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

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OYSTER INVESTIGATIONS.

LOUISIANA.

In May, 1897, a communication was received from Hon. Adolph Meyer, member of Congress from Louisiana, transmitting a resolution of the general assembly of that State requesting the Commission to make an investigation of the oyster-grounds of Louisiana. The special object of the desired investigation was to obtain information on which to base a revision of the oyster laws, with a view to place the oyster industry on a more substantial basis. The legislature was informed that the Commission would undertake the investigation at the earliest practicable date.

In August, 1897, Dr. H. F. Moore went to Louisiana to make some preliminary inquiries that could not be satisfactorily undertaken at any other season. It had been determined to detail the steamer *Fish Hawk* (Lieut. Franklin Swift, U. S. N., commanding) early in the winter for the proposed investigation, but the vessel could not reach the field of operations before February 2, 1898, and the time available for this work was curtailed by the exigencies of the annual shad-hatching operations of the *Fish Hawk* on the Atlantic coast, so that only 21 days could be devoted to the examination of the oyster-grounds, which time was somewhat further reduced by stormy weather.

It being apparent that only a limited area could be surveyed in the time available, the oyster-beds of St. Bernard Parish were selected as presenting the most satisfactory features for examination. This parish comprises the extreme eastern part of Louisiana and contains some of the most important oyster-beds of the State. Owing to the shallowness of the water over the greater part of the region it was impossible to make use of the steamer for the active work of the survey, and this duty was therefore performed entirely by the two launches, the ship being used as a base. The limited time at the disposal of the party made it impossible to erect signals and make a regular survey, such as was originally contemplated, but by engaging pilots and running lines of soundings from point to point it was possible to make a reconnaissance showing the main hydrographic features and the general location and extent of the oyster-beds. The work was carried on over an area of about 200 square miles, and as it was sometimes necessary to run

long distances from the ship much time was lost. Should the work be again taken up, with a view to making a finished survey, it would be desirable to obtain one or two light-draft sailing vessels, which could be taken into the interior waters to serve as bases of operation and living quarters for the field parties using the launches.

The survey was under the direction of Lieutenant Swift, who was assisted by Dr. Moore as zoologist. After the *Fish Hawk* left Louisiana waters, on February 26, Dr. Moore remained and made a rapid examination of the remaining oyster-grounds of the State.

The oyster-beds of Louisiana lie principally between Mississippi Sound and the mouth of the Atchafalaya, the only beds to the westward of the latter place being comparatively unimportant ones in the vicinity of Vermilion Bay and Calcasieu River. The most productive natural beds at present are in St. Bernard and Terrebonne parishes, the latter being the most important oyster region in the State.

There is ample evidence that some of the practices now and formerly in vogue are detrimental to the best interests of the State and have resulted in the practical extermination of the oyster in certain regions in which it was formerly abundant. Dr. Moore's report upon this investigation, which will be transmitted to the Louisiana authorities, contains suggestions concerning the laws and methods necessary to secure the growth and welfare of the industry, and also deals with the history, condition, and prospects of the oyster-grounds. It will be found in the appendix to this volume (pp. 45–100), accompanied by a chart showing the location of the oyster-beds of St. Bernard Parish.

The oyster-planting industry is capable of great expansion within the limits of Louisiana. At present planting is practically confined to Plaquemines Parish, where a rather crude method of oyster-culture has been found to yield satisfactory profits and is now engaged in by a considerable number of persons. Practically all of the oysters sold from this parish, most of which are put on the market as "Bayou Cooks," are planted—generally as seed obtained from the natural beds, but sometimes as spat caught on artificially distributed shells.

The rather limited biological investigation of the Louisiana oyster which it has been possible to make indicates that it spawns during nearly all the year, but most of the spawn is undoubtedly expelled between April 1 and September 15. The rate of growth is rapid and there are doubtless few places in the State in which oysters will not reach a good marketable size within three years from the time of spawning.

The principal enemies of the oyster in Louisiana are the drumfish (*Pogonias cromis*) and a snail (*Melongena?*). Other foes do a limited amount of damage, but the starfish and drill (*Urosalpinx*), which create such havoc on the beds of the North, are here practically unknown as destructive agents. Storms and crevasses occasionally prove very injurious to the oyster-beds of the State, but crevasses are often followed by a peculiar process of regeneration (not satisfactorily explained) which soon renders the beds more productive than before. This phe-

nomenon, concerning which there can be no doubt, seems to occur with sufficient frequency to convince the oystermen that a crevasse is a desirable thing in the case of semidepleted beds.

The density of the water on the coast of Louisiana undergoes great fluctuation, being largely conditioned by the direction of the prevailing wind and the amount of precipitation. In general it is lower in winter than in summer. In the bays, bayous, and lagoons it is increased by southerly or (east of the Mississippi) easterly winds, and lowered by northerly winds and rains.

LYNNHAVEN BAY, VIRGINIA.

The experiments, in charge of Dr. H. F. Moore, begun during the last fiscal year at Lynnhaven, Va., looking toward a practical solution of the difficulties encountered in fattening oysters for market, have been continued without as yet having reached definite results. The claire established there has now been in operation about a year, during which time it has been cut off from accessions of sea water excepting during high tide, such as occurs several times during each month. On two occasions the claire has been flooded to a depth of several feet above the dam crest by extraordinary storm tides. Oysters have been kept in the claire during the entire period of the experiment, and from time to time others have been placed in several parts of the pond, but none of them has developed a condition superior to those in the open waters of Lynnhaven Bay, and most of them are decidedly inferior. It appears that in this particular case there is no advantage to be gained by simply inclosing a cove or pond after the method which has been attended with marked success in Europe. The conditions in this pond, therefore, can not be held to favor the experiment, and if it can be demonstrated that the food-producing powers of this claire can be materially increased by artificial means an important advance in oyster-culture will have been made.

Laboratory experiments appear to indicate that artificial conditions can be established which will tend to increase the rapidity of multiplication of the diatoms upon which the oyster mainly subsists, and it now remains to adapt the same experiments to the larger body of water contained in the claire. That this can be done is by no means clear, as certain intermediate attempts during the past year have yielded contradictory and unsatisfactory results, and it may take a long time to perfect the proper methods. It is proposed to continue the experiments during the coming year.

PACIFIC COAST.

The acclimatization of the eastern oyster (*Ostrea virginica*) on the Pacific coast and its subsequent increase by natural propagation would prove a great boon to an extensive section; and the Commission has made a number of experiments to test the adaptability of the shores of the Pacific States to the growth of this mollusk.

