

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

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FUR-SEAL INVESTIGATIONS.

During the summer of 1895 the investigations respecting the natural history of the fur-seal and the changes in the condition of its rookeries or breeding-grounds, which devolve upon the Fish Commission by act of Congress, were prosecuted upon a much larger scale than in any previous year. The plans for this work were briefly outlined in the last report. The regular annual examination of the rookeries on the Pribilof Islands, including their delineation and photographing, was made, as heretofore, by Mr. C. H. Townsend, naturalist of the steamer *Albatross*, aided by Mr. N. B. Miller, the general assistant on the same vessel. Mr. A. B. Alexander, fishery expert of the *Albatross*, was attached during August to one of the successful pelagic sealing vessels, which gave him the opportunity of making important observations on the pelagic habits of the seals. The part taken by the *Albatross* itself in connection with this subject is described under another heading.

Novel features of the season's operations were detailed studies respecting the several problems connected with the welfare of the seal herds on both the American and Asiatic coasts, these inquiries having been conducted on the Pribilof Islands by Mr. Frederick W. True, curator of mammals in the U. S. National Museum, assisted by Mr. D. W. Prentiss, jr.; and on the Commander Islands by Mr. Leonhard Stejneger, curator of reptiles in the National Museum, and a well-known authority on the mammalia. These gentlemen were transported to their stations by the steamer *Albatross*, reaching the Pribilof Islands on June 24 and the Commander Islands on July 3, respectively. Mr. True remained in the field until August 23, and Mr. Stejneger until September 16.

The results of this season's investigations by these several parties, as well as the reports of previous work by the Fish Commission in this direction, have been published during the past fiscal year.*

*The Russian Fur-Seal Islands. By Leonhard Stejneger, of the United States National Museum. Bull. U. S. Fish Com., xvi, for 1896, pp. 1-148, pls. 1-66.

Reports of the agents, officers, and persons, acting under the authority of the Secretary of the Treasury, in relation to the condition of seal life on the rookeries of the Pribilof Islands, and to pelagic sealing in Bering Sea and the North Pacific Ocean, in the years 1893-1895. In two parts. Part II. With maps and illustrations. Results of investigations under the direction of the U. S. Commissioner of Fish and Fisheries. Printed as Senate document 137, part 2, Fifty-fourth Congress, first session. Washington: Government Printing Office, 1896. This part is published in two volumes, one of text (154 pages), with numerous maps, charts and plates; the other being a portfolio of photographic reproductions.

Mr. Townsend spent the 25th and 26th of June, while the *Albatross* was at St. Paul Island en route to the Commander Islands, in making a preliminary examination of Lukannon, Ketavie, Reef, Lagoon, and Tolstoi rookeries, on which the female seals were then scarce, the season being still early. He returned to the Pribilof Islands on July 9, beginning then his systematic observations, which were continued until August 9. Detailed studies were made of each rookery, and its condition determined and compared as closely as possible with that in 1894. Marked changes were found to have occurred in the abundance of the seals, which were less abundant than in the previous year, this fact being graphically demonstrated by a comparison of the maps and photographs covering the two seasons. The thinning out of the breeding seals, the most marked feature of the decrease, is clearly indicative of the effects of pelagic sealing, which is now being severely felt upon the islands. An approximate count of the seals was made in conjunction with Mr. True, and special attention was paid to the question of the loss of young seals by starvation through the killing of the parents at sea while seeking food.

Mr. Townsend's report also covers the operations of the pelagic sealing fleet during 1895, based upon the direct observations of the *Albatross* during the open season in Bering Sea and upon subsequent inquiries at the several ports where the fares were landed. The important subjects discussed in this report are the total number of seals taken, with the places and dates of killing, showing their distribution in both the North Pacific Ocean and Bering Sea during the hunting seasons; the proportionate number of each sex represented in the catch, and the breeding condition of the females; the ages and food of the seals so obtained, and the condition, present and prospective, of the business of pelagic sealing. Elaborate tables and charts are given, showing in detail the facts brought out by the catch of each vessel.

The object of Mr. True's inquiries was to study the natural history of the seals on the Pribilof Islands from a comprehensive standpoint with special reference to the measures necessary to insure the preservation of the rookeries. His work was partly carried on in company with Mr. Townsend, and to some extent covered the same subjects which have been mentioned above. The practical results of his observations related more especially to the extent and causes of mortality among the pups; the conditions of the rookeries as evidenced by the number of seals of each sex and of different ages upon them; the extent and causes of decrease, and the remedies which might prove effectual therefor; the effects of pelagic sealing and of the present methods of driving and culling on the islands, etc.

The investigations of Mr. Stejneger on the Commander Islands were undertaken for the purpose of securing more definite information concerning the Asiatic herd of fur-seals, which it was thought might be of value in reaching final conclusions respecting the sealing problems now in controversy, as it was understood that the habits of these animals,

as well as the methods of their pursuit, were identical on the two coasts. His inquiries were 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 indorsement of the objects of his visit. The local representatives of the Government, as well as of the Russian Seal Skin Company, also gave their hearty cooperation in the work, and were instrumental in bringing it to a successful issue. Mr. Stejneger was especially well qualified to make this study and to pass upon the changes in the seal herd which had taken place in recent years, as he had been stationed upon the islands, under the auspices of the Smithsonian Institution, during eighteen months in 1882 and 1883, at which time, in addition to his regular natural-history observations, he paid considerable attention to the habits of the fur-seals and the conditions of the rookeries.

Mr. Stejneger's report, already cited, is in reality a comprehensive monograph on the subject of his study. The natural history of the Asiatic seals in relation to their physical surroundings, both on the land and in the sea, is described at some length, much pains having been taken to secure the data for this purpose. The methods of driving and killing, the changes in the condition of the rookeries and their causes, the mortality among the pups, pelagic sealing, the history of the sealing industry, and all other matters which were pertinent to his inquiry are discussed in detail. The illustrations consist of a very elaborate series of charts and photographic reproductions which picture the principal features of interest connected with the subject, the more important and significant being those which graphically represent the changes in the population of the rookeries from 1883 to 1895.

The experiences of Mr. Alexander in connection with the sealing fleet during the summer of 1895 were of special interest. He was given accommodations by Capt. H. F. Siewerd, on board the *Dora Siewerd*, a schooner of 100 tons register, belonging at Victoria, British Columbia, and every facility was afforded him to conduct the inquiries for which he had been detailed. This vessel was among the more successful ones, securing a total of 1,577 skins between August 1 and September 20. Mr. Alexander's observations related to the proportionate number of each sex killed at sea, the food of the seals, their condition and habits, their distribution, the temperature and other conditions of the sea and air, the methods of working, and all incidents of the voyage which might be instructive in respect to the several sealing problems. Detailed notes were kept, and all important facts obtained have been embodied in his report.

As elsewhere explained, the *Albatross* was again detailed to take part in the fur-seal inquiries of the season of 1896, which were planned upon a much more comprehensive basis than heretofore. This was done in accordance with a joint resolution of Congress authorizing the President to assign a Government vessel for that purpose, and placing the

conduct of the work under the direction of the Secretary of the Treasury. This resolution further provided for the organization of a party of experts, both by employment and by detail from the Government service, to conduct a scientific investigation into the present condition of the fur-seal herds on the Pribilof, Commander, and Kuril islands. Similar action was taken by the Government of Great Britain, but no provision was made for joint cooperation by the two parties, either in carrying on their investigations or in considering the results of their observations. In the lack of better facilities for transportation, however, two of the British representatives accepted accommodations on the *Albatross*, which had been extended to them by the Secretary of the Treasury.

When the vessel set sail from Seattle, therefore, on June 24, 1896, it carried a large scientific party, as follows: Representing the United States, Dr. David Starr Jordan, in charge; Mr. Leonhard Stejneger and Mr. F. A. Lucas, of the United States National Museum; Lieut. Commander Jeff. F. Moser, U. S. N., commander, and Mr. C. H. Townsend, naturalist, of the steamer *Albatross*; Col. Joseph Murray, special agent of the Treasury Department; Mr. G. A. Clark, secretary. Representing Great Britain, Prof. D'Arcy W. Thompson, of University College, Dundee, Scotland; Mr. James M. Macoun, of the Geological Survey of Canada, and Mr. A. Marett, photographer.

