,000	do	Nashua, N. H.
	50,000	do	Holden, Vt.
	207,000	do	Northville, Mich.
Silver salmon	1,722,000	Baker Lake, Wash	Birdsview, Wash.
Smelt	5,250,000	Green Lake, Me	Craig Brook, Me.
Sockeye salmon	3,402,000	Afognak, Alaska	Puget Sound Stations, Wash.
	30,700	Quinault, Wash	Rogue River, Oreg.
Steelhead salmon	50,000	Clackamas, Oreg	Little White Salmon, Wash.
	75,000	Applegate, Oreg	Spearfish, S. Dak.

HATCHERY FISH-CULTURAL NOTES

NEW HATCHERIES

Surveys have been made of possible sites for the new auxiliary of the Warm Springs (Ga.) station, and final investigations are now under way for the location of the hatchery. Preliminary arrangements have been completed for the establishment of a proposed auxiliary of the San Marcos (Tex.) station at Fort Worth, Tex., and actual construction work is now waiting on the clearing of the title to the property under consideration.

ENTOMOSTRACA FOR PONDFISH

The superintendent of the Wytheville (Va.) station received from the New Jersey State hatchery at Hackettstown, N. J., a stock of two species of daphnia. One form, *Daphnia magna*, attains a very large size and is useful for that reason. The other, *Daphnia moina*, is a Japanese form and is unusually prolific. These organisms constitute the main food supply of young bass. The cultures transferred to the Wytheville ponds flourished, and the superintendent reports a notable increase in growth in the fish receiving them. A stock has been shipped to the bureau's Georgia and Tennessee stations and also to the State of Kentucky.

NEW DIET FOR PONDFISH

The superintendent of the Warm Springs (Ga.) station has been experimenting in feeding shrimp heads to the brood fish in the station ponds. This material is largely a waste product of the coastal fisheries. The fish appear to take it readily and thrive upon it, but it has not been used sufficiently long to determine fully its actual value as food for pondfish.

COMMERCIAL FISHES

Fishes of great commercial importance constituted a large part of the output for the past year. The hatching of Pacific salmons is supplementary to conservation by legal restriction. The propagation of whitefish, cisco, lake trout, and pike perch probably is one of the most important factors in the perpetuation of these fishes. The propagation of the marine species as well as the anadromous shad and herring of the Atlantic coast is responsible for the salvaging of eggs that otherwise would be lost in marketing. The culture of carp and buffalo fish also is directed toward the improvement of the economic fisheries.

PACIFIC SALMONS

As the collection of eggs from these species is dependent upon the natural runs, considerable fluctuation in the numbers taken occurs from year to year. During the past year, however, smaller collections in some fields were offset by gains in others, so that the total take of all species aggregated 1,000,000 more than in 1926. Brook trout were hatched during the year at the Puget Sound (Wash.) stations and at the Yes Bay (Alaska) station. A more detailed résumé of the work follows:

AFOGNAK (ALASKA) STATION

[FRANK L. SNIPES, Superintendent]

This station handles sockeye salmon mainly, although smaller numbers of humpback and steelhead salmon also are collected. An escapement of 22,250 sockeye salmon was counted through a rack into Letnik Lake, or virtually double the escapement of the previous season. Egg collections from this run amounted to over 21,000,000. During August a run of 4,626 humpback salmon made their way to Letnik Lake and enough fish were taken below the rack to furnish 4,212,000 eggs, all of which were shipped to the Puget Sound stations. Over 1,000,000 steelhead eggs were forwarded to the same destination. Destruction of Dolly Varden trout was continued, and approximately 100,000 of these predacious fish were accounted for in the course of the year. The results of the campaign of the past two years against them have become quite noticeable.

YES BAY (ALASKA) STATION

[J. L. GARDNER and A. T. LOOFF, Superintendents]

During part of the fiscal year this station was without a superintendent, being in charge of an employee attached to the Clackamas (Oreg.) station. Chinook salmon exclusively are handled here, although a shipment of 60,000 brook-trout eggs was received for incubation. The collection of over 30,000,000 sockeye eggs represents almost half of the bureau's total take of that species. Low water during the fishing season and a sudden rise at the close probably prevented the securing of at least 10,000,000 additional eggs. Twenty million salmon eggs were hatched at the station; the remainder were shipped away or lost through normal mortality. Whereas on July 1 of last year only 2,892,000 fingerlings were being carried over for feeding, the close of the fiscal year 1927 found 10,473,000 on hand. This is indicative of the attempt to make the work at this station more effective by rearing a larger proportion of the stock to larger size. The fry are carried through the sac stage in stacked trays very successfully. This system lessens the amount of attention and care that must be given to the fry. Five thousand fish are held in each tray. A campaign was waged to eradicate the predatory Dolly Varden trout. The practice of liberating fingerlings in the feeding ponds, from which they can work their way gradually into the lake and become adapted to new conditions by degrees, was continued. Condemned canned salmon and salted salmon were used successfully as food. The cost of this material varies from ¼ to ½ cent per pound.

BAKER LAKE (WASH.) STATION AND SUBSTATIONS

[JOSEPH KEMMERICH, Superintendent]

This important group consists of five permanent stations and one egg-collecting station at Walcotts Slough near Brinnon, Wash. Steelhead trout and all species of Pacific salmon except the humpback were handled. Weather and water conditions were unusually favorable during the past year, but in several cases the run of fish failed to meet expectations. The run of chum salmon in the Hoods Canal region was an exception, however. A light run of sockeye salmon occurred in the Baker River, and, in addition, numbers of fish were injured in being carried over the dam at Concrete, Wash. Consequently only 2,823 fish were caught in Baker Lake for the work at the Baker Lake station. Egg collections from all points totaled 34,743,800, an increase of more than 8,000,000 over those of the previous year. In addition, numbers of eggs were transferred for incubation and distribution from points outside this field.

Baker Lake (Wash.) station.—Since the submission of last year's report, the combined fish ladder and elevator in the power dam at Concrete, Wash., has been put in operation. In the fiscal year 1926 practically no fish reached Baker Lake, but 2,823 sockeyes were taken at that point during the past year. It is believed that the total run amounted to about 4,000 fish, and a comparison of the figures will give an idea of the effectiveness of the device. The discrepancy between 4,000 and 2,823 was due largely to injuries received by the fish in making the ascent. Other species that entered the ladder, such as the chinook and silver salmons, apparently were put over with less tendency to injury, and the percentage of the total run that surmounted the dam probably was greater. So far as can be observed, the passage of the fingerlings downstream over the dam is accomplished with little loss. During the spring run of steelheads in 1927 the ladder and elevator were out of commission because of the construction of an addition to the dam and certain changes in the racks designed to divert the fish into the fishway. The apparatus will be in operation in time to care for the coming run of sockeyes. The changes and improvements mentioned should increase the effectiveness of the fishway and lessen the tendency to injure the fish.

The first sockeye entered the fishway on June 18, and the first fish were observed in the trap in Baker Lake on July 1. As usual, the trapped fish were held in an inclosure until spawning commenced on September 17. The season's collection of eggs amounted to 3,921,000, which were hatched with small loss. A number of advanced fry were liberated in the inclosure stream, from which they could work gradually into the lake. Eggs were received from the Yes Bay (Alaska) and Birdsview (Wash.) stations, and 200,000 of the resulting fingerlings are being held and fed.

A good proportion of the silver-salmon run surmounted the dam, and 2,286 fish were trapped. Only 623 proved to be females, and 1,766,000 eggs were taken. All eggs were hatched and the resulting fish distributed at the Birdsview station.

Birdsview (*Wash.*) *substation.*—The year opened with a larger stock of feeding fingerlings on hand than in any previous year. In addition to chinook, silver, and sockeye salmon, brook trout were being held for the account of the Skagit County Game Commission. The run of chinook and silver salmon in the Skagit River was below normal. A few sockeye eggs were secured from Grandy Creek and also a small number of chinook eggs. Over 1,000,000 of the latter were transferred from the Little White Salmon River station. The light run of silver salmon in Grandy Creek necessitated the shipping in of 600,000 from the Quinault station to supplement the local collection of 850,000. All silver-salmon eggs secured at Baker Lake were hatched and distributed at Birdsview to avoid planting this species in Baker Lake. The steelhead-egg collection surpassed that of any year since 1918. Almost 1,000,000 fry and fingerlings of this species were on hand on June 30. A shipment of ornamental Japanese carp, goldfish, and killifish was received and part of the fish distributed to other points.

Duckabush (*Wash.*) *substation.*—The permanent trap in the Duckabush River is so low that any rise in water submerges it; consequently but few silver salmon or steelheads were taken. It will be necessary to rebuild a new and higher trap at this point for future work. Chum-salmon eggs in a quantity beyond the capacity of the station were obtained from Walcotts Slough and in the Duckabush River. Egg losses were greater than normal, due, it is believed, to certain changes in the practice of hardening the eggs. The late run of fish at the slough was heavy, and a good supply of eggs was obtained. The chum salmon were liberated as sac fry. Chinook salmon from the Little White Salmon station were hatched and liberated in the Duckabush River in the hope of establishing a run there.

Illabot Creek (*Wash.*) *substation.*—Illabot Lake and Illabot Creek are tributary to the Skagit River. It has been considered desirable to establish a sockeye run in this system, and, beginning in 1925, plants of eyed eggs were made in the gravel. A number of plants have been made since then, but it was found in November, 1926, that the eggs were not hatching. A subsequent investigation of the November plantings showed that only about one-fourth of the eggs were hatching. In view of this situation it was deemed necessary to make future plantings of fingerlings, and 20,000 sockeye fingerlings were reserved at the Birdsview station to be transported to Illabot Lake by pack horse later in the season.

Lake Crescent (*Wash.*) *substation.*—Operations at this point consisted mainly in the rearing of 1,000,000 fingerling sockeyes in the ponds of the Washington State hatchery at that point. It is considered that Lake Crescent and its outlet, the Lyre River, constitute the most feasible place in the State of Washington for the establishment of a sockeye run. The river apparently supports a good run of steelheads and silver salmon, and no fish-cultural operations have been conducted upon it. Sockeye eggs to the number of 1,013,098 were shipped from the Yes Bay station and incubated at the State hatchery. The resulting fish were fed until June 14, on which date they were liberated because the ponds were needed for other work.

Ozette (*Wash.*) *substation.*—Mention was made in last year's report that hatchery operations were contemplated at this point and that retaining pens for sockeye salmon had been constructed. Later developments have shown that the waters of the lake and of Umbrella Creek become too warm, and it was necessary to release all fish. A survey was made of the entire Quillayute River watershed, and at no other point was there any indication of a run of sockeyes. Consequently all work at Ozette Lake has been abandoned and all equipment removed.

Quilcene (Wash.) substation.—Collections of chum-salmon eggs from the Duckabush River as well as the Quilcene River gave an extra large output of this species. The collection of silver-salmon eggs from the Quilcene River did not represent the full run of fish in that stream, as unavoidable defects in the traps permitted the escape of many fish. Egg-collecting operations at Walcotts Slough in cooperation with the Duckabush station have been mentioned already. In addition, attention was given to both early and late runs of chum salmon in the Quilcene River territory, giving a total take of 7,944,000 eggs of that species. A half million chinook eggs from the Little White Salmon River station were hatched with the object of creating a run of this species in the Quilcene River. The escape of the greater part of the silver-salmon run up the river reduced the total number of eggs to only 427,000. Three hundred thousand additional eggs were transferred from the Quinault station for hatching and local distribution. The only humpback-salmon eggs hatched at the Puget Sound stations consisted of 3,617,900 eyed eggs shipped from Afognak, Alaska, to this station. Being the off year for this species in Puget Sound waters, no local collections were attempted. A light run of steelheads gave a short collection of only 240,000 eggs. The resulting fry and fingerlings are being held at the station and fed.

Sultan (Wash.) substation.—While water conditions appeared favorable, there was an inexplicably light run of all species in this territory. A collection of 199,000 chinook eggs was secured by gaffing females, which do not ascend Elwell Creek to the trap. The small run of silver salmon in the Skyhomish River was deflected into Elwell Creek, and only a little over 1,000,000 eggs were taken. This number was increased by the transfer of 1,000,000 eggs from the State fisheries department. The steelhead run in the Skyhomish River was reported as large, but comparatively few of the fish reached the bureau's trap in Elwell Creek.

Quinault (Wash.) Station

[Marcus S. Meyer, Superintendent]

At this station efforts have been devoted largely to the handling of sockeyes, with incidental collections of silver and chinook salmon. Almost 2,500,000 sockeye eggs were obtained during the season. The use of traps has been abandoned largely, and dependence is now placed in seining for securing the fish. The egg-taking season, extending over a month, brings about a prolongation of hatching, so that earlier fingerlings can be reared and fed in outside pools until a later hatch necessitates their distribution to provide space. At the close of the year 837,080 sockeye fingerlings and a small number of chinooks were being held for later distribution.

Clackamas (Oreg.) Station and Substations

[Philo B. Hawley, Superintendent]

This station, with its group of seven substations, is a factor in the maintenance of the salmon runs in three States—Oregon, Idaho, and Washington. Their operations are concerned mainly with the chinook, silver, and steelhead salmons, although the sockeye salmon and several species of trout are handled in small numbers. The total production for last year failed to equal that of the preceding year, although it was well up to the average. As in previous reports, acknowledgment should be made of the hearty cooperation afforded by the State of Oregon, both financially and otherwise.

Clackamas (Oreg.) station.—Facilities at this point have been improved by the construction of 16 concrete rearing ponds each 36 feet in length. The racks were set up at the usual time with the expectation of a normal run of fish, but it failed to materialize, and the collection of chinook-salmon eggs at this point was the smallest in the history of the station. The fish hatched from the eggs secured were reared to No. 1 fingerlings or larger before liberation. Over 2,000,000 chinook eggs were transferred from other points and hatched here. In addition to the usual shipments of steelhead eggs from Applegate Creek, eggs of the brook trout and black-spotted trout from the Springville and Yellowstone Park hatcheries, respectively, were hatched and distributed in local waters. It has been found difficult to raise trout to a size greater than 2 inches at this station, therefore the distribution must be made at that stage of growth or earlier.

Upper Clackamas (Oreg.) substation.—The usual egg-collecting operations yielded a disappointing total about one-third as large as that of the previous year. The Chinook eggs were transferred to the main Clackamas station to be hatched, and the fry were planted in the waters from which the eggs were derived.

Little White Salmon (Wash.) substation.—While racks were installed during late August and early September, low water retarded spawning until September 23. A good yield of chinook eggs was had until the close of the season on October 13. Sockeye salmon were noticed in the Little White Salmon River, and 60,000 eggs were secured. More might have been obtained except for inability to trap the fish in a rack designed for the larger chinooks. Steelhead and brook-trout eggs transferred here were hatched and reared to fingerling size. Seventy barrels of salmon were salted for fish food.

Big White Salmon (Wash.) substation.—Preparations for the spawning runs were made in Big White Salmon River and Spring Creek. The number of eggs taken during the season exceeded that of the previous year, and the 4,315,000 secured from Spring Creek established a record for that field. The latter has been built up from a stream barren of salmon to a first-class egg-collecting station by virtue of frequent and heavy stockings. About 4,000,000 eyed chinook eggs were shipped, part of them going to the Clackamas station and the remainder to the Oregon fish commission. Fingerling fish were retained until May, when the exhaustion of the food supply of salted salmon necessitated their release. Two hundred and fifty thousand were retained for marking experiments, to be conducted by the division of scientific inquiry with the view of securing data on the migrations and survivals of fingerlings of various ages. A number of brook trout, were hatched and distributed to the bureau's applicants and for the account of the Klickitat County Game Commission.

Rogue River (Oreg.) substation.—The opening of the chinook-salmon spawning season at this point occurred on August 16, and eggs were taken until October 4, the season's collection amounting to 3,271,000. A very high proportion of male to female fish (frequently 8 to 1) was experienced. A new rack for intercepting silver and steelhead salmon was erected in Elk Creek, but high water retarded the collections. The flooding of the station grounds permitted the escape of all fish, but no property damage was suffered, although the water was 3 feet deep in some of the buildings.

Applegate Creek (Oreg.) substation.—The work at this point is confined to the silver and steelhead salmons. Egg collections of the former were very light, only 650,000 being obtained. A large run of steelheads aroused expectations of a good yield from that species, but freshets carried away part of the dam and rack and allowed most of the fish to escape. In spite of this mishap the egg collections amounted to 1,250,000.

Salmon (Idaho) substation.—One hundred and thirty thousand rainbow-trout fingerlings carried over from the previous season were distributed in local barren streams and in Williams Lake with the aim of establishing an egg-collecting field. Racks erected in the Pahsimeroi River in June were washed out by a cloud-burst in July; consequently the take of eggs in this field was largely negligible. Spawning operations in the Lemhi River yielded only about half the number of eggs secured the previous year, an unusually dry season being given as the cause. Eggs were incubated at the main station at Salmon, Idaho. Three million chinook eggs were transferred to this point for the purpose of determining the effectiveness of feeding "spring" and "fall" fingerlings. No fish under 1½ inches in length were released.

Wind River (Wash.) substation.—Results at this station were unsatisfactory, with collections less than half as large as the previous year's take. No eggs were hatched here, all of them being transferred to other points. This station, the property of the State of Washington, is in such condition that there is little hope of making it highly productive without a heavy expenditure of funds, and it is suggested that it be discontinued.

Baird (Calif.) Station and Substations

[W. K. Hancock, Superintendent]

A series of mishaps prevented the full realization of expectations at the Baird station. At this point dependence is placed in the seining of chinook salmon below the racks for an egg supply. Escape of fish through openings in the rack and high and muddy water materially checked operations with the early fall run of fish. During the winter high water carried out a supply dam and washed out some rearing ponds. The construction of racks in the spring was attended by great difficulty for the same reason. The presence of a tremendous amount of volcanic ash from Mount Shasta in the McCloud River has been a constant source of difficulty. The continual turbidity prevented examination of the racks to keep them fish tight, deposited thick layers of mud on the spawning grounds, and an inordinate amount of attention was required to prevent its smothering the eggs.

Battle Creek (Calif.) substation.—A repetition of the high water noted at Baird rendered seining difficult at this point and in November damaged the rack so that all fish could ascend the river. Four million salmon eggs were taken, with the probability that half that number was lost through the break in the rack. Muddy water gave continuous trouble throughout the whole incubation period.

Mill Creek (Calif.) substation.—Similar conditions washed out the rack at Mill Creek after 5,000,000 eggs had been collected, and as many more probably were lost on account of the accident. Muddy water hindered incubation here, also, with heavy losses resulting. Constant attention to the eggs was necessary. An aggravated condition of mud and high water in the river seriously curtailed all operations in the California field.

FISHES OF THE GREAT LAKES

Operations in this field also are contingent upon weather conditions, egg collections of the important lake trout, whitefish, cisco, and pike perch fluctuating with the prosecution of the fisheries. The four main stations, with an equal number of substations and numerous collecting points, are concerned largely with the species mentioned above, though minor commercial fishes, such as yellow perch and carp and the game fishes, likewise are included in the output.

DULUTH (MINN.) STATION

[S. P. WIRES, Superintendent]

The take of lake trout and whitefish was light this season although slightly in excess of that of last year. Unfavorable weather conditions influenced the limited collections and probably were partially responsible for a poorer quality of eggs. These conditions prevailed not only on the south shore but at various points on Isle Royale. From the 16,717,295 lake-trout eggs taken, 615,400 eyed eggs, 8,380,000 fry, and 321,000 fingerlings were distributed; 2,732,000 whitefish eggs were collected.

Pike-perch work in cooperation with the State of Minnesota near Bemidji was successful. Eggs were eyed at the State's hatchery at Bemidji and transferred to other points for hatching. The bureau's share from these operations was 19,600,000 eggs. Almost 250,000 brook-trout eggs from various sources were handled. The hatch of 204,000 was distributed to applicants.