As is well known, transplanted eastern oysters have been successfully grown in San Francisco Bay for many years.* In October, 1894, 80 barrels of oysters, from New York, New Jersey, and Chesapeake Bay, were planted by the Commission in Willapa Bay, Washington;† and in November, 1896, 25 barrels of 3-year-old and 4-year-old oysters from Princess Bay and East River, New York, were deposited in Humboldt Bay, California, and an equal quantity in Yaquina Bay, Oregon.

In Yaquina Bay the oysters were deposited on Oysterville Flat, 2 miles above Yaquina City and about 7 miles from the ocean, and were spread over an area of about half an acre, the bottom consisting of mud and shells. The flat is a natural bed of the native oyster (*Ostrea lurida*) but has been so closely worked that oystering is no longer profitable; at low tide it is covered with 10 feet of water and at high tide with 18 to 20 feet. During the spring and summer of 1897 Prof. F. L. Washburn of the State University at Eugene, Oreg., was engaged by the Commission to examine the beds of eastern oysters that had been planted in Yaquina Bay in the previous year, and also to study the physical conditions of other bodies of water on the Oregon coast with reference to the introduction of the Atlantic oyster. His observations showed that the transplanted oysters exhibited considerable growth, and were in a spawning state. Many million eggs were artificially fertilized and the embryos released in the waters of the bay.

No spat of the eastern oyster was discovered up to the close of the season's inquiries on September 12, but an abundant "set" of the native oyster was observed on the shells of the introduced species. Sufficient time has not yet elapsed to demonstrate whether the waters are adapted to the multiplication of the Atlantic oyster, and three or four years might be required in order to definitely settle the matter. The most serious condition to which the spat would be subjected seems to be the sudden and marked variation in the salinity of the water, owing to changes in the tide, strong winds from the ocean, and heavy rainfall.

Examinations of some other bays on the Oregon coast with reference to their suitability for eastern oysters showed that Coos Bay was too salty for successful growth except near Marshfield, where the oysters might suffer from freshets and sewage; that Tillamook Bay was very salt and cold except at its extreme head, where mud and fresh water would kill the oysters during winter; and that the water of Netarts Bay was too dense.

An examination of the waters at Gearhart Park, on the ocean adjacent to Astoria, at the request of Mr. M. J. Kinney, the well-known salmon-canner, disclosed no localities in which oyster-culture is feasible.

It is proposed to have Professor Washburn continue his observations on the planted oysters in Yaquina Bay during the fiscal year 1898–99.

* See "Report of observations respecting the oyster resources and oyster fishery of the Pacific coast of the United States." By C. H. Townsend. Report U. S. Fish Commission, 1889–91.

† "The transplanting of Eastern oysters to Willapa Bay, with notes on the native oyster industry." By C. H. Townsend. Report U. S. Fish Commission, 1895.

The physical features of Humboldt Bay, California, seem unfavorable for oysters, the salinity of the water being almost as great as in the ocean, and the summer temperature being too low to warrant the free development of eggs. Furthermore, starfish and stingrays are reported as destructive, and Professor Washburn found one starfish with an eastern oyster in its grasp. The plants were in only fair condition in August, and but few showed spawn, thus contrasting strongly with the Yaquina Bay oysters.

GREEN OYSTERS.

During the season of 1897–98, the oysters in the lower Chesapeake basin, notably at Lynnhaven Bay, Va., were affected with green gills, which condition, by rendering the crop unmarketable for the time being, was financially very serious to the oystermen. At Lynnhaven the first indications of this affection were noticed in June, 1897. The color at that time was quite faint, and had completely escaped the notice of the oystermen, but it gradually grew in intensity, until by the first of September it had become extremely pronounced. At the opening of the season (in September) a few oysters were shipped, but the greenness proved so repugnant to the consumers that the demand soon entirely ceased, and practically no oysters were shipped from Lynnhaven during the remainder of the season.

The Commission received a large number of inquiries from boards of health, boards of trade, oyster-dealers, and oyster-fishermen regarding the wholesomeness of green oysters. It is the popular opinion that green-gilled oysters owe their viridity to the presence of copper, and are therefore unwholesome; and this view has been recently strengthened by newspaper references to a paper by two eminent English investigators, Prof. Rupert Boyce and Dr. W. A. Herdman, in which they record the discovery of copper in unusual quantities in certain green American oysters in England. Stimulated by this discovery, a reexamination of the question was begun by Dr. H. F. Moore, but has not yet been completed, owing to the intervention of other duties. Enough has been accomplished, however, to show conclusively that the green color of the oysters at Lynnhaven was not produced by copper. All of the customary tests were applied without securing a copper reaction, and specimens of the green oysters were submitted for quantitative tests to Prof. J. D. Hird, of the Medical Department of Georgetown University, who found mere traces of copper, and reported that "the green color was due to a hydrated ferrous compound." The exact source of the green color has not been satisfactorily determined, but in no case is it injurious.

All attempts to obtain the pigment in solution have failed, and, like "marennin," as Lankester has named the substance which produces the characteristic green color of the oysters of Marennes, it is insoluble in alcohol, ether, benzole, benzine, glycerin, water, dilute alkalies, and dilute acids.

The diatom *Navicula ostrearia*, which produces the green pigment investigated by Lankester and others, was not found in the Lynnhaven oysters, and the stomach contents presented the same golden-brown coloration commonly found in normal oysters. It is evident that this greenness is quite different from that investigated by Boyce and Herdman,* and before them by Ryder. The green color was confined to the gills and palps, and no pigment whatever was found in the heart, pericardium, or blood cells. Practical tests have shown that these oysters may be safely eaten in large quantities.

RED OR "BLOODY" OYSTERS.

During the oyster season of 1896–97, the oysters on certain parts of the Virginia coast were affected with a peculiar condition which has heretofore been very rarely observed in this section. In making a canvass of the oyster industry of the State in the spring of 1898, Mr. W. A. Wilcox, agent of the Fish Commission, secured the following information regarding the extent and appearance of the affection: It seems to have been first noticed in the season of 1895–96, when a few oysters from the upper oyster-grounds in the Rappahannock River were found to have a reddish color, and received the local name of "bloody oysters." At the outset the grounds involved were not extensive, but by the next season most of the beds down the river were affected, as well as numerous adjacent smaller-water courses in Lancaster and Middlesex counties and a limited area in Chesapeake Bay off the mouth of the river.

It is reported that there were "bloody" oysters also on the shores of Chesapeake Bay north of the mouth of the Potomac. Information has been received indicating the occurrence of a similar condition in parts of Chesapeake Bay about ten years ago.

