

# REPORT UPON THE INQUIRY RESPECTING FOOD-FISHES AND THE FISHING-GROUNDS.

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## FUR-SEAL INVESTIGATIONS.

In the last annual report a brief outline was presented of the inquiries conducted by this Government, immediately preceding and subsequent to the Paris Tribunal of Arbitration, relative to the natural history of the fur-seal and the industry to which it gives rise in the North Pacific Ocean and Bering Sea, and also of the part taken by the Fish Commission in connection therewith. By act of Congress approved March 3, 1893, the Fish Commissioner was instructed to have examinations made annually respecting the condition of the rookeries on the Pribilof Islands, the same to be carried out under the direction of the Secretary of the Treasury, to whom the results are to be submitted, and he was also charged with the further investigation of the pelagic habits and life-history of the seals. The former of these subjects, although requiring a prolonged series of observations during each season, does not present any serious obstacles in the way of execution, but the study of the latter is rendered exceedingly difficult on account of the wide pelagic distribution of the seals through a large part of the year, their extensive migrations and rapid movements, and their well-known timidity at sea, especially in the presence of a steamer. Nevertheless, much important information of this character has been obtained both by direct observation and by the inspection of the catch made by sealing vessels.

As it has been found inexpedient to attempt the killing of seals from the steamer *Albatross*, and the examination of a large number of fresh specimens was considered advisable, Mr. A. B. Alexander, the fishery expert of that steamer, was detailed to accompany one of the pelagic sealers in Bering Sea during the open part of the season of 1894. Accommodations were furnished to him on board the schooner *Louis Olsen*, of Astoria, Oreg., through the courtesy of her master, Captain Guillems, thus affording an excellent opportunity for making accurate observations regarding the proportion of each sex obtained by the sealers in the open waters of Bering Sea, the condition of the females so taken as to nursing and pregnancy, the nature of the food, etc. These observations were further supplemented in the fall by the custom-house inspections at United States ports as the vessels returned with their

cargoes, both Mr. Townsend and Mr. Alexander taking part in that examination, and by their familiarity with the structure of the seals insuring greater precision in the results.

The customary examination of the rookeries on St. Paul and St. George islands, including the delineation of their outlines and the photographing of characteristic areas, was made between July 12 and August 1, 1894, by Mr. C. H. Townsend, naturalist of the *Albatross*, assisted by Mr. N. B. Miller in the photographic work. Mr. Townsend and Mr. Miller again visited these islands between September 9 and 13, for the purpose of ascertaining the extent of mortality among the seal pups, caused by the destruction of the females in connection with pelagic sealing, and succeeded in obtaining a very fair count of the loss by that means.

In planning for the sealing investigations during the season of 1895, arrangements were made for much more extensive operations than had previously been undertaken in any one year, and before the close of the fiscal year the work was well under way. Besides the regular annual examination of the rookeries by Mr. Townsend and the detailing of Mr. Alexander to a second cruise on board one of the pelagic sealers, two additional series of inquiries have been provided for, one on the Pribilof Islands, the other on the Commander Islands. These are designed especially to cover the natural history of the seals as exemplified under the conditions now existing, with the object of affording the means for comparison with the results of earlier researches, and of establishing more clearly the relations of the different practices connected with their killing, both on land and at sea, to the depletion of the seal herds.

To carry on these special investigations it was fortunately possible to secure the services of two accomplished and experienced naturalists, Mr. F. W. True and Mr. Leonhard Stejneger, the former curator of mammals, the latter of reptiles, in the United States National Museum. Mr. True was assigned to the Pribilof Islands and took with him as assistant Mr. D. Webster Prentiss, jr., also detailed by the National Museum.

They proceeded with the *Albatross* from Port Townsend to Alaska in June, 1895, being landed upon the Pribilof Islands in the latter part of the month. Mr. Stejneger had had a previous acquaintance with the Commander Islands, where he was stationed during eighteen months in 1882-83, under the auspices of the Smithsonian Institution, and in the course of his observations at that time he paid considerable attention to the habits of the fur-seals, as well as to the condition of the rookeries. He is, therefore, especially well qualified to pass upon the changes which have taken place during the past twelve years, covering the entire period of extensive pelagic sealing; and the study of this problem has therefore been assigned to him. The accomplishment of this part of the investigation has been rendered possible through the courtesy of the Russian Government, which not only granted permission for Mr. Stejneger to reside upon the islands and make the

necessary observations, but also signified its hearty indorsement of the objects of his visit. Mr. Stejneger left San Francisco June 6, 1895, on the Alaska Commercial Company's steamer *Bertha*, for Unalaska, where he joined the *Albatross*, and was taken thence to the Commander Islands, stopping for a few days en route to examine the rookeries of the Pribilof Islands.

#### OPERATIONS OF THE ALBATROSS IN THE NORTH PACIFIC OCEAN AND BERING SEA.

During the summer of 1894, as in the previous year, the steamer *Albatross*, Lieut. Commander F. J. Drake, U. S. N., commanding, was again serving in connection with the sealing patrol fleet in the North Pacific Ocean and Bering Sea, under the direction of the Secretary of the Navy. Her movements were therefore subject to the orders of the senior naval officer in charge, but, so far as the exigencies of this special detail permitted, the customary inquiries respecting the Alaskan fishing-grounds and the pelagic habits of the fur-seal were to be carried on, and complete instructions covering those subjects were issued to the commanding officer. The annual examination of the rookeries of the Pribilof Islands also devolved upon the naturalist of the *Albatross*, whose observations in that regard are elsewhere referred to.

On May 17, 1894, in company with the flagship of the fleet, the U. S. S. *Mohican*, the *Albatross* left Port Townsend, Wash., and proceeded to Unalaska, going thence to Attu Island, at the western end of the Aleutian chain, for the purpose of conveying Lieutenant Jacobs, U. S. R. M., to that place, which had been selected as the point of registry for the fur-seal vessels entering Bering Sea from the Asiatic side. On the return trip an outlook was kept for sealing schooners among the passes of the Aleutian Islands, and stops were made at the islands of Agattu, Kyska, and Atka, the fishing-grounds in their vicinity being hastily examined. The regular patrolling work in Bering Sea was taken up before the close of June, 1894, and was continued until after the middle of September, being interrupted only by visits to Unalaska for coal and to the Pribilof Islands in connection with the rookery investigations, and by a trip to the region of the Sannak Islands. In the course of the season the cruising-ground of the *Albatross* was extended practically to all sides of the seal islands, both outside and inside of the protected zone of 60 miles radius.