NORTHVILLE (MICH.) STATION AND SUBSTATION

[W. W. THAYER, Superintendent]

The Northville station handles none of the commercial species but propagates game fishes, both trout and the pond varieties. Almost 1,500,000 brook-trout eggs were received from commercial dealers. Part of these were shipped to the Alpena substation. Of the resulting fry, 200,000 were shipped to the cooperative nursery of the Turtle Lake Club. Difficulty was experienced in holding brook trout in the ponds, although no trouble was had with rainbows under similar conditions. An attempt to hold the fish longer than usual undoubtedly made the losses heavier than would have been the case if all of them had been distributed soon after May 1.

The smallmouth-bass operations were encouraging, with a large increase in the fall distribution of fingerlings carried over. Winter losses of adult stock were lower than in the previous year. The 1927 hatch already has yielded 132,250 fry and fingerlings. The usual collections of brood bass were made for other stations. Some bluegill sunfish also were produced. Several hundred thousand rainbow-trout eggs were hatched, and at the close of the year 118,000 were being held over. The work with this species was very successful. This station is supervising the Turtle Lake (Mich.) cooperative nursery and another one at Metamora, Mich.

Alpena (*Mich.*) *substation.*—Whitefish-egg collections were carried on under the handicap of extremely stormy weather, with a consequent reduction in the number of eggs taken. Inability to secure experienced spawn takers was reflected in eggs of poorer quality. Further experiments at penning whitefish were made at Huron Beach, but with the same handicaps as were present in other fields. The possibilities of this practice are promising, however, and it should be continued. Weather conditions were more favorable for lake-trout collections, and a normal yield was obtained. The eggs were of good quality, but losses through an accident cut down the percentage of hatch.

A lake-trout nursery has been established at Rogers, Mich., and 300,000 fish are being reared. An equal number are being reared at the hatchery. A cooperative brook-trout nursery in Wilson Township also is being conducted under the supervision of this station. In the spring pike-perch operations were conducted in cooperation with the State of Michigan. It was found that the use of muck to prevent adhesion gave better results than did starch.

Charlevoix (*Mich.*) *substation.*—The bad weather affecting the whitefish work at the above-mentioned stations was, of course, operative here. Its effect was noticeable chiefly in the quality of the eggs, as a larger number was obtained than in the preceding year. A period of bad weather prevents the lifting of the nets, and when the fish are removed they are in bad shape and the eggs are of poor quality. Greater cooperation on the part of the fishermen would go a long way toward perpetuating the whitefish by artificial propagation. The same general conditions have applied to the lake-trout work. An attempt was made to develop a collecting station for rainbow trout near the station, and a few eggs were taken.

Put in Bay (Ohio) Station

[David Davies, Superintendent]

The usual arrangements were made for opening the whitefish egg-collecting stations in the fall. The collection of whitefish eggs, however, was the smallest in several years. This, of course, was a reflection of the fact that unusually small catches were made by the commercial fishermen. There appears to have been a change in the habits of the fish, reduction of spawning on the grounds west of Put in Bay apparently having taken place. Fish are now spawning more plentifully in waters east of Kelleys Island. The season's yield was 122,800,000 eggs, of which over 79,000,000 hatched.

In the pike-perch work there was a decrease of 50,000,000 eggs from the Port Clinton field, being offset largely by a gain in the Toledo field, so that the season's take approximated that of last year. The spawning season was prolonged, and early breaking of the ice gave a longer fishing season. The percentage of hatch was rather low. Large collections of yellow-perch eggs were made, a number being shipped to Missouri and Montana and the remainder being incubated and planted in Ohio waters. The carp work at Port Clinton was only partly successful as the commercial catch of this species was very light. No satisfactory explanation for this condition is evident. Collections of smallmouth black bass were made in Lake Erie for brood stock for other stations.

Cape Vincent (N. Y.) Station and Substation

[J. P. Snyder, Superintendent]

Spawn takers were placed at four points on Lake Ontario during the lake-trout season. An innovation was attempted in the seining of lake trout to be held in pens to ripen. Difficulty in securing State permission for this work delayed its start, but a total of 600 fish penned, of which only 153 were females, gave 767,000 eggs. The yield for the season from all sources was more than double that of any previous year. A fair hatch resulted, and the majority of the young fish were returned to Lake Ontario.

Adverse conditions confronted the whitefish work. Coupled with a failure to secure permission to take eggs from any but the most unproductive fields in Canadian waters, there were continual high winds that permitted the lifting of nets only four or five times during the spawning season. The largest number of eggs was obtained in the vicinity of Chaumont Bay. The adverse conditions prevailed during the lake-herring spawning season also. In spite of this, a heavy increase over the collections of the previous year was noted. A 78 per cent whitefish hatch was achieved, which is an excellent return for that species.

The Cape Vincent station has become an important factor in the production of trout by virtue of rearing stations under its direction. Brook, rainbow, and

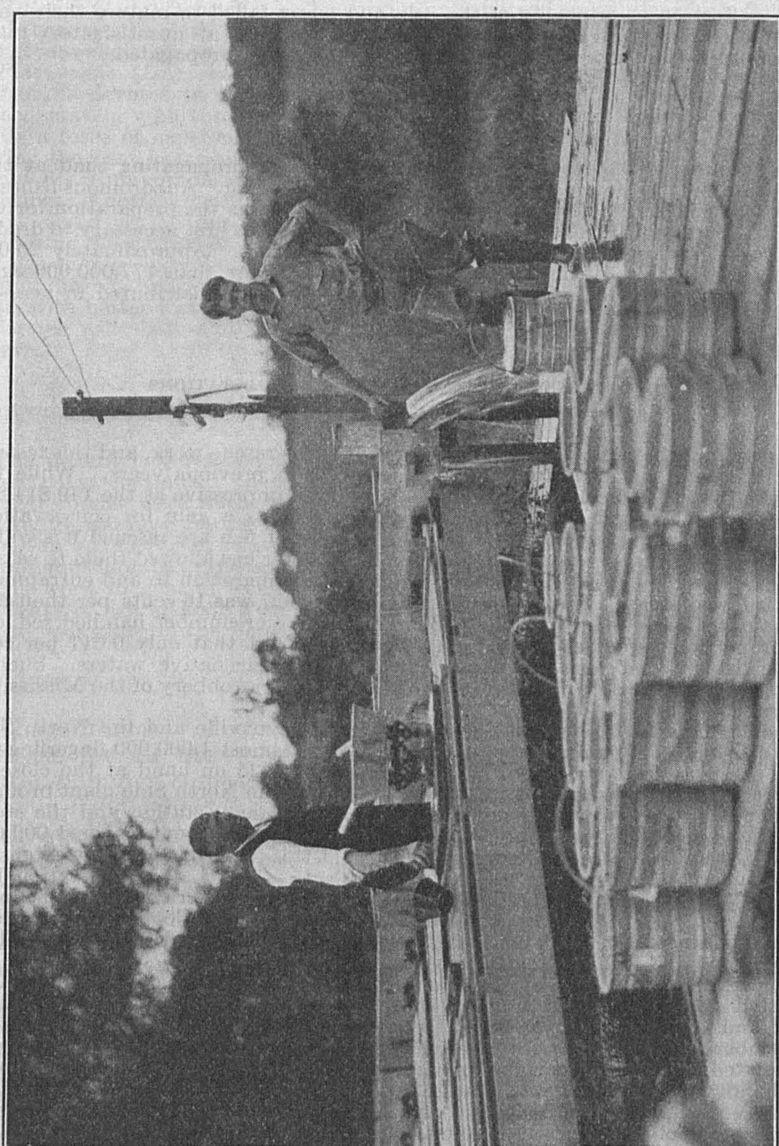

FIG. 4.—Preparing fish for distribution from nursery troughs, Watertown, N. Y.

Loch Leven trout were hatched at the main station and transferred to cooperative nurseries at Malone, N. Y.; Averill, Vt.; and the substations at Watertown and Barneveld, N. Y. At the close of the fiscal year the latter two were feeding 527,000 and 277,000 fingerlings, respectively.

Swanton (Vt.) substation.—The usual cooperative agreement between the States of Pennsylvania and Vermont and the Bureau of Fisheries was the basis of operation at this station for the past year. A period of warm weather early in March prompted an early start on this work, but a return to normal conditions delayed the maximum run until about the usual time. A very low water level in the lake rendered the retaining of many fish in the old pens a dangerous procedure, so new floating crates were constructed hastily and used in deeper water. The premature warm weather and the inadequacy of the water apparently had an effect on the ripening of the fish, and many failed to mature their eggs. An unsatisfactory hatch followed, and the net result was an unsatisfactory pike-perch output from this point. Yellow perch also were propagated.

Bryans Point (Md.) Substation

[L. G. Harron, Superintendent]

An account of the results secured in the work of propagating shad at this substation may be found on page 712 under the heading "Anadromous fishes of the Atlantic coast." The initial work of the season was the preparation for the season's operations in yellow-perch propagation. It was first necessary to dredge out Accokeek Creek to permit the floating of live cars. Approximately 20,000 brood perch collected from the fishermen provided more than 177,000,000 eggs. A good percentage of hatch resulted, and the fry were distributed in near-by waters.

RESCUE OPERATIONS

La Crosse (Wis.) Station and Substations

[C. F. Culler, in charge]

The major function of this group of stations is the rescue work, and this feature did not attain the magnitude that was reached in previous years. While the record of 88,110,645 salvaged fish in 1927 is not so impressive as the 149,814,899 of the preceding year, the situation really represents a gain for conservation. When conditions are such that a smaller number of fish are rescued it signifies that very few fish have been lost, and that high water has allowed them to escape from the sloughs or low water and prevented their migration to and entrapment in overflowed areas. The cost of rescuing fish in 1927 was 16 cents per thousand as compared with 14⅛ cents in 1926, when the larger number handled reduced the proportional overhead. It should be pointed out that only 0.017 per cent of the fish rescued were distributed away from their native waters. Such a diversion of the stock can hardly be said to constitute a robbery of the Mississippi waters.

The La Crosse station and its subsidiaries at Lynxville and the North Side have developed into an important trout station. Almost 1,000,000 fingerlings of three species were distributed, and there were 317,225 on hand at the close of the year. An increase in the number of troughs at the North Side plant brought the number to 48, which, together with 64 at the main station and the stock tanks at Lynxville, bring the total capacity of the station to over 1,000,000 good-sized fingerlings. A feature of the work at this point has been the extensive development of cooperative fish-cultural projects. The La Crosse station has exercised supervision over and furnished fish for 34 nurseries within the past year. These include both trout nurseries and bass ponds. Cooperative relations were maintained with the Lincoln Park Aquarium at Chicago, the bureau furnishing eggs and fish and distributing the output therefrom.

Homer (Minn.) substation; H. L. Canfield, in charge.—As usual, this station was operated as a holding station and a base for rescue operations only. The latter work and mussel infection were interfered with seriously by heavy rains in September. Thus, a season that usually lasts until November was prematurely terminated. The improvement in river conditions, however, more than offset the handicap imposed upon salvage work. Supervision of cooperative trout nurseries occupied considerable of the superintendent's time. At the Homer station much of the construction and overhauling of boats and other equipment for the entire group of stations was carried on. Surveys were made of various sites within the proposed limits of the Upper Mississippi River Wild Life and Fish Refuge, and when the property finally is secured it is believed that these areas can be made very productive of fish for stocking purposes.

Lynxville (Wis.) substation.—The same conditions that limited mussel infection and rescue work elsewhere were operative at this point. The greater proportion of the fish taken consisted of commercial species that were returned to their native waters. The taking over of certain areas by the State of Wisconsin also reduced the field of operations materially. Some carp eggs were taken and planted in the Mississippi River after fertilization.

Marquette (Iowa) substation.—Operations at this point were more successful than was generally the case elsewhere. Most of the bass fry distributed were derived from the Marquette and Gutenburg (Iowa) field.

Bellevue (Iowa) substation.—The results of the collecting season at Bellevue were comparable with those at other points. A limited output was reported, but river conditions were favorable to a good survival of fish.

Plaquemine (La.) substation.—This station, replacing the Atchafalaya substation, is devoted to the propagation of buffalo fish. The work is conducted in cooperation with the State of Louisiana, which has furnished the equipment, while a force of experienced employees is supplied by the bureau. Operations during the past year were a practical failure, less than 3,000,000 fry being distributed. Unfavorable weather conditions were largely responsible for the poor showing. Another factor tending to decrease the yield was the newly inaugurated closed season during the spawning period (February 15 to March 30). No fishing was carried on during this time, and it was impossible to hire fishermen for egg-taking operations alone. The protection afforded by a restriction of fishing during the spawning stage will be of undoubted benefit, and it is hoped that, with better weather conditions in the future, opposition on the part of the fishermen will abate and that a larger number of eggs than ever before can be secured.

Mussel Infection

[Conducted by the Fairport (Iowa) and La Crosse (Wis.) stations in conjunction with the rescue of landlocked fishes]

The infection of rescued fishes with the glochidia of commercial species of mussels was continued. A total of 1,169,014,650 larval mussels of three commercial species were released by inoculating rescued fish. This output was a marked reduction from the 2,800,000,000 of last year, and the cost per thousand therefore was increased relatively, ranging from $0.0303 to $0.0565 per thousand at different points. The same adverse conditions that militated against the rescue work in general were responsible for this limited output. An unusual mortality of fish at Lake Pokegama also was a detrimental factor. The general rescue operations in the Fairport field amounted to 162,765 fish of various sizes.

MARINE FISHES

The summary of operations in this field exhibits a gratifying increase for all the species handled. Cod, haddock, pollock, and winter flounder comprise the forms propagated. A total collection of over 6,000,000,000 eggs is indicative of the significance of this work, even though many of the eggs were merely fertilized and planted on the spawning grounds without attempting to incubate them. Three stations occupy this field, two in Massachusetts and one in Maine. The season's work was marked by a resumption of the collection of cod eggs at the Boothbay Harbor (Me.) station after a cessation of several years. In work of this nature, carried on chiefly by placing spawn takers on the fishing boats, a greatly increased number of eggs, if available, may be handled with but little increase in cost.

Boothbay Harbor (Me.) Station

[E. E. Hahn, Superintendent]

The output of this station for the year 1927 was the greatest since its establishment. The resumption of cod-egg collections helped to augment the total output of 2,419,873,000 cod and flounder eggs, although collections of the latter were very large. It was found impossible to incubate the cod eggs at the hatchery, due to water conditions, and they were planted immediately after fertilization. To take full advantage of this opportunity in the future it will be necessary to place the steamer *Gannett* in commission or to provide a new boat.

Flounder operations opened March 1, when the nets were set. All grounds except Casco Bay yielded good catches of fish. Brood fish to the number of

8,909 were obtained, and eggs were plentiful and of good quality. At times it was necessary to utilize floating hatching boxes moored to the wharf. The usual aquarium exhibit was maintained during the summer.

GLOUCESTER (MASS.) STATION

[C. G. CORLISS, Superintendent]

The season's work opened November 1 with the collection of pollock eggs in Massachusetts Bay. Fishing was poor early in the season, and when it improved many unripe fish were taken. Early in December a sharp increase in collections was experienced, 50,000,000 to 75,000,000 being taken in a day. This enabled the station to increase its total take of pollock eggs substantially over the collections of the past two years

Cod collections showed a slight regression. Absence of fish on the inshore spawning grounds for the greater part of the winter was responsible for this. Spring collections in New Hampshire waters were more satisfactory. Most of these eggs were planted on the spawning grounds, because it was impossible to secure a satisfactory percentage of hatch at the hatchery. The total collections were 798,158,000 eggs.

Only one steamer was engaged in the inshore haddock fisheries, but it made a collection of eggs unsurpassed since 1922. The capture of the first brood flounder on March 10 initiated this work, and good catches were made until the latter part of March. From a brood stock of 327 fish, 192,832,000 eggs were secured, which produced upward of 170,000,000 fry.

The offshore spawning operations registered a slight increase in the take of haddock and cod eggs. A preponderance of unripe fish prevented a take of eggs as large as the catch of fish would seem to justify.

WOODS HOLE (MASS.) STATION

[G. R. HOFFSES, Superintendent]

Fish-cultural operations at this station, which is maintained as a scientific laboratory during the summer, were of approximately the same extent as last year. The cod work differs from that at other stations in that the brood fish are retained in a pool until they are ripe. Shipments of cod were made from Newport, R. I., and from local sources in November until a total stock of 2,851 fish was secured. These yielded 291,274,000 eggs, of which 113,826,000 were planted in the eyed stage. At the close of the season the fish were tagged for scientific purposes and released.

The flounder work at this point opens in January. Station fyke nets were set in Waquoit Bay and yielded 2,297 fish. A continuation of the recently developed practice of transporting the adults packed in wet seaweed has proved very satisfactory. Over 863,000,000 flounder eggs were taken and the resulting fry planted in adjacent waters.

A number of necessary and important improvements to buildings and grounds were effected. There continues a pressing need for a new boat of sufficient size to transfer brood cod from the traps to the hatchery.

ANADROMOUS FISHES OF THE ATLANTIC COAST

The decline of the fisheries for shad and Atlantic salmon has made the propagation of these species uncertain. The Bryans Point (Md.) station, devoted exclusively to shad and yellow-perch culture, is operated only during the run of these fish. The Edenton (N. C.) station raises pondfish as well as shad, while the only Atlantic-salmon unit (the Craig Brook (Me.) station) handles as many trout as salmon. The past year has shown an increase in the number of shad hatched, due to a greater output of the Bryans Point hatchery.

SHAD. BRYANS POINT (MD.) SUBSTATION

[L. G. HARRON, in charge]

Notwithstanding the small catch of shad in the Potomac River and the unfavorable weather that prevailed during most of the spawning season, there was a marked increase over the previous season's take of eggs, a sufficient number being secured to yield upward of 21,000,000 vigorous fry. All of these were released on the spawning grounds in the river.

The constantly increasing pollution from the cities and towns bordering the Potomac has reached the point where it tends to limit the spawning grounds of the fish that escape the nets in the lower bay. So serious has the matter become that the usefulness of the Bryans Point station is lessened materially. The question of moving the station has become acute, and negotiations are under way for securing a site on Government-owned land farther down the river, where fish are available in greater numbers.

Shad and River Herring. Edenton (N. C.) Station

[William S. Vincent, Superintendent]

From the fish-culturist's standpoint, the run of glut herring was a failure, although fishermen well up the rivers made good catches. A prolonged dry season allowed the water in Albemarle Sound and the vicinity of Edenton station to become unusually brackish, and it is believed that the herring, failing to encounter the normal fresh water in this region, did not linger on their customary spawning grounds but continued up the rivers. In any case, the catch of herring near the hatchery was small and consisted chiefly of run-down fish.

Virtual failure likewise attended the shad operations. Large numbers of shad were secured at the Capehart fishery, but the great majority were males, and of the roes only a few carried mature eggs. This unfavorable condition probably is connected with the situation mentioned above in regard to the herring. A take of 800,000 eggs from a catch of 25,000 fish tells the story, but it offers no explanation as to the cause.

Atlantic Salmon. Craig Brook (Me.) Station

[George N. Montgomery, Superintendent]

All of the Atlantic-salmon eggs handled at this station during the year were received from the Canadian Government in exchange for eggs of other species. Slightly over 1,500,000 were received, and with the exception of a few incubated at the Maine State hatcheries for convenience in distribution all were hatched at the Craig Brook station. The resulting fish were distributed in various salmon rivers in the State, only 9,000 being carried over for distribution during the present year.

An improvement in weir fishing in the Penobscot River is noted, and fishermen have expressed a desire to capture salmon for the station in accordance with the former practice. Obtaining eggs from the present source, however, is considerably less expensive. Angling in the salmon pool at Bangor is reported as improving, and it is evident that the continued stocking with Atlantic salmon is having its effect.