When these oysters were examined in October, 1896, the red discoloration involved only the region of the gills, but a little later it extended throughout the oyster and its liquor. During the early spring of 1897 the color gradually disappeared; by the close of the season few, if any, red oysters were to be found, and none has since been reported.

The existence of red oysters in the Rappahannock region resulted in a serious disturbance of the oyster fishery and trade. The greatest pecuniary loss was due to the prejudice which arose against the oysters from the affected districts, the fear being generally entertained that those which seemed normal when first gathered might develop the red color before reaching the consumer. In some instances cargoes of oysters that on close inspection were entirely normal would, on arriving at Norfolk or other markets, show the reddish color, which gradually involved the entire cargo, necessitating the return and replanting or the throwing away of the oysters.

In conversation with Norfolk oyster-dealers, the writer was informed

*On a green leucocytosis in oysters, associated with the presence of copper in the leucocytes.—Proceedings of the Royal Society, vol. 62.

that about 50,000 bushels of such oysters were brought to that city during the season of 1896-97.

The red oysters seemed to be fat and well flavored, the few persons who ventured to eat them reporting no ill effects.

The nature of this affection could not be determined, as no opportunity to examine the oysters was afforded the Commission, nor does the condition seem to have been previously described. Possibly the infusorian *Peridinium*, which gives a reddish color to sea water and is occasionally reported on the Atlantic coast, may be the cause.

SPONGE FISHERY OF FLORIDA.

In January, 1898, the writer visited Key West, Florida, in order to obtain information concerning the present condition and recent changes in the Florida sponge fishery and trade which center at this place. Data were furnished by the purchasing firms showing the quantities of sponges landed by the fishing vessels in the years 1896 and 1897. By correspondence and other means, similar figures were secured from dealers at the other sponge centers of the State. The Commission having in 1896 canvassed the sponge industry for the preceding year, a continuous record was thus acquired giving the sponge catch for the three years ending 1897, during which some marked changes in production were manifested. The results of the inquiries were incorporated in a report* by the writer presented at the National Fishery Congress, held at Tampa, Fla., in January, 1898.

The investigation shows that in 1897 the Florida sponge fishery yielded 331,546 pounds of sponges, having a first value of $284,640; in the previous year 234,111 pounds, worth $273,012, and in 1895 306,120 pounds, valued at $386,871. The condition of the fishery can not be accurately gauged from the foregoing bare figures, which show a larger yield in 1897 than in 1895 or 1896, although it is known that the industry, as a whole, was in a declining state. The explanation is that the catch in 1897 consisted of a much larger percentage of the lower grades of sponges. Thus, the output of the comparatively cheap grass sponges (having an average value of only 23 cents a pound) increased from 7 per cent of the aggregate catch in 1895 to 19 per cent in 1896 and 39 per cent in 1897; while the yield of the most valuable sponge, the sheeps-wool (average value $1.53 per pound), declined from 76 per cent in 1895 to 64 per cent in 1896 and 47 per cent in 1897.

It is the almost unanimous opinion of those who have given the matter careful attention that the sponge-grounds of Florida, while still very productive, are being seriously depleted; and the fact is generally recognized that a continuance of the present conditions will in a short time result in great loss to those having capital invested in vessels, equipment, and warehouses.

*The Florida Commercial Sponges. By Hugh M. Smith. Bull. U. S. Fish Commission 1897, pp. 225-240, 20 plates.

The following facts may be cited in evidence of a decline in the abundance of sponges: Grounds along the Florida coast that were formerly very productive (and in fact yielded most of the supply) have been completely abandoned, although the industry is not 50 years old. The spongers have had to resort to deeper and deeper waters, as the shoaler grounds have become depleted, until it is impracticable, with the present methods, to extend their operations further.

The average catch per vessel and per man is now much less than formerly; and what in the past was considered an average yield for a vessel is now an exceptionally good catch. The history of the sponge fishery during the past few years records an extraordinary number of trips that resulted in loss to the owners or equippers of sponge vessels. Furthermore, the catch now consists of a large proportion of small sponges, many being under the size sanctioned by law.

The reason for the decline of the fishery is not obscure and may be comprehended under a single head—indiscriminate fishing. Chief among the causes contributing to a decrease is the gathering of small sponges. While an excellent State law of fifteen years' standing prohibits the taking of sponges less than 4 inches in diameter across the top, the law has always been practically a dead letter. Excessive fishing has given the grounds no opportunity to recuperate from one season to another, and has made the collection of undersized sponges a necessity in order to fill out the cargoes. Almost from the beginning of the fishery there has been a total disregard for the preservation of the supply, and the present unsatisfactory conditions are the natural consequence.

Under proper restrictions there seems no reason to doubt that the Florida sponge-grounds are capable of regularly yielding a large annual catch without any danger of jeopardizing the supply. The area of the grounds is so large (estimated at over 3,000 miles) and the growth of sponges thereon is so rapid that the most ordinary precautions would probably insure a permanent crop. The remedial measures suggested for existing conditions are (1) the strict enforcement of the law as to taking small sponges, and (2) the suspension of sponging on given grounds during every second or third season. A careful survey of the productive and depleted grounds is a great desideratum, and the Commission has engaged to make such a survey as soon as practicable, employing the steamer *Fish Hawk* for the purpose.

MACKEREL INVESTIGATIONS.

Among the appendices to the present report of the Commissioner is a paper by Dr. J. Percy Moore upon the results of the investigations and experiments conducted by him for this division in the summer of 1897 relative to the embryology, natural spawning, and artificial propagation of the mackerel (*Scomber scombrus*). The investigations, which were begun in June of the last fiscal year, were conducted at Woods Hole, Massachusetts, and on board the *Fish Hawk* in Casco Bay, Maine, and were completed in the latter part of August.

These inquiries were prompted by the great scarcity of mackerel, which has now extended over a longer period than ever before in the history of the fishery, and by the large mortality among the artificially-hatched mackerel fry, to which reference has been made in earlier reports of the Commission. The supply of mackerel, as gauged by the catch, decreased markedly after 1885, and for the succeeding 13 years remained at a very low ebb, the average annual output being probably only one-seventh that of the 10 preceding years. After referring to the fact that short periods of scarcity have in the past been followed by seasons of abundance, Dr. Moore states in his report:

> Why the mackerel supply is thus subject to periodical wax and wane is unknown. There are no certain data upon which to venture a solution of the problem. Are their numbers depleted by disease? There is no evidence that the mackerel is subject to any serious infectious disease. Is the decrease due to a period of lowered fertility, of less or greater duration? Here again we lack facts. We know but little to what extent the biological and physical conditions of the sea have varied, nor yet how variations in these factors affect the vitality and habits of the mackerel. There may have been no actual diminution in the propagating capacity of the fish, but some condition peculiarly detrimental to the development of the eggs and embryos may have existed, causing their consequent destruction on a large scale. Has there been a real or only an apparent decrease due to migrations of the fish from our waters to other parts of the ocean? This view, most frequently accepted as explaining the fact, has little to support it, and is a mere guess founded on the known wandering habits of the mackerel.