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

The operations of the steamer *Albatross* during the summer of 1895 were again chiefly directed, as in the previous four years, to the study of the several problems connected with the fur-seal question in Bering Sea, under the immediate direction of her commander, Lieut. Commander F. J. Drake, U. S. N., but, instead of being attached to the patrol fleet, as had been the custom heretofore, the vessel was given an independent status under the orders of the Commissioner of Fisheries, so that the special line of work which she is particularly fitted to engage in might be carried on uninterruptedly. The commanding officer, however, was commissioned to board and inspect such pelagic sealers as might be encountered, in order to afford the opportunity for securing the important information only to be obtained in that way. The instructions provided for the same general character of observations as in preceding years. The investigation of the pelagic habits and distribution of the fur-seals was to be made the principal feature of the cruise, but fishing trials were to be conducted whenever the vessel was on suitable ground for that purpose. Special attention was to be paid to the hydrographic features of the sea, both in the shallow waters of the platform and in the deeper areas, with reference to their bearing upon the different sealing and fishery problems, and assistance was to be rendered the several parties detailed to conduct the shore inquiries on both the Pribilof and Commander islands, as elsewhere explained.

The cruise began on May 18, 1895, when the *Albatross* left San Francisco for Puget Sound. Several days were occupied at Port Townsend, Wash., and Victoria, British Columbia, in collecting information respecting the operations of the sealing fleet, after which the vessel proceeded northward through the passage inside of Vancouver Island, having on board Mr. F. W. True and his assistant, Mr. D. W. Prentiss, jr., who were to spend the season at the Pribilof Islands. Unalaska was reached on June 15, where Mr. Leonhard Stejneger joined the ship soon afterwards, and the seal islands on the 24th of the same month. Messrs. True and Prentiss and Mr. N. B. Miller were landed at the latter place, and on the 26th the vessel proceeded on the way to the Commander Islands, off the Siberian coast, running a line of soundings westward along the parallel of 56° N., from longitude $177^{\circ} 30'$ W., to which position her hydrographic work had been carried during a previous season.

This line of soundings was in progress at the beginning of the fiscal year, July 1, 1895, stations being made at intervals of 50 miles. An average depth of about 2,106 fathoms was carried across the deep basin of Bering Sea, a distance of 530 miles, to a point 22 miles N. $\frac{3}{4}$ W. from the northeast point of Bering Island, the bottom throughout this area being composed principally of brown mud and ooze, but changing to gray sand and mud as the shelf surrounding Bering Island was approached. Cape Yushin, the most northerly point of the island, was sighted on the morning of July 3, the high table-land of the interior standing out through the mist, while the shore line was obscured by a low fog bank. A line of reefs runs parallel to the northern shore line, with outlying rocks not definitely located. The water shoals up rapidly in places. The soundings were carried around the northwest end of Bering Island, passing within 5 miles of the northwest point, with 20 fathoms on the reef which extends west from the point. Anchorage was then made in Nikolski Harbor, where visits were exchanged with the governor of the islands, Col. N. A. Grebnitsky, and arrangements made for the landing of Mr. Stejneger and for the conduct of his inquiries. During the short stay in port a visit was paid by several of the officers of the vessel to the North Rookery, of which some excellent photographs were obtained by Mr. Townsend.

Leaving Nikolski on July 6, and connecting with the previous line of soundings in 70 fathoms, 5 miles off Cape Yushin or North Cape, Bering Island, a course was laid N. 51° E., true, for a distance of 315 miles, crossing the Kamchatka basin. In a run of 9 miles a depression of 1,017 fathoms was found, the bottom on this slope consisting of gray sand and mud. The greatest depth, 2,137 fathoms, green ooze, was reached at a distance of 99 miles from Bering Island. One hundred miles farther a rise of 1,727 fathoms, or a depth of 410 fathoms, was developed, this position being in latitude $57^{\circ} 29'$ N., longitude $170^{\circ} 09'$ E., or inside of the 100-fathom curve as at present delineated on the charts of the United States Coast and Geodetic Survey. Continuing

the soundings southeastward at 10-mile intervals for a distance of 40 miles, the extent and nature of the eastern face of the platform was determined at a mean depth of 556 fathoms, the bottom being composed of brown ooze, sand, and gravel. A rise of temperature here of 3° , as compared with the Kamchatka basin north of Bering Island, indicated that a branch of the Japan Stream flows around the Oliutorsk platform. Proceeding 70 miles farther in the same direction the ship was carried off the platform, the margin of which descends with a gentle slope, a depth of 1,898 fathoms having been reached 111 miles S. 46° E., true, from Cape Oliutorsk. The above line of soundings took the *Albatross* into localities where depths of less than 50 fathoms are recorded on the charts of Bering Sea. The original soundings were evidently made along lines running southward from the above-named cape, and the observations of the *Albatross* tend to confirm the report that this coast line is now charted 15 miles too far to the eastward, as noted on sheet III of Hydrographic Office chart No. 528, North Pacific Ocean.

Again entering the deep basin, a second line of soundings was run across it, S. 76° E., true, from latitude $58^{\circ} 37'$ N., longitude $172^{\circ} 54'$ E., to a point 145 miles from St. Paul Island, in latitude $56^{\circ} 55'$ N., longitude $174^{\circ} 48'$ W., the greatest depth encountered being 2,084 fathoms, and a slight rise occurring at the eastern end of the line. The characteristic features of the bottom were blue, brown, and green ooze and mud. The two lines made this season indicate a comparatively level floor, with no traces of the remarkable rise of 1,481 fathoms discovered the previous year 65 miles farther north.

St. Paul Island was reached on July 9, and Mr. Townsend was there landed with the necessary outfit for delineating and photographing the rookeries. The *Albatross* then proceeded to Unalaska for coal and returned to the Pribilofs on the 16th, spending the remainder of the month in that locality, in order to render assistance in connection with the shore work, in which the commanding officer also participated, with the assistance of Ensign W. G. Miller of his staff. Mr. A. B. Alexander was left at Unalaska, where he secured accommodations on board the Canadian sealing schooner *Dora Siewerd*, for the purpose of making observations on the hunting-grounds during the open season beginning August 1.

On August 4 the *Albatross* began the investigation of the habits and distribution of the seals during their pelagic movements in search of food, giving most attention to the waters outside of the protected zone, east of the one hundred and eightieth meridian and north of the fifty-fourth parallel. In connection with this work the sealing belt of the season was developed, soundings were made, the beam trawl and towing nets were frequently employed, and observations were taken at all stations respecting the temperature and density of the water. A large part of the region to which the seals resort from their breeding-grounds on the islands at this time of year was visited, and much progress was

made toward perfecting the knowledge of the more important features of this exceedingly interesting area. The following pelagic sealing vessels were boarded and information obtained from them regarding the extent and character of their catch both in Bering Sea and in the North Pacific Ocean during the earlier part of the season, namely, the *Rattler*, *Maud S.*, *Borealis*, *M. M. Morrill*, *Enterprise*, *Vera*, *Victoria*, *Triumph*, *George W. Prescott*, and *Columbia*. It was found that much greater care was exercised in discriminating between the sexes in the catch made by the United States than by the Canadian vessels, due no doubt to the fact that all fares are carefully inspected by custom-house officials when landed at ports in the United States, while no such precautions are taken on the other side.