FISHES OF MINOR INTERIOR WATERS

The propagation of the game species, both the trout and warm-water varieties, and their distribution on a nation-wide scale have become functions of increasing importance. The public demand, evinced by the thousands of applications submitted, has taxed the facilities of the trout stations, and the production of pondfish has been unable to keep pace with the demand. The fact has become established that, while civilization and development have doomed most forms of wild life, almost every clean body of water will support some species of fish if sufficiently stocked. The difficulty has been enhanced further by the widespread conviction that fish must be reared to fingerling size if stocking is to be effective.

The output of the trout stations has been limited because the supply of fish eggs for any one season is strictly limited. In one sense it is an annual crop, and the yield can not be increased any more than can that of agricultural products. The bureau has developed domesticated brood stocks and wild-egg collecting stations to the point where it is largely self-sufficient for its supply of rainbow, Loch Leven, steelhead, and lake trout, and landlocked salmon, but the satisfaction of the requirements for brook trout still remains a problem. The commercial hatcheries supply this demand, but the States are filling their needs from the same source, and the supply of good eggs is often inadequate and always expensive. Once the eggs are secured and hatched, the question of space for rearing arises. This is in process of solution through the system of cooperative rearing heretofore referred to and through physical expansion of the stations.

In one sense, the culture of pondfishes is not artificial propagation; it is merely the provision of optimum conditions for the natural reproduction of the species. It is subject, therefore, to the same checks and limitations, such as unfavorable weather conditions, etc., that apply in a state of nature. The chief limiting factor is the lack of pond space and the difficulty of obtaining a satisfactory brood stock. The various stations are creating new ponds and enlarging present ones as fast as possible, and provision has been made for the establishment of four new pond stations. Until these are placed on a productive basis there probably will be a considerable "carry over" of unfilled applications annually.

ROCKY MOUNTAIN TROUT STATIONS

These stations, in addition to propagating brook, rainbow, Loch Leven, and black-spotted trout for stocking the waters of the region, constitute a source of supply for eggs of these species to be transferred to eastern stations. While there are eight main stations, the operation of a number of subsidiary egg-collecting fields influences a wide territory. The maintenance of good fishing in the national parks and national forests is an important function of these stations.

Bozeman (Mont.) Station and Substations

[W. T. Thompson, Superintendent]

This station reports the greatest output since its establishment. A grand total of 32,190,960 fish and eggs handled sets a very high mark for game-fish production.

Bozeman (Mont.) station.—Continuation of cooperative relations with the State of Montana has been an important factor in making 1927 a banner year at this station. In return for furnishing 2,370,200 Loch Leven and 150,000 rainbow eggs, the bureau received 3,221,050 grayling eggs for cooperative planting in waters in which both agencies were interested. In addition, the State furnished 3,941,780 black-spotted trout eggs, 2,000,000 of which were to be repaid from later Yellowstone Park collections; the remainder were for planting on a general cooperative basis. The early receipt of black-spotted trout eggs to be replaced by later park collections is of great assistance to the bureau, as it permits distribution before the cars are needed on the Mississippi River and permits a shorter season in Glacier National Park.

Brook-trout eggs were received by transfer from the Leadville station and from outside sources. While losses in incubating and rearing some of these lots were unduly high, there was less evidence of an outbreak of Octomitiasis, which usually accounts for a heavy mortality in the spring. A cold, late season and the provision of plenty of space delayed any evidence of the trouble until near the close of the fiscal year. It is hoped that plans for early distribution will minimize any further losses from this cause during the present summer. One-half the fingerlings on hand at the opening of the year were lost during the summer and fall of 1926. The matter will require detailed study before a remedy can be prescribed. Some 430,000 brook-trout fingerlings and between 1,100 and 1,200 yearlings and adults were on hand at the close of the fiscal year 1927.

The small station stock of rainbows yielded 45,000 eggs. Over 800,000 more eggs were received from Meadow Creek, and 700,000 of the resulting fry are being carried into the new year. Fingerlings to the number of 529,000 held over from last year were distributed during September, October, and November.

The opening of the year showed a stock of black-spotted trout eggs and fry sufficient to permit distribution of 512,800 fingerlings, with an additional lot received from the State of Montana. One million three hundred thousand of the same species were being carried at the close of the fiscal year. Loch Leven fingerlings to the number of 17,000 on hand at the beginning of July, 1926, were augmented by the hatching of a stock of 2,765,760 eggs received from the Meadow Creek station in November. Virtually all of these fish were distributed as fingerlings No. 2.

Meadow Creek (Mont.) substation.—The Loch Leven operations at this point showed an egg harvest exceeding last year's by 2,225,000 at a reduced cost. The season opened a week early, and the high mark for a single day's collection was reached on November 11, when 1,410,860 were secured. The quality was excellent, with a loss to the eyed stage of about 4 per cent. It has been found by experiment that green eggs can be shipped for short distances and periods during cold weather in ordinary distribution cans. The total output of this species was 13,476,212, and the cost of eyed eggs, allowing for all proper charges, was $142 per million. In spite of unfavorable weather, the spring collection of rainbow eggs at this point exceeded that of last year by 500,000. Forty per cent of the hatch of 3,300,100 was retained for stocking parent waters. A number of the eggs were shipped to the Glacier Park station.

Attempts to make the Madison Valley field a Loch Leven area have been continued, and to this end 1,309,200 fingerlings of last year's hatch were planted in conjunction with the State of Montana and the local rod and gun club.

There is indication that the grayling is becoming well established in Madison Valley. To further this desirable end, the Montana fish and game department in June made a shipment of over 2,000,000 grayling eggs from Georgetown Lake. These proved to be of exceptional quality, with a percentage of hatch far above the usual 50 per cent. They were planted as fry.

Glacier Park (Mont.) substation.—At the opening of the year 1,022,000 black-spotted trout fry and 507,000 rainbow fry were on hand. These were planted by Glacier National Park employees as fingerlings Nos. 2 and 1 before the termination of the season. During the spring of 1927 over 1,000,000 black-spotted-trout eggs were received at the hatchery, and these are being reared, with normal losses, for later distribution.

Mystic Lake (Mont.) substation.—It has become apparent that the high altitude of this field station unfits it for rainbow-trout culture or spawn taking. Accordingly, it was deemed expedient to handle only black-spotted trout at this point, and the hatching equipment was utilized for incubating 275,000 eggs transferred here. During the early part of the year 248,000 fry of this species were planted in neighboring waters.

Leadville (Colo.) Station

[C. H. Van Atta, Superintendent]

The Leadville station differs from the other trout stations in that its entire egg supply is derived from field collecting stations owned by private parties and operated under an agreement whereby the bureau keeps the lakes stocked and turns over to the station owners a certain proportion of the output in return for the privilege of taking spawn. Brook and rainbow eggs to the number of 6,944,000 were secured by conducting spawn-taking operations at eight different points during the season. This was three more stations than were operated last year, and the result was an increase of almost 1,000,000 in the take of eggs. As usual, there was a wide variation in the cost of collections, with a range from $0.016 to $1.55 per thousand. These differences are due to the nature of the waters that are being worked and to deviations in the agreements under which the owners permit the work to be conducted. At some of the projects the fish are collected and penned ready for the visits of the spawn takers two or three times a week, while at other points it is necessary for the bureau's employees to seine the fish as well as take the eggs. At the Hosselkus Lakes the loan of the services of an experienced spawn taker was repaid by the allotment of 752,000 brook-trout eggs. One of the projects, Bolts' Lake, which has been stocked for a number of years, is just coming on to a productive basis. Besides brook and rainbow eggs, a few Loch Leven eggs were obtained at Turquoise Lake and some black-spotted trout eggs at the Mount Massive Trout Club property.

A shipment of lake-trout eggs was received from the Duluth (Minn.) station. A portion of these was distributed in Colorado waters, leaving 43,000 on hand at the close of the year. A shipment of steelhead eggs was received from Oregon, and the fish were planted in waters of the Mount Massive Trout Club. At the close of the year the station had on hand more than 4,412,000 trout of the different species.

Yellowstone National Park (Wyo.) Substation

[C. F. Culler, in charge]

The period covered by this report opened in the latter part of the fiscal year 1926 and ran through the early portion of the fiscal year 1927. The season's output was increased notably over that of 1925, the collections amounting to 17,000,000, as compared with the previous figure of approximately 11,500,000. While the collections have not been brought up to the earlier records, a gratifying increase is noted. The season opened unusually early, with the first eggs being secured on May 16, apparently a record for this field. The quick melting of the snows brought on high water, and several racks were washed out. It was noticeable that certain streams, which formerly yielded an abundance of eggs, declined to the point where their output was negligible. Examination showed that very few fish ascended, but no explanation is forthcoming as to why the run should have diminished in spite of the plantings that have been made repeatedly. The bulk of the take was from the South Arm and from Chipmunk and Grouse Creeks. The percentage of fertility was lower than in previous years; it is believed that vibration caused by work carried on in the hatchery was partly to blame for the greater mortality. No further returns from the fish tagged in 1925 were noted, and no inferences could be drawn from such meager data. Mention should be made again of the hearty cooperation extended by the superintendent of the park and the employees of the park service. Much of whatever success has been attained is due to the assistance received from these sources.

Saratoga (Wyo.) Station

[S. M. Ainsworth, Superintendent]

The year opened with 164,000 brook-trout fingerlings, 159,400 Loch Leven fingerlings, and 129,000 rainbow fingerlings on hand. A station brood stock of brook trout has been built up, yielding 357,000 eggs, in comparison with 131,000 the previous season. The Big Creek Lakes field station furnished over 1,250,000 eggs of this species, more than three times as many as were secured the previous year. All eggs were of good quality, and a satisfactory hatch was achieved. An increased number of Loch Leven eggs (415,000) was secured from the station brood stock, and these showed the very high percentage of hatch of 98. Almost 2,300,000 rainbow eggs were secured from wild fish in the Lost Creek field, a marked increase over last year's collection. From the Yellowstone Park operations 300,000 black-spotted trout eggs were transferred to the Saratoga station.

All of the eggs handled were hatched with very slight loss. An ample proportion of these was reserved for return to parent waters, the State of Wyoming was supplied a considerable number, and shipments of eggs were made to other stations. There were on hand at the close of the year almost 1,000,000 fingerling trout of the species mentioned above. Attempts to develop a collecting station for native trout at Baby Lake were a failure, due to unexplained dispersal of the fish, but in all other respects the year's work at Saratoga was very successful.

Spearfish (S. Dak.) Station

[D. C. Booth, Superintendent]

During the past year improvements to the station property were continued. Fish-cultural operations were confined to brook, rainbow, Loch Leven, and steelhead trout, the egg supply being secured through purchase or exchange and from the station brood stock.

The favorable cooperative arrangement with the State of South Dakota, whereby that State purchased over 1,000,000 brook-trout eggs to be reared at the Spearfish station on equal shares, was continued. The 5,000 yearlings from the previous season were turned over to the State. It also received 234,000 fingerlings of the 1927 output, the remainder being held for October delivery.

The station brood stock yielded 353,000 brook-trout, 152,000 rainbow-trout, and 230,000 Loch Leven-trout eggs. A good percentage of hatch was obtained. A shipment of 50,000 steelhead-trout eggs was received from the Pacific coast for incubation in local waters for the account of the State of South Dakota, with about 210,000 fingerlings of various species on hand.

SPRINGVILLE (UTAH) STATION

[CLAUDIUS WALLICH, Superintendent]

The improvement of the concrete pond system by the installation of an individual drain and feed system for each of 20 ponds was reflected in a greater output of fingerlings. Operations at the field stations showed a gratifying increase in the collection of eggs from wild fish.

A stock of 92,000 brook-trout fingerlings on hand at the beginning of the year was disposed of during the fall. The first brook-trout eggs were taken at the Fish Lake collecting station on October 29. In addition to generous shipments to the State hatcheries in accordance with agreements, 3,342,000 eggs of good quality were received at the station, 655,000 of which were hatched at Springville while the remainder was shipped to outside points.

Rainbow eggs were derived from the station brood stock, which yielded 1,532,400, and from the collecting stations at Salem and Fish Lakes. The Salem Lake project is a small one, which it is hoped can be developed to produce a much larger number of eggs. The spring run of rainbows at Fish Lake yielded almost 2,000,000 eggs in addition to those taken by the State. The percentage of hatch for both lots was somewhat higher than last year, but it was still somewhat below what might be expected. Successful shipments of rainbow eggs have been made from this station to Switzerland, Japan, and Hawaii.

The only lot of native black-spotted trout handled consisted of 175,000 fry, which were on hand at the beginning of the year and were distributed at the close of the year. There were also on hand 883,000 fingerlings of the 1927 collection of rainbows. Cooperative relations of mutual benefit have been maintained with the States of Utah and Nevada, and these have been an important factor in placing the output on such a high level.

NEW ENGLAND TROUT AND SALMON STATIONS

The New Hampshire, Vermont, and Massachusetts stations are devoted to work with trout, and these species are an important part of the output of the Craig Brook (Me.) station also, which handles the commercial salmons as well. The scope and nature of the projects in this field are indicated by the extracts from the superintendents' reports, cited below.

HARTSVILLE (MASS.) STATION

[E. P. THOMPSON, Acting Superintendent]

Operations at this station were more than ordinarily successful in 1927. A smaller number of eggs was obtained from the station brood stock of brook trout, but freedom from disease, which usually occasions heavy losses in the spring, resulted in an increased output of fry. The same can be said concerning trout eggs received from outside sources. Lake trout and rainbow trout were received from the Cape Vincent station, and a small number of these is being held over. Brook-trout fingerlings to the number of 89,405 are still being held for later distribution. In May the Cape Vincent station also furnished 60 adult smallmouth bass for breeding, but as yet no fry have appeared.

CRAIG BROOK (ME.) STATION AND SUBSTATIONS

[GEORGE N. MONTGOMERY, Superintendent]

Mention has been made previously regarding the Atlantic-salmon work at this point. Brook-trout eggs to the number of 1,483,618 were received at the station, of which 376,000 were taken from the station brood stock. The rest were secured by exchange or purchase from commercial dealers. These were of varying quality, and 1,492,960 fry were produced in addition to a shipment of 100,000 eyed eggs. The opening of the fiscal year 1927 showed a "carry-over" of 135,445 fingerlings, all but 896 of which were distributed in the course of the year. The stock on hand at the close of the year, including the brood stock, numbered over 250,000. In view of the demands for this species the accomplishments at the Craig Brook station have been particularly gratifying.

As Maine is the chief source of landlocked salmon at the present time, the Craig Brook station is the only one of the bureau's hatcheries that produces them. Over 500,000 eggs were obtained from the collecting stations in Maine. Virtually one-half were shipped as eyed eggs, and the remainder was distributed or held for future planting. At the close of the year 41,070 were on hand, as compared with 134,000 on hand on July 1, 1926. Smallmouth bass and white perch were collected from near-by waters to supply applicants in Maine.

Grand Lake Stream (Me.) substation.—This substation is being brought to a condition of greater efficiency. The year 1927 opened with about 80,000 landlocked-salmon fry retained in the pools for feeding. These constituted a vigorous, healthy lot of fish. The usual setting of three trap nets was made in Grand Lake in the fall prior to the opening of the salmon-spawning season. Captures of these fish were reduced materially by the closing of a sluice gate at the outlet, which tended to check the movement of the fish into the nets. A total catch of 248 female and 423 male salmon gave 592,890 eggs, somewhat less than in the previous year. Over 160,000 of the hatch from these eggs are being held in the canal ponds. A shipment of 100,000 brook-trout eggs was received from Craig Brook, and about half of these are now being fed for fingerling distribution. The presence of many small 2-year-old and 3-year-old salmon in the lake indicates that the liberal apportionment of fry to these waters has been effective and that the future work at this point will be done on a sound basis.

Green Lake (Me.) substation.—Two varieties of smelt were propagated from eggs collected at the Green Lake station. Eggs to the number of 9,250,000 were collected and the fry resulting from them were distributed in local waters, with the exception of one shipment made to Vermont. A small number of landlocked-salmon eggs also were collected.

St. Johnsbury (Vt.) Station and Substation

[A. H. Dinsmore, Superintendent]

Water conditions at the St. Johnsbury station have continued to restrict the work to the hatching of eggs and the distribution of fry. Experimental lots of steelhead and Loch Leven adults were held successfully to the close of the year, when the latter were distributed. A small number of steelhead and Loch Leven fingerlings was produced. Brook trout, Loch Leven trout, and landlocked salmon are being held this season in small quantities for experimental use. No brook-trout eggs were available from the Darling Pond (Vt.) collecting station, but a number were hatched cooperatively with J. C. Nickerson, a commercial producer of Plymouth, Mass. Cooperative collections of lake trout at Lake Dunmore yielded a small number of high-quality eggs, and the fry from them were distributed locally. Landlocked salmon also were hatched.

York Pond (N. H.) substation.—This project, located in the White Mountain National Forest, has undergone further development. The first stage in the plan for making this station the bureau's chief source of supply for brook-trout eggs was completed by the opening of the West Branch diversion ditch and the flooding of some pond areas. Several breaks in the ditch necessitated shutting off the water during the winter, so that repairs could be made. General improvements intended to increase the efficiency of the plant have been made. Steps have been taken to obtain a supply of colder water, with the object of checking losses of fish. A total of 630,100 eggs was secured from the station stock of brook trout. Part of this stock was reared, and the remainder was secured by fishing waters in the vicinity of the station. The practice of allowing yearlings and small fish to spawn naturally in the raceways was followed, and there was a considerable production of fry from this source. Collection of spawning fish from the semi-natural ponds was began in September, and these were held in spawning races until the eggs were mature. Eggs were taken from 1,505 fish, of which about 200,000 were hatched at the station and the remainder were shipped. Depredation by predatory animals, such as frogs, snakes, mink, etc., constitutes a problem at this station. Mention is made of one mink that took about 200 yearling fish from a single pool. Excellent fishing has been maintained in the surrounding public waters by virtue of the fry produced at this station.

NASHUA (N. H.) STATION

[J. D. DE ROCHER, Superintendent]

Extensive improvements were made at this station during the year The old hatchery building was razed and a new building constructed. This has not yet been equipped completely, but it will be in condition for operation during the fiscal year 1928. Other buildings, including the carpenter shop, apprentice fish culturist's cottage, and office, were moved and repaired.

The station maintains a small brood stock of brook trout and rainbow trout. From these 116,500 and 193,000 eggs, respectively, were taken. A shipment of rainbow-trout eggs was received from the White Sulphur Springs (W. Va.) station, and a small collecting station at Lebanon, N. H., was developed, which yielded 122,000 eggs. The usual shipments of brook-trout eggs were received from commercial dealers, and over 500,000 fry of that species were distributed. A small number of landlocked salmon was hatched for distribution to applicants in that vicinity. The Loch Leven fingerlings on hand at the opening of the year were distributed. While this station operates no ponds for the warm-water species, 31,500 smallmouth bass were collected in Lake Sunapee, N. H., and a small number of catfish fingerlings was collected from near-by waters. It is the practice to hold a considerable number of fingerlings over the summer at this station, and at the close of the fiscal year there were on hand more than twice as many brook trout, rainbow trout, and landlocked salmon as was the case at the close of June, 1926.

COMBINATION TROUT AND POND STATIONS

While the five stations comprising this group are listed as combination trout and pond stations, the bulk of their output is trout. Satisfactory increases have been noted in the output of trout, but the bass, crappie, and sunfish production at some of these stations has not been so successful.

ERWIN (TENN.) STATION

[A. G. KEESECKER, Superintendent]

Considerable change in the pond system of the station was effected by constructing new walls, extending old ones, and rebuilding outlets. The supply canal was cleansed of two years' accumulation of silt, and a water tank for a domestic supply was constructed. Considerable effort is required to keep the ground in an attractive condition.