The first part of July Shaw Bay, on the north side of Unimak Island, and Akutan Bay were visited. On the 12th of the same month Mr. C. H. Townsend and Mr. N. B. Miller were landed on the Pribilof Islands to begin the photographing and delineation of the rookeries, and the steamer proceeded thence to the southern entrance to Isanotski Strait, between Unimak Island and the mainland, in order to intercept any sealing vessels that might attempt a passage through. After remaining there and at Morzhovoi village several days she joined with the U. S. S. *Petrel* in an examination of the anchorages about the Sannak

Islands to which small vessels resort, and also did some sounding work between those islands and the mainland. The latter part of July Mr. A. B. Alexander, fishery expert of the *Albatross*, was detailed to the sealing schooner *Louis Olsen*, of Astoria, Oreg., to enable him to make more complete observations relative to the fur-seal at sea than were possible from the steamer. He remained with the schooner during her entire cruise, and went with her to Victoria, B. C., where he subsequently rejoined the *Albatross*.

Early in August, while tracing the limit of seal movements to the northwestward of St. Paul Island, in the direction of Cape Nazarin, on the Siberian coast, a line of soundings was run out into the deep water beyond the 100-fathom curve, which developed an elevation or submarine ridge of proportionally great height above the surrounding bottom, but the examination was too limited in extent to show its relations with the platform. The region is a favorite feeding-ground for seals, and Lieutenant-Commander Drake believes that the ridge has more or less influence upon the currents bordering the platform, possibly affecting the presence and abundance of pelagic life. Only a comparatively small number of fishing trials by hand lines were made during this season, but the shore fisheries were studied and collections made by seining at all places visited by the steamer. Many important hydrographic results, both at sea and along the coast (the latter relating to the shore line, harbors, etc.), were accomplished.

The *Albatross* left Unalaska on September 20, and proceeded by way of Sitka and Port Townsend to the Mare Island navy-yard, where she arrived on October 17. A brief stop was made in the Puget Sound region in order to obtain information from the recently returned sealing vessels respecting the extent and character of their catch and their experiences during the past season. Mr. Townsend and Mr. Alexander were also left in this region, where they remained for several weeks, continuing the investigation of the local sea and salmon fisheries which had previously been taken up.

The control of the *Albatross* was relinquished by the Secretary of the Navy on October 20, soon after which extensive repairs to the hull and fittings were begun; they were not finally completed until the middle of May, 1895. During this interval two examinations of Willapa Bay, Washington, were made by Mr. Townsend and Mr. Miller, respectively. The former visited the bay in the fall of 1894, for the purpose of determining the best location for making a plant of eastern oysters. The latter was there in March, 1895, and made a general study of the bottom and of the density and temperature of the water with reference to oyster-culture.

The work of the *Albatross* for the summer of 1895 was planned upon a different basis from that of the previous two years, although her cruising ground was to be essentially the same. Instead of being attached to the patrol fleet, the steamer was given an independent status, under the direction of the Commissioner, in order that the several lines of

inquiry which more properly belonged to her might be carried on with less interruption. The commanding officer, however, was duly commissioned to board and inspect any pelagic sealers which he might encounter, so as to afford the means of securing the important character of information only to be obtained in that way. Besides serving for the transportation of the several persons detailed to conduct the special researches relative to the fur-seal on the Pribilof and Commander islands, as elsewhere explained, the work laid out provided for the same character of observations as heretofore. The hydrographic features of Bering Sea, both on the eastern platform and in the deeper waters, were to be studied with reference to their bearing upon the different fishery and sealing problems. The pelagic sealing investigations were to be made the principal feature of the cruise, and fishing trials were to be conducted whenever the vessel was on suitable ground for that purpose. Arrangements were also made to have Mr. Alexander join one of the larger sealing schooners during the open season for hunting in the sea, in order that he might confirm and extend his observations of the previous season.

Leaving San Francisco on May 18, 1895, the *Albatross* proceeded to Victoria, B. C., and Port Townsend, Wash., where several days were spent in gathering information respecting the spring seal-fishery and the intention of the hunters relative to summer fishing in Bering Sea. She was joined at Port Townsend by Mr. True and Mr. Prentiss, bound for the Pribilof Islands. On June 15 the vessel reached Unalaska, where Mr. Stejneger reported on board for transportation to the Commander Islands. St. Paul Island was visited on June 24 for the purpose of landing Messrs. True, Prentiss, and Miller, and on the 26th of that month the *Albatross* started for the Asiatic side, running a line of soundings westward along the parallel of  $56^{\circ}$  N. from longitude  $177^{\circ}$   $30'$  W., to which point her hydrographic surveys had previously been carried. This work was still under way at the close of the fiscal year, but enough progress had been made to show the comparatively uniform level of the bottom across this part of the Bering Sea basin, the depths ranging only from 2,056 to 2,105 fathoms, and the bottom consisting of brown mud and ooze.

During the fiscal year 1894-95 the *Albatross* was at sea 112 days and steamed 13,181 miles.

#### JOINT INVESTIGATION OF FISHERIES IN WATERS CONTIGUOUS TO CANADA AND THE UNITED STATES.

The investigation of the fisheries in the waters contiguous to Canada and the United States, undertaken in accordance with the provisions of the joint agreement of December 6, 1892, between this country and Great Britain, was continued during the summer, fall, and spring months and related chiefly to the chain of the Great Lakes and Lake of the Woods, and to the mackerel fisheries. The two representatives, Dr. William Wakeham, on the part of Great Britain, and Mr. Richard

Rathbun, on the part of the United States, visited all of the waters examined and gave their personal attention to the different problems arising in connection with each of them. The study of the Great Lake system was first taken up by them in the fall of 1893, at which time the inquiries were restricted to the upper part of the St. Lawrence River and the Canadian shores of Lake Ontario and Lake Erie. The work was resumed in June, 1894, when the examination of the United States waters was begun, a large force being organized for this purpose in order to complete the task in as short a time as possible.