Mr. True and Mr. Prentiss embarked on board the *Albatross* at St. Paul Island on August 23, having completed their inquiries. The vessel was at Unalaska from August 25 to 30, and left that port on the latter date, bound south. The trip was made by way of Kadiak, Yakutat Bay, Sitka, and the inland passage to New Whatcom, Wash., which was reached on September 18. Nearly a month was spent in the Puget Sound region in obtaining information respecting the salmon industry, in order to supplement the observations made during the summer by the members of the Joint Fishery Commission, as elsewhere explained. Attention was paid chiefly to locating, mapping, and photographing the large salmon traps and the several canneries, all of the principal fishing centers being visited for that purpose. Some inquiries were also made relative to the fishery resources of Hood's Canal. During the State fair held at New Whatcom, the *Albatross* remained for several days at that place, being opened up to visitors, very many availing themselves of the opportunity to examine the novel features of the ship. Mr. Townsend was principally engaged during this period in completing the records concerning the results of pelagic sealing during the past season by inquiries at Port Townsend and Victoria and in inspecting the catch of returning vessels.

Leaving Puget Sound on October 16, the *Albatross* proceeded southward, reaching San Francisco on the 20th and the Mare Island navy-yard on the 24th. She remained at the latter place until January 22, 1896, undergoing general repairs and overhauling, and from January 30 to April 12 was stationed at San Diego, Cal. While here an examination of San Diego Bay was made by means of the steam launch and other small boats, the object of this inquiry being to determine the principal characteristics and resources of the bay, and especially its suitability for oyster-culture.

On April 12 the ship proceeded to the vicinity of Cortes and Tanner banks, which lie some distance off the coast in about the latitude of San Diego, for the purpose of working out the depths and character of the bottom immediately to the westward of these small submarine elevations, which seem to promise considerable inducement for a local fishery whenever a demand shall have been established. After the

first day, however, operations were interrupted by stormy weather, but a number of soundings and one successful haul of the beam trawl were made. Leaving this region, the *Albatross* went to Santa Barbara, where she remained from the 14th until the 20th of April, participating, by invitation of the authorities, in the annual flower festival of the town. From the 20th to the 26th of the same month the ship was at San Pedro, where she took part in "la Fiesta de los Angeles." San Francisco was reached on April 28 and Mare Island on May 1.

From May 7 to 18 the steamer *Albatross* was under the orders of the president of the Naval Trial Board, being used in connection with the official speed trial of the battle-ship *Oregon*, which took place off Santa Barbara on the 14th of the month. On completion of this duty preparations were made for the season's work in northern waters. Mr. C. H. Townsend, the naturalist of the steamer, who had been stationed in Washington during most of the winter, on duty connected with the preparation of his report on the fur-seal inquiries of the previous summer, returned to the *Albatross* about May 1. The greater part of that month was spent by him in making investigations in San Francisco Bay relative to its oyster-grounds and the suitability of its water for oyster-culture, supplementing his studies begun in 1891. Special attention was given to the changes which had occurred in the extent and character of the industry during the past few years, the position and extent of territory occupied by eastern oysters, the methods employed, and the relations of planted beds to their surroundings with reference to their extension by natural processes of reproduction. The *Albatross* assisted directly in this work by making a series of dredgings in the deeper water, which was commenced at the mouth of the lower bay and was carried up the channels as far as Point San Bruno.

Mr. A. B. Alexander, fishery expert, was dispatched to Puget Sound on the 17th of May, for the purpose of taking up some special inquiries respecting the halibut, salmon, and oyster fisheries of that region.

An understanding having been reached early in the season that the services of the *Albatross* would not be required in connection with the fur-seal operations of the Government during the summer of 1896, except to make the customary delineations and photographs of the rookeries on the islands, plans were perfected looking to the investigation of the more important fishery resources of southeastern Alaska. The principal species on which observations were desired were the halibut and salmon. The extent of coast to be covered by the inquiries was from the southern boundary of Alaska to the vicinity of Kadiak Island. The halibut-grounds were to be located and their productiveness ascertained, mainly with the view of establishing their value for vessel fishing; while the salmon rivers were to be studied more especially with reference to suggesting measures to prevent their depletion.

While halibut are known to be generally distributed along the entire Alaskan coast, no systematic attempt has yet been made to define the

areas where they might be fished for profitably south of the banks in the vicinity of Kadiak, most of the information regarding the southern grounds having been obtained from the fishing vessels which occasionally visit that region. A considerable quantity of this species has been marketed during the past few years through ports on Puget Sound, the most of these fish having been caught in Hecate Strait, off the north ends of Graham and Vancouver islands, and at the mouth of the Strait of Fuca. Although very little hydrographic work has been done along the outer coast of southeastern Alaska, the indications are that the shore platform is there relatively narrow, thus precluding the existence of such extensive fishing-banks as occur farther north. It is probable, however, that good halibut grounds will be found along the outer coast as well as in the channels among the islands, where some fishing on a small scale has been carried on for some time. The development of the continental slope was one of the important features of the season's work as laid out.

The salmon investigations contemplated determining primarily the relations of the several species of that important group to the different rivers, inlets, and other channels which they enter in sufficient numbers to afford the means for commercial fishing. The physical inquiries were to relate to the characteristics of each waterway, with the special object of supplying data which might be useful in determining the character of fishing methods proper to be allowed in each locality, and the restrictions necessary to insure the perpetuation of the salmon runs. This information is urgently demanded in view of the rapid development of the salmon canning business in Alaska, and the imminent danger of this important industry receiving permanent injury should the present practices continue unrestrained.

Circumstances, however, necessitated an entire change in the summer plans, and the postponement until another year of the investigations above detailed. The *Albatross* left San Francisco on June 5, and proceeded to Seattle, Wash., where arrangements were completed for the northern work in conformity with an act of Congress, providing for extensive inquiries by a scientific party relative to the fur-seal in Bering Sea and on the Asiatic coast, as elsewhere explained.

Departure was taken from Seattle on June 24, the ship proceeding by way of the passage inside of Vancouver Island, and on June 30, the close of the fiscal year, being in the North Pacific Ocean, en route to Unalaska.

During the year the *Albatross* was at sea 124 days, and steamed 11,702 miles. The number of sounding stations made was 139, and of dredging stations, 33. A daily record was also kept of meteorological and of water temperature and density observations, as well as of all other important data collected in the course of cruising.

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

The investigations undertaken in conformity with the provisions of the joint agreement of December 6, 1892, between the United States and Great Britain, were practically completed during the past year, and considerable progress was made in the preparation of the report relating thereto. Field work was carried on in the waters adjacent to the boundary line between the State of Washington and British Columbia, in the region of Lake of the Woods and Rainy Lake, in Passamaquoddy Bay, at the mouth of the Bay of Fundy, and throughout the mackerel region of the Atlantic coast.

The two representatives, Dr. William Wakeham, on the part of Great Britain, and Mr. Richard Rathbun, on the part of the United States, left Ottawa for the Pacific Coast on July 8, 1895. Making a short stop at Port Arthur, on the north shore of Lake Superior, for the purpose of completing arrangements for the inquiries in the waters between Minnesota and Canada, they reached Vancouver, British Columbia, on July 15. One month was spent by this party on the west coast, chiefly in studying the conditions and requirements of the important salmon fisheries of the Fraser River and of the adjacent salt waters of the Gulf of Georgia, Puget Sound, and the Strait of Fuca, but some attention was also paid to other branches of the fisheries which are of international interest. Visits were paid to all points on both sides of the boundary where salmon are taken extensively or where salt-water fishing is carried on, the fishermen and others connected with the industry were interviewed, and as much information was obtained by direct observations as was possible in the short time available.

The salmon fisheries greatly exceed all others in this region in the extent and value of their production, and they are still rapidly growing. Up to the present time no decrease in the abundance of the fish has been observed, but over a considerable part of these waters no regulations are in force, and unless some protective measures are introduced there is every reason to expect that the resources will sooner or later be overtaxed. The salmon are taken not only in the Fraser River, but over a wide area of the salt waters as well, an excellent quality of fish being obtained and the canneries finding a ready sale for all they can put up. Quite a large quantity of fresh salmon is also shipped to the interior and eastern part of the country, and an important trade in fresh halibut is being established.