The output of fish was smaller than in the previous year, as 2,000 rainbow trout that should have spawned this year failed to produce any appreciable number of eggs. The actual collections amounted to 786,115, an increase over the previous year, but a low percentage of hatch cut down the output. Loch Leven and steelhead trout were incubated to meet some special requests for these species, and 20,000 brown-trout eggs purchased by a private party were hatched and delivered to him. A shipment of 20,000 rainbow eggs from wild fish was received, and the fingerlings are being reared to form a future brood stock. The station was unfortunate in receiving a poor quality of brook-trout eggs from commercial dealers, and this was partly responsible for a smaller output. The building of a State road through the station grounds was a contributing cause of an unsatisfactory year with the pond species. Cold and rainy weather kept the ponds constantly turbid from the wash of new earth from the highway work. Distribution of about 40,000 largemouth bass was made up to the first of the year, and the muddy water makes it impossible to say how many more black bass, rock bass, and sunfish remain in the ponds. Unless some provision is made to take care of surface drainage, it is likely that difficulty will be experienced in producing adequate numbers of these species for several years to come.

MANCHESTER (IOWA) STATION

[G. H. GILL, Superintendent]

Recovery from the effects of the flood of 1925 has been complete so far as the physical damages are concerned. Production has been brought almost up to normal, and over 1,000,000 eggs and fingerlings were shipped. Over 455,000 eggs were obtained from the station brood stock. Two of the smaller earth ponds have been combined into one as a result of the flood. Brook-trout eggs to the number of 604,000 were handled, having been received in exchange for eggs of other species, and a good hatch resulted. The take of 455,900 rainbow eggs exceeds that of last year, and approximately 85 per cent were hatched. In addition to a stock of breeders carried over from previous years, 4,000 yearlings and 28,000 fingerlings are being held as a reserve stock. An unusual loss of 1,000 rainbow yearlings occurred in one of the ponds within a period of a few hours. Apparently toxic conditions developed for some unknown reason. The usual shipment of 25,000 wild eggs was received from the Montana field with the view of insuring a vigorous brood stock for future use. As the adults become too old for breeding they are released in near-by waters.

Negligible results were secured from the propagation of largemouth and smallmouth bass and from the sunfish. These were the only pond species handled. Several ponds were inspected with the object of initiating cooperative work in Iowa.

NEOSHO (MO.) STATION

[GEORGE A. NEILL, J. P. SNYDER, AND W. H. THOMAS, in charge]

The season's fish-cultural activities have been supplemented by considerable work directed toward the improvement and repair of buildings and upkeep of grounds. The large number of people that visit the hatchery necessitates considerable attention to the appearance of the establishment. Leakage of some of the ponds required considerable repair work and the construction of concrete sides and bottoms. Rainbow trout again constituted the bulk of the output at this point. Considerable trouble from diseases was experienced, but these were checked before losses became excessive. The eggs produced by the station brood stock suffered excessive mortality during the period of incubation. The 20,000 rainbow eggs received from the Bozeman station were hatched with small loss. Some feeding experiments were carried on with the object of evaluating various diets.

The collection of 1,037,700 rainbow eggs from the station brood stock failed to equal the record of the previous year. Most of them were shipped to other points but enough were left at the station to hatch 165,248 fry. A shipment of 25,000 Loch Leven eggs was received from the Bozeman station. Success was experienced in hatching them, but difficulty attended the rearing of the fingerlings; 15,700 were supplied to applicants. At the close of the year 57,000 rainbow trout were on hand.

In the culture of the pond species the ponds were cultivated and fertilized. The production appeared to be about normal, however. Cold, unseasonable weather during the spring appears to have checked the spawning of the sunfish. Later spawning may offset this. The same condition prevailed to a considerable extent with the bass and crappie. There is indication that there has been a fair production of fry of the former, but no crappie have been seen. No fry of channel catfish had been observed up to the close of the year, and no distribution was made of the spring hatch. The drawing of the ponds in the fall of 1926 yielded over 40,000 of the above species.

Bourbon (Mo.) substation.—This cooperative station, owned by the Von Hoffman Press of St. Louis and operated by the bureau on a share basis, has experienced the most profitable year since its establishment. A collection of 2,042,690 rainbow eggs was made, and they proved to be of excellent quality. Most of them were shipped as eyed eggs, although some were reared and distributed in Missouri waters. No difficulty was experienced with epidemics of disease at this station. At the request of the owners of the plant 50,000 fingerlings were reserved.

Langdon (Kans.) substation.—These leased ponds supplied a satisfactory output of bass, rock bass, crappie, and bream for filling applications in this territory.

WHITE SULPHUR SPRINGS (W. VA.) STATION

[EDW. M. HAYNES, Superintendent]

At this station emphasis has been laid on the development of a brood stock of rainbow trout and on the production of this species, although large numbers of both brook and Loch Leven trout are handled. Almost 5,000,000 trout eggs were handled during 1927, surpassing previous production; and considering the comparatively large size of the fingerlings distributed, the plant was at all times operating at nearly the limit of its capacity.

Past experience has demonstrated the fallacy of maintaining a brook-trout brood stock at this point. All but 15,000 brook-trout eggs were secured from outside sources. Of a total of 1,836,086 eggs handled, 1,000,000 were for the account of the State of West Virginia under the usual cooperative agreement. These eggs, together with 250,000 Loch Leven eggs purchased and 250,000 rainbow eggs furnished by the bureau, were hatched at the station and distributed by the State. The bureau received 250,000 brook-trout eggs in return for those of the rainbow. One lot of commercial brook-trout eggs was of inferior quality but a good percentage of hatch was obtained from the remainder.

There is being built up a station stock of Loch Leven trout, and this year 355,000 eggs were taken from these fish, numbering 1,800 adults and 1,000 yearlings. The eggs were of fine quality and produced healthy, vigorous fry. The fish thrive well in these waters and are becoming established locally. Two hundred thousand Loch Leven eggs were received from the Bozeman (Mont.) station for the State of West Virginia.

Emphasis was placed on the rainbow work and the take of eggs was increased 950,000 over that of the previous year. The total was 2,430,000 eggs, of which approximately 71 per cent hatched. Of the resulting fish, 763,250 were distributed as fingerlings and 25,000 were on hand at the close of the year.

Touching upon the production of pond species, the results with rock bass, sunfish, and smallmouth black bass were unsatisfactory. Difficulty in securing good adult stock for breeders is a retarding factor, and climatic conditions are generally unfavorable. In the comparatively high altitude of White Sulphur Springs late May usually is cold, which delays spawning or causes the eggs and fry to be killed. However, from a stock of 225 adult largemouth bass, 134,500 fingerlings were distributed, as against 38,800 of the same species last year. A number remain on hand for fall distribution. Constant effort is being made to overcome handicaps and secure a greater production of these species. Distribution of the output of the station was continuous from March 9 to June 22.

WYTHEVILLE (VA.) STATION

[C. B. GRATER, Superintendent]

The experience with rainbow-trout collections at this station during the fiscal year 1927 can be said to be a repetition of that in 1926, when the yield fell far below the average of other years. The dry weather, resulting in a diminution of the flow of water, caused a very light egg production per fish, and the ravages of furunculosis, which reached its greatest development during the spawning season, was a further handicap. As yet no precautions have been effective in preventing this disease. A slightly better percentage of hatch than last year was obtained from these eggs. Octomitiasis, a disease that affects fingerlings, also was present, but early distribution minimized its ravages. The usual shipment of wild eggs for maintaining the brood stock was received. A shipment of 400,000 brook-trout eggs from a commercial dealer turned out very poorly. Only about 25 per cent of the lot could be raised to a size suitable for distribution. The brood stock of brown trout was wiped out entirely by furunculosis.

A fair output of pondfish was had. The largemouth bass spawned exceptionally early; cold weather followed, and no fish from the first spawning were captured. Later spawnings produced some fish for distribution. A small stock of smallmouth bass produced 27,000 fry for distribution, and this stock was increased by a shipment of 60 adults from Lake Erie late in the season. Most of the sunfish brood stock died, and very few of this species were produced.

PONDFISH STATIONS

The stations exclusively or partially engaged in the production of warm-water fishes are situated in the Southern States. Several of them exceeded all previous records for the production of pondfish, and the output of the group as a whole was very satisfactory. Extension of the pond area, particularly at the Tupelo (Miss.) and the Mammoth Springs (Ark.) stations, has increased production. The success or failure of pond-cultural operations is dependent largely upon weather conditions, and in general the past season has been favorable in this respect. The difficulty in obtaining sufficient adult fish for brood stock, cited in previous reports, is becoming more acute yearly. Many of the fish produced at the southern stations go to stock newly constructed artificial ponds. The development of good fishing in such areas, even though they may be privately owned, goes far to relieve the danger of overfishing public waters.

Cold Spring (Ga.) Station

[Charles A. Bullock, Superintendent]

The number of bass distributed from this station in 1927 was exceeded in only one year since its establishment, and the output of 159,700 bream represents a high mark for this species. The use of lime in the ponds, as well as a continuation of the practice of drawing down the ponds for cleaning in the summer, with the transfer of the breeders to the stock ponds at that time, is believed to be a factor in maintaining production at a high rate. The inability to secure brood stock that will become acclimated to the water at this station continues to be a handicap. Importation of bass and bream from Florida waters was unsuccessful, the losses being almost total. A continuation of the use of shrimp heads for fish food further confirmed the value of this material in feeding pondfishes.

The work at the Harris Ponds substation was discontinued in the spring of 1927. The stock of adult bream was transferred to the station ponds, where sufficient space was available. At the same time a number of adult catfish were removed for introduction into the station ponds. Observations indicate that the supply of bream to be derived from the 1927 hatch will fall short of that of previous years. It appears, however, that there has been a heavy hatch of catfish in at least one pond and that there will be an ample supply of this species for fall distribution.

During the fall of 1926 distribution was made from the Harris Ponds of bream hatched the previous spring. The output was highly successful, 157,000 good-sized fish being seined and distributed. The production of catfish was very light, however.

Edenton (N. C.) Station

[W. S. Vincent, Superintendent]

Mention was made of the propagation of shad and yellow perch at this station under the heading "Anadromous fishes of the Atlantic coast." Grading and enlarging of pond C, which was under way at the close of the past fiscal year, was completed at no cost to the bureau by allowing the dirt to be removed and hauled away for road-building operations conducted near by. The contractor was induced to use the same scheme in pond B, also, which virtually was redoubled in area thereby. Considerable work remains to be done in grading the banks and stopping leaks.

The output of sunfish was limited, probably because the brood stock was inadequate. Four thousand fingerlings No. 1 were secured from 40 adults. A larger stock of the latter was obtained, and their presence should result in an increased hatch during the present season. Difficulty in obtaining a brood stock of crappie also has caused uncertainty as to the output to be obtained for the present season. No fish whatever were obtained from the hatch of the previous season. The adults are secured by netting in North Carolina waters, but they suffered a high mortality when introduced into the ponds.

In December and January visits were made to commercial fishermen for the purpose of securing brood bass to augment the depleted stock carried over from the previous year. A comparatively small number of the fish have died, but the depredations of fish hawks appear to have been serious. Apparently a good hatch of bass was secured, but weather conditions prevented the collection of fry until late in May, when the schools had disbanded. However, 88,500 fry were distributed among 106 applicants in the spring. A larger percentage of these was shipped as advanced fry than was the case in former years. The brood stock was fed on coarse fish obtained from local fishermen.

Louisville (Ky.) Station

[Charles W. Burnham, Superintendent]

During the year the station grounds were improved by the erection of an ornamental steel fence along the public highway.

At this station emphasis is placed upon the production of smallmouth bass, and gratifying results have been achieved. A brood stock of 480 adults, divided among 4 ponds, produced over 500,000 fry and fingerlings. It has been found that much better results are achieved when the adult fish have been kept at the station a year and have become acclimated. The stock was partly renewed by a shipment of adults from Lake Erie, but considerable loss was experienced and the production of fry was limited from this lot of fish. The majority of the output is shipped as fry, and these are placed directly in the cans without "hardening" in running water, as is usually the case. A small brood stock of largemouth bass produced 5,100 fingerlings for distribution. A few rock bass and bream also were produced.

As has been the practice in previous years, a shipment of 15,000 lake-trout eggs from the Duluth station was incubated at Louisville. The fry produced from this lot were turned over to the Kentucky Fish and Game Commission for planting in Kentucky waters.

Mammoth Spring (Ark.) Station

[Dell Brown, Superintendent]

In addition to enlarging and deepening several of the ponds, a shed was constructed over the concrete retaining tanks. The station was visited by a flood on April 20, and the overflowing of the ponds caused a mixing of the species and a considerable loss of fish. Twenty early nests of smallmouth bass as well as 50 adults were lost by this means, but spawning was active later, and 45 nests produced 133,750 fingerlings for shipment. Similar conditions prevailed with the largemouth bass, 30 early nests of eggs and fry being lost through the flood. Later recovery was satisfactory, however, and shipment was made of 106,670 fingerlings, while 10,000 or 15,000 were carried over. The stock of adult breeders on hand is in excellent shape, and with an opportunity to clean and dry the ponds each season it is believed that production can be increased materially.

The shipment of rock bass in the fall of 1926 contained 18,500 good-sized fingerlings. Only one pond, containing 125 adults, is utilized for this species. The bream, also distributed during the fall months, gave gratifying results, with a production of 44,600 fingerlings from 165 adults. Apparently the hatch of the present season has been up to normal, and a satisfactory output is expected. Although handicapped by a flood, as stated above, the year as a whole was the most successful in the history of the station, 303,520 fingerlings having been distributed. Fifty thousand rainbow-trout eggs were shipped to the station in January. A 95 per cent hatch was secured, and the fry were planted at various times in Spring River. Previous plants of rainbows in this river have borne results, and good fish are taken frequently.

Orangeburg (S. C.) Station

[G. W. N. Brown, Superintendent]

The small number of bass produced at this station in 1927 is believed to have been due in some measure to the excessive number of old brood fish that were past their reproductive prime. Many were replaced in the fall by purchase of young stock. Of the season's production of approximately 260,000 fingerlings, 3,825 were of the previous season's hatch and 1,800 were purchased.

The discarding of aged and worthless brook stock among the bream was effective in increasing the output of this species. Distributions to applicants accounted for 31,475. Attempts at producing warmouth bass, crappie, and catfish were largely unsuccessful. Certain improvements, particularly the construction of a canal, will be necessary to utilize to the fullest advantage the available water area of the station.

San Marcos (Tex.) Station

[O. N. Baldwin, Superintendent]

The reconstruction of one of the residences and the initation of a program of widening and deepening ponds constituted the most important improvements undertaken at this point. Difficulty is experienced still in making collections of brood bass sufficient to maintain the stock. Some yearlings are reared for replacement purposes, but one large pond should be devoted entirely to the rearing of brood fish.

Ponds were prepared for fish early in February, but the majority of the bass spawned late, and shipment could not be undertaken until April. Fish were distributed at a considerably larger size than last year. While fewer were carried in the cans they probably had a greater value for stocking purposes. It is believed that a substantial number remains in the ponds to be distributed during the coming year.

The output of bream at San Marcos was restricted because the San Marcos River overflowed the bream ponds and the fish were scattered and mixed. By seining, 15,000 fingerlings were recovered, and it is likely that a considerable number will be carried over, which will help to meet the requirements of the coming year. Crappie are not produced in the station ponds but are secured from ponds and tanks in the surrounding country. From this source 48,115 fingerlings were obtained for filling 224 applications. An attempt is being made to rear a brood stock of rock bass, and a few warmouth bass were produced. The green sunfish also is propagated, and there appears to be a fair number of fingerlings in the ponds at present. The pond auxiliary at New Braunfels was the source of 47,275 bream, and it is thought that a goodly number can be carried over. The substation at Medina Lake is having great difficulty due to the condition of the ponds, which leak so badly that water can not be kept up to the proper level. Apparently the only way to overcome the trouble is to reconstruct the ponds completely.

Tupelo (Miss.) Station

[Charles R. Wiant, Superintendent]

The construction of three new ponds, covering 5.3 acres, at this station has provided a 70 per cent increase in the pond area. No water was available for these ponds during the present season. One of the older ponds was enlarged and deepened. It is interesting to note that the diversion of surface water into some of the ponds during the winter has, to a noticeable extent, curtailed the amount of pumping necessary to maintain a level.

A larger number of brood bass in the greater pond space, together with favorable weather conditions, produced the high total of 37,847 young. In the distribution of this output 22½ per cent were distributed as fingerlings of 1 to 4 inches, compared with 16.8 per cent last year.

Two species of sunfish were handled during the year, and it was found that fingerlings of *Lepomis heros*, the strawberry bass, were much larger in the fall than was the case with *Lepomis pallidus*. It was also noted that a greater production per adult was attained where the sunfish were kept in the bass ponds than when the ponds were devoted exclusively to the former. The output was increased from 113,050 last year to 313,200 in 1927. The production of crappie was a failure, as is usually the case. A few warmouth bass were produced. The total output of combined species for 1927 exceeded that of the previous year by 200,000, attaining the high figure of 956,952.

Lakeland (Md.) Ponds Substation

[Supervised by Washington office of fish culture]

These leased ponds, situated a few miles out of Washington, were stocked in the spring, as in previous years. However, a repetition of the excessive development of algæ experienced during recent years, due to insufficient water, restricted the output and only a few thousand fish, largely bass and sunfish, were recovered in the fall. Very few crappie were obtained because of this condition and also because there appeared to be only a light hatch of this species, although conditions were favorable for the spawning of the other species.

CENTRAL STATION AND AQUARIUM, WASHINGTON, D. C.

[L. G. HARRON, Superintendent]

In order to display the methods and apparatus used in connection with fish-cultural work, an effort was made to exhibit, at the proper seasons, the hatching of eggs and fry of suitable species. The use of chlorine in the city water supply again had a disastrous effect on eggs and fry.

In addition, a creditable exhibit of fish and other aquatic animals was maintained. There were shown 1,920 individual specimens representing 33 species. Considerable distribution was made of fry hatched at the aquarium and of fingerlings taken from the Potomac River. Applicants in Maryland, Pennsylvania, New York, Massachusetts, Virginia, West Virginia, and Delaware received rainbow trout, cisco, silver salmon, and pike perch from the hatchery exhibit, as well as warm-water species collected from the river and the Lakeland ponds.

Part 2.—DISTRIBUTION OF FISH AND FISH EGGS

[E. C. FEARNOW, Superintendent of Fish Distribution]

In the distribution of the record-breaking output of 6,481,073,000 fish and fish eggs from the bureau's stations, it was necessary to make shipments to all parts of the United States. Shipments of fish eggs were made to Costa Rica, Italy, Japan, and Switzerland, and a consignment of small fish was forwarded to Canada. About 97 per cent of the year's output consisted of eggs and fry of the commercial fishes, and virtually all of these, with the exception of the comparatively few supplied to State fish commissions, were planted in the waters from which the eggs were obtained. The fishes included in this classification are as follows: Glut herring, whitefish, cisco, salmons, pike perch, yellow perch, carp, buffalo fish, cod, haddock, and winter flounder. The species distributed to interior waters are the brook, rainbow, black-spotted, and Loch Leven trouts, the largemouth black bass, smallmouth black bass, crappie, rock bass bream, and catfish. While the number of such fishes produced is comparatively small, representing 1 to 2 per cent of the entire output, at the time of shipment such fish are quite large, averaging approximately 3 inches in length, so that their distribution is quite a difficult problem. As a rule the fry of the commercial species are carried 50,000 to 100,000 to the can, while not more than one hundred and fifty 3-inch fish can be carried safely in one of the regulation containers. It is the distribution of fish in interior lakes and streams that brings the bureau in close contact with the general public, and by this means a sentiment in favor of fish propagation and the conservation of fish in streams is being created throughout the United States.