The report cited first gives the results of studies relating to the spawning time of the mackerel, the development of eggs in the ovary, the characters of the ova, the process of fertilization, the vitality of the milt, the changes in the egg after fertilization, and the hatching and growth of the fry. The results of surface towings and the outcome of hatching experiments are then given, followed by a summary of conclusions and recommendations.

A point of practical importance in the artificial hatching of the fish is that during development the specific gravity of the egg gradually increases, so that, while the egg floats at the surface of the inshore waters during the early stages, it sinks to a considerable depth before hatching ensues. This fact was emphasized by the failure to obtain in surface towings any eggs in the more advanced stages of development; very few mackerel, however, were spawning in Casco Bay during the progress of the work, although the region is ordinarily one of the best spawning-grounds on our coast.

As bearing on the relatively poor results attending the artificial hatching of mackerel eggs, Dr. Moore conducted a number of experiments with different hatching methods and apparatus. These indicated that for the first two days of development no apparatus is superior to the ordinary tidal boxes, provided their sides are smooth and the screens are kept clean. Subsequently the requirements are pure water of higher density, and a hatching vessel that affords better circulation and keeps the eggs in suspension instead of permitting them to settle on the bottom among decaying organic matter.

Under the most favorable conditions it seems that the number of eggs obtainable under present methods is so insignificant, when compared with those which must be naturally hatched, that no effect on the mackerel supply is to be expected. The necessity for extensive operations suggests the possibility of securing the cooperation of the mackerel purse-seine fishermen in utilizing the eggs of the ripe fish caught by them. As is well known, the mackerel vessels frequently meet with schools of spawning fish, all of whose eggs are lost. As the artificial fertilization of mackerel eggs is very easily and quickly accomplished, and as the stripping of the fish might be carried on without interfering with the vessel's fishing operations, it is thought that the cooperation of the mackerel fishermen may be readily secured by providing each vessel with instructions as to processes, together with proper pans for mixing the spawn and milt, the eggs after fertilization being poured overboard. In this way many more eggs might be obtained from a single school of fish than would be possible in years of ordinary collecting operations.

INVESTIGATIONS OF WESTERN LAKES AND STREAMS.

WALLOWA LAKE, OREGON.

The importance of Wallowa Lake and vicinity as spawning-grounds of several species of *Salmonidæ*, and the great decrease in numbers of these fish in late years, especially of redfish, made an investigation of these waters desirable. The lake is in the extreme northwest corner of the State, at the head of Wallowa River, one of the tributaries of Snake River, the principal branch of the Columbia. Reference to a preliminary examination of this region was made in the last report of the division. In the present year the lake was visited and an extensive investigation was carried on. A party from the Commission, consisting of Dr. W. C. Kendall, in charge; Mr. Barton A. Bean, Mr. Hoffman Philip, and Mr. C. M. Rowe, reached the lake on July 13, and remained until November 14, two or three persons always being on the ground.

As was ascertained to be the case in the Idaho lakes, two forms of the redfish (*Oncorhynchus nerka*) inhabit Wallowa Lake and breed in the inlets; but the Oregon fish differ in size and other respects from the Idaho fish. The smaller fish, having a maximum length of 9½ inches, were abundant, and valuable observations on their habits were made. No important observations on the large redfish were possible, as they were almost entirely absent from these waters, only four being seen.

While the question of the migrations of the small redfish was not absolutely settled, the evidence obtained is almost conclusive that these fish have their permanent residence in the lake.

In former years a seine was operated at the head of Wallowa Lake for trout and the large redfish, considerable quantities being taken and salted annually. This fishery had to be abandoned, owing to the scarcity of fish and the enactment of a law prohibiting seining. The great diminution in the abundance of large redfish and other migratory

salmon was doubtless due to excessive fishing and the destruction of young salmon by irrigating ditches.

Other salmonoids found in these waters permanently or periodically are the chinook salmon (*Oncorhynchus tschawytscha*), which appears during the summer and early fall; the silver salmon (*O. kisutch*), known here as dog salmon, which comes in October and November; the steelhead trout (*Salmo gairdneri*), locally known as salmon trout and not always distinguished from the black-spotted trout, which appears in March and April, and is caught in the lake by trolling and gigging; the black-spotted trout (*Salmo clarkii*) and the bull trout (*Salvelinus malma*), which are permanent residents of the region; and the whitefish (*Coregonus williamsoni*), which is not uncommon, but not much fished for. Other fishes inhabiting the lake and its tributaries are lampreys, small dace, several suckers, and two or three blobs.

The most feasible method of replenishing these waters seems to be the enactment of suitable protective laws and their impartial enforcement. The remoteness of the lake from the railroad makes the introduction of fish very difficult.

BAKER LAKE, WASHINGTON.

The establishment of a hatchery for the blueback salmon or sockeye (*Oncorhynchus nerka*) at some point on the northwest coast has been under consideration by the Commission for several years. This is by far the most important species of salmon inhabiting the Puget Sound region, and the call for its artificial propagation has come chiefly from people of that section, although in the Columbia River it is taken in large quantities, ranking next to the chinook in importance.

Information having been received showing the existence of extensive spawning-grounds in Baker Lake and its tributaries, in Washington, Prof. B. W. Evermann, in August, 1898, made an examination of it with reference to its adaptability for a hatchery site.

This body of water is located in Whatcom County, in the northwestern corner of the State, near the international boundary. The nearest railroad station is Hamilton, a village on the Skagit River, 36 miles distant, whence the lake is reached by wagon road and trail, more than half the distance being a trail crossing several creeks which are at times difficult of passage; one of them, Boulder Creek, is fed by melting glaciers on Mount Baker, and for a few weeks each summer is a raging torrent in the afternoon and early evening, fording being very dangerous. The lake is about 1 mile wide and 1¼ miles long, and is little more than an expansion of Baker River, the principal northern tributary of the Skagit. It is well surrounded by high mountains, among them Mounts Baker, Shuksan, and Cleveland, on whose slopes are glaciers and large snow fields which feed the headwaters of the Skagit basin. Dense forests of cedar, spruce, hemlock, and other trees exist on all sides. Two streams, Noisy Creek and Sutter River, flow into the head of this lake, in addition to several smaller streams carrying sufficient water for hatching purposes.