The investigations along the boundary between Minnesota and Ontario were conducted during the latter half of July and during August by Mr. A. J. Woolman, of Duluth, Minn., with two assistants. Their work was begun in the upper part of this very diversified water system and was carried thence down through Rainy Lake and River and Lake of the Woods. The latter body of water had been examined in 1894, as explained in the last annual report, but it was deemed advisable, in view of the rapid growth of the sturgeon fishery, to repeat the obser-

ventions and to obtain a more complete knowledge of the fishes inhabiting this lake as well as the upper waters of the chain. Mr. Woolman has submitted a very full report upon his inquiries, including a detailed account of the changes which have taken place in the fisheries during the past year. The sturgeon constitute the important feature of Lake of the Woods from a fishery standpoint, and their capture gives rise to the principal industry which it affords. They occur there in unusual abundance, and are readily taken in large numbers, but the small size of the lake makes their depletion a question of only a few years if fishing is allowed to continue unrestrained, as it is at present.

The inquiries in Passamaquoddy Bay related mainly to the herring or sardine fisheries, but in part also to those for the lobster and other species, and were conducted by Mr. H. F. Moore, who was engaged upon the same subject in 1893. Mr. Moore accompanied the steamer *Fish Hawk* eastward from Portland during July, 1895, while detailed to the mackerel investigations, and was thereby enabled to extend his observations along a considerable part of the Maine coast. Subsequently he established headquarters at Eastport, Me., working from that center until the last of September. The mackerel investigations, which were carried on partly in connection with the joint inquiries, are discussed under their appropriate heading.

The notes collected by the joint commission are very voluminous and relate to a great variety of subjects. Their reduction and compilation have been carried on at all times when the representatives have not been engaged in field work, but it has been impossible to forward their consideration as rapidly as was expected. The representatives met in Washington on March 1, 1896, for the purpose of engaging conjointly in the preparation of their report, and continued to be so occupied until into April, when it became evident that the work could not be finished within the limit of time set by the agreement, which was June 1, 1896. An extension of time to December 31, 1896, was accordingly arranged by an exchange of notes between the two Governments.

MACKEREL INVESTIGATIONS.

Investigations respecting the natural history of the mackerel and the fisheries which it affords were assiduously carried on during all parts of the year when this species is present on the coast. These inquiries, begun several years ago and inaugurated mainly with the object of determining to what extent, if any, the fluctuations in the abundance of this fish may have resulted from human agencies, have recently been conducted as a part of the work of the joint commission referred to above.

At the beginning of the fiscal year the schooner *Grampus*, commanded by Mr. E. E. Hahn, master, with Mr. W. C. Kendall as naturalist, was at Gloucester, Mass., having just completed a cruise in Canadian waters. Operations were resumed on July 8, 1895, and were continued until the latter part of September, the field of work being the coast of New

England, between the Bay of Fundy and Block Island. During this period the cruises were made partly in company with the fishing vessels and partly independently, in order to cover the largest possible area. The observations related to all subjects which have customarily been covered by these investigations, including the physical conditions of the sea, the distribution, abundance, habits, sizes, and food of the mackerel, the operations of the fishermen, their methods, extent and character of catch, etc. This was the first year that extensive inquiries had been made in the offshore waters of northern New England, and many important results were secured. While in port, from time to time, advantage was also taken of the opportunity to keep track of the operations of the fishing fleet in the Gulf of St. Lawrence, so as to complete the record of the year, the information on this subject being obtained from the returning vessels.

The spring cruise in 1896 began on April 11, on which date the *Grampus* left Gloucester, Mass., reaching Lewes, Del., on the 16th of the same month. The instructions issued for the guidance of the vessel, which were carried out in all particulars as closely as the circumstances permitted, were essentially the same as in previous years. The general purpose of the cruise was to observe and record the principal events connected with the first appearance of the mackerel on the southern Atlantic coast, and with their subsequent movements northward into the Gulf of St. Lawrence. The schooner remained most of the time in company with the fishing fleet, as affording the best means of keeping track of the schools of fish and of obtaining an abundance of specimens for examination. Occasionally, however, trips were made back and forth across the area traversed by the mackerel, in order to determine the width of territory which they occupy, and every effort was made to keep track of the position of the advance schools and of the main center of their abundance, with the object of ascertaining, so far as possible, the principal influences, physical and biological, which control their movements. Some fishing was done directly from the *Grampus*, and hourly observations were made respecting the temperature and density of the sea, meteorological conditions, and the amount of life present at the surface.

Lewes was made the headquarters until May 8, the vessel returning to port, however, only when the weather was too stormy to continue operations. The first mackerel taken by the fleet this year were caught in a purse seine on April 6, in latitude 37° north, on the edge of soundings. The species was more than usually abundant throughout the season, a larger number of fish being seen and a greater quantity captured than in any one spring during a considerable period. The total quantity obtained was about ten times greater than in 1895. After leaving Lewes on the 8th, the *Grampus* worked northward along the New Jersey coast, and thence eastward off Long Island and Block Island, reaching Woods Hole on the 14th.

The regular cruising closed at this time, the vessel being detailed to engage in the collecting of mackerel eggs for hatching purposes. This

work, however, necessitated her keeping in localities where spawning fish were expected to occur, and the customary observations were continued so far as possible, Mr. Kendall giving his entire time to this subject. The *Grampus* remained in the Vineyard Sound region until about June 1, when she proceeded to the eastern part of the coast of Maine, being still engaged in procuring eggs of the mackerel at the close of the fiscal year.

Inshore work respecting the mackerel was carried on during the summer of 1895 by Capt. A. C. Adams and Dr. W. E. Wolhaupter, on the same plan as in 1894. These two assistants remained in company on the coast of Maine during the month of July, having the use of the steamer *Fish Hawk*, Lieut. Franklin Swift, U. S. N., commanding, in order to facilitate their movements and afford the opportunity of reaching outlying fishing-grounds. Reaching Portland on July 2, this vessel remained in the vicinity of Casco Bay until July 11; thence proceeding to Booth Bay, Monhegan Island, Port Clyde Harbor, Rockland, Seal Harbor, Matinicus Island, Great Duck Island, Southwest Harbor, Bar Harbor, Long Island Harbor, Burnt Cove Harbor, Isle au Haut, and back to Rockland, where the cruise ended. Many places of less prominence were also visited. Dr. Wolhaupter subsequently extended his observations east to Machias, Cutler, and Eastport, after which both he and Captain Adams returned southward along the coast of New Hampshire and Massachusetts. Capt. Adams completed his field work at Gloucester the last of August, while Dr. Wolhaupter also visited Boston, several places on Cape Cod, Woods Hole, Newport, Block Island, New York, and the northern part of the New Jersey coast, reaching Washington early in October.

During the early spring fishery of 1896, the Commission was represented at Fulton Market, New York City, by Mr. A. G. Maddren, temporary assistant, who carried on the customary inquiries at that place from the middle of April until the latter part of May. These related to the fresh mackerel landed at New York by the purse-seiners and to those brought there from the shore fisheries, both to the southward and eastward. His observations were largely supplemental to those made on board the schooner *Grampus*.

OYSTER INVESTIGATIONS.

Apalachicola Bay, Florida.—In compliance with a resolution of the United States Senate, adopted February 15, 1895, the steamer *Fish Hawk*, commanded by Lieut. Franklin Swift, U. S. N., was detailed to make investigations respecting the oyster fisheries on the coast of Florida during the winter of 1895-96. As the extent of the coast referred to was far too great to be covered in a single season, it was concluded to restrict the operations at that time to Apalachicola Bay and the adjacent waters, where the fishery has for some years been of relatively much importance, on the ground that more satisfactory and useful results could be accomplished in that way. The survey was begun on November 12 and completed on March 28. The inquiries

were conducted entirely by Lieutenant Swift and the other officers of the vessel, among whom Mate James A. Smith, U. S. N., should be especially mentioned for efficient services, his previous long experience on the Fish Commission having well fitted him for work of this character.

The total area included within the scope of the investigation extended about 21 miles east and west, with a greatest width of $6\frac{1}{2}$ miles, and consisted of Indian Lagoon, St. Vincent Sound, Apalachicola Bay, East Bay, and the western end of St. George Sound.