The work of distribution was exceedingly heavy at the bureau's trout-producing stations, due to the establishment of a large number of cooperative stations in several States. Small trout are delivered at such stations during May and June and are reared until they are 3 or 4 inches in length, when they are planted in suitable local waters. In addition to the general distribution to applicants during the spring, 5 carloads of trout were delivered to cooperative projects in the State of Pennsylvania to be reared for distribution in the fall of 1927. A number of trout nurseries in Wisconsin and Minnesota required several carloads of trout to meet their requirements.

The bureau's southern bass stations had a normal output of fish, but the collecting stations along the Mississippi River furnished virtually no fish for distribution, due to the high stage of the river during the summer and fall months; so it was impossible to obtain such species as the largemouth black bass, crappie, and bluegill for filling applications in the States usually supplied from our collecting fields, making it necessary to defer shipment on a large number of applications for waters in some of the Western, Northern, and Eastern States for special attention during the fall of 1927.

The following table shows, in summarized form, the distribution of fish and fish eggs during the fiscal year to applicants in the United States and its territories. It also shows plants of fish made on the bureau's initiative in the public waters of the country in connection with the propagation of the commercial fishes and the salvage of fish from temporarily flooded lands. The output of the hatcheries that handle the commercial fishes is planted, so far as practicable, on the natural spawning grounds from which the eggs are derived, this course being essential for the maintenance of the fisheries, especially in regions where commercial fishing is prosecuted extensively and also in the case of the anadromous fishes. The activities of the commercial fishermen are coincident with the spawning of the fish.

Summary, by species, of the distribution of fish, fiscal year 1927

State and species	Number
Alabama:	
Rainbow trout	3,000
Brook trout	6,000
Largemouth black bass	358,249
Crappie	230
Sunfish	114,000
Alaska:	
Sockeye salmon	22,234,960
Humpback salmon	30,000
Arizona:	
Rainbow trout	18,000
Brook trout	37,500
Lake trout	18,750
Largemouth black bass	1,680
Bream	900
Arkansas:	
Rainbow trout	55,100
Loch Leven trout	1,200
Largemouth black bass	115,125
Smallmouth black bass	131,125
Rock bass	20,250
Sunfish	47,286
California: Chinook salmon	9,305,400
Colorado:	
Rainbow trout	470,600
Black-spotted trout	332,000
Loch Leven trout	408,680
Lake trout	6,000
Brook trout	1,756,000
Crappie	1,300
Largemouth black bass	14,200
Rock bass	360
Sunfish	3,900
Connecticut:	
Rainbow trout	5,300
Loch Leven trout	10,500
Lake trout	50,000
Brook trout	20,100
Delaware:	
Crappie	150
Black bass	500
Rock bass	800
Yellow perch	112
District of Columbia:	
Brook trout	2,550
Pike perch	100,000
Georgia:	
Catfish	1,030
Rainbow trout	41,150
Loch Leven trout	21,000
Brook trout	15,400
Largemouth black bass	178,292
Sunfish	128,800
Idaho:	
Chinook salmon	4,445,000
Landlocked salmon	25,000
Rainbow trout	310,300
Black-spotted trout	170,500
Loch Leven trout	41,000
Brook trout	10,600
Illinois:	
Catfish	1,900,000
Buffalo fish	222,000
Carp	1,300,000
Pike perch	45,600,000
Rainbow trout	117,500
Pike and pickerel	100
Loch Leven trout	50,000
Largemouth black bass	17,380
Crappie	2,545,875
Sunfish	349,060
Yellow perch	10,160
Miscellaneous fishes	657,000
Indiana:	
Rainbow trout	15,500
Brook trout	40,000
Largemouth black bass	4,700
Smallmouth black bass	63,850
Rock bass	650
Iowa:	
Catfish	16,722,480
Buffalo fish	5,652,700
Carp	10,240,800
Rainbow trout	101,100
Brook trout	22,500
Pike and pickerel	200,250
Crappie	8,452,292
Largemouth black bass	86,275
Yellow perch	133,550
White bass	10,755
Miscellaneous fishes	1,585,000

Summary, by species, of the distribution of fish, fiscal year 1927—Continued

State and species	Number
Kansas:	
Rainbow trout	50
Crappie	1,662
Largemouth black bass	3,820
Sunfish	400
Kentucky:	
Rainbow trout	11,500
Lake trout	8,000
Largemouth black bass	8,375
Smallmouth black bass	513,025
Rock bass	1,800
Sunfish	6,400
Louisiana:	
Catfish	15,700
Buffalo fish	2,888,000
Crappie	122,080
Largemouth black bass	4,195
Sunfish	692,400
Fresh-water drum	6,350
Maine:	
Atlantic salmon	922,000
Landlocked salmon	676,690
Rainbow trout	101,250
Lake trout	220,800
Brook trout	1,377,606
Smallmouth black bass	12,176
White perch	9,000
Smelt	13,800,000
Cod	267,660,000
Winter flounder	2,203,109,000
Maryland:	
Shad	10,150,000
Silver salmon	12,000
Rainbow trout	241,000
Brook trout	18,912
Largemouth black bass	2,250
Smallmouth black bass	90
Yellow perch	84,096,375
Massachusetts:	
Whitefish	87,000
Cisco	200,000
Steelhead salmon	25,000
Landlocked salmon	10,178
Rainbow trout	120,100
Loch Leven trout	4,000
Lake trout	3,608,000
Brook trout	158,709
Largemouth black bass	1,200
Pike perch	978,000
Cod	1,136,942,000
Haddock	379,281,000
Pollock	845,899,000
Winter flounder	1,049,466,000
Michigan:	
Chub	240,000
Whitefish	31,400,000
Cisco	7,000,000
Rainbow trout	187,950
Loch Leven trout	10,500
Lake trout	23,090,500
Brook trout	658,550
Largemouth black bass	6,000
Smallmouth black bass	119,803
Sunfish	600
Pike perch	25,800,000
Minnesota:	
Catfish	1,681,900
Buffalo fish	5,025
Carp	780,850
Whitefish	30,000
Rainbow trout	176,400
Loch Leven trout	556,755
Lake trout	946,000
Brook trout	330,900
Crappie	3,403,850
Largemouth black bass	3,933,905
Sunfish	1,673,450
Pike perch	7,842,785
Yellow perch	702,350
White bass	1,215
Fresh-water drum	4,610
Mississippi:	
Catfish	375
Crappie	20
Largemouth black bass	414,160
Warmouth bass	3,650
Sunfish	234,850
Missouri:	
Catfish	81
Rainbow trout	1,760,082
Loch Leven trout	104,500
Crappie	1,940
Largemouth black bass	21,431
Rock bass	2,600
Sunfish	15,870
Yellow perch	6,300,000
Montana:	
Catfish	695
Whitefish	4,000,000
Rainbow trout	1,074,400
Black-spotted trout	3,658,800
Loch Leven trout	4,787,960
Brook trout	270,075
Grayling	1,800,000
Crappie	600
Largemouth black bass	4,400
Sunfish	90
Yellow perch	1,901,000
Nebraska:	
Rainbow trout	15,000
Brook trout	76,100
Crappie	450
Largemouth black bass	1,800
Sunfish	90
Yellow perch	750
Nevada:	
Rainbow trout	169,800
Brook trout	70,000
New Hampshire:	
Catfish	9,300
Steelhead salmon	10,700
Landlocked salmon	10,700
Rainbow trout	1,000
Loch Leven trout	16,000
Brook trout	521,260
Largemouth black bass	5,000
Smallmouth black bass	9,000
Pike perch	1,760,000
New Jersey:	
Rainbow trout	250
Brook trout	1,500
Largemouth black bass	800
New Mexico:	
Rainbow trout	7,500
Black-spotted trout	449,000
Loch Leven trout	500,000
Largemouth black bass	2,450
Rock bass	70
Sunfish	6,170
New York:	
Whitefish	87,800,000
Cisco	106,960,000
Steelhead salmon	102,250
Landlocked salmon	140,584
Rainbow trout	49,350
Black-spotted trout	18,000
Loch Leven trout	3,250
Lake trout	1,676,450
Brook trout	1,414,490
Largemouth black bass	880
Smallmouth black bass	6,450
North Carolina:	
Shad	600,000
Glut herring	2,000,000
Steelhead salmon	25,000
Rainbow trout	725,800
Loch Leven trout	101,280
Lake trout	20,000
Brook trout	100,750
Crappie	610
Largemouth black bass	76,800
Smallmouth black bass	50

Summary, by species, of the distribution of fish, fiscal year 1927—Continued

State and species	Number
North Carolina—Continued.	
Rock bass	7,575
Warmouth bass	400
Sunfish	13,245
North Dakota:	
Catfish	2,000
Crappie	1,500
Largemouth black bass	425
Sunfish	120
Yellow perch	2,700
Ohio:	
Carp	18,500,000
Whitefish	74,880,000
Steelhead salmon	100,000
Rainbow trout	4,200
Loch Leven trout	2,400
Brook trout	16,800
Largemouth black bass	1,400
Smallmouth black bass	46,211
Rock bass	450
Pike perch	86,000,000
Yellow perch	16,800,000
Oklahoma:	
Rainbow trout	500
Loch Leven trout	10,000
Crappie	2,045
Largemouth black bass	22,069
Sunfish	6,615
Oregon:	
Chinook salmon	13,158,000
Silver salmon	640,900
Steelhead salmon	15,000
Rainbow trout	95,800
Black-spotted trout	543,000
Loch Leven trout	50,000
Brook trout	241,500
Pennsylvania:	
Whitefish	3,000,000
Cisco	6,080,000
Silver salmon	5,600
Rainbow trout	305,300
Loch Leven trout	188,998
Lake trout	50,000
Brook trout	791,617
Largemouth black bass	8,330
Rock bass	1,800
Sunfish	19,920
South Carolina:	
Catfish	130
Rainbow trout	15,300
Brook trout	19,000
Crappie	40
Largemouth black bass	205,255
Rock bass	2,525
Warmouth bass	615
Sunfish	23,935
South Dakota:	
Catfish	605
Steelhead salmon	50,000
Rainbow trout	148,564
Loch Leven trout	674,259
Brook trout	1,055,101
Crappie	7,350
Yellow perch	8,100
Tennessee:	
Rainbow trout	76,950
Brook trout	25,400
Largemouth black bass	7,650
Rock bass	5,200
Sunfish	12,371
Texas:	
Rainbow trout	22,100
Crappie	46,268
Largemouth black bass	183,682
Rock bass	500
Warmouth bass	1,515
Sunfish	57,755
Utah:	
Rainbow trout	1,065,700
Black-spotted trout	42,000
Lake trout	50,000
Brook trout	1,305,100
Vermont:	
Steelhead salmon	9,500
Landlocked salmon	34,000
Loch Leven trout	132,677
Lake trout	157,192
Brook trout	696,605
Smallmouth black bass	4,945
Smelt	1,875,000
Pike perch	19,480,000
Yellow perch	769,800
Virginia:	
Catfish	40
Shad	10,004,000
Rainbow trout	229,970
Loch Leven trout	5,600
Brook trout	105,500
Largemouth black bass	224,235
Smallmouth black bass	30,650
Rock bass	3,200
Sunfish	8,130
Yellow perch	84,096,580
Washington:	
Catfish	55
Chinook salmon	10,094,778
Chum salmon	15,986,725
Silver salmon	5,795,957
Sockeye salmon	19,939,300
Humpback salmon	3,544,000
Steelhead salmon	969,729
Rainbow trout	10,000
Black-spotted trout	6,903,000
Loch Leven trout	200,000
Lake trout	25,000
West Virginia:	
Rainbow trout	513,650
Loch Leven trout	188,000
Lake trout	100,000
Brook trout	929,410
Largemouth black bass	143,790
Rock bass	4,550
Sunfish	150
Wisconsin:	
Catfish	6,227,580
Buffalo fish	151,400
Carp	2,805,100
Rainbow trout	230,280
Loch Leven trout	218,650
Brook trout	839,550
Pike and pickerel	72,850
Crappie	2,253,050
Largemouth black bass	25,984
Smallmouth black bass	50
Sunfish	1,900,225
Pike perch	8,860,400
Yellow perch	187,160
White bass	4,800
Fresh-water drum	500
Miscellaneous fishes	1,100,410
Wyoming:	
Catfish	1,405
Rainbow trout	1,786,402
Black-spotted trout	6,258,000
Loch Leven trout	780,320
Lake trout	250,000
Brook trout	1,056,025
Crappie	1,050
Largemouth black bass	3,975
Sunfish	210
Yellow perch	450

METHOD OF DISTRIBUTION

In making distribution of fish the bureau first supplies the waters from which the eggs are collected. After such waters have been stocked shipments are made to suitable public or private waters on applications previously submitted. The bureau aims to apportion the output of its hatcheries so as to obtain the best results, giving special attention to waters where it is apparent that the fish planted will find suitable spawning grounds. Blanks on which formal requests for fish may be made are furnished to applicants on request. Such blanks call for a complete description of the waters to be stocked, and from the information supplied the bureau assigns species that are suitable. It is decidedly important that the information given in applications be as accurate and complete as possible.

Applicants are notified at once as to the species that will be sent them and the approximate date of delivery, and they are given instructions for receiving and caring for the fish. Before shipment is made, a second notice is given, usually by telegram, stating the exact time of arrival of the fish at the railroad station. The fish are delivered to the applicant's railroad station without expense to him. In the event that the shipment is delayed, the applicant is notified accordingly.

Fish usually are shipped in carload lots to central points, and messengers leave the cars at various points to deliver fish to applicants whose railroad stations are on branch lines. These messengers travel in the baggage cars of passenger trains, and therefore the deliveries necessarily must be made at the time when the train makes its customary stops. A messenger often has a dozen or more deliveries to make before rejoining his car and must return his full quota of pails promptly in order that further shipments may be made in accordance with the prearranged schedule. As the pails are a part of the car's equipment, it is obvious that if they were lent to applicants it would necessitate suspension of the bureau's work until they were returned. Applicants are expected, therefore, to provide themselves with receptacles suited to carrying fish. Such receptacles should be in readiness at the railroad station specified in the advance notice of delivery. The vessels should be uncovered and empty. If no receptacles have been provided, the fish will not be delivered, nor will they be delivered even though the receptacles are in readiness unless the applicant or his representative is on hand to take care of the consignment.

In making allotments of fish on applications the following items are taken into consideration: The area of water to be stocked, as stated in application; size and number of fish available for distribution; and the distance the fish must be transported. The bureau distributes fish as fingerlings or yearlings. At some stations, however, it is necessary to distribute a portion of the output before this stage is reached in order to prevent overcrowding. The basses, bream, and other pondfishes are distributed three weeks to several months after they are hatched. The basses usually range from 2 to 6 inches and the sunfishes from 2 to 4 inches in length. Commercial species, such as whitefish and pike perch, are hatched in large numbers and necessarily are planted as fry.

As a general rule the bureau delivers fish in the order in which the applications are received. Failure to make delivery within the time specified on the formal notice sent to the applicant invariably is because the output at one or more of the bureau's stations has been light. Applications remain on file until delivery of the desired fish can be made, so that in the event of a failure of the output of a station in one year the applications in that region are given special consideration when the next year's output is available. The bureau does not carry a stock of fish on hand at all times for distribution.

The heavy expense involved in shipping fish necessitates rigid economy in planning the itineraries of cars and messengers. Delivery of fish to an applicant in a remote section of the country can not be made until a sufficient number of applications from that section have been received to warrant the expense of making a messenger shipment. Shipments of trout from the bureau's eastern stations usually are made during the months of May and June, and applications received after March 1 are carried on file for attention in the following year. The distribution of trout from stations in the Rocky Mountain regions is made from May to October, and applications from that section should be submitted prior to May 1 in order to assure early delivery. Requests for such species as bass, sunfish, and crappie should be on file with the bureau prior to May 1, as deliveries of such species are made between May and December.

RECEIVING AND PLANTING FISH

It involves considerable expense to produce and transport fish to their destination, as they must be accompanied by a skilled attendant. In order to attain the best results from a given number of fish, applicants should acquaint themselves with the following instructions:

The fish should be hurried to the waters where they are to be planted.

Keep the water cool and avoid sudden changes in temperature. To lower the temperature use ice on the lids of the vessels or place it in the water. Wet sacking wrapped around the vessels will help to keep the temperature even. The lids of the vessels should be perforated to permit the entrance of air.

While in transit over rough roads the splashing of the water in the cans will provide sufficient aeration for the fish. In case of delay en route to the waters in which the fish are to be planted, the water in the vessels should be dipped up and allowed to fall back into the container from a height of about 18 inches. This process causes tiny bubbles of air to become mixed with the water.

When fish come to the surface and gasp it is evident that the supply of oxygen is exhausted and that the water needs dipping. The warmer the water the less oxygen it holds in solution and the more attention the fish require. A uniform temperature of 60° F. for bass and 50° F. for trout is desirable, as at these temperatures the fish in the containers will not require much attention.

Before planting the fish the temperature of the water in the containers should be made to equal that of the water in the stream in which they are to be deposited. This can be done by removing some of the water from the containers and replacing it with water from the stream or lake. The change should be gradual, at least half an hour being consumed in changing the temperature 10°.

Give the small fish a chance to live by scattering them in the shallow, spring-fed tributaries unfrequented by large fish, selecting places where there is plenty of natural food. Bear in mind that the smaller the fish the more care should be used in planting them. Make a wide distribution in order to insure a plentiful supply of food for the fish. If planted in deep water, a few large bass or pike may devour them all. Even in shallow water, if not scattered, they may exhaust the food supply, when the smaller fish will become the prey of the larger ones.

Study the waters you intend to stock and spend some time in making the plant and you will be amply awarded for your efforts. One hundred fish properly planted will yield better results than a thousand indiscriminately dumped into a stream or lake at the most convenient point.

Take with you a dipper to aerate the water and to dole out the fish—a few at each place where conditions are ideal for them.

The Federal Government is besieged with requests for fish, but its facilities for producing them are limited by its appropriations. It is never possible to furnish more than the nucleus of a brood stock of small fish. The bureau has no adult fish for distribution. As a rule fish are very prolific, single specimens producing thousands of fry, so by careful planting and proper protection a few will multiply, if conditions are favorable, until the waters become well stocked.

DISTRIBUTION CARS

The necessity for two steel cars to replace cars Nos. 3 and 4, which are of the old wooden type, is reiterated. The cost of repairing cars of the wooden type is very great, as they are antiquated to such an extent that much trouble is experienced in obtaining parts for replacements. The annual repair bill is twice as great for a wooden car as it is for one of steel construction. Moreover, a wooden car carries but 150 pails of fish while the steel cars are equipped for carrying 250 pails. It is believed that a new car could be built to carry 300 pails or twice the number that one of the wooden cars is capable of transporting.

The annual expense of maintaining a car in active distribution work, including transportation, repairs, etc., is approximately $10,000. The construction of one steel car will result in a saving of $5,000 per year if no extension is made in our distribution work. The opportunities for extending fish distribution are without limit. The recently adopted policy of rearing trout on a cooperative basis until they are 4 or 5 inches long greatly increases the distribution work. Fish that formerly were carried 500 and 1,000 to the can now are reared to a size that permits only 100 per can. This policy of giving the public large-sized fish instead of fry necessitates more cars of greater carrying capacity. Furthermore, the wooden cars can not be used in the best trains; so with this type of car there are many delays that make necessary the renotification of applicants and even result in losses of fish. Finally, the wooden car is unsafe in a modern train made up of steel coaches.