In 1896 the State of Washington established a hatchery on the lake and took 6,500,000 eggs of the sockeye salmon. It is reported that many more eggs could have been secured if the facilities for handling them had warranted it. In 1897, the capacity of the hatchery having been increased to 14,000,000, the indications were that there would be no difficulty in obtaining the full quota. It seems certain that the most extensive spawning-beds of the sockeye to be found in the United States are here, and this fact, together with the excellent water-supply to be obtained by gravity, makes the lake the best-known hatchery-site for this species of salmon.

YOUNG SALMON IN THE SACRAMENTO BASIN.

The systematic studies of the movements, habits, growth, food, and enemies of young chinook salmon in the Sacramento River, referred to in the last report, were continued during this year under the charge of Mr. Cloudsley Rutter, in association with Mr. F. M. Chamberlain, who was detailed from the *Albatross*, and Mr. N. B. Scofield, who was engaged in making inquiries for the California Fish Commission.

As a preliminary measure, in order to make a general survey of the river, Mr. Rutter, in April, 1898, went by steamer from San Francisco to Redbluff, situated about 300 miles above the mouth of the Sacramento, and then extended his reconnaissance to Redding, 40 miles beyond. The river for the whole distance has a strong current and is very crooked; the lower half is comparatively narrow and deep, while the upper part is wider, with many shoals, sand-bars, and gravel-banks. Brief trials for young salmon were made near Sacramento and Redbluff; at Tehama, a few miles above Redbluff; at Battle Creek, 20 miles above, and at Redding—at each of which places, except Sacramento, salmon were abundant. On returning to the mouth of the river, salmon were found in only limited numbers, suggesting that the main body of young fish was still in the upper river.

Mr. Chamberlain was then detailed to pursue his inquiries in the lower part of the river and in the bays at its mouth, while Mr. Rutter went to the headwaters near Sisson and, in conjunction with Mr. Scofield, began a careful examination of the entire stream above Sacramento. On reaching Redbluff, May 20, on the downward trip, the further study of the river was made by means of a skiff, in which, during the following 10 days, the party rowed from Redbluff to Sacramento, a distance of 250 miles, numerous observation stations being made at suitable points.

The remainder of the fiscal year was occupied in studies adjacent to the mouth of the river. The California Fish Commission tendered the use of its steam launch, which permitted the examination of parts of San Pablo Bay that could not otherwise have been visited.

The results of the work, so far as it has been carried, are quite satisfactory and interesting. It seems that by May a large majority of the young salmon had left the smaller streams where they were hatched and had become scattered throughout the upper part of the river as far

down as Chico, about 225 miles from its mouth. Below Chico they became fewer and fewer toward Princeton, about 50 miles farther downstream, below which place they were scarce. In the latter part of May, 12 were taken in brackish water about the mouth of the river, and two weeks' work in June in the lower river and bays yielded only 5, while in the upper river from 20 to 70 were taken at each haul of a short collecting seine.

After reaching the main river the young salmon prefer to keep in the current, never being found in shallow, quiet water. A large series of specimens has been kept to show the rate of growth and the food, which will be noted in the final report. Young of the year, varying in length from 1.4 inches to 3.9 inches, have been found. The smallest—those less than 2 inches long—have been observed only in the upper river and small streams, practically none below Tehama. Those above 2 inches were about evenly distributed throughout the river.

It is thought that by the continuation of these studies for a short time sufficient information may be obtained on which to base a report giving the complete history of the quinnat salmon from the time of hatching until it runs to sea.

SOUTHERN OREGON LAKES.

Along the southern border of Oregon is a series of large isolated lakes about whose fauna nothing was known until July and August, 1897, when an examination of some of them was made by a party from the Commission, consisting of Prof. B. W. Evermann in charge, Mr. W. P. Hay, and Mr. Charles M. Rowe. The party outfitted at Ashland, Oreg., and traveled by wagon more than 600 miles. The object was to ascertain the physical and biological features of the lakes, and to make collections of the fishes and other animals found therein.

The waters examined were Goose Lake and New Pine Creek, near Lakeview; the Warner Lakes, near Plush; Abert Lake and Chewaucan River, near Paisley; Summer Lake and Summer Lake River; Silver Lake and Silver Lake Creek. These lakes are unconnected with each other, have no outlets, are quite shallow, and are more or less alkaline.

Goose Lake, the Warner Lakes, and Silver Lake are very slightly brackish and contain fish, while Abert and Summer lakes are strongly alkaline and entirely destitute of fish, although containing several kinds of small crustaceans. In Goose and Warner lakes black-speckled trout of very large size and excellent food qualities were abundant.

A study of the collections made in this region will throw much light on the characteristics of isolated fish faunas and on the origin of the faunas of these and other similar lakes in Oregon, California, and Nevada. Before a full understanding of all the questions presented is possible, it will be necessary to extend the investigations to lakes Harney and Malheur, located farther to the eastward in Oregon, and also to explore the isolated lakes in the northern part of the adjoining State of Nevada.

The Klamath Lakes, on the Oregon-California border, have already been examined by the Commission.* The relations of the faunas of these lakes to each other and to those of the Snake River Basin and the Great Salt Lake Basin present a very interesting problem in geographical distribution; and it is the purpose of the Commission to continue these investigations until a full knowledge of the fish life of these waters is obtained.

COASTAL STREAMS OF WASHINGTON, OREGON, AND CALIFORNIA.

In the summer and fall of 1898 a systematic examination of the salmon streams of the coast of Washington was taken up. Mr. Cloudsley Rutter was in charge of the investigations, and was assisted at times by Mr. C. F. Foote and Mr. E. R. Brady. The inquiry was begun about July 25, immediately north of the Columbia River, and was concluded on October 1, by which time the streams on the south side of the Strait of Fuca were reached.

The investigations had for their object the determination of the physical character of the principal streams, the nature of the general fish fauna, and the distribution, abundance, habits, spawning, etc., of the different species of salmon.

Among the numerous waters visited were the following: Nasel, Willapa, and North rivers, tributary to Willapa Bay; Chehalis River, which empties into Grays Harbor, with its more important branches, including Black River and Black Lake, Satsop River, Wynooche River, the east and west forks of Wishkab River, and a number of smaller streams; east and west forks of Humptulips River, which enters Grays Harbor; Lake Quinault and its tributaries; Elk Creek, a branch of Quinault River; Raft River; Queets River with its tributaries, Salmon River, Tacoma Creek, Mud Creek, Clearwater River, and Hurst Creek; Hoh or Ohalot River; Bogachiel River, tributary of the Quillayute River; Ozette Lake and tributaries; Pleasant Lake, Beaver Lake, Beaver Creek, and Soleduc River, in the Quillayute Basin; Crescent Lake and Sutherland Lake, with their feeders and outlets.