The main objects of the inquiry, as stated in the instructions, were to determine—(1) the positions, outlines, characteristics, and richness or productiveness of all oyster beds located in the waters named; and (2) the positions, outlines, and characteristics of all areas of the bottom suitable for the planting of oysters, either in their natural condition or after preparation. The carrying out of these directions involved a detailed and careful survey of the entire region with respect to hydrographic features, as well as to the density and temperature of the waters, and the location and condition of oyster growths. The work was conducted in an exceedingly able manner, and the results as presented by Lieutenant Swift* can not fail to prove both instructive and suggestive. So far as the surveys made some years ago by the Coast Survey were applicable to the purpose they were utilized, but many changes in the contour of the bottom were found to have taken place, and a large number of the signal stations had disappeared, partly through the wearing away of the shores. The amount of hydrographic work which it was necessary to undertake was, therefore, very great, and owing to the care shown in making these observations, the chart accompanying the report is as important for navigation as for the oyster fisheries.

The general scheme and methods of work adopted are described as follows by Lieutenant Swift:

The work, in accordance with the instructions given, was not to be a mere reconnaissance or examination of a few important beds, but a complete survey of every bed and area where oysters were found, as well as a thorough examination of the bottom of the whole region covered, in order to determine its suitability for oyster planting. Therefore it was necessary to adopt a scheme of hydrographic surveying in which the lines of sounding should be close enough together to insure the detection of every oyster reef, however small, and show the character of the bottom in every locality, and at the same time not to run the lines unnecessarily close, so that the work might be pushed on as quickly as possible. The local oystermen, although able to give the approximate location of the more important beds, could not, of course, be depended upon to give the limits of all regions where oysters were found or to give the location of the smaller beds. These facts could only be determined by actually running the lines, keeping an accurate record, and plotting the resulting development on the projection. However, the elaborate development of the bottom, as generally required in the Coast Survey work, was not here necessary, and the ground could be covered more quickly as far as the hydrographic part was concerned. But, in addition to the hydrographic work, there were many other considerations;

* Report of a survey of the oyster regions of St. Vincent Sound, Apalachicola Bay, and St. George Sound, Florida. By Lieut. Franklin Swift, U. S. N. Report U. S. Fish Com. 1896, pp. 187-221.

of the first importance was the question of density or salinity of the water, the determination of which alone would show, to a great degree, the suitability of any locality for cultivating purposes.

The questions of the physical observations on the beds and the examinations of the oysters themselves were of the greatest importance. It was necessary that sufficiently accurate current observations should be taken to establish the approximate velocity and the general set of ebb and flood tides, as such data is essential in connection with the food supply of the oyster and the amount of silt or mud deposited on the beds.

As the spawning habits of the oyster depend to a great extent on the temperature of the water, the temperature observations were important. Information in regard to the spawning was to be collected from local sources and from a study of the specimens preserved.

On account of the shallowness of the water in localities where oysters were found, it was impossible to use the ship for dredging purposes. The oystermen employ tongs entirely, and tongs were found to be more serviceable than the boat dredge for our purpose. In estimating the number of oysters to the stated given area—as, for instance, a square yard, the comparison generally used in former surveys—the boat was moored, and the oysters on the bed were tonged and counted within the limits covered by the bottom of the boat, and the result reduced to square yards. Any method employed for this purpose, although correct enough for the particular locality where used, would, of course, only give a rough approximation for the whole oyster region, unless an almost infinite number of such observations were made. Still this method gives a standard to which observations made in future surveys may be compared, and thus shows the increase or decrease from time to time in the number of oysters on the beds.

The shoalness of the water allowed the use of poles in taking soundings and obtaining the character of the bottom. * * *. These poles were 1½ inches in diameter at the lower end and slightly tapering to the upper end. They were 14 feet long, and, constructed as described, were light, well balanced, and strong. By their use the presence of oysters could be immediately detected, not only by the “feel” of the pole to the poleman, but also by the ringing sound given out on striking shells, easily heard by the officer in charge of the boat. * * *. All oyster reefs and areas of scattered oysters were carefully located, the reefs composed solely of old shells, as well as those of live oysters, and whether of the raccoon type or not.

Full notes were kept in the record books of the results of the examinations—the type of oyster, shape, size, and appearance of the shell, whether single or in clusters, growth on shell, appearance of spat or young growth, flavor and condition of oyster, number of oysters to stated area, proportion of live oysters to dead shells, appearance of bed, growth and cleanliness of bed. A careful lookout was kept for enemies of the oyster, as starfish, drumfish, drills, conchs, sponges, etc., and their presence noted. * * *. In considering the question of bottom suitable for the planting of oysters, those areas were recorded favorable when the bottom was sufficiently hard to prevent the oyster from sinking, and, at the same time, possessing sufficient cohesion to resist the shifting action of the waves, all other conditions being also favorable. Very soft, muddy bottoms were considered unsuitable, but those of a somewhat firmer consistency it was considered possible to make suitable by covering them with layers of stones or shells.

The results of the survey are discussed in detail for all parts of the region studied, beginning with St. Vincent Sound and Indian Lagoon at the west. The principal features brought out for each are the depth of water and composition of the bottom, the physical characteristics, the nature and extent of the oyster growths, whether dense or scattered, of marketable quality or of raccoon type, and the position and extent of territory which it is thought may be adapted to oyster planting.

Formerly a large part of the oysters marketed at Apalachicola were obtained in St. Vincent Sound, but the principal seat of operations has been shifted farther eastward. In this sound the best oyster growths are found to be eastward of the Bulkhead, but here, as elsewhere throughout the region, there has been a very extensive destruction of oyster beds by recent hurricanes. The whole eastern part of St. Vincent Sound is well fitted for the cultivation of oysters. The density and temperature are favorable, the bottom is smooth and uniform in depth, and the locality is generally well sheltered from violent storms.

Apalachicola Bay has a total area of 63 square miles, and, with the exception of a single deep channel, is generally shallow. The most noticeable hydrographic feature is an oyster reef called St. Vincent Bar, which is composed mostly of dead shells and practically divides the western part of the bay. Between St. Vincent Bar and Apalachicola are located all the oyster reefs of this section of the bay. These beds were formerly productive, but are not worked at present. The central part of the bay is devoid of oyster beds, and only a few beds, mostly of scattered oysters, are found in the eastern part until St. George Sound is reached. A considerable area of bottom was ascertained to be suitable for planting purposes.

The only oyster beds in St. George Sound which are now important are the large ones at the west end. There are other beds eastward of the limits of the survey, some of which were formerly productive, but at present none are worked. The area from Cat Point southeast to St. George Island, for an average width of nearly three-fourths of a mile, forms one large continuous oyster bed, although different names are given to different parts of it. It is here that the oyster fleet, consisting of about 32 vessels, has recently been concentrated, and during the season of the survey practically all the oysters brought into Apalachicola were obtained on these beds.

According to Lieutenant Swift, oysters were first taken for the local market in the region covered by the investigations in 1836, but not in any quantities until 1850. During the war the beds were left undisturbed and they improved so much that they were subsequently in very good condition. The business was again resumed, but was not carried on extensively until 1878. During the winter of 1893-94 the beds of St. Vincent Sound and Apalachicola Bay were nearly destroyed, and since then practically no oysters have been obtained in those places. This destruction was partly the result of overfishing, but was due mainly to the effects of freshets, hurricanes, and freezing. The Bulkhead and Cat Point bars have lately furnished about all the oysters brought into market, although some few have been taken at Porters Bar to the eastward. It seems to be the general opinion that the beds are deteriorating at the Platform and on the Bulkhead and Cat Point bars, where oystering is going on at present, and the reason assigned is that the beds are overworked, the supply being unequal to the demand.