The statistical inquiries were prosecuted by the Division of Statistics under the direction of Dr. Hugh M. Smith, the assistant in charge, while the investigation of the fishes and fishing methods was carried on by several special parties, as follows:

Lakes Ontario, Champlain, and Memphremagog, and the upper St. Lawrence River, by B. W. Evermann and R. R. Gurley, of the Fish Commission, assisted by Barton A. Bean, of the United States National Museum, and R. H. Hineckley, of Bowdoin College.

Lake Erie and Lake St. Clair by H. F. Moore, of the University of Pennsylvania; B. L. Hardin, of the Fish Commission, and Cloud, Rutter, of Stanford University.

Lake Huron by J. T. Scovell and D. C. Ridgely, of Indiana.

Lake Superior and Lake of the Woods by Dr. Wakeham, Mr. Rathbun, and A. J. Woolman and U. O. Cox, of Minnesota.

The examinations along the Canadian shores of Lake Superior and Lake Huron, including Georgian Bay, were made by the representatives themselves, having the use of the Canadian fishery cruiser *Petrel* in the last-mentioned waters. They also held conferences with the fishermen at all the important fishery centers along the chain of lakes except on Lake Michigan, which was omitted from their inquiries as not forming a part of the boundary system.

The investigations made in these waters were conducted upon as comprehensive a basis and in as thorough a manner as the time and circumstances permitted. Their object, as explained in previous reports, was to determine the present condition of the fisheries as compared with their condition in the past, the extent and causes of any decrease which had occurred, the necessity for remedial measures, and the regulations best suited to insure the maintenance of the supply of fishes and to provide for its increase where a depletion had taken place. The scope of the work, in view of the short period available for its completion, precluded to a great extent the making of the detailed researches essential to positive conclusions on all points. The testimony of the fishermen had, therefore, to be depended upon in large part, but their statements were carefully weighed in the light of the combined evidence obtained, and much important and accurate information was secured through the direct observations of the field assistants.

The most essential feature of the investigation was the study of the important market fishes in their relation to fishing methods employed

for their capture. This required a knowledge of the distribution of the several species, of their habits and movements, their food, their spawning seasons and places, and of the history of the younger stages. With respect to the apparatus, it was essential to ascertain the character, location, and amount of each kind in use and the conditions under which their operation is effective. The position and extent of all fixed appliances were accurately determined and represented on a series of charts to illustrate graphically their relations at different periods to the bodies of fishes which they intercept, and the distribution by quantity of the movable appliances, the gill nets especially, was worked out, for each season, with as much definiteness as possible. The sizes at which the different fishes reach maturity in relation to the sizes of the mesh in the several kinds of nets by which they are taken, and the extent of capture of immature sizes were also studied, as well as the effects of fishing during the spawning seasons and at other periods when harmful results are claimed to be produced, the effects of polluting agencies, etc.

The relations of the size of mesh in the pound nets to the sizes of the fishes taken by that means was, moreover, made the subject of experiment both in the fall of 1894 and in the spring of 1895, a pound net specially constructed with a different size of mesh on each side being employed for that purpose. During the former period it was fished off Huron, Ohio, in one of the pound-net strings owned by Messrs. Wickham & Co., and during the latter period off the south side of Kelley Island in one of the strings belonging to the Sandusky Fish Company. The net was operated free of charge by both of these firms, and every means was taken by them to insure it a fair trial. Mr. Rutter was in charge during the fall season and Mr. Hardin during the spring.

The mackerel inquiries conducted in part with reference to the requirements of the joint investigation were continued during the summer of 1894 and were again taken up in the spring of 1895, as explained under another head. During May, 1895, the representatives visited the southwestern coast of Nova Scotia for the purpose of investigating the movements and other points in the natural history of the mackerel, as well as the fisheries to which they give rise in that region, no previous observations having been made with respect to that subject there.

During July and August, 1894, a detailed hydrographic survey of the upper tidal part of the St. Croix River, lying between the State of Maine and the Province of New Brunswick, was made by Ensign W. L. Dodd, U. S. N., executive officer of the steamer *Fish Hawk*, assisted by H. A. Ross and W. F. White, of Bowdoin College. The object of this work was to provide the necessary data for determining the extent to which the sawmill refuse from the mills above have affected the river channel since the previous Government surveys, and its consequent influence upon navigation and upon the salmon and other anadromous fishes which resort to those waters.

## MACKEREL AND MENHADEN INVESTIGATIONS.

## MACKEREL.

The observations made in 1893-94 respecting the natural history of the mackerel and the fisheries to which it gives rise were repeated during the past year in accordance with the same plan and on practically the same basis. The capricious habits of the species, its fluctuating abundance as indicated by the size of catch, its wide distribution and far-reaching movements make it one of the most difficult of all the commercial fishes to study or to comprehend. It is thought, however, that the series of investigations which has been in progress for several years and which is still to be continued will throw much new light upon the practical questions connected with its history, and will aid in determining to what extent, if any, the supply may be affected by the several methods employed for its capture.

At the beginning of the fiscal year the schooner *Grampus*, E. E. Hahn, master, and W. C. Kendall, naturalist, was investigating the offshore mackerel fisheries in the Gulf of Maine, with headquarters at Gloucester, Mass. The latter part of July and the first half of August, 1894, were spent in cruising in the Gulf of St. Lawrence, the season's work terminating at Gloucester the last of August. In the spring of 1895 the *Grampus* was again detailed to the study of this species and continued to be so employed until the end of the fiscal year. The inquiries were of the same character as in previous seasons, being designed to secure as complete a history as possible of the early movements of the mackerel as they approach and work up the coast on the way to their several spawning and summer schooling grounds. The cruise began on April 12. Lewes, Del., was made the headquarters until May 10, when, the body of fish having left southern waters, the *Grampus* proceeded to the region off New York and thence eastward over Georges and Browns banks to the coast of Nova Scotia. Here the schools of fish were closely followed to Cape North, Cape Breton Island, and a short cruise made into the Gulf of St. Lawrence. The schooner returned the last of June to Gloucester, where preparations were made to continue the inquiries during the summer in the Gulf of Maine.