Many of the foregoing waters are very remote from regular lines of communication and had never before been examined with reference to their fish life. Large collections of the fishes and other water animals were made for future study.

The investigation showed that both the quinnat salmon and the silver salmon are found in all the principal streams, and that the dog salmon is distributed throughout the region and ascends even the smallest streams. The blueback salmon, or redfish, enters the Quinault River and Lake, and also Ozette Lake. The dwarfed redfish exists in Ozette Lake, and probably in Quinault Lake. Ozette Lake affords good facilities for a conclusive study of the question as to whether the small redfish are migratory or permanent residents of lakes.

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*The Fishes of the Klamath Basin. By Charles H. Gilbert. Bull. U. S. Fish Commission, 1897.

The examination of the coast streams of California begun in May, 1897, and referred to in the last annual report, was continued until August 15, 1897, by which time all the rivers of California north of San Francisco and some of those of southern Oregon had been visited. The inquiries were in charge of Dr. C. H. Gilbert, of Leland Stanford Junior University, assisted by four students of that institution. The streams were very thoroughly examined with reference to their fish life, large collections of fish, crustaceans, mollusks, etc., being made.

OTHER INVESTIGATIONS.

SHAD OF THE OHIO RIVER BASIN.

From time to time the capture of shad in the Ohio and Mississippi rivers and their tributaries has been reported. The fish have locally been regarded as identical with the shad of the Atlantic coast (*Alosa sapidissima*), and have been called "Potomac shad," "white shad," etc. In view of the large numbers of shad fry planted in the Mississippi Valley, it has been thought that their attempted acclimatization may have proved successful. Ichthyologists have had little opportunity to examine these shad from the Ohio basin, but the Commission has recently been able to make some interesting observations thereon. In the spring of 1896 it was reported from Montgomery, W. Va., that shad were being taken in some numbers in the Kanawha River at that place. In May, 1897, a fish-dealer in Louisville, Ky., stated that considerable quantities of shad were being caught at the Falls of the Ohio, and four fresh specimens were sent for identification. The same dealer, in May, 1898, wrote that the shad had again appeared, and forwarded six specimens. An examination showed that these represented a species of true shad (*Alosa*), and not a hickory shad or skipjack (*Pomolobus*), gizzard shad (*Dorosoma*), or mooneye (*Hiodon*), which are popularly known as shad in various parts of the interior. It was also seen that they were closely related to the shad of the rivers of the Atlantic slope, but had certain characters which were apparently sufficiently marked to render the fish specifically distinct from the common shad, and also from the shad (*Alosa alabamæ*) recently described from the Black Warrior River, Alabama.

In order to secure more definite information regarding the nature, movements, and abundance of this fish, Prof. B. W. Evermann, in May, 1898, was instructed to proceed to suitable points on the Ohio River and tributaries.

Montgomery, W. Va., was first visited. No shad had yet arrived, but additional information concerning the runs in 1896 and 1897 was obtained. In 1896 the fish appeared during the third week in May, the largest number being caught on May 20. Several hundreds were taken for home use by the people of the town, and the run was reported to consist of thousands of fish. In the following year the shad came about the same time and were reported to be quite as numerous.

When Louisville was visited, May 16–19, the shad were running and good opportunities were afforded for studying them. They were being caught in seines at the Falls of the Ohio, chiefly on the Indiana side, together with spoonbill catfish, shovel-nose sturgeon, and drum. It is said that the shad from the Ohio first came under the observation of the Louisville dealers in about 1876; the fish were at once identified as "Potomac shad" by those dealers familiar with the shad of the Atlantic coast. A good many were caught at the Falls of the Ohio that year and met with a ready sale. A few were taken in some of the succeeding years, but no large catch occurred until 1897, when a change in the method of rigging the seines may have had some effect on the number taken. In 1897 the run was large, and several thousand were secured, the daily catch during the first three weeks in May being from about 125 to 740. In 1898 the first shad was caught April 28; from that time the number increased until about May 17, when the run began to decline. The total yield in 1898 was about the same as in 1897.

This species of shad has not, so far as known, been taken in large numbers, except at Louisville, but it has been reported from various places on the Mississippi, and at a number of places below Louisville on the Ohio and Mississippi rivers. In March, 1898, a Louisville fish-dealer saw 25 or 30 captured at Cahoma, Miss., where the fishermen stated that a good many were taken, and thought they were a species of skipjack. The same dealer has seen the shad in the Ohio River at Concordia, Ky., 90 miles below Louisville, and at Brandenberg, Ky., 40 miles below Louisville. About fifteen years ago they were reported at Vicksburg, Miss., in 1884 at Hickman, Ky., and in 1886 and since at Aurora, Ind. A fish-dealer at Evansville, Ind., reports that some years ago he caught shad in the Wabash River near its mouth, and that about twenty years ago, and also in 1897, he saw a few that had been taken in the Ohio River.

None of the dealers at Vincennes has ever seen any shad from the Ohio or the Wabash, but one states that in the spring of 1898 he received a few from St. Louis. None of the dealers and fishermen interviewed at Terre Haute had ever seen shad from the Wabash River. That shad have not been taken in this stream may be due to the legal restrictions on all methods of fishing which would be likely to result in the capture of such a fish.

STUDIES OF YOUNG SHAD IN POTOMAC RIVER.

The studies of young shad in the Potomac River, referred to in the previous report, were continued throughout the fiscal year 1897–98. The inquiries, which were in charge of Mr. M. C. Marsh, related mainly to the movements, food, and rate of growth. While much has been definitely established, further inquiries will be necessary before the full history of the young shad is known.

The observations have shown that shad hatched in the spring of one year are abundant during the ensuing summer months throughout the fresh portion of the river below Little Falls. They feed in the shore

waters all summer, with practically no downward migration. At this season, also, near the surface in the open water of the river, they seem to be present in moderate numbers and are perhaps abundant, but the means available for collecting in the offshore waters have not been satisfactory. With the approach of cold weather the young shad do not descend the river along the shores in order to reach warmer water, but withdraw to the river channel. When the temperature of the water falls to a point between 46° and 56°, which happens in November, they leave the places they have frequented during the summer. This movement is perfectly well marked throughout the section above brackish water. Observations in winter and spring indicate that there is some downward movement after the fish leave the shores, and this must necessarily take place in the deeper water. Seining in the Lower Potomac and along the western shore of Chesapeake Bay in the latter half of February showed that no young shad were there, but about the end of March numbers were noticed in the pound nets set along the shores of the Lower Chesapeake near Old Point Comfort and the Virginia capes. These were the previous spring's hatch, and such fish have also been noted in the Lower Potomac. Shad of apparently two years' growth have been taken in both the bay and lower river, but the young do not reappear on the shores in spring in the fresh water of the river.