The advantages of these waters for the cultivation of oysters and the benefits which might be gained by utilizing for that purpose the bottoms where oysters do not occur at present are thus discussed by Lieutenant Swift:

As before stated, planting was tried experimentally on the north side of St. Vincent Sound, and enough was done at the time to show that it could be made a decided success, if the laws of the State regarding planting could be enforced. As it was, no protection whatever was given, and the experiment proved unsuccessful for that reason. The State laws protect the planters, but there appears to be no attempt to enforce the laws, and the moral sentiment among the oystermen is not in favor of such protection. This is due to a misunderstanding of the subject by the oystermen; the law makes a distinction between the cultivated beds and natural beds and relates wholly to the cultivated beds, but the oystermen have the idea that any protection given the planters is of the nature of a monopoly and is an encroachment on their rights. Of course such is not the case, as the laws protecting planters do not in any way interfere with oystering as it is now carried on on the natural beds. All oyster cultivation would be carried on entirely away from the natural beds, and in some cases in localities quite remote from them. The chart shows exactly where oysters may be cultivated, and any intelligent person by using a compass may locate himself with sufficient accuracy to find the limits of the planting ground; in this connection a sounding pole will be of great assistance, as by it he can judge of the character of the bottom as well as the depth of water. By closely studying the limits of the planting area a person can select certain natural ranges which will help him locate himself.

The whole question of oyster cultivation is of the greatest importance to the people of Apalachicola and vicinity, as undoubtedly if the law is enforced and the planters protected it may be made a great industry, and it is only necessary to cite as an example the great success met with by the oyster cultivators of Long Island Sound in order to show what a great business may be developed. But first the oystermen must be brought to a realization of the fact that the protection of oyster cultivation does not in any way infringe upon their rights, and that on the contrary it is directly for their best interests. All have equal rights, and any man having sufficient thrift and energy may, without much doubt, better his condition by undertaking the cultivation of oysters and uniting with others to respect the laws.

The cultivation of oysters would be more easy on account of the number of oyster shells brought into Apalachicola. By simply spreading these shells over the areas of planting ground, the spat would attach itself to the culch, and only a little care in cleaning and spreading would be required to form, in time, a productive bed. It should always be borne in mind, as has already been mentioned, that oysters grow and thrive much better in a current than in still water, as they have a better food supply. In transplanting oysters the clusters should be broken up and each oyster should be thoroughly cleaned of barnacles and mussels.

It is almost certain that if the question of oyster cultivation were taken up in the proper way by the people of Apalachicola and vicinity, excellent results would be obtained. No better flavored or conditioned oysters can be found anywhere than those at Cat Point Bar and at Sylvas Bar, and by using the seed from these bars it can be safely prophesied that oysters of the cultivated bed will excel those of the natural beds. There is little doubt that if the oysters on the Bulkhead, where the vegetable growth renders them unfit for canning purposes, were transplanted to other localities, they would lose the peculiar characteristics so injurious to them, and become, like the Cat Point oysters, most excellent in quality.

Pacific coast.—The inquiries made during the year on the Pacific coast relative to the oyster-grounds and the opportunities for oyster cultivation are referred to under the operations of the steamer *Albatross*.

THE LOBSTER.

In 1890, at the invitation of the Commissioner, Prof. Francis H. Herrick, of Adelbert College, Cleveland, Ohio, began the preparation of a comprehensive work upon the habits and development or general biology of the American lobster, the most important, by far, of all the crustaceans of this country. As very little attention had been paid by anyone to the natural history of this species, it became necessary for Professor Herrick to take up the subject as a practically novel one and to conduct a protracted series of observations which extended through five years.

The material required for this purpose was obtained and the study of living material carried on chiefly at the Woods Hole station of the Commission, where exceptionally favorable advantages are presented for researches of this character. Brief references to the progress of Professor Herrick's work have been made from year to year in the annual reports. His task was completed during 1895, and his monograph was published before the end of the past fiscal year.*

Professor Herrick's training and his previous elaborate studies of the Alpheus group of crustaceans especially qualified him to undertake this important work, which he has conducted in the most conscientious and painstaking manner. The result has been exceedingly gratifying. From a purely scientific standpoint the report submitted is of the highest merit, and in that respect will justly attract widespread attention; but it is more than a scientific memoir, as, under the influence of his practical surroundings, the author has carried his researches to a point where their utility will readily be perceived by the fish-culturist and the legislator. No other object of the fisheries has received more thorough and systematic treatment by a single writer.

It would be impossible to review even the more essential features of Professor Herrick's work within the limits of this report. Its scope is indicated by the principal chapter headings, as follows: Habits and environment; reproduction; molting and growth; defensive mutilation and regeneration of lost parts; large lobsters; enemies; the tegumental glands and their relations to sense organs; variations in color and structure; structure and development of the reproductive organs; habits from the time of molting until the period of maturity; history of the larval and early adolescent periods; embryology. Aside from a few photographic reproductions, the illustrations, which number nearly 300 figures in all, are almost exclusively from drawings and paintings by the author. They relate to practically all the subjects discussed which are capable of being graphically presented.

*The American Lobster: A study of its habits and development. By Francis Hobart Herrick, Ph. D., professor of biology in Adelbert College of Western Reserve University. Bull. U. S. Fish Com., xv, for 1895, pages 1-252, plates A-J and 1-54.

A brief summary is given of the most important observations made, especially in those directions bearing upon the artificial propagation of the species. The extreme geographical range of the lobster is from Labrador to North Carolina, and its range in depth from about 1 to upward of 100 fathoms, but its distribution in abundance is restricted within much narrower limits. There appears to be no pronounced coastwise migration, but large numbers move to and from the deep waters in the fall and spring. They approach the shores in the Vineyard Sound region when the temperature of the water rises to between 50° and 55° in the spring.

The adult lobsters feed chiefly on fish and invertebrates, but they also take small quantities of algae and eelgrass. About 80 per cent of the spawning females extrude their eggs during July and August, the remainder at other seasons, but the hatching period is chiefly in the late spring and early summer, the eggs in the majority of cases being carried, therefore, from 10 to 11 months. The number of eggs produced at each laying varies from about 5,000, in an 8-inch lobster, to over 60,000 in one measuring 17 inches long, but in a few instances over 90,000 eggs have been observed on lobsters from 15 to 16 inches long.

The female lobsters become sexually mature when from 8 to 12 inches long. They spawn not oftener than once in two years, the spawning interval being apparently biennial. Molting takes place chiefly during the four months from June to September, inclusive, but there is no month in which soft lobsters may not be caught. It is concluded that the rate of growth varies considerably with the individual and its surroundings. The length of the young lobster when it hatches from the egg is about 7.84 mm., and the increase in length at each molt is about 15.3 per cent. The lobster molts from 14 to 17 times during the first year. A 10½-inch lobster has molted from 25 to 26 times, and is about 5 years old. The greatest size attained by the species is thought to be about 25 pounds, most of the accounts of the extreme weights of these animals being unreliable.

The lobster hatches from the egg as a pelagic free-swimming larva. It lives at the surface of the ocean from six to eight weeks, when, after having molted five or six times, it goes to the bottom and appears in habit and structure like a very small adult lobster. After reaching the bottom it travels toward the shore and establishes itself in rock piles in harbors and at the mouths of rivers, where it remains until driven out by ice. At very low tide they can be found by digging away the loose stones. The larvæ feed upon minute pelagic organisms of all kinds, showing little discrimination at this time. Great destruction is wrought upon the free-swimming stages by both animate and inanimate enemies. A survival of 2 in every 10,000 larvæ hatched would maintain the species at an equilibrium, and the destruction of the young under the present conditions of the fishery is probably even greater than this implies.

INDIAN RIVER, FLORIDA.