Shore parties were at work at all seasons of the year during which the mackerel were present on the coast. During July and August, 1894, Capt. A. C. Adams and Dr. W. E. Wolhaupter, with the assistance of the steamer *Fish Hawk*, were engaged on the coast of Maine, their investigations extending eastward from Portland as far as Jonesport. All important fishing localities were visited, the nets and catch inspected, and the fishermen interviewed. Subsequently and until late in the fall, Captain Adams was occupied mainly with the study of the fishery from the ports of Gloucester, Boston, and Portland, while Dr. Wolhaupter returned to the southern coast of New England to complete his observations begun there the previous spring. Both of these assistants again took up the field work in April, 1895. Captain Adams's



inquiries during the spring season were restricted to the coast of Massachusetts north of and including the waters about Cape Cod. Dr. Wolhaupter began at Virginia Beach, Va., which is nearly as far south as the mackerel strike the shore, and proceeded thence northward along the coast as far as Cape Cod, visiting in succession nearly all localities where mackerel are taken in shore nets. For a short period in the course of his trip he was stationed in New York City, and then continued to the important spawning region off Rhode Island and southeastern Massachusetts, where most of the month of June was spent.

Mr. B. L. Hardin was detailed, as heretofore, to conduct the customary inquiries at Fulton Market, New York City, his observations being mainly supplemental to those made on board the schooner *Grampus* and designed to complete the records bearing upon the offshore fishery. Every fare landed by the purse-seiners, which were then at work exclusively on the southern grounds, and also all catches marketed there from the shore fisheries were carefully inspected, and all information that could be obtained relating to the capture and condition of the fish, etc., was fully noted. Through the courtesy of Hon. E. G. Blackford, convenient office and laboratory accommodations were provided, and to him as well as to the other prominent fish-dealers of New York Mr. Hardin was indebted for the means of carrying on his work successfully. Mr. Hardin reached New York about the middle of April and continued there until the end of the first week in May, when he was replaced by Dr. Wolhaupter, who remained until the close of that month.

Some of the observations made this year at Fulton Market relative to the spawning season and habits of the mackerel were especially interesting. The first fish received were two individuals caught in shad nets on the coast of North Carolina on April 6 and 8. The first fare brought in from the offshore grounds consisted of 7,700 mackerel taken in a purse seine on April 17, about 65 miles southeast of Cape Henry. They measured from 10 to 17½ inches long. In some of the larger of these fish the reproductive organs were found to be spent, indicating that they had already spawned, and giving an earlier date for the beginning of the spawning season, at least in some years, than had previously been supposed. The location where the spawning had taken place could not, of course, be told, but that it was not situated close to the shore would seem to be shown by the fact that never more than small quantities of mackerel are ever taken so far south in the shore apparatus. In several subsequent purse-seine catches made off the Virginia coast up to the last of April, and even into May, the same conditions were observed, more or less of the fish having apparently spawned, while in others the eggs were approaching maturity, but in no case did the fish seem actually to have been spawning at the time when taken. It should be explained, in this connection, however, that only a relatively small number of the fish from each fare marketed could be obtained for examination, and are the basis for the facts above mentioned.

About May 1 the shore nets on Long Island and along the southern coast of New England began to take their first mackerel, which appeared latest and continued longest at the eastern end. The fish which reached New York from this region were either in spawning condition or nearly ripe.

#### MENHADEN.

On November 1, 1894, a number of menhaden, which were evidently very nearly in spawning condition, were received at Washington from Cape Charles City, Va., having been captured outside of the capes of Chesapeake Bay. Evidence had previously been obtained pointing quite conclusively to the occurrence of a late fall spawning season for this species in at least part of the area covered by its distribution. These specimens furnished additional testimony to the same effect, and called attention to what seemed an excellent opportunity to secure more definite information on the subject. Dr. W. E. Wolhaupter was accordingly detailed to investigate the matter, and proceeded at once to Cape Charles City, where he was joined by the launch *Petrel*, which was fully equipped to carry on whatever inquiries might be suggested by the circumstances. The work was continued in the lower Chesapeake Bay until near the middle of December and was vigorously prosecuted during all of that time, the examinations covering both shores of the bay and including an inspection of the fish brought in by the menhaden steamers. Subsequently Dr. Wolhaupter's observations were extended to the coast of North Carolina in the neighborhood of Beaufort. Although unsuccessful in obtaining spawning fish or in locating the spawning-grounds at this season, he was able to add many important facts to our knowledge of the habits of the species.

Dr. Wolhaupter is led to conclude that during at least the latter part of October, all of November, and the early part of December no large body of menhaden enters Chesapeake Bay for spawning or other purposes. During more or less of this period, however, large numbers are present on the outer coast between the capes of the Delaware and Cape Lookout, North Carolina, evidently making their way southward. At times, owing to weather conditions, the presence of enemies possibly, and other causes, small quantities may be driven a short distance into the bay, where they are sometimes caught a few miles inside of the capes. A thorough examination, however, of a number of the creeks and rivers emptying into the bay to which the menhaden resort in the spring failed to disclose any, and only a few scattered ones, of relatively small size, were found along the bay shores. All the large specimens seen came from outside the bay and were obtained from the steamers. In the majority of the larger females dissected the ovaries contained large and well-defined eggs, round and free, but opaque. No milt could be secured by ordinary pressure on the body of the males, but the handling of these fish, as a rule, generally caused some milt to ooze out. Most of the fish measuring  $10\frac{1}{2}$  inches long seemed nearly ready to spawn, but there was no way of measuring the length of time which

must still elapse before they became actually ripe. Those examined toward the end of the runs were apparently no further developed than those obtained in the beginning, but it might well happen that in passing down the coast the fish of each successive school or body attained practically the same stage of development upon reaching corresponding latitudes. On this point, however, nothing positive can be said.