It seems probable that at least some of the young shad of a particular season's spawning do not reach the ocean during the ensuing year, and it is possible that some reach maturity (in three or four years) without visiting the ocean. Deep-water collecting in Chesapeake Bay in midwinter will do much to fill the present hiatus in our knowledge of the shad during that season.

Insects and entomostracans are the most important food of the young shad in fresh water. Of entomostracans, the genera *Daphnia*, *Cyclops*, *Cypris*, and *Bosmina* are largely represented in the stomach contents. Rhizopods, nematodes, amphipods and gastropods are eaten; vegetable food is rarely taken. In a few cases small fish had been ingested and shad fry have been found in the stomach, but this is unusual.

When 2 months old, shad are about 2 inches long; having attained this size, they add about an inch to their length in from 2½ to 3½ months, so that when they leave the fresh water in the fall they are from 3½ to 4 inches long. They grow slower in the river than in ponds (such as the Government fish-ponds at Washington). Fish from the upper part of the river are distinctly smaller than those from the lower, having been hatched later.

FISHES AND FISHING-GROUNDS OFF SAN DIEGO COUNTY, CALIFORNIA.

In March and April, 1898, Messrs. C. Rutter and F. M. Chamberlain were assigned to an examination of the fishery resources and fishing-grounds of the southern California coast. The steamer *Albatross*, which was then lying off San Diego, was made the headquarters of these assistants while working in the vicinity. It was the intention to have

shore inquiries conducted in conjunction with the dredging, collecting, and hydrographic work on the vessel, but the *Albatross* was transferred to the Navy Department shortly after the investigations were begun, and the only studies made were those relating to the fish, fishing, and fishing-grounds of San Diego County. The recent marked development of the fishing industry of the southern counties of California makes it very desirable that a thorough examination of the outlying fishing-grounds should be carried on with reference to the habits, migrations, abundance, food, spawning, etc., of the fishes found thereon. This work should be taken up by the *Albatross* as soon as practicable.

The barracuda (*Sphyræna argentea*) is by far the most important food-fish taken in this section. It makes its appearance in February or March and remains until November, rarely until December, being most abundant from April to August. It is found off the shores of Lower California in January, which leads the fishermen to believe that it travels northward along the coast; but the fact that in one season recently the barracuda was caught at San Pedro, Los Angeles County, a few weeks earlier than at San Diego, would indicate that its movements toward the coast are chiefly from deep water offshore.

Other important fishes of the San Diego region are bonito (*Sarda chilensis*), yellow-tail (*Seriola dorsalis*), several species of bass (*Paralabrax*), flounder (*Paralichthys californicus*), and rockfishes (*Sebastodes*) of many species.

EXPERIMENTS WITH SALMON OVA.

In October and November, 1897, during the prosecution of salmon-hatching work at Battle Creek Station, Cal., Mr. Cloudsley Rutter, scientific assistant, conducted some experiments having a practical bearing on fish-cultural work, and chiefly directed to questions relating to the fertilization and development of the eggs of the quinnat salmon (*Oncorhynchus tschawytscha*). Among the subjects specially considered were the influence on fertilization of the exposure of the eggs to water, the vitality of the milt, the fertilizing of eggs from dead fish, the fertilization of bloody, slimy, and foamy eggs, the effects of handling eggs at supposed critical periods, and the percentage of eggs fertilized under natural and artificial conditions. The studies were not completed and they will probably be resumed next season. An outline of the general results is here given.

Numerous experiments were tried to determine how long salmon eggs might remain in water and still be capable of fertilization. This subject has a very important bearing on fish-cultural operations as well as on natural reproduction. No eggs were fertilizable after they had been in water more than 5 minutes, and only 2 per cent on 5 minutes' immersion. After being in water 2½ minutes, 16 per cent were fertilized. After rapidly washing the blood from eggs taken from fish already stripped, only 11 per cent were fertilized.

Spermatozoa were found to live for more than 10 minutes after the milt was mixed with water, but their fertilizing powers rapidly dete-

riorate. Thus, the experiments showed that after milt had been in water 1 minute it fertilized 19 per cent of the eggs treated; after a lapse of 3½ minutes, only 9 per cent were fertilized; after 6 minutes, 8 per cent; after 8½ minutes, 2 per cent; and after 11 minutes, 2 per cent, no fertilization occurring after a longer interval.

It occasionally happens that a fish is injured before spawning, and when the eggs are pressed out they are mixed with more or less blood. Eggs from three such fishes were selected, in order to ascertain the percentage of fertilization. About 8 per cent of them died within 5 days, and of the remainder, 2 per cent were unfertilized. This is not very different from the average results under normal conditions. Of several lots of bloody eggs taken from stripped fish, 89 per cent were fertilized. In the passage of eggs through the oviduct the natural liquids of the part often become foamy. It was not known whether such eggs were fertilizable, but tests showed that this condition did not impair the susceptibility of the egg to the action of the milt. The slime from fishes is thought by some fish-culturists to be fatal to spermatozoa; some eggs were thoroughly mixed with slime and then treated with milt in the usual way; less than 2 per cent were unfertilized.

The question of killing the female salmon before attempting to take the eggs received some consideration. Stripping the female is very hard work, requiring the services of three men, one to hold the head and one the tail, while the third expresses the eggs. Even when the fish is ripe, a man's entire strength is often required to force the eggs through the oviduct. Many good eggs are necessarily left in the fish and thus lost. In 21 stripped salmon examined with this point in view, there were found on an average 700 ripe eggs, or about 14 per cent of the total average production per fish. It had been claimed by some fish-culturists that eggs from fish killed before spawning would produce deformed fry, but this was shown by experiments to be erroneous. In view of the foregoing experiments and the additional fact that these fish die after spawning, there would seem to be good reasons for killing or stunning them by a blow on the head and for removing the eggs through an artificial opening in the abdominal wall.

It is well known that at certain ages eggs are much more delicate than at other times. These critical periods are when the eye-spots first appear (ninth to fifteenth day) and just before hatching. When first taken, eggs may be handled comparatively roughly with impunity. The spawning-place at Battle Creek is 1½ miles from the hatchery, the eggs being hauled that distance in wagons over a rather uneven road without any injury. Nearly 700,000 eggs 43 days old were sent from Battle Creek to Olema; they were first taken 10 miles in a heavy wagon, and were then carried on a railroad train 15 hours, being out of the water 48 hours; the loss in transit was only 300 eggs. At other times such treatment would kill almost every egg, the simple turning of the eggs with a feather often causing a large loss. In one experiment 120,000

eggs, in four equal lots, were employed to demonstrate the critical periods; two lots were picked daily to remove dead eggs; the other two lots were picked only on the first, third, twenty-second, twenty-fourth, and forty-first days, so as to avoid the critical times. The percentages of loss in the first two lots were 56 and 32, respectively, and in the second two 11 and 9, respectively.