CAR NO. 3

[E. R. WIDMYER, Captain]

During July two carloads of trout were moved from the Manchester (Iowa) station to cooperative ponds at Eyota, St. Charles, Winona, Lewiston, and Plainview, Minn. Upon completion of the trout distribution to cooperative stations the car was returned to La Crosse, Wis.

The distribution from the rescue stations was begun on August 9, when a carload of warm-water species was delivered to applicants in Illinois and Indiana. During the season of rescue operations four car trips were made from the upper Mississippi River stations, delivering to applicants 4,750 catfish, 42,100 black bass, 490 bream, 15,750 crappie, and 15,910 yellow perch. The distribution from the rescue stations was brought to a close unusually early in the fall due to high water, which allowed the fish to pass from the landlocked sloughs into the river. After the distribution season closed, the crew was sent to fish-cultural stations for the winter, the car being held on the tracks of the Chicago, Milwaukee & St. Paul Railway at La Crosse until January 16, when it was moved to the Milwaukee (Wis.) shops for repairs. Subsequently the car returned to La Crosse, where the crew was reassembled and the equipment placed in readiness for the coming season.

The trout distribution was begun on April 30 and extended to May 24, at which time the car left for Duluth, Minn. From April 30 to May 24 the car and its messengers delivered to applicants and cooperative stations approximately seven carloads of trout from the La Crosse station.

The car arrived at Duluth on May 25 and immediately took up the distribution from that station. From May 28 to June 16 approximately nine carloads of fish were delivered, including 8,100,000 lake trout, 11,500,000 pike perch, and 200,000 brook trout. Heretofore it has been thought inadvisable to transport pike perch and whitefish in Fearnow pails, but an experiment along this line was carried out with the best of success when 109 pails of pike-perch fry, each containing 50,000 fish, were carried from Duluth, Minn., to Crystal Falls, Mich., the fish reaching the applicants in excellent condition. On completion of the Duluth distribution the car was ordered to La Crosse to finish the distribution of trout from that station.

During the fiscal year 1927 the car traveled 9,417 miles and distributed 21,049,400 fish. The table below shows the number and size of the species delivered during the year:

Species	Fry	Fingerlings	Yearlings
Catfish		4,750	
Rainbow trout		132,900	
Loch Leven trout		127,800	
Lake trout	8,100,000	270,000	
Brook trout		839,700	
Crappie		15,750	
Largemouth black bass		42,100	
Bream		150	340
Pike perch	11,500,000		
Yellow perch		15,910	
Total	19,600,000	1,449,060	340

CAR NO. 4

[F. W. A. ENGELHARDT, Acting Captain]

At the beginning of the fiscal year a number of detached-messenger shipments of smallmouth black bass and brook trout were made from Nashua, N. H., to points in New Hampshire, Vermont, and New York. On July 27 the car left Nashua with a load of trout for distribution in Pennsylvania, proceeding thence to Washington, D. C., to take up the bass distribution from the Lakeland (Md.) station. On account of the unusually warm weather the Lakeland distribution was postponed to be taken up in the fall and the messengers were detailed to the central office for duty. The car left Washington on September 8 to assist in the distribution of fish from the Upper Mississippi River collecting stations. Owing to excessive rains during the spring and summer the Mississippi River continued to rise, obviating rescue operations and preventing the customary distribution of fish. The car proceeded to Langdon, Kans., and made shipments of largemouth black bass, crappie, bream, and rock bass to various points in Oklahoma, Kansas, Colorado, New Mexico, Arkansas, Texas, Arizona, and Missouri. The car left Langdon on November 23 for Neosho, Mo., to transfer a carload of fingerling rainbow trout to the Leadville, Colo., station, returning to Neosho on December 3. The Neosho distribution was completed for the season on December 12, and the crew was then detailed to fish-cultural stations for the winter months. On January 18, 1927, the car was placed in the Kansas City Southern Railway shops at Pittsburg, Kans., for annual repairs. The work was completed on February 7 and the car returned to Neosho.

On May 4 the car was loaded with rainbow trout for distribution in Michigan en route to Northville, Mich., to take up the smallmouth black bass and trout distributions from that station.

On May 28 the car proceeded to Frederick, Md., for a carload of brook trout for distribution in the vicinity of Lock Haven, Pa. The car then went to Great Barrington, Mass., for a load of brook trout for distribution to various points in Pennsylvania, proceeding afterwards to Nashua, N. H., for a load of brook trout for distribution at Hillman, Mich., and returning to Northville on June 10.

From June 11 to June 30 shipments of smallmouth black bass and trout were sent to various parts of Michigan, Wisconsin, Illinois, Indiana, and Ohio.

During the fiscal year the car made 16 trips and traveled 12,458 miles. Detached messengers made 66 trips from the car and stations.

Species and size of fish delivered by car No. 4

Species	Fry	Finger-lings	Year-lings	Adults
Rainbow trout		134,455		360
Loch Leven trout		1,000		
Brook trout		565,235		
Crappie		5,007		
Largemouth black bass		35,284		
Smallmouth black bass	20,000	6,250		50
Rock bass		430		
Sunfish		25,190	1,060	2,525
Total	20,000	772,851	1,060	2,935

CAR NO. 7

[E. M. LAMON, Captain]

From July 1 to July 20 car No. 7 distributed from the Northville (Mich.) station 36,350 smallmouth black bass to applicants in Indiana, Michigan, and Ohio. The car left Northville on July 21 for Dubuque, Iowa, delivering 1,350 smallmouth black bass to applicants at that point. At Dubuque the car was placed in the shops for minor repairs. On August 16 the car obtained from the Homer (Minn.) station 21,350 fingerling pondfishes for distribution to points in Iowa and after completing this trip returned to Dubuque and made several messenger shipments from the Bellevue (Iowa) substation to points in Iowa. On August 30 the car loaded at Manchester, Iowa, taking 59,000 fingerling brook trout for distribution to points in Minnesota, returning to Dubuque early in September.

During the year the air equipment was renewed on the car, ⅛-inch galvanized pipe and ¼-inch rubber hose being used. This work was performed by the crew.

The car crew was detailed to fish-cultural stations for the winter months. Early in January, 1927, it was placed in the Chicago, Milwaukee & St. Paul Railway shops for general overhauling. This work was completed in February.

The spring distribution from the Manchester (Iowa) and La Crosse (Wis.) stations was taken up on May 10. During May and June, 4 trips were made from Manchester, 2 from La Crosse, 2 from Lynxville, Wis., and 1 from Chicago to points in Minnesota and Wisconsin. A number of detached shipments also were forwarded from La Crosse during June by messengers operating from the car. Fish were distributed from these stations as follows: Manchester, 303,600 brook trout and 142,200 rainbow trout; La Crosse, 62,800 Loch Leven trout, 35,100 brook trout, and 51,500 rainbow trout; Lynxville, 103,750 brook trout; and Lincoln Park Aquarium, Chicago, 38,500 rainbow trout and 22,000 Loch Leven trout. During the year the car made 12 trips and traveled 6,047 miles. The messengers operating from the car made 46 trips and traveled 16,567 miles. The numbers and species of fish distributed by the car during the year are shown in the following table:

Species	Fingerlings No. 1	Fingerlings No. 2	Fingerlings No. 3	Fingerlings No. 4	Fingerlings No. 5
Catfish					1,250
Rainbow trout	22,000	276,800	42,500		
Loch Leven trout	132,100	1,500			
Brook trout		225,800	220,900		
Largemouth black bass			8,000	6,200	
Smallmouth black bass	37,700				
Yellow perch			7,500		
Total	191,800	503,100	278,900	6,200	1,250

CAR NO. 8

[E. K. Burnham, Captain]

From July 1, 1926, to June 30, 1927, car No. 8 distributed fish from the Leadville, Wytheville, Erwin, White Sulphur Springs, Nashua, and East Orland stations and the Upper Mississippi River collecting stations. It made 30 trips with fish, traveled 13,516 miles over 15 railroads, and sent out 62 side trips, which, with the fish the car delivered en route, gave a total of 3,704,316 fingerlings delivered in 18 States at a cost of $5,395.77. The following table shows the species and numbers of fish handled:

Species	Fingerlings	Species	Fingerlings
Atlantic salmon	1,229,000	Brook trout	1,564,700
Landlocked salmon	190,500	Smallmouth black bass	50
Rainbow trout	499,350	Rock bass	6,000
Black-spotted trout	166,250	Sunfish	516
Loch Leven trout	25,200		
Lake trout	22,750	Total	3,704,316

Besides the 62 side trips made from the car, its messengers made 29 trips with fish from the hatcheries, at a cost of $376.50. The following table shows the species and the numbers of fish the messengers thus handled:

Species	Fingerlings	Species	Fingerling
Rainbow trout	74,800	Rock bass	400
Brook trout	235,900		
Black-spotted trout	112,000	Total	424,300
Loch Leven trout	1,200		

The car's crew made all needed minor repairs to its interior during the year, one of the most economically valuable changes effected being in the arrangement of the air pipes in the fish compartments so that it is now possible to aerate 230 aluminum fish pails instead of seventy 10-gallon cans and 100 aluminum fish pails, thereby increasing the carrying capacity of the car.

CAR NO. 9

[H. F. Johnston, Captain]

At the beginning of the fiscal year car No. 9 was stationed at Washington, D. C., the members of its crew being on detail at the central office of the bureau. On July 12 the car proceeded to White Sulphur Springs, W. Va., for the purpose of completing the distribution from that station for the season of 1926. The load of trout obtained was delivered to applicants at Cowan, W. Va., and by means of a logging train were transported from Cowan to various points along the Gauley River.

After completing the White Sulphur Springs distribution the car was ordered to Manchester, Iowa, where a load of trout was obtained for distribution to applicants, the destination of the car being Red Granite, Wis. Early in August the car was detailed to distribute the output of trout of the Bozeman (Mont.)

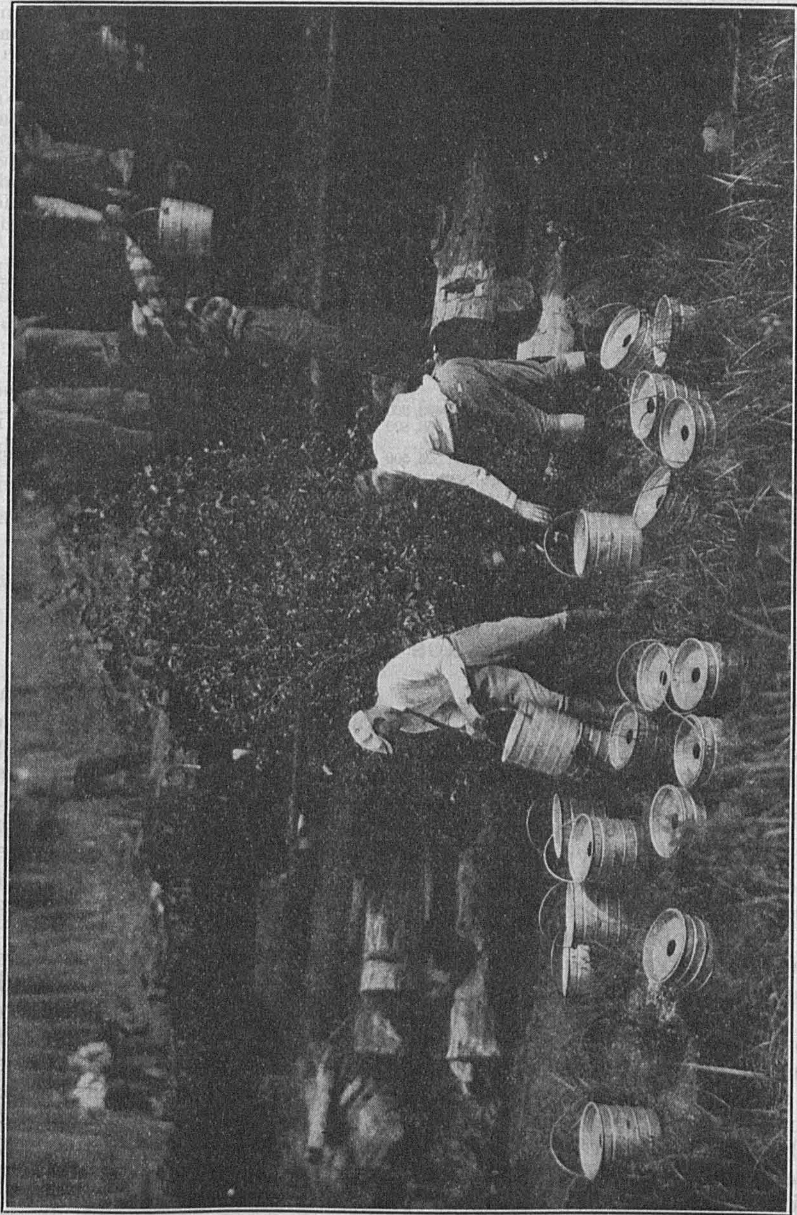

FIG. 5.—Unloading fish from flat car to stock isolated waters that could not be reached by the bureau's distribution car

station, and on August 4 it left La Crosse, Wis., with a load of miscellaneous pondfishes for delivery to applicants in Nebraska, Wyoming, and Montana en route to Bozeman. The Bozeman distribution continued during the months of August, September, and part of October, during which time numerous applicants in Montana, Wyoming, and Idaho were supplied with brook, rainbow, black-spotted, and Loch Leven trouts.

The car returned to Dubuque on October 10, and, as the distribution of the warm-water fishes from the various substations along the Mississippi River in the vicinity of Dubuque had been completed, the car was ordered to Fairport, Iowa, where it received a load of pondfishes for delivery to applicants in Pennsylvania. After completing this trip it proceeded to Washington, D. C., the members of its crew being sent to various stations of the bureau for the winter. Annual repairs were made during January, 1927, at the Pennsylvania Railroad shops at Wilmington, Del.

From April 1 to June 30 the car was used in distributing the 1927 output of trout from the White Sulphur Springs station to applicants in Pennsylvania, Virginia, West Virginia, and Maryland, which necessitated making carload shipments to the following points: Uniontown, Williamsport, Kane, Bellefonte, Pittsburgh, and Scranton, Pa.; Elkins and Grafton, W. Va.; and Oakland, Md. In completing this distribution the car made 24 trips, traveled 19,800 paid and 2,176 free miles, and supplied 890 applicants in 11 States with 4,743,845 trout and pondfishes, as follows:

Species	Fry	Fingerlings No. 1	Fingerlings No. 2	Fingerlings No. 3	Fingerlings No. 4	Adults
Catfish						2,940
Rainbow trout		403,200	551,400	69,750		
Black-spotted trout		268,800	81,000			18
Loch Leven trout			237,700			
Brook trout		525,500	210,600	269,800		5,012
Grayling						18
Largemouth black bass				11,600	4,575	12
Smallmouth black bass				2,600		
Sunfish		11,100				420
Pike perch	2,080,000					
Yellow perch			8,750	1,200	300	
Total	2,080,000	1,211,150	1,084,450	354,950	4,875	8,420

FILTROS PLUGS

The porous substance known as filtros, which was used on the bureau's distribution cars for the first time some years ago, has proved quite satisfactory as a means of diffusing air into the water of the fish container. Prior to the introduction of this material plugs made of basswood were used in specially designed holders of hard rubber having three threaded openings where the plugs were inserted. The old-type wooden plug, of course, was subject to contraction and expansion and required a great deal of attention, it being necessary to examine the plugs carefully at the end of each trip and to replace them once or twice a year. Moreover, the combination could not be purchased from any dealer, the plug holder being made in a special matrix and the plugs by hand. This made the cost quite high, and their use by the States was prohibitive. The bureau has standardized the filtros plug, and States desiring to use it may purchase their supplies from the dealer who supplies the bureau. This plug does not require a special holder, as it can be inserted in the end of the rubber tube leading from the pipe line to the fish container. It is always in condition for use and need not be replaced for at least three years. It may be purchased in a size to fit a ½-inch rubber tube. All the bureau's cars are using this material with satisfactory results.

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STATISTICS OF THE CATCH OF COD OFF THE EAST COAST OF NORTH AMERICA TO 1926[1]

By Oscar E. Sette, *Assistant in Charge, Division of Fishery Industries*

The fishery for cod on the east coast of North America is probably the most international fishery of North America. No less than five nations have an important part in it; named in order of the size of their cod catch they are Newfoundland, France, Canada, the United States, and Portugal.[2] This report is intended to bring together the available statistics on this fishery in order to show its size, trend, and relative importance of the fisheries of each participating country. As the statistics of each country are shown in different units of quantity and represent various stages in the preparation of cod for market, all have been reduced to the same basis—pounds of round cod as caught. The treatment of the data is given in detail for each country in the following sections.

NEWFOUNDLAND

With the exception of the year 1925, the only statistics available on the total production of cod by Newfoundland are the number of quintals of dry-salted cod exported annually. Statistics on this subject are available from 1804 to date. The data for 1804 to 1904, inclusive, are taken from "Report on the Trade and Commerce of Newfoundland for the Four Years ended June 30, 1906," by William MacGregor; from the annual reports of the Department of Marine and Fisheries for the years 1905 to 1924; and from the report of the American consul, St. Johns, Newfoundland, for 1925 and 1926. It is understood that these include the catch on the Labrador coast as well as that of Newfoundland proper. Virtually all of the catch is exported. In a letter of December 1, 1926, Alan Goodridge, deputy minister, says: "To this (export) may be added, roughly, three quintals per family eaten during the year. There are, roughly, 80,000 families in the population of 275,000." This gives us an estimate of 240,000 quintals of cod consumed in Newfoundland in 1925. On this basis it is possible to make an estimate of the amounts consumed in previous years, on the basis of previous populations, figures for which are given in Table 1.

Table 1.—*Population of Newfoundland, various years, 1804 to 1925*

Year	Population	Source of information
1804	20,000	Encyclopedia Brittanica.
1832	60,000	Do.
1836	75,094	Do.
1857	124,288	Do.
1874	161,374	Do.
1901	220,249	International Encyclopedia.
1920	263,383	World Almanac.
1921	259,358	American Annual.
1925	275,000	Goodridge Letter.

[1] Appendix IX to Report of the U. S. Commissioner of Fisheries for 1927. B. F. Doc. No. 1034. Contribution No. 1 from the North American Committee on Atlantic Fishery Investigations.

[2] The Greenland cod fishery has been omitted from this report because it is comparatively unimportant and for lack of complete statistics. During the five years 1919 to 1923 the annual yield averaged 525,000 kilograms of salt cod and klipfish, the equivalent of about 3,500,000 pounds of fresh round cod.

Assuming that the population has increased at a uniform rate during the years for which we have no population statistics, we have calculated the number of quintals consumed on the basis of 3 quintals per family, or 0.873 quintal per capita. The resulting totals are shown in Table 2 in terms of quintals of dry-salted cod and also converted to the basis of pounds of fresh round cod, using as factors 112 pounds to the quintal and 3 quintals of fresh round cod to 1 quintal of dry-salted cod.

In addition to the statistics here presented, data are available on the number of vessels in and total catch of the vessel fishery for the years 1889 to 1904 and on the number of vessels, tonnage, crew, and catch for the years 1897 to date. These are published in the annual reports of the Department of Marine and Fisheries of Newfoundland and are presented here in Table 3. Beginning with 1925, statistics are available also on the shore catch of cod in Newfoundland by districts.