Dr. Wolhaupter's observations, therefore, although confined to a single season as regards the fall run of fish, would appear to indicate that the large schools of menhaden which pass down the coast during the latter half of the fall, and in which the mature sizes contain nearly ripe eggs and milt, do not enter Chesapeake Bay except as they may be driven in momentarily to a slight extent by outside influences. The fish composing this fall run differ from those taken in the bay in that they are apparently shorter and thicker in build and have a brighter and more silvery look. Of the specimens examined by Dr. Wolhaupter not one contained the peculiar isopod parasite lodged in the mouth, which is so characteristic of the bay schools. This run, moreover, does not resort to the inlets of North Carolina in the neighborhood of Beaufort, and apparently not elsewhere. Does it find its spawning-grounds in the open sea or in more southern rivers and bays?

During the following winter and spring the menhaden inquiries, with special reference to the spawning habits of the species, were continued in the lower Chesapeake Bay by the steamer *Fish Hawk* under the direction of her commanding officer, Lieut. Robert Platt, U. S. N. These investigations were begun on January 19 and terminated on May 1. The west shore of the bay, just below the mouth of the Potomac River, was selected as the principal seat of operations, as the creeks in this vicinity were known to teem with young menhaden during the spring and summer months. During most of the time headquarters were maintained in Cockrell Creek, from which place trips were made to neighboring localities, and occasionally to more distant ones. Fishing was carried on by means of fyke-nets, seines, and gill nets in the inclosed waters, as circumstances permitted, and after the opening of the spring season the trap-net catches of the regular fishermen were inspected daily. The work was greatly interfered with by ice until about March 1, previous to which date but little fishing could be done. The first menhaden secured in the vicinity of Cockrell Creek was a single individual taken in the *Fish Hawk's* seine on March 11. Traps were first set in this region about March 5, but they were not extensively fished until some time later. Two small menhaden were caught by this means on March 23, and about 50 on the 25th. On the 26th the *Fish Hawk* made its first catch in the upper part of any of the creeks, namely, 30 individuals, measuring from  $2\frac{1}{2}$  to 5 inches long each. Around Hampton a few small menhaden had been taken in the traps as early as March 8.

About April 9 the menhaden struck in more abundantly between Wicomico and Smith Point, and from this time the trap nets made

larger catches, but they never became very abundant at any time during this month. The *Fish Hawk* continued to take small quantities of the younger sizes, finding them almost exclusively in the upper parts of the creek. Although comparatively large numbers of the adults were examined, no positive evidence was obtained, based upon the condition of their reproductive organs, as to the time at which they spawn. No further light, moreover, was thrown upon the location of their spawning-grounds, but the continued finding of the young fish in the brackish streams adds weight to the supposition expressed in former reports that to some extent at least the species spawns in such situations.

#### OYSTER INVESTIGATIONS AND EXPERIMENTS.

Willapa Bay, formerly known as Shoalwater Bay, abounds in the native oyster of the Pacific Coast, the *Ostrea lurida*, which has there been cultivated to a greater extent than in any other locality. This bay has been a source of supply of this species for the San Francisco market during many years, dating back to the period before the introduction of the eastern variety in Californian waters, and its principal fishery now consists in the rearing of this mollusk. The primary source of supply consists of the natural deposits from which the oysters are tonged, and, being sorted or culled, the largest are marketed at once and the rest transplanted to suitable bottoms for further growth, requiring from two to three years. In 1895 over 2,000 acres were under cultivation in Willapa Bay, the output in that year having been valued at over \$66,000, and the number of persons employed about 350.

It has for some time been the desire of the inhabitants of this region to attempt the introduction and cultivation of the Atlantic Coast species, the belief being strong that Willapa Bay was well adapted to this purpose, as indicated by the richness of its native stock. Large quantities of small eastern oysters or seed oysters have been transported annually across the continent for planting in San Francisco Bay, where they attain a suitable size for the market in the course of three or four years. It has generally been supposed until recently, however, that the eastern stock did not propagate in San Francisco Bay, and the industry has been restricted to the transplanting and growing of the seed. Investigations made within a few years show quite conclusively that this species is capable of reproducing in Californian waters to some extent at least, and that a natural growth has there been taking place for some time, practically unnoticed. One of the principal reasons for the slow progress apparent in this natural increase is probably the limited extent of bottom suitable for the attachment of the spat, although the low temperature of the water, as has always been claimed, as well as other causes, may also have some effect.

The establishment of the fact that the eastern oyster will propagate on at least some parts of the Pacific Coast, leading to the supposition that the formation of self-sustaining beds is a possibility, has greatly stimulated the interest in this mollusk and has led to renewed demands

for practical experiments in that line. During a visit to Willapa Bay in 1893, the Commissioner of Fisheries was much impressed with the advantages which that locality seemed to offer in respect to oyster-culture, and arranged for investigations to determine the most favorable site for making a preliminary planting of the eastern species. This examination was made in October, 1894, by Mr. C. H. Townsend.

Willapa Bay, which indents the southern part of the coast of Washington, is about 25 miles long, with an average width of about 5 miles. It contains extensive shoals and tide flats, but deep channels make navigation possible through most of its extent. There are several tributary streams, none of which are navigable for more than a few miles above their mouths and some not at all. The natural oyster deposits occur along the channels, from the mouth of the Willapa River in the north to the extreme head of the bay in the south, but the cultivated beds are confined to the northern half of the bay. Many places apparently favorable to the experiment were found in different parts of the bay, but the importance of placing the introduced oysters where they could be constantly under surveillance led to the selection of a site in Palux Channel, close by the village of Bay Center. The conditions here seem to be as favorable as in any part of the bay. The channel lies well back of extensive flats, which would have a tendency to increase the summer temperature, which is desirable, and it has a depth of 8 feet at low water, sufficient security against the winter frosts that injure oysters on shallow, transplanted beds. The bottom is firm, and is well supplied with native oysters, while starfishes are reported to be less abundant here than elsewhere. The stingrays, so destructive to oysters in Californian waters, are not found on the coast of Washington, and the placing of a fence of closely driven stakes about the beds, so essential in San Francisco Bay, will not be necessary here. The most uncertainty arises in regard to the question of temperature, and this matter can only be settled by actual experiment in the manner now to be done.