Indian River, Florida, was made the subject of an investigation during January, 1896, with respect to the character and condition of its fisheries, in accordance with a provision of the sundry civil appropriation bill, approved March 2, 1895, as follows: That it shall be the duty of the Commissioner of Fisheries to make special investigations as to the extermination of migratory fishes on the Indian River of Florida. The scientific inquiries were conducted by Prof. Barton W. Evermann, assisted by Mr. Barton A. Bean, of the United States National Museum, and Mr. A. G. Maddren, and those relating to the statistics and methods of the fisheries by Mr. W. A. Wilcox. The field work was planned on a comprehensive basis, and contemplated securing as complete information as possible on the following subjects: The kinds of food-fishes occurring in the river, either continuously or as regular visitants; their distribution, movements, spawning, and other habits; their abundance at present as compared with the past, the extent of any decrease among them, and its causes; and the remedial measures advisable to take in order to preserve, and if need be to restore, the fishery resources of these waters. In determining these matters it was necessary to study the physical characteristics as well as the natural history of the region, and to obtain a thorough knowledge of the history of the fisheries from their inception to the present time. The work was carried on chiefly by interviewing the fishermen, fish-dealers, and others acquainted with the subject, and by examining the catches as they were landed or received at market, but much seining was done and observations were made respecting the temperature and density of the waters and other physical conditions.

Indian River is in reality a long, narrow, and shallow salt-water lagoon or sound, about 135 miles long and separated from the sea by a narrow strip of very low land. It is connected more or less directly with the ocean at four different places. The commercial fishes number about 24 species, of which, however, only about 16 species occur in sufficient abundance to be important, the most conspicuous among these, based upon the value of the catch in 1895, being the mullet, pompano, sheepshead, and squeteague. Oysters are also obtained in considerable quantities.

The fisheries of Indian River have been developed only within a comparatively few years, beginning practically in 1878, and it was not until railroad communication had been opened up in 1886 that they became thoroughly established. With the increase of facilities in this regard the industry has grown rapidly and has been extended to a large part of the river. More than half the catch and nearly a third of its value were represented by the mullet. The pompano, the most highly esteemed species, has decreased greatly in abundance, especially since 1894, and the explanation of the fishermen, that this is due chiefly to the severe weather during the winter of 1894-95, is not without reason. As this species seems to spawn inside the river, it is thought that a close season during its spawning period would prove advantageous.

Although the mullet may be less abundant at present in some parts of the river than when fishing first began, they are now sufficiently plentiful to more than meet the current demands, and the dealers are frequently obliged to place a limit on the catch. While these conditions continue, the fishery will regulate itself, but with the improvement in means of preserving and of transporting fish from this region, a larger market will undoubtedly soon be opened up, and some restrictive measures are required to insure the preservation of the supply of this species. No decrease is reported among the other fishes of the river. Turtles, however, are much less abundant than formerly, owing to overfishing, and there has also been a large reduction in the average size of those caught. The oysters are of fair size and good quality, but have received little attention. Their more general utilization and the formation of artificial beds, doubtless soon to be undertaken, will be one of the principal factors in the future development of the fishing industry.

INVESTIGATIONS OF INTERIOR WATERS.

COLUMBIA RIVER BASIN.

The inquiries respecting the salmon and other fishes in the Columbia River basin, begun in 1892, have been continued systematically during each succeeding year, with interesting results. The investigations of 1894 showed that both the redfish or blueback salmon and the chinook salmon have important spawning-grounds in the regions of Big Payette Lake and the Redfish lakes of Idaho, and these waters were selected as the field of operations for 1895, a party being sent to each. The work was directed by Prof. Barton W. Evermann. Mr. Thomas M. Williams, of Stanford University, was assigned to Big Payette Lake, where he remained from July 19 until September 25. Redfish lakes were covered by Prof. Evermann, Prof. Seth E. Meek, of the Arkansas Industrial University; Dr. Oliver P. Jenkins and Mr. N. B. Scofield, of Stanford University, and Mr. William Barnum, of the Fish Commission, whose observations extended from July 17 to September 24.

Two forms of redfish have been found to breed in the inlets to these lakes. They differ, however, only as to size, the smaller weighing about half a pound each and the larger from $3\frac{1}{2}$ to 6 pounds, and are considered to represent only a single species. Both of these varieties, as well as the chinook salmon, were the subject of careful daily observations, gill nets of different-size mesh being employed, so as to intercept their movements in certain of the inlets and outlets and furnish the opportunity for keeping a close watch upon their habits. The results obtained were of great value, leading to definite conclusions on several points in the natural history of these species, which have never been clearly understood. Some of the more important may be briefly stated as follows: Both forms of redfish had reached the lakes prior to July 20, when the nets were first used. The larger form is considered to be anadromous, but the evidence that the smaller one comes up from the sea is not complete. The mutilations, sores, fraying out of fins, etc.,

are not received while en route to the spawning-grounds, but subsequent to reaching them; and all the redfish die soon after spawning. The young remain in the lakes and connecting waters for at least one year after the eggs are laid. The chinook salmon arrived on or about July 24, at which time they were practically without mutilations or sores. They all die after spawning, the same as the redfish, and the young appear to remain for one year after the period of spawning near where they were hatched.

In the report of the season's work* Professor Evermann describes at length the methods and progress of the examination. Besides the inquiries respecting the salmon and other fishes collected, observations were made upon the physical features of the lakes and streams and upon the plant and lower animal life which belong to them. All of the facts obtained are fully discussed, and many illustrations are given. The paper concludes with a "Detailed report upon the salmon and other fishes observed," in which 21 species are enumerated, with very complete natural-history and technical notes, especially upon the *Salmonidae*.

The investigations of this season must be regarded as especially noteworthy in their results, having added conspicuously to the sum of knowledge previously acquired respecting the habits and life history of the Pacific group of salmon.

INVESTIGATIONS IN THE NORTHWESTERN STATES, 1896.

In the spring of 1896 plans were drawn up for extensive investigations in the northwestern part of the United States, relating more especially to the requirements of that region from a fish-cultural standpoint. In accordance with the directions of the Commissioner that arrangements be made looking to the increase of hatching operations in regard to the salmon, it was necessary to provide for the examination of as many important rivers as possible, in order to ascertain the best locations for new and auxiliary stations, where eggs could readily be obtained and where a supply of water by gravity was available.

The carrying out of these instructions necessitated a change from the methods of previous years, and called for a rapid reconnoissance of a wide extent of territory, although it was intended that the work should everywhere be executed in as thorough a manner as the time permitted. These inquiries were to cover not only the Columbia River basin, but the entire Pacific watershed of the States of Washington, Oregon, and California, to the southern limit of salmon distribution. In the Columbia River basin it was considered important that several good sites for the collecting of eggs should be discovered and their advantages in that respect carefully determined. In the Puget Sound region it was furthermore desired to ascertain, especially in the interest of the Joint Fishery Commission, to what rivers the blueback or sock-

* A report upon salmon investigations in the headwaters of the Columbia River, in the State of Idaho, in 1895, together with notes upon the fishes observed in that State in 1894 and 1895. By Barton Warren Evermann. Bull. U. S. Fish Comm., xvi, for 1896, pages 149-202, plates 67-72.

eye salmon resort for spawning purposes, and their relative abundance in each. Arrangements were also made for repeating the observations begun on Big Payette Lake and the Redfish Lakes in 1894, with respect to the presence and the spawning and other habits of the several varieties of salmon, by detailed observations carried on continuously during that part of the season when the fish occur in those upper waters. In view of the prolonged strike of the fishermen on the lower Columbia River, which was then in progress, and the opportunity thus afforded for the uninterrupted movement of the fish during a considerable period, it was expected that the results of the observations this year would have unusual significance.

An additional subject to be attended to in connection with the above inquiries was the examination of Lake Washington, at Seattle; of lakes Pend d'Oreille and Cœur d'Alene, Idaho, and of Crater and Klamath lakes, Oregon, with regard to the following matters, namely: The commercial and game fishes which are native to them, the expediency of introducing new species, and the survival of the plants of whitefish which have been made in some of them.