TABLE 2.—*Newfoundland cod catch, 1804 to 1926* [1]

Year	Exports of dried cod	Consumed in Newfoundland	Total	Total on basis of fresh round cod
Calendar year	*Quintals*	*Quintals*	*Quintals*	*Pounds*
1926	1,438,852	240,000	1,678,852	564,094,272
1925	1,237,630	240,000	1,477,630	496,483,680
Fiscal year				
1924–25	1,165,097	240,075	1,405,172	472,137,792
1923–24	1,264,674	237,702	1,502,376	504,798,336
1922–23	1,483,587	235,327	1,718,914	577,555,104
1921–22	1,592,046	232,952	1,824,998	613,199,328
1920–21	1,363,792	230,577	1,594,369	535,707,984
1919–20	1,788,015	228,202	2,016,217	677,448,912
1918–19	1,681,770	226,312	1,908,082	641,115,552
1917–18	1,821,206	224,421	2,045,627	687,330,672
1916–17	1,568,020	222,530	1,790,550	601,624,800
1915–16	1,421,372	220,640	1,642,012	551,716,032
1914–15	1,094,242	218,749	1,312,991	441,164,976
1913–14	1,247,314	216,858	1,464,172	491,961,792
1912–13	1,408,582	214,967	1,623,549	545,512,464
1911–12	1,388,178	213,076	1,601,254	538,021,344
1910–11	1,182,720	211,185	1,393,905	468,352,080
1909–10	1,502,269	209,295	1,711,564	575,085,504
1908–9	1,732,387	207,404	1,939,791	651,769,776
1907–8	1,509,269	205,513	1,714,782	576,166,752
1906–7	1,422,445	203,622	1,626,067	546,358,512
1905–6	1,481,025	201,731	1,682,756	565,406,016
1904–5	1,196,814	199,841	1,396,655	469,276,080
1903–4	1,360,373	197,950	1,558,323	523,596,528
1902–3	1,429,274	196,059	1,625,333	546,111,888
1901–2	1,288,955	194,168	1,483,123	498,329,328
1900–1901	1,233,107	192,277	1,425,384	478,929,024
1899–1900	1,300,622	190,300	1,499,922	503,973,792
1898–99	1,226,336	188,324	1,414,660	475,325,760
1897–98	1,145,540	186,347	1,331,887	447,514,032
1896–97	1,135,817	184,370	1,320,187	443,582,832
Calendar year				
1895	1,312,608	182,393	1,495,001	502,320,336
1894	1,107,696	180,416	1,288,112	432,805,632
1893	1,060,335	178,440	1,238,775	416,228,400
1892	1,049,310	176,463	1,225,773	411,859,728
1891	1,244,834	174,486	1,419,320	476,891,520
1890	1,040,916	172,509	1,213,425	407,710,800
1889	1,076,507	170,532	1,247,039	419,005,104
1888	1,175,720	168,556	1,344,276	451,676,736
1887	1,080,024	166,579	1,246,603	418,858,608
1886	1,344,180	164,602	1,508,782	506,950,752
1885	1,284,710	162,625	1,447,335	486,304,560
1884	1,457,637	160,648	1,618,285	543,743,760
1883	1,532,023	158,672	1,690,695	568,073,520

[1] Data on exports are from following sources: 1804–1904, Report on the Trade and Commerce of Newfoundland, by Sir William McGregor; 1905–1924, annual reports of the Department of Marine and Fisheries, Newfoundland; 1925 and 1926, report of the American consul, St. Johns, Newfoundland, May 7, 1927.

TABLE 2.—*Newfoundland cod catch, 1804 to 1926*—Continued

Year	Exports of dried cod	Consumed in Newfoundland	Total	Total on basis of fresh round cod
Calendar year—Continued	*Quintals*	*Quintals*	*Quintals*	*Pounds*
1882	1,391,107	156,695	1,547,802	520,061,472
1881	1,535,573	154,718	1,690,291	567,937,776
1880	1,383,531	152,741	1,536,272	516,187,392
1879	1,387,770	150,764	1,538,534	516,947,424
1878	1,035,013	148,788	1,183,801	397,757,136
1877	1,034,101	146,811	1,180,912	396,786,432
1876	1,068,471	144,834	1,213,305	407,670,480
1875	1,144,196	142,857	1,287,053	432,449,808
1874	1,595,827	140,880	1,736,707	583,533,552
1873	1,316,785	138,974	1,455,759	489,135,024
1872	1,116,843	137,070	1,253,913	421,314,768
1871	1,167,488	135,165	1,302,653	437,691,408
1870	1,170,176	133,261	1,303,437	437,954,832
1869	1,104,106	131,356	1,235,462	415,115,232
1868	888,063	129,452	1,017,515	341,885,040
1867	1,005,088	127,547	1,132,635	380,565,360
1866	886,690	125,643	1,012,333	340,143,888
1865	961,339	123,738	1,085,077	364,585,872
1864	1,016,294	121,834	1,138,128	382,411,008
1863	999,089	119,929	1,119,018	375,990,048
1862	1,269,837	118,025	1,387,862	466,321,632
1861	1,238,373	116,120	1,354,493	455,109,648
1860	1,338,202	114,216	1,452,418	488,012,448
1859	1,222,244	112,312	1,334,556	448,410,816
1858	1,038,089	110,407	1,148,496	385,894,656
1857	1,392,322	108,503	1,500,825	504,277,200
1856	1,268,334	106,457	1,374,791	461,929,776
1855	1,107,388	104,412	1,211,800	407,164,800
1854	774,117	102,367	876,484	294,498,624
1853	922,718	100,322	1,023,040	343,741,440
1852	972,952	98,297	1,071,249	359,939,664
1851	1,017,152	96,232	1,113,384	374,097,024
1850	1,089,182	94,187	1,183,369	397,611,984
1849	1,175,167	92,142	1,267,309	425,815,824
1848	920,366	90,097	1,010,463	339,515,568
1847	837,973	88,052	926,025	311,144,400
1846	879,005	86,007	965,012	324,244,032
1845	1,000,233	83,962	1,084,195	364,289,520
1844	852,162	81,917	934,079	313,850,544
1843	936,202	79,872	1,016,074	341,400,864
1842	1,007,980	77,827	1,085,807	364,831,152
1841	1,009,725	75,782	1,085,507	364,730,352
1840	915,795	73,737	989,532	332,482,752
1839	865,377	71,692	937,069	314,855,184
1838	724,515	69,647	794,162	266,838,432
1837	786,946	67,602	854,548	287,128,128
1836	851,454	65,557	917,011	308,115,696
1835	712,588	62,262	774,850	260,349,600
1834	806,265	58,968	865,233	290,718,288
1833	683,536	55,674	739,210	248,374,560
1832	619,177	52,380	671,557	225,643,152
1831	755,667	51,129	806,796	271,083,456
1830	948,408	49,882	998,290	335,425,440
1829	924,237	48,635	972,872	326,884,992
1828	900,000	47,388	947,388	318,322,368
1827	900,000	46,141	946,141	317,903,376
1826	963,942	44,894	1,008,836	338,968,896
1825	973,464	43,647	1,017,111	341,749,296
1824	873,426	42,400	915,826	307,717,536
1823	864,741	41,153	905,894	304,380,384
1822	881,476	39,906	921,382	309,584,352
1821	897,345	38,659	936,004	314,497,344
1820	901,159	37,412	938,571	315,359,856
1819	924,237	36,165	960,402	322,695,072
1818	1,008,642	34,918	1,043,560	350,636,160
1817	1,023,462	33,671	1,057,133	355,196,688
1816	1,046,626	32,424	1,079,050	362,560,800
1815	1,086,266	31,177	1,117,443	375,460,848
1814	947,762	29,930	977,692	328,504,512
1813	891,360	28,683	920,043	309,134,448
1812	711,059	27,436	738,495	248,134,320
1811	923,540	26,189	949,729	319,108,944
1810	884,474	24,942	909,416	305,563,776
1809	810,219	23,695	833,914	280,195,104
1808	576,132	22,448	598,580	201,122,880
1807	674,810	21,201	696,011	233,859,696
1806	772,809	19,954	792,763	266,368,368
1805	625,519	18,707	644,226	216,459,936
1804	664,277	17,460	681,737	229,063,632

TABLE 3.—*Analysis of the Newfoundland vessel fishery for cod*

Year	Vessels	Tonnage	Crew	Catch				
				Dried cod	Fresh round cod	Per vessel	Per man	Per ton
	Number	*Number*	*Number*	*Quintals*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1925	41	3,048	753	101,384	34,065,024	830,854	45,239	11,176
1924	36	2,612	607	70,013	23,524,368	653,453	38,755	9,006
1923	51	3,797	939	69,372	23,308,992	457,039	24,823	6,139
1922	53	3,738	934	132,699	44,586,864	841,262	47,738	11,928
1921	41	2,874	697	94,461	31,738,896	774,119	45,536	11,043
1920	50	3,154	793	95,484	32,082,624	641,652	40,457	10,172
1919	41	2,770	732	94,770	31,842,720	776,652	43,501	11,496
1918	56	3,904	940	98,300	33,028,800	589,800	35,137	8,460
1917	78	5,334	1,298	134,298	45,124,128	578,514	34,764	8,460
1916	87	6,792	1,645	151,888	51,034,368	586,602	31,024	7,514
1915	102	7,526	1,806	170,390	57,251,040	565,285	31,700	7,607
1914	105	7,770	1,882	124,067	41,686,512	397,014	22,150	5,365
1913	104	7,551	1,803	152,374	51,197,664	492,285	28,306	6,780
1912	124	8,696	2,065	155,517	52,253,712	421,401	25,304	6,009
1911	122	8,281	1,924	149,924	50,374,464	412,905	26,182	6,083
1910	101	6,630	1,567	144,524	48,560,064	480,793	30,989	7,324
1909	100	5,818	1,377	131,452	44,167,872	441,679	32,075	7,592
1908	107	5,976	1,433	120,000	40,320,000	376,822	28,137	6,747
1907	83	4,286	1,261	88,086	29,596,896	356,589	23,471	6,905
1906	----	----	----	75,153	25,251,408	----	----	----
1904	87	5,039	1,215	70,872	23,812,992	273,713	19,599	4,726
1903	100	5,529	1,386	89,331	30,015,216	300,152	21,656	5,429
1902	111	5,964	1,444	131,102	44,050,272	396,849	30,506	7,386
1901	118	6,282	1,531	113,841	38,250,576	324,157	24,984	6,089
1900	112	5,757	1,400	116,278	39,069,408	348,834	27,907	6,786
1899	90	4,723	1,163	97,399	32,726,064	363,623	28,139	6,929
1898	74	4,224	1,000	74,002	24,864,672	336,009	24,865	5,887
1897	66	----	872	58,762	19,744,032	299,152	22,642	----
1894	58	----	----	53,824	18,084,864	311,808	----	----
1893	71	----	----	58,494	19,653,984	276,817	----	----
1892	100	----	----	90,467	30,396,912	303,969	----	----
1891	165	----	----	103,688	34,839,168	211,146	----	----
1890	279	----	----	147,948	49,710,528	178,173	----	----
1889	330	----	----	236,822	79,572,192	241,128	----	----

FRANCE

The statistics of the French catch of cod off the east coast of North America are taken from "Statistique des Peches Maritimes," an annual publication of the Service des Peches Maritimes, Paris, which gives a separate table on the cod fishery of Terre-Neuve. The following statement is from a letter dated June 16, 1927, from Chester Lloyd Jones, United States commercial attaché at Paris, who secured his information from the Comité Central des Armateurs de France:

> The French statistics indicate only the weight of the cod on arrival in France. These weights refer to the prepared cod; that is to say, cod salted after having been slit and the head removed. The fish are prepared aboard the fishing boats and are given an actual weighing only on unloadings. For this reason it is impossible to indicate precisely the weight of the cod when caught. This fresh cod is known as "morues rondes" (round cod). Nevertheless, tests made on a certain number of boats permit the establishment of a rough relation between the "round" or fresh cod and the prepared or green cod after slitting and salting. It is generally accepted that 150 kilograms of round cod equal 55 kilos of green salt cod. This is only a rough approximation and is subject to error according to the promptness with which the green cod are weighed. There may be considerable variation due to the drying, which may occur between the time of original salting and the time of weighing. This may involve a period of several months.

In converting the French statistics to the standard basis of pounds of fresh round cod we have used the factor six $\left(\frac{150}{55} \times 2.205 = 6.0\right)$. The resulting totals are given in Table 4.

TABLE 4.—*Catch of cod off the east coast of North America by French vessels, 1874–1925* [1]

Year	"Totaux Morue Terre-Neuve" (total cod) [2]	On basis of round cod [3]	Year	"Totaux Morue Terre-Neuve" (total cod) [2]	On basis of round cod [3]
	Kilograms	*Pounds*		*Kilograms*	*Pounds*
1925	57, 255, 541	343, 533, 246	1899	36, 130, 438	216, 782, 628
1924	45, 868, 298	275, 209, 788	1898	29, 932, 896	179, 597, 376
1923	52, 598, 160	315, 588, 960	1897	31, 263, 477	187, 580, 862
1922	37, 777, 346	226, 664, 076	1896	24, 383, 926	146, 303, 556
1921	33, 095, 350	198, 572, 100	1895	18, 575, 387	111, 452, 322
1920	30, 116, 672	180, 700, 032	1894	14, 238, 863	85, 433, 178
1919	27, 216, 090	163, 296, 540	1893	14, 316, 548	85, 899, 288
1918	9, 494, 018	56, 964, 108	1892	13, 182, 590	79, 095, 540
1917	12, 295, 038	73, 770, 228	1891	11, 957, 778	71, 746, 668
1916	10, 320, 660	61, 923, 960	1890	21, 030, 630	126, 183, 780
1915	17, 977, 817	107, 866, 902	1889	21, 309, 306	127, 855, 836
1914	22, 455, 516	134, 733, 096	1888	22, 141, 852	132, 851, 112
1913	34, 762, 357	208, 574, 142	1887	38, 613, 915	231, 683, 490
1912	27, 662, 919	165, 977, 514	1886	33, 715, 858	202, 295, 148
1911	35, 273, 000	211, 638, 000	1885	26, 871, 000	161, 226, 000
1910	63, 890, 334	383, 342, 004	1884	25, 326, 123	151, 956, 738
1909	52, 219, 899	313, 319, 394	1883	21, 315, 853	127, 895, 118
1908	41, 592, 683	249, 556, 098	1882	17, 803, 924	106, 823, 544
1907	34, 581, 564	207, 489, 384	1881	17, 683, 289	106, 099, 734
1906	19, 845, 965	119, 075, 790	1880	18, 382, 910	110, 297, 460
1905	22, 632, 343	135, 794, 058	1879	18, 481, 384	110, 888, 304
1904	19, 599, 187	117, 595, 122	1878	16, 070, 560	96, 423, 360
1903	21, 896, 066	131, 376, 396	1877	13, 922, 714	83, 536, 284
1902	24, 469, 623	146, 817, 738	1876	16, 296, 993	97, 781, 958
1901	37, 862, 775	227, 176, 650	1875	14, 955, 928	89, 735, 568
1900	32, 706, 993	196, 241, 958	1874	18, 565, 090	111, 390, 540

[1] From "Statistique des Peches Maritimes." Service des Peches Maritimes. Paris, France. Published annually.

[2] Green-salted cod as landed in France. See text, p. 740.

[3] Conversion data: 150 kilos round cod = 55 kilos green-salted; 1 kilo = 2.205 pounds $\left(\frac{150}{55}\times 2.205 = 6.0\right)$. See text, p. 740.

CANADA

For the statistics of the cod catch of Canada we have drawn upon the annual reports of fisheries statistics of Canada, published by the Canada Dominion Bureau of Statistics, Fisheries Division. The total catch of fresh round cod is given for the years 1910 to 1926. For the years 1869 to 1909 statistics are given on the quantities of cod as marketed. From 1903 to 1909 two items appear—"dried" and "fresh or green." In previous years only dried cod appear in the statistics. In converting these figures to the basis of fresh round cod we have used a factor of 1 for fresh, 2 for green salted, and 3 for dried. Inasmuch as the fresh and green salted are shown together it was necessary to calculate an average conversion factor for this item. This was done by using the four fiscal years, beginning with 1910–11, in which both cod caught and landed and cod marketed were given. The method of calculation is shown in Table 5 and results appear to correspond very closely with the assumed factors. The resulting totals are shown in Tables 6 and 7.

TABLE 5.—*Study of the conversion factors for reducing statistics of Canadian cod as marketed to the basis of cod as caught*

Item	As given in Canadian statistical reports	Assumed conversion factors	Calculated weight as caught	Remarks
1910–11	*Hundredweight*		*Hundredweight*	
Marketed:				
Fresh	105,398	1	105,398	Calculated conversion factor for "fresh and green-salted": $\frac{256,428}{180,913}=1.42$.
Green-salted	75,515	2	151,030	
Dried	1,017,895	3	3,053,685	
Caught and landed	3,126,563		3,310,113	Calculated weight as caught is 6 per cent more than reported weight as caught.
1911–12				
Marketed:				
Fresh	124,695	1	124,695	Calculated conversion factor for "fresh and green-salted": $\frac{327,061}{225,878}=1.45$.
Green-salted	101,183	2	202,366	
Dried	593,433	3	1,780,299	
Caught and landed	2,072,195		2,107,360	Calculated weight as caught is 2 per cent more than reported weight as caught.
1912–13				
Marketed:				
Fresh	104,164	1	104,164	Calculated conversion factor for "fresh and green-salted": $\frac{255,260}{179,712}=1.42$.
Green-salted	75,548	2	151,096	
Dried	481,714	3	1,445,142	
Caught and landed	1,700,490		1,700,402	Calculated weight as caught is nearly the same as reported weight as caught.
1913–14				
Marketed:				
Fresh	73,951	1	73,951	Calculated conversion factor for "fresh and green-salted": $\frac{257,293}{165,622}=1.55$.
Green-salted	91,671	2	183,342	
Smoked	1,128	2	2,256	
Dried	458,643	3	1,375,929	
Caught and landed	1,635,379		1,635,478	Calculated weight as caught is nearly the same as reported weight as caught.
				Average conversion factor 1.46

TABLE 6.—*Canadian cod catch on the Atlantic seaboard, 1910 to 1926*

Calendar year	Alongshore (total minus offshore)	Offshore (caught by vessels remaining out more than two days)	Total (caught and landed)	*Fiscal year*	Alongshore (total minus offshore)	Offshore (caught by vessels remaining out more than two days)	Total (caught and landed)
	Hundredweight	*Hundredweight*	*Hundredweight*		*Hundredweight*	*Hundredweight*	*Hundredweight*
1926			2,666,871	1916–17			1,962,860
1925	1,094,313	1,183,051	2,277,364	1915–16			2,116,886
1924	906,701	941,085	1,847,786	1914–15			1,772,864
1923	793,238	979,268	1,772,506	1913–14			1,635,379
1922	975,990	1,344,218	2,320,208	1912–13			1,700,490
1921	1,028,026	976,217	2,004,243	1911–12			2,072,195
1920	911,088	1,037,516	1,948,604	1910–11			3,126,563
1919	1,465,103	1,094,343	2,559,446				
1918	1,257,099	905,295	2,162,394				
1917			2,216,455				

TABLE 7.—*Canadian cod catch on the Atlantic seaboard, 1869–1910*

Year	Dried	Fresh or green	Calculated weight as caught [1]	Year	Dried	Fresh or green	Calculated weight as caught [1]
Fiscal year	*Hundred-weight*	*Pounds*	*Hundred-weight*	*Calendar year*	*Hundred-weight*	*Pounds*	*Hundred-weight*
1909–10	814, 041	3, 272, 171	2, 489, 897	1889	904, 560		2, 713, 680
				1888	1, 050, 847		3, 152, 541
Calendar year				1887	1, 078, 255		3, 284, 765
				1886	1, 080, 716		8, 242, 148
1908	700, 530	4, 802, 100	2, 171, 701	1885	1, 077, 393		3, 232, 179
1906	670, 775	1, 459, 695	2, 033, 637	1884	1, 022, 389		3, 067, 167
1905	738, 637	1, 208, 100	2, 233, 549	1883	1, 075, 121		3, 225, 363
1904	792, 881	510, 985	2, 386, 103	1882	903, 030		2, 709, 090
1903	824, 756	504, 500	2, 481, 634	1881	1, 075, 582		3, 226, 746
1902	997, 244		2, 991, 732	1880	1, 092, 514		3, 277, 542
1901	999, 666		2, 998, 998	1879	1, 067, 484		3, 202, 452
1900	892, 280		2, 676, 840	1878	902, 496		2, 707, 488
1899	927, 182		2, 781, 546	1877	815, 068		2, 445, 204
1898	709, 458		2, 128, 374	1876	830, 860		2, 492, 580
1897	791, 781		2, 375, 343	1875	748, 788		2, 246, 364
1896	796, 736		2, 390, 208	1874	797, 891		2, 393, 673
1895	803, 595		2, 410, 785	1873	880, 842		2, 642, 526
1894	934, 845		2, 804, 535	1872	824, 438		2, 473, 314
1893	888, 358		2, 665, 074	1871	674, 602		2, 023, 806
1892	898, 212		2, 694, 636	1870	578, 423		1, 735, 269
1891	848, 969		2, 546, 907	1869	513, 358		1, 540, 074
1890	857, 734		2, 573, 202				

[1] Conversion factors: Dried ×3; "fresh or green" ×1.46. (See Table 5.)