The planting was made in the fall of 1894, under the supervision of Mr. Townsend and with the cooperation of the State fish commissioner of Washington, Mr. James Crawford, a large number of the oystermen of the region being also present. The oysters were shipped from New York City on October 26, making up a carload of 80 barrels, representing the following well-known oyster localities, namely: East River, 13 barrels; Princess Bay, 14 barrels; Newark Bay, 8 barrels (seed oysters); Raritan Bay, 10 barrels (natural growth); Keyport, 23 barrels; Chesapeake Bay, 12 barrels. They were planted seventeen days later, an examination of each barrel as it was opened showing the oysters to be in good condition, only a very small number of dead ones being found. The entire lot was massed in one locality, covering an area of about 3 acres, thereby increasing the chances of fertilization and making it more convenient to keep track of and protect the bed.

Early in the spring of 1895 Mr. N. B. Miller, of the steamer *Albatross*,

was detailed to make an extended series of observations relative to the densities and temperature of the water in different parts of Willapa Bay. This work was begun on March 18 and was continued until April 5. Observations were made hourly in each locality visited, and while the temperature was naturally low in all places, owing to the season of the year, the density generally was found to come within the limits considered favorable to oyster growth. In the channel of Palux River, where the oyster deposit had recently been made, the density ranged from 1.00968 to 1.01746, according to the state of the tide. Ninety of the introduced oysters were tongued up by Mr. Miller, and of these 83 were living, the remainder being empty shells.

In October, 1895, the bed was again inspected by State Commissioner Crawford, who examined a sufficient number of specimens to ascertain that the oysters were doing well and that the general condition of the plant was excellent. A few that were opened were found to be fat and well flavored. It will be advisable to arrange for the placing of a quantity of cultch or spat-collectors in proximity to the bed at the proper season. The legislature of the State of Washington has passed an act for the protection of this oyster bed.

#### INVESTIGATIONS OF INTERIOR WATERS.

##### COLUMBIA RIVER BASIN.

The investigations begun in the Columbia River basin in the spring of 1894 by Dr. Charles H. Gilbert and three assistants from Leland Stanford Junior University were continued by the same party during the entire succeeding summer. The primary object of these inquiries, as explained in previous reports, was the study of the life-history of the quinnat and other species of salmon which ascend the Columbia River for spawning purposes, and respecting which more definite information is required in order to provide for the better protection and maintenance of the supply. The salmon were followed in their movements upstream and their location was noted from time to time. The waters examined were the main Columbia River, the Snake River between its mouth and Upper Salmon Falls, and several of the smaller tributaries. Attention was also paid to fishes other than the salmon whenever favorable opportunities occurred, and suitable collections representing all the species observed were preserved for future study.

Dr. Gilbert was obliged to resume his college duties the 1st of September, when the field work was taken up by Prof. B. W. Evermann, of the Fish Commission, assisted by Dr. J. T. Scovell, of Terre Haute, Ind. It was continued into the early part of October. During this period the observations related chiefly to the three following regions: The streams and lakes constituting the headwaters of Salmon River in Idaho, the streams and lakes at headwaters of Payette River in Idaho, and that part of Snake River lying between the Great Shoshone Falls and Huntington, Oreg. Though less than five weeks were given to

this part of the work, a number of new and important facts were discovered respecting the habits of the three principal species of *Salmonida* which spawn in these upper waters, namely, the chinook or quinnat salmon (*Oncorhynchus tshawytscha*), the blueback salmon or redfish of Idaho (*Oncorhynchus nerka*), and the steelhead trout or salmon trout (*Salmo gairdneri*). A preliminary report upon the investigations made in Idaho has been published.\*

Important spawning-beds of the chinook salmon were found in Salmon River and Alturas Creek near Sawtooth, in Payette River just below Big Payette Lake, and in Snake River at Upper Salmon Falls, while less important ones occur in the different tributaries of Weiser River. It is also believed that large numbers of this species spawn in other parts of Snake River and in other of its tributaries, but the location of such grounds has not been definitely determined. The spawning time of the chinook salmon which ascend to the colder waters was found to be considerably earlier than in the case of those which spawn in the Snake River. In the upper Salmon River it was over by September 12, and in Payette River by September 27, but at Salmon Falls it did not terminate until about November 1. This difference is supposed to depend upon differences in the temperature of the water.

The steelhead trout spawns extensively in the headwaters of Salmon River, Payette River, and Weiser River, and in Snake River, but as its spawning season is in the early spring nothing definite was learned regarding its habits or abundance in the region examined. In September and October it was not found in any of the waters named except the Snake River, in which it was quite common at Weiser during September, and a few were also seen at Upper Salmon Falls.

The most interesting salmon which occurs in Idaho waters is the blueback, known locally as the redfish. It was observed spawning in September in the inlet of Alturas Lake near Sawtooth, and in that of Big Payette Lake. The inhabitants of the region have long been acquainted with these spawning grounds, but they had never been visited by a naturalist until this year. The examinations were made on September 12 and 13 at the inlets of Alturas and Pettit lakes, and on September 27 at the inlet of Big Payette Lake, and individuals were seen upon the beds on each of those dates. Many dead fish were found at each lake and the spawning season of the species in these places was evidently about over. Nearly all the live fish observed were more or less covered with sores, and their fins were frayed out. It is probable that the redfish which spawn in these waters never return to the sea, and that all die after accomplishing their reproductive functions.

Two forms of the redfish are known to spawn in the inlets of the lakes mentioned. One of these, known as the little redfish, measures 10 to 13 inches long and weighs almost invariably about half a pound apiece. The other is very much larger, being from 20 to 25 inches

\* A preliminary report upon salmon investigations in Idaho in 1894, by Barton W. Evermann, Bull. U. S. Fish Comm., xv, for 1895, pp. 253-284.

long and weighing from 3½ to 6 pounds apiece. Whether two distinct species are here represented or not is an unsettled question. The larger form agrees with the blueback salmon caught in such great numbers in the lower Columbia River, and is doubtless the same fish. Individuals corresponding to the smaller form, however, have never been taken in the lower Columbia, and some maintain that it represents a landlocked variety which does not ascend from the sea. The absence of important structural differences and our present knowledge of the habits of the two forms render doubtful the correctness of this opinion, and further study is required to determine the matter satisfactorily.