These investigations were placed in the direct charge of Prof. Barton W. Evermann, and the following persons were designated to assist him: Mr. A. B. Alexander, fishery expert of the steamer *Albatross*; Prof. S. E. Meek; Prof. U. O. Cox, of Mankato, Minn., and Mr. A. G. Maddren. The field work was to be actively taken up on July 1, the beginning of the fiscal year, but the following inquiries were made before that date:

Lake Washington.—Having been detailed from the *Albatross* in May, Mr. Alexander proceeded to Seattle, where he made an investigation of Lake Washington, extending from May 28 to June 17, 1896, for the purpose of determining, if possible, the presence of the common whitefish of the Great Lakes (*Coregonus clupeiformis*), the fry of which had been planted there by the Fish Commission several years before. The examinations were conducted mainly by means of gill nets having 3½-inch mesh, in all depths from the shallow water around the shores to a depth of 25 fathoms. Drag seines were also employed. The results of the numerous trials made were entirely negative, nothing but a species of sucker being obtained in the gill nets, although quite a large variety of forms was secured in the seine. Mr. Alexander is led to conclude from his observations and from the testimony of several inhabitants about the lake that the whitefish did not survive; but whether this was due to unfavorable physical conditions or to the destruction of the fry or young by predaceous fishes he was unable to ascertain. The inquiries will be repeated in the fall, at which season this species spawns in the Great Lakes, coming into shallow water for that purpose.

While at Seattle, Mr. Alexander also made inquiries respecting the vessel halibut fishery of the past year, the extent of that industry, the grounds resorted to, the size and quality of the fish found on each, etc. He likewise paid some attention to the oyster-grounds in the Puget Sound region.

Lake Pend d'Oreille.—This lake, situated in the northern part of Idaho, was the subject of investigation by Mr. Alexander and Professor Cox, beginning on June 25, 1896, and extending for some time into July. The object of the inquiry was similar to that concerning Lake Washington, namely, to ascertain if the fry of the common whitefish planted there by the Commission in 1889 had survived, and the result was also the same. Both gill nets and seines were employed in the examination, but the conditions proved very unsatisfactory for the work, the water being unusually high. Important observations, however, were made respecting the physical characteristics of the lake and the fishes and other forms of life which inhabit it. This was done with the object of determining whether its waters were suitable for any of the important fishes not now native to it, and whether the introduction of new forms was advisable.

INQUIRIES RESPECTING THE SHAD.

In the spring of 1896 specimens of shad were received from the Black Warrior River at Tuscaloosa, Ala., which proved upon examination to present such marked differences from the common shad of the Atlantic coast rivers that it has been classed as a new species under the name *Alosa alabamae* Jordan and Evermann.* It agrees entirely in structure with a number of young shad collected at Pensacola, Fla., in 1882, by Dr. David S. Jordan, who considered them at the time to represent a new species, but withheld his description of them from publication. The significance of the discovery in 1896 was not appreciated until it was too late to make extensive investigations in the South, but the collections contained in the United States National Museum were carefully gone over, and visits were paid to the Potomac, Susquehanna, Delaware, Hudson, and Connecticut rivers, where large numbers of specimens were examined. No examples of the new species were found among the material from any of the rivers on the eastern coast. According to Prof. Evermann—

This is undoubtedly the native shad of the Gulf of Mexico and tributary streams, though it is probably less abundant in those waters than *Alosa sapidissima*, which has been extensively introduced there by the United States Fish Commission.

WOODS HOLE LABORATORY.

The Woods Hole laboratory of the Commission, with its exceptional advantages for the study of marine biology in all its branches, was kept open as usual during the summer of 1895. Besides the inquiries conducted there by its employees, advantage was taken of the customary facilities granted to independent workers by thirty persons interested in special lines of investigation, who represented twenty different institutions of learning of greater or less prominence. The supervision generally given to the station at this season by the Commissioner, whose illness prevented his being present, and whose death occurred at the close of the summer, was greatly missed.

* Description of a new species of shad (*Alosa alabamae*) from Alabama. By Barton Warren Evermann. Rept. U. S. Fish Com. for 1895, pp. 203-205.

The laboratory was in charge of Dr. James I. Peck, of Williams College. The others in attendance were as follows:

Dr. William Patten, of Dartmouth College; Dr. Henry V. Wilson, of the University of North Carolina; Mr. James E. Peabody and Mr. S. Gato, of Harvard University; Mr. Ulric Dahlgren, of Princeton University; Mr. George Lefevre, Mr. Hubert L. Clark, and Mr. Arthur L. Lamb, of Johns Hopkins University; Mr. John A. Sampson, of Johns Hopkins Medical School; Dr. Ira Van Gieson and Mr. Israel Strauss, of the College of Physicians and Surgeons, New York; Mr. J. R. Slonaker, of Clark University; Dr. Lewis Murbach, of Berkey, Ohio; Mr. Alvin Davison, of Lafayette College; Mr. Herbert Tetlow, of Adelbert College; Dr. Thomas H. Montgomery, jr., of the Wistar Institute of Anatomy, Philadelphia; Mr. Maurice Bigelow, Mr. Charles Hazzard, and Mr. W. S. Nickerson, of Northwestern University; Mr. William H. Dudley, of Lake Forest University; Mr. N. R. Harrington, of Columbia University; Mr. E. R. Boyer, Dr. H. S. Pepoon, Mr. Frederic C. Lucas, and Mr. W. Whitney, of the high schools, Chicago; Dr. Mary A. Schively and Miss Alice H. Beckler, of Philadelphia; Miss Bessie V. Gaines, of Adelphi Academy, Brooklyn; Mr. John I. France, of Johnstown, N. Y.

The researches carried on by Dr. Peck were undertaken in the interest of the Commission, and related to the food and feeding habits of the younger stages of a large number of the important food-fishes of the region. The work was in continuance of studies which have now been in progress during three consecutive seasons, the earlier results being referred to in previous reports. This year's inquiries had reference mainly to the length of the period elapsing from the hatching of the egg until the young fish begins to feed and to the character of its first food, subjects of great importance in respect to fish-cultural methods.

Other investigations which may be noted in this connection are the following: Dr. H. V. Wilson was engaged in the preparation of a report upon marine sponges collected by the steamer *Albatross*. Dr. Patten continued his studies on the central nervous system of the young horse-shoe-crab and of the young of several kinds of fishes. Dr. Montgomery was occupied with researches on the anatomy, histology, and development of Nemertean worms, and completed, while at the station, a paper on the origin of the land and fresh-water species of that group. Dr. Murbach studied the embryology and the netting organs of the Medusæ. Dr. Van Gieson's investigations were directed toward determining the difference in structure between the sensory and motor ganglion cells of both vertebrates and invertebrates, in which work he secured the cooperation of several of the students present at the laboratory, which gave the opportunity for extending the observations to many forms representing a number of different groups. Besides these a great variety of subjects was represented by the inquiries of other investigators and students, many of which relate to structural features among the useful fishes and invertebrates. In this manner and by such voluntary labors important facts, which ultimately derive practical significance at the

hands of specialists in fishery matters, are brought to light each season, showing how dependent on the precise methods and deductions of science are the improvements which are taking place in the means for preserving and increasing the objects of our fisheries.

Mr. Vinal N. Edwards, the permanent observer at Woods Hole, has continued his almost daily collecting trips throughout the year, as well as his record of the seasonal appearance and disappearance of the different fishes and of their relative abundance from time to time. Some of the special inquiries conducted by him are referred to in another connection. During the summer he assisted those in attendance at the laboratory in obtaining the materials for their studies.

The aquaria and the exhibition collection of marine animals and plants have been properly maintained throughout the year, and many additions have been made to the latter. The aquaria are especially serviceable to the workers in the laboratory, as they afford not only the means of keeping animals alive for an indefinite period, so as to have them available for study at all times, but also the opportunity of observing their habits under conditions which are as nearly natural as it has been possible to provide them. The names of the different species contained in each tank are displayed on a large label for the benefit of the public, which continues to find the exhibition rooms on the lower floor an attractive place to visit.

TEMPERATURE OBSERVATIONS.

The Fish Commission has continued to receive, through the courtesy of the Light-House Board and the Southern Pacific Company, the daily records of water-temperature observations taken at the following sea-coast 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: Brenton 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: Charleston Bar light-ship, Martin's 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 Kings 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.