UNITED STATES

The statistics for the cod catch of the United States are taken from the annual reports of the Commissioner of Fisheries. These consist of two series: (1) Annual reports of the quantities of cod landed by vessels at Boston and Gloucester, Mass., and Portland, Me. (1891 to date); (2) the total cod catch by New England fishermen for the years 1880, 1887, 1888, 1889, 1902, 1905, 1908, 1919, and 1924. The statistics, as published, represent the weight of cod as marketed by the fishermen, some of it salted and some fresh. The salt cod was converted to the equivalent of fresh cod by multiplying by two, thus reducing all items to a comparable basis. Having totals for only certain years, it was necessary to estimate the catches in intervening years. Using as a basis those years in which total statistics were available, it was possible to ascertain the amounts landed at Boston, Gloucester, and Portland by vessels, the amounts landed by vessels elsewhere, and the amounts taken in the shore fishery. Having annual statistics on the principal New England ports, which include the greater portion of the catch, it is necessary only to estimate the landings elsewhere by vessels and the catch of the shore fishery in the intervening years. Assuming that the trends of these fisheries were constant in the intervening years, the estimates were made and added to the landings at the principal ports. The resulting totals were then multiplied by the factor 1.25 to offset the loss in dressing, giving finally the totals shown in Table 8. Because they are estimates, these are only approximately correct. We believe they reflect the actual catch sufficiently well to be of value as used in this report.

TABLE 8.—*United States cod catch off the east coast of North America*

Year	Shore catch	Vessel catch			Total shore and vessel	Add 25 per cent to offset loss in dressing	Grand total fresh, round basis
		Landed at Boston, Gloucester, and Portland	Landed elsewhere	Total			
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1926	19,500,000	82,800,477	12,600,000	95,400,000	114,900,000	28,700,000	143,600,000
1925	18,900,000	70,118,974	12,300,000	82,400,000	101,300,000	25,300,000	126,600,000
1924	18,344,256	63,995,450	11,111,440	75,106,890	93,451,146	23,362,786	116,813,932
1923	17,400,000	66,718,136	9,600,000	76,300,000	93,700,000	23,400,000	117,100,000
1922	16,800,000	59,759,695	8,300,000	68,100,000	84,900,000	21,200,000	106,100,000
1921	16,200,000	58,456,532	7,000,000	65,500,000	81,700,000	20,400,000	102,100,000
1920	15,600,000	65,825,084	5,700,000	71,500,000	87,100,000	21,800,000	108,900,000
1919	14,975,867	69,695,432	4,404,885	74,100,317	89,076,184	22,269,046	111,345,230
1918	15,100,000	75,028,832	5,450,000	80,400,000	95,500,000	23,900,000	119,400,000
1917	15,200,000	62,518,654	6,500,000	69,000,000	84,200,000	21,000,000	105,200,000
1916	15,300,000	50,626,493	7,550,000	58,200,000	73,500,000	18,400,000	91,900,000
1915	15,400,000	55,110,151	8,600,000	63,700,000	79,100,000	19,800,000	98,900,000
1914	15,500,000	58,024,594	9,650,000	67,700,000	83,200,000	20,800,000	104,000,000
1913	15,700,000	60,552,395	10,700,000	71,300,000	87,000,000	21,800,000	108,800,000
1912	15,800,000	71,891,436	11,750,000	83,600,000	99,400,000	24,800,000	124,200,000
1911	15,900,000	73,435,211	12,800,000	86,200,000	102,100,000	25,500,000	127,600,000
1910	16,000,000	87,129,584	13,850,000	101,000,000	117,000,000	29,200,000	146,200,000
1909	16,200,000	104,078,875	14,900,000	119,000,000	135,200,000	33,800,000	169,000,000
1908	16,327,000	85,280,185	15,974,815	101,255,000	117,582,000	29,395,500	146,977,500
1907	15,200,000	76,688,791	13,800,000	90,500,000	105,700,000	26,400,000	132,100,000
1906	14,000,000	72,841,802	11,500,000	84,300,000	98,300,000	24,600,000	122,900,000
1905	12,771,968	71,841,821	9,178,229	81,020,050	93,791,968	23,447,992	117,239,960
1904	11,600,000	73,522,679	11,900,000	85,400,000	97,000,000	24,200,000	121,200,000
1903	10,500,000	84,947,481	14,600,000	99,500,000	110,000,000	27,500,000	137,500,000
1902	9,490,657	96,869,838	17,244,301	114,114,239	123,604,896	30,901,224	154,506,120
1901	10,550,000	95,410,126	19,600,000	115,000,000	125,500,000	31,400,000	156,900,000
1900	11,700,000	93,989,034	22,000,000	116,000,000	127,700,000	31,900,000	159,600,000
1899	12,850,000	122,104,886	24,400,000	146,500,000	159,300,000	39,800,000	199,100,000
1898	13,966,554	84,646,547	26,827,424	111,473,971	125,440,525	31,360,131	156,800,656
1897	13,400,000	76,752,504	29,400,000	106,200,000	119,600,000	29,900,000	149,500,000
1896	12,800,000	93,527,647	32,000,000	125,500,000	138,300,000	34,600,000	172,900,000
1895	12,200,000	110,526,602	34,600,000	145,100,000	157,300,000	39,300,000	196,600,000
1894	11,600,000	99,420,048	37,200,000	136,600,000	148,200,000	37,000,000	185,200,000
1893	11,000,000	89,000,501	39,800,000	128,800,000	139,800,000	35,000,000	174,800,000
1891	9,800,000	100,745,788	45,000,000	145,700,000	155,500,000	38,900,000	194,400,000
1889	8,721,377			155,401,270	164,122,647	41,030,662	205,153,309
1888	9,325,876			186,894,224	196,220,100	49,055,025	245,275,125
1887	9,279,725			198,178,003	207,457,728	51,864,432	259,322,160
1880					235,480,677	58,870,169	294,350,846

NOTE.—Figures given in even 100,000's are estimates. See text, p. 743, for explanation.

PORTUGAL

The statistics of the Portuguese fishery for cod off the eastern coast of North America were taken from Estatistica des Pescas Maritimas, published by the Comissao Central de Pescarias at Lisbon. They cover the years 1896 to 1925, inclusive. We are informed by the American consul at Lisbon that the statistics represent "salted cod, not dried; that is, such as is unloaded from the ships at Portuguese ports when returning from the banks, to be dried afterwards." In converting to the basis of pounds of fresh round cod we have used factor 6, as in the French statistics. (See p. 740.) In addition to the total catch, the Portuguese statistics also give the number of vessels, tonnage, crew, and number of dories. These figures are shown in Table 9.

TABLE 9.—*Catch of cod off the east coast of North America by Portuguese vessels* [1]

Year	"Navios" (vessels)	"Tonelagemde" arqueacao dos navios (tonnage)	"Tripulants" (crew)	"Canoas," (dories)	"Produto, bacalhan" (product cod)	
					As published [2]	Converted to basis of fresh round cod [3]
	Number	*Thousands of kilos*	*Number*	*Number*	*Kilos*	*Pounds*
1925	44	10, 253	1, 562	1, 471	5, 031, 710	30, 190, 260
1924	65	13, 806	2, 269	2, 063	6, 521, 611	39, 129, 666
1923	47	10, 887	1, 756	1, 642	4, 436, 959	26, 621, 754
1922	45	10, 560	1, 667	1, 510	4, 276, 570	25, 659, 420
1921	35	7, 921	1, 278	1, 186	4, 097, 649	24, 585, 894
1920	19	3, 795	622	311	1, 678, 184	10, 069, 104
1919	13	2, 947	481	433	1, 241, 655	7, 449, 930
1918	11	2, 387	394	344	1, 810, 897	10, 865, 382
1917	22	4, 333	705	621	2, 039, 945	12, 239, 670
1916	31	6, 134	1, 017	883	3, 451, 644	20, 709, 864
1915	38	8, 112	1, 277	1, 113	3, 899, 086	23, 394, 516
1914	34	6, 854	1, 151	973	2, 445, 000	14, 670, 000
1913	38	7, 265	1, 301	1, 199	2, 587, 067	15, 522, 402
1912	37	7, 838	1, 211	1, 156	3, 854, 358	23, 126, 148
1911	39	7, 270	1, 099	1, 107	5, 330, 564	31, 983, 384
1910	28	6, 529	886	793	4, 914, 014	29, 484, 084
1909	31	6, 746	987	799	4, 971, 543	29, 829, 258
1908	30	6, 231	946	----------	4, 379, 041	26, 274, 246
1907	25	5, 035	770	----------	3, 623, 772	21, 742, 632
1906	18	3, 956	593	----------	3, 454, 075	20, 724, 450
1905	13	2, 817	432	----------	2, 480, 400	14, 882, 400
1904	17	3, 743	559	----------	2, 381, 440	14, 288, 640
1903	17	3, 576	462	----------	2, 030, 287	12, 181, 722
1902	15	3, 352	----------	----------	2, 574, 445	15, 446, 670
1901	12	2, 313	----------	----------	2, 336, 090	14, 016, 540
1900	12	2, 313	----------	----------	----------	----------
1899	12	2, 313	----------	----------	2, 080, 035	12, 480, 210
1898	12	2, 313	----------	----------	1, 614, 775	9, 688, 650
1897	12	2, 313	----------	----------	901, 172	5, 407, 032
1896	12	2, 313	----------	----------	1, 647, 790	9, 886, 740

[1] Source: "Estatistica das Pescas Martimas," Comissao Central de Pescarias. Lisbon, Portugal. Published annually.

[2] Green-salted cod.

[3] Converted on basis of 55 kilograms of green-salted cod equals 150 kilos round cod and 1 kilogram equals 2.205 pounds $\frac{150}{55}\times 2.205=6.0$).

TABLE 10.—*Catch of cod off the east coast of North America*

[Figures are in millions; that is, 000,000 omitted]

Year	Newfoundland	France	Canada	United States	Portugal	Total
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Average, 1896-1925	538	190	225	130	19	1, 103
1926	564	----------	267	144	----------	----------
1925	496	344	228	127	30	1, 225
1924	[1] 472	275	185	117	39	1, 088
1923	[1] 505	316	177	117	27	1, 142
1922	[1] 578	227	232	106	26	1, 169
1921	[1] 613	199	200	102	25	1, 139
1920	[1] 536	181	195	109	10	1, 031
1919	[1] 677	163	256	111	7	1, 214
1918	[1] 641	57	216	119	11	1, 044
1917	[1] 687	74	222	105	12	1, 100
1916	[1] 602	62	[1] 196	92	21	978
1915	[1] 552	108	[1] 212	99	23	994
1914	[1] 441	135	[1] 177	104	15	872
1913	[1] 492	209	[1] 164	109	16	990
1912	[1] 546	166	[1] 170	124	23	1, 029
1911	[1] 538	212	[1] 207	128	32	1, 117
1910	[1] 468	383	[1] 313	146	29	1, 339
1909	[1] 575	313	[1] 249	169	30	1, 336

[1] Fiscal year.

TABLE 10.—*Catch of cod off the east coast of North America*—Continued

[Figures are in millions; that is, 000.000 omitted]

Year	Newfoundland	France	Canada	United States	Portugal	Total
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1908	[1] 652	250	217	147	26	1,292
1907	[1] 576	207	[2] 210	132	22	1,147
1906	[1] 546	119	203	123	21	1,012
1905	[1] 565	136	223	117	15	1,056
1904	[1] 469	118	239	121	14	961
1903	[1] 524	131	248	138	12	1,053
1902	[1] 546	147	299	155	15	1,162
1901	[1] 498	227	300	157	14	1,196
1900	[1] 479	196	268	160	[2] 13	1,116
1899	[1] 504	217	278	199	12	1,210
1898	[1] 475	180	213	157	10	1,035
1897	[1] 448	188	238	150	5	1,029
1896	[1] 444	146	239	173	10	1,012
1895	502	111	241	197		
1894	433	85	280	185		
1893	416	86	267	175		
1892	412	79	269			
1891	477	72	255	194		
1890	408	126	257			
1889	419	128	271	205		
1888	452	133	315	245		
1887	419	232	323	259		
1886	507	202	324			
1885	486	161	323			
1884	544	152	307			
1883	568	128	323			
1882	520	107	271			
1881	568	106	323			
1880	516	110	328	294		

[1] Fiscal year. [2] Estimated.

TABLE 11.—*Percentage of cod caught off the east coast of North America by each country, 1896–1925*

Year	Newfoundland	France	Canada	United States	Portugal	Total
Averages, 1896–1925	49	17	20	12	2	100
1925	40	28	19	10	2	99
1924	43	25	17	11	4	101
1923	44	28	15	10	2	99
1922	49	19	20	9	2	99
1921	54	17	18	9	2	100
1920	52	18	19	11	1	101
1919	56	13	21	9	1	100
1918	61	5	21	11	1	99
1917	62	7	20	10	1	100
1916	62	6	20	9	2	99
1915	56	11	21	10	2	100
1914	51	15	20	12	2	100
1913	50	21	17	11	2	101
1912	53	16	17	12	2	100
1911	48	19	19	11	3	100
1910	35	29	23	11	2	100
1909	43	23	19	13	2	100
1908	50	19	17	11	2	99
1907	50	18	18	12	2	100
1906	54	12	20	12	2	100
1905	53	13	21	11	1	99
1904	49	12	25	13	1	100
1903	50	12	24	13	1	100
1902	47	13	26	13	1	100
1901	42	19	25	13	1	100
1900	43	18	24	14	1	100
1899	42	17	23	16	1	99
1898	46	17	21	15	1	100
1897	44	18	23	15	(1)	100
1896	44	14	24	17	1	100

[1] Less than 0.5 per cent.

SUMMARY

The cod catches of the countries participating in the fishery off the east coast of North America are summarized in Tables 10 and 11 and Figure 1.

During the last 30 years the total catch of cod averaged 1,103,000,000 pounds annually, varying between 872,000,000 and 1,339,000,000 pounds. The plotted curve of total annual production appears at the beginning of the 30-year period to be rising from a minimum, which probably occurred in 1893, to a maximum in 1899 to 1902; another minimum occurred in 1904, a maximum in 1908 to 1910, and another minimum in 1914. Since then the yield has been increasing fairly continuously. If a straight-line trend were fitted to the curve it would be nearly horizontal. Thus we may conclude that, on the whole, the productivity of the cod fishery, while subject to fluctuations, has neither increased nor declined during the last three decades.

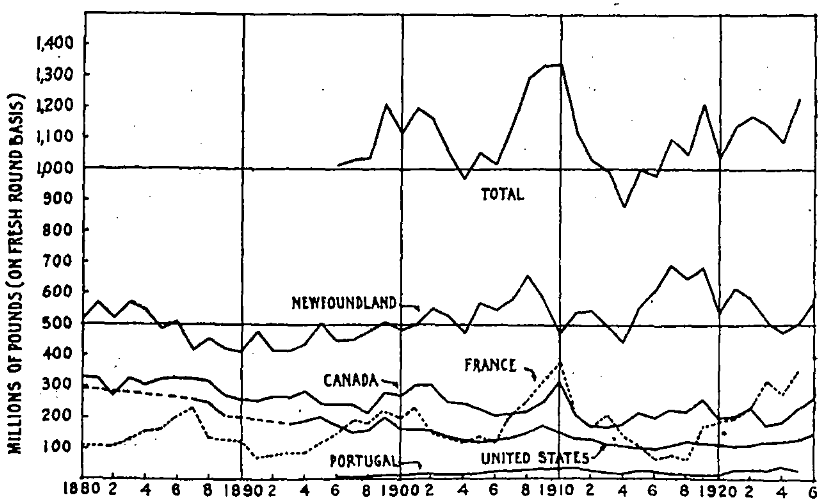

FIGURE 1.- THE CATCH OF COD OFF THE EAST COAST OF NORTH AMERICA.

With regard to the yields of the separate countries the situation is somewhat different. Newfoundland had the lion's share of this fishery, her catch averaging 538,000,000 pounds, or 49 per cent of the total, during the 30-year period. In general, it has been increasing since 1890. Canada averaged 225,000,000 pounds, or 20 per cent of the total, during the 30 years. On the whole, her yield has suffered a general decline but has been recovering moderately since 1913. The French catch averaged 190,000,000 pounds, or 17 per cent of the total, and has been subject to such large fluctuations that it is difficult to say whether there has been any well-defined trend during the last 30 years, though since 1880 the trend has been slightly upward. The United States yield averaged 130,000,000 pounds, or 12 per cent, during the 30-year period, and, on the whole, shows a distinctly downward trend. Since 1916, however, there have been farily consistent increases. The Portuguese catch averaged 19,000,000 pounds, or 2 per cent of the total, for the last 30 years. Its trend has been noticeably upward.

That there should be such differences in the trends of the various countries is not surprising, for there are basic differences in both the production and marketing conditions in the different countries. The Newfoundland fishery is largely a shore fishery on the coasts of Newfoundland and Labrador. Her market is entirely dependent on her export trade in the dried product. The Canadian production is about equally divided between the shore and bank fisheries. The former is conducted on the coasts of Nova Scotia and the Gulf of St. Lawrence, the latter largely on the "Western Banks." Her product is largely dried cod, and the export trade is an important part of her market, although her domestic market for both fresh and dried cod is much more important than that of Newfoundland. The United States catch is largely made by vessels operating on the near-by banks, of which Georges Bank is most important. Her shore fishery is of considerable importance, however, providing about 20 per cent of the catch. Her market is largely domestic and in recent years has been chiefly for fresh cod. The French fishery is almost entirely a vessel fishery on the Grand Banks, though some cod are caught along the shores of St. Pierre et Miquelon and on the Western Banks. Her market is for dried cod and is largely domestic. The Portuguese fishery is entirely a vessel fishery and is prosecuted mostly on the Grand Banks. Her market is domestic and for dried cod.

Although differences in the conditions surrounding the fisheries of the various countries may be pointed out readily, and while we may be sure that the differing trends may be caused by the different conditions it is impossible to deduce the specific causes without many more extensive data on the various factors that influence the fisheries of each country.

NOTE.—Since writing the above it has been found that the Canadian statistics shown in this report are not wholly comparable to the figures shown for the other countries. At the time the compilations were made there was reason to believe that the figures published under the heading "Caught and landed" represented fresh round cod, but it has since been found that the cod landed fresh is actually reported on the basis of fresh gutted weights and the landings of green salted cod are usually reported on the basis of 300 pounds to every 100 pounds of dried product. This practice is not entirely uniform at present and presumably was not in the past. Under the circumstances it is difficult to determine an accurate conversion factor, but it seems that the Canadian figures might be rendered more comparable to those of the other countries by adding approximately 25 per cent.