The bulk of the fish caught in connection with the extensive fisheries of the lower Columbia River is made up of the three species of salmon above referred to. The important questions which have been raised in respect to their decrease and the necessity for active measures to secure the maintenance of the supply of each have stimulated the comprehensive and detailed observations which have been carried on during the past three years. Substantial progress has been made toward determining the movements of the several forms throughout the basin, their general habits, and times and places of their spawning, information necessary as a firm foundation for legislative action on fish-cultural operations; but the wide extent of this river system precludes the early completion of the work. It is proposed to continue the investigation until more decisive results have been accomplished.

#### ARKANSAS.

During August, 1894, Prof. Seth E. Meek, of the Arkansas Industrial University, spent a short time in the service of the Fish Commission making a study of the fishes of the St. Francis River, in northeastern Arkansas. This river was remarkably rich in fish life as regards the number, both of species and of individuals. A total of 61 species was obtained, including no fewer than 20 important food varieties. In his report upon the investigation,\* Professor Meek states:

It was a comparatively easy matter, with a collecting seine, to catch pickerel and black bass weighing from 1 to 3 pounds. The water was quite clear, and large gars, buffalo, pickerel, black bass, and sunfishes could be seen in abundance. The usual method of catching black bass (the favorite food-fish) was trolling. The parts of two days I spent on Old River I saw many black bass taken this way. Two men would be out one or two hours and return with a dozen or more black bass weighing from 2 to 5 pounds. In all of my collecting I have never seen another stream that seemed to contain the enormous amount of fish life found in Old and St. Francis rivers.

#### THE GREAT LAKES.

Extensive investigations were carried on during the season of 1894 throughout the entire chain of the Great Lakes, except Lake Michigan, and also on the Lake of the Woods, as explained in connection with the work of the Joint Fisheries Commission.

\* A list of fishes and mollusks collected in Arkansas and Indian Territory in 1894 by Seth Eugene Meek. Bull. U. S. Fish. Comm., xv, 1895, pp. 341-349.



## WOODS HOLE LABORATORY.

The Woods Hole laboratory of the Commission was opened as usual during the summer of 1894 for the prosecution of scientific researches bearing upon the marine animals and plants of the region, and advantage was taken of the excellent facilities there afforded for that purpose by twenty-three investigators, representing thirteen prominent educational institutions. Several of these workers arrived during the latter half of June, but the greater number were present during July and August only, a few, however, remaining into September. Less work was undertaken here this year than last in the direct interest of the Commission, as its scientific assistants, both permanent and temporary, were mostly employed in other places.

The Commissioner made Woods Hole his headquarters during the greater part of the summer, and, as usual, gave much of his time to the scientific problems which were in course of study, aiding and promoting the inquiries by suggestion and by active participation in certain branches of the work. As in 1893, Mr. J. Percy Moore, instructor in biology in the University of Pennsylvania, was in charge of the laboratory, reaching there on June 4 and remaining until September 14. The other naturalists in attendance were the following: Prof. F. H. Herrick, of Adelbert College; Dr. James I. Peck and Mr. N. R. Harrington, of Williams College; Dr. William Patten, Mr. W. A. Redinbaugh, and Mr. Herbert Tetlow, of Dartmouth College; Mr. F. S. Conant, Mr. H. McE. Knowler, and Mr. George Lefevre, of Johns Hopkins University; Dr. Charles McClure and Mr. Ulric Dahlgren, of Princeton College; Dr. Jacques Loeb, of the University of Chicago; Dr. Ira van Gieson, of Columbia University; Mr. W. E. Castle, of Harvard University; Dr. W. S. Nickerson, of the University of Colorado; Dr. John A. Ryder and Mr. Philip P. Calvert, of the University of Pennsylvania; Mr. Maurice A. Bigelow and Mr. Edgar A. Bedford, of the Ohio Wesleyan University; Mr. Warren H. Everett, of Hamilton College; Mr. Howard A. Ross and Mr. William Frye White, of Bowdoin College; Dr. W. E. Wolhaupter, of the Fish Commission.

It was hoped that the opportunity would be afforded for the study of the embryology of the mackerel by Mr. Moore, but unfortunately the circumstances did not permit. During June he cooperated with Mr. Vinal N. Edwards and Dr. W. E. Wolhaupter, who were engaged in making observations respecting the habits of the mackerel and the mackerel fisheries in the important breeding region along the southern coast of New England, but the practical failure of the fishermen to obtain fares at the proper season made it impossible for him to secure the material required for his special researches.

During the remainder of the season Mr. Moore was chiefly occupied, under the direction of the Commissioner, in reorganizing the type collection of local marine animals, being assisted at different times by Messrs. Bedford, Ross, and White. This collection has gradually

been brought together, partly as a result of the summer investigations during many years past, and partly through the active exertions of Mr. V. N. Edwards, whose collecting work at all seasons during a long period has been productive of many important discoveries and has furnished a practically complete history of the fishes of the region. The series is most perfect as regards the fishes, but it also contains a very large representation of the groups of invertebrates, illustrating the fauna of both the littoral zone and of the adjacent deeper waters.

The collection is especially valuable to the investigators studying at Woods Hole, who are thereby enabled to identify, with little trouble, the material on which they are at work, and as the basis of a local check list it must prove of great assistance. One of the small rooms on the second floor of the building has all along been assigned to the purposes of a museum, but the limited space, as well as the open board shelving provided, have not been adequate to the safe-keeping and appropriate display of the specimens. At the close of the World's Columbian Exposition, a number of substantial and ornamental cases used there were transported to Woods Hole, and those have afforded the means for the new arrangement consummated during the summer of 1894. They have been placed in the north hall on the main floor, where there is ample space and where they can conveniently be reached by the public. It is proposed to make up the desiderata in the collection as opportunities occur. The marine aquaria have also been rearranged in an artistic manner in a room adjacent to the above, where they will better serve the purpose of both the student and the general visitor.

Experiments were also carried on under Mr. Moore's direction in the use of the new preservative, formalin, which is now attracting much attention, and the most satisfactory results were obtained. It was found to be admirably suited to the preparation both of museum specimens and of those intended for future study, whether of delicate organization, like the polyps, or of more hardy texture, like the fishes. The contraction and distortion is much less than with alcohol; the specimens retain a strikingly life-like appearance and the colors are preserved to a considerable extent.

Dr. James I. Peck, assistant professor of biology in Williams College, continued for the Commission his interesting observations on the food of marine fishes, begun in 1893, with the menhaden as his subject. These consisted, in part, of the determination of the stomach contents of specimens of several of the important fishes and in part of plankton studies. The fishes examined were the squeteague, bluefish, sea bass, scup, and tautog, which exhibit considerable differences in feeding habit, although all are carnivorous. Of the squeteague, 570 individuals were opened, much more than in the case of any of the other species. The character and quantity of each kind of food were accurately determined, and the resulting tables are of great interest. The studies were carried much further, however, in the direction of tracing back the food of fishes, through successive stages, to its primary basis, leading to the

more novel of Dr. Peck's inquiries. In the report upon the results of his work this season he explains, as follows, the purpose and general plan of his observations on the fundamental food elements contained in the coastal waters:\*

In order to contribute toward a knowledge of the quality, quantity, life-history, and conditions of environment of this primary food supply, consisting of Protozoa, Protophyta, free-swimming larvæ, and the like, many observations were made during the earlier part of the summer of 1894 with respect to the surface water in the larger harbor at Woods Hole, where collections of the organisms were systematically obtained from measured quantities of the water at different times of the day and tide, and under different conditions of temperature. Likewise, by means of the steamer *Fish Hawk*, which was provided with suitable apparatus for the purpose, I was enabled to collect many samples from the waters of Buzzards Bay, not only at the surface, but also at mid-depth and at the bottom. A definite section was laid out across the bay and another running longitudinally through the same body of water some distance out to sea. These lines of section were divided into equal intervals with definite stations established, in order that a rigid system of representative localities might be followed, by a study of which a knowledge of the bay as a whole might be increased.

After describing briefly the variety, nature, and habits of the microscopic plants and animals occurring under these conditions, Dr. Peck proceeds to discuss the details of his investigation, which consisted chiefly in determining quantitatively the relations of the more prominent groups of these pelagic organisms at different levels and at different times of the tide and day along the two sections in Buzzards Bay above referred to. At the several stations at the time of each observation samples were taken from the surface, mid-depth, and bottom—from the two latter by means of hose operated by the vessel's pump, which permitted of the rapid collecting of any quantity desired under the most favorable conditions. The solid organic contents of each of these samples, which measured 5 liters apiece, was isolated by filtration through a bed of fine-washed sand resting on a screen at the lower end of the stem of a large glass funnel. The examinations under the microscope were made in a graduated cell prepared especially for the purpose, which insured the same amount of material being contained in each sample.

The object of these investigations, of which the work accomplished during the season of 1894 is to be considered only as the initiatory step in what it is hoped will be a long-continued series, is to determine the quantity of available "pasturage" or primitive food-supply in any given region, under the varying conditions of seasons, temperature, salinity, etc., as establishing the relative value of its waters for originating, so to speak, and for maintaining a stock of fishery products. Both Mr. Conant and Mr. Harrington rendered assistance to Dr. Peck in connection with his inquiries.

Dr. Herrick continued his researches on the American lobster, and, before the close of the year, had nearly completed the important mono-

\*The Sources of Marine Food, by James I. Peck, assistant professor of biology in Williams College. Bull. U. S. Fish Comm., xv, for 1895, pp. 351-368, plates 64-71.

graph on this subject which he has had in preparation for some time. The rest of the investigators were occupied with special studies of their own selection, some of which have a more or less direct bearing upon fishery topics, and in course of time will undoubtedly be found useful in arriving at practical deductions.

Mr. Vinal N. Edwards, the permanent collector of the Fish Commission at Woods Hole, kept up during the entire year his customary daily observations on the fishes of the region and on the temperature of the water. During the summer he also assisted in obtaining material required for the laboratory.

The steamer *Fish Hawk*, Lieut. Robert Platt, U. S. N., commanding, was at Woods Hole from August 25 to October 2, and during that period was utilized mainly in running the lines of observing stations in connection with the investigations of Dr. James I. Peck on the food of fishes. During the week preceding her arrival at Woods Hole she was placed by the Commissioner at the service of the biological section of the American Association for the Advancement of Science, which was then meeting at Brooklyn, N. Y., and made two dredging trips from that point.

#### TEMPERATURE OBSERVATIONS.

The Fish Commission has continued to receive, through the courtesy of the Light-House Board and of the Southern Pacific Company, the daily records of water-temperature observations taken at the following seacoast and inland stations:

##### *Temperature stations on the Atlantic Coast.*

##### Stations of the Light-House Board:

- Coast of Maine: Petit Manan Island, Mount Desert Rock, Matinicus Rock, Seguin Island, Boon Island.
- Coast of Massachusetts: Race Point, Pollock Rip light-ship, Great Round Shoal light-ship, Nantucket New South Shoal light-ship, Vineyard Sound light-ship.
- Coast of Rhode Island: Brnton Reef light-ship, Block Island southeast light.
- Long Island Sound: Bartlett Reef light-ship.
- Coast of New Jersey: Absecon Inlet, Five Fathom Bank light-ship.
- Delaware Bay: Fourteen Foot Bank light-ship.
- Coast of Virginia: Winter Quarter Shoal light-ship.
- Chesapeake Bay: Windmill Point, Stingray Point, York Spit.
- Coast of North Carolina: Cape Lookout, Frying Pan Shoal light-ship.
- Coast of South Carolina: Rattlesnake Shoal light-ship, Martins Industry Shoal light-ship.
- Coast of Florida: Fowey Rocks, Carysfort Reef, Dry Tortugas.

##### *Temperature stations on the Pacific Slope.*

##### Stations of the Southern Pacific Company:

- Sacramento River at Tehama and Yolo bridges and Knight's Landing, California.
- Feather River at Feather River Bridge, California.
- American River at American River Bridge, California.
- Mokelumne River at Lodi, Cal.
- Tuolumne River at Modesto, Cal.
- San Joaquin River at the upper and lower railroad crossings.
- King River at Kingsburg, Cal.
- Colorado River at Yuma, Ariz.