A number of tests indicated that even after a fish has been dead in the water for a comparatively long time the contained eggs remain in good condition. On November 25 a female salmon that had died below the spawning rack was selected for experimentation. Eggs were taken and fertilized at periods of 2, 4, 6, 8, and 24 hours after its death. In the case of the first four lots the percentages fertilized were 99, 98, 92, and 92, respectively, and at the end of 26 days the eggs were healthy. The eggs taken after a lapse of 24 hours were not sound, and although most of them were fertilized, the entire lot died within 2 weeks. On the 13th of November eggs were obtained from 2 fish that had died in the water, one having been dead 2 hours and the other over 6 hours; of the former, 97 per cent and of the latter 85 per cent hatched and produced healthy fry.

LAKE SUPERIOR.

The investigations of Mr. A. J. Woolman in Lake Superior begun in April, 1897, and referred to in the last report, were continued until the latter part of August, 1897. They had for their object the determination of the food-supply of the fishes of the lake and its relation to the abundance and movements of the commercial fishes. Large collections of the minute animal life, which directly or indirectly constitutes the principal food of the fishes, were made with fine-meshed nets used at the surface, bottom, and intermediate depths on the fishing-grounds along the south shore. The study of the collections has not yet been completed.

Different regions were found to differ very materially in the variety of small aquatic animal forms inhabiting them and in the abundance of those forms. Some extensive areas were shown to be abundantly supplied with minute animals in great variety, which in other areas were almost completely absent. If further observations show that the distribution of the minute animals is in any way constant in given areas, information of value in the planting of fish fry will have been obtained.

One noteworthy feature of the inquiries was the discovery of small crustaceans (*Diaptomus*) in large numbers in certain very deep waters where there has recently been a remarkable increase in the abundance of the bluefin whitefish (*Argyrosomus nigripinnis*).* These crustaceans occur in large quantities only in deep water (100 to 130 fathoms), where they are the predominating animals of this class. Another observation was that apparently well-defined areas are occupied by cladocera, as

* See Report U. S. Fish Commission for 1897, pp. CXXI, CXXII.

distinct from regions occupied by certain copepoda and the still more localized areas inhabited by ostracoda.

FISH PATHOLOGY.

Assistants of the division have made a number of examinations of fishes that have died at various stations of the Commission, but usually the results of the studies have been unsatisfactory. Lesions have sometimes been found which would result in death, but the causes of the morbid processes or conditions have not been apparent. In other cases no clew to the disease has been detected.

One of the most important subjects now connected with fish-culture is fish pathology. With the exception of the effects produced by a few animal and vegetable parasites, practically nothing is known of the diseases of fishes. This is a very inviting field for study from the scientific standpoint and from the practical standpoint of fish-culture. A very large mortality not infrequently prevails among young and mature fish at hatching stations, in stocked waters, and among wild fish, for which there is no known cause or remedy. The annual unavoidable losses in the Commission, while not excessive, are yet sufficiently serious to demonstrate the necessity, which has long been appreciated, for an assistant who could devote his whole time to the consideration of fish diseases, and who is fitted by previous training in human pathology to fully comprehend the nature, cause, and possible remedies for the now obscure affections prevailing among the food and game fishes. It is strongly urged that the Commission be provided with a permanent expert in fish pathology.

WOODS HOLE, MASSACHUSETTS.

WORK IN THE LABORATORY.

During the summer of 1897 the Woods Hole laboratory was occupied by a small number of investigators, the Commission having restricted the attendance to representatives of those institutions which had furnished financial aid in the construction and equipment of the laboratory. Among those at the station were Dr. John Y. Graham, of the University of Alabama, and formerly of Princeton University; Mr. F. N. Balch, of Harvard University; Mr. Charles W. Greene, of Johns Hopkins University; Dr. J. Percy Moore, of the University of Pennsylvania, who was engaged in studies on the embryology of the mackerel in the interest of the Commission. At the request of the Smithsonian Institution, Prof. C. C. Nutting, of the University of Iowa, was granted laboratory privileges to enable him to complete his work on American hydroids for the institution.

In the spring of 1898 it was determined to take steps to increase the opportunities for scientific study at Woods Hole, by providing for the prosecution of inquiries throughout the year instead of only during the summer months, as heretofore. It was also decided to place the laboratory in the charge of some competent biologist, who would be in

attendance during most of the year and give personal direction to the investigations. The laboratory was opened on March 14, and Dr. H. C. Bumpus, professor of comparative anatomy in Brown University, was appointed director. Correspondence was entered into with the principal universities and colleges, notifying them of the opening of the laboratory and stating that nominations of a limited number of persons to represent them would be received. During April fourteen investigators availed themselves of the privileges of the laboratory, and by the 1st of June accommodations for the ensuing summer had been assigned to the full capacity of the station.

During a period of six weeks in May and June the work of the laboratory was facilitated by the courteous action of the trustees of the Marine Biological Laboratory in placing their steam launch at the disposal of the Commission.

Reports on the aquatic life present in the vicinity of the station during March, April, and May were published in the current issues of "Science," by Dr. Bumpus and Dr. A. D. Mead, for the guidance of those who may desire to pursue studies at the laboratory in the spring months. In an article on "The breeding of animals at Woods Hole during the month of March, 1898," Dr. Bumpus stated:

> The water has swarmed with animal life, and many forms rarely or never captured during the warmer months have been found in abundance. Breeding animals have yielded rare embryological material, and all forms of life have had great vitality, due probably to the low temperature of the water (38° to 43° F.).

MORTALITY AMONG BROOD COD AT WOODS HOLE.

During the cod-hatching season of 1897–98 at Woods Hole there was a very large death rate among the adult cod retained in live-cars. In previous seasons numbers of the brood cod had died, but the mortality during the present year was greater than heretofore. These fish were caught with hand-lines on Nantucket Shoals and brought to the station in welled-smacks. Between October and February 3,507 were received, of which 2,696 died, or more than 76 per cent; 1,977 dying in November, 315 in December, 203 in October, 143 in February, and 58 in January.

In November 14 cod, each weighing 5 or 6 pounds, that had died in the live-cars, were sent to Washington in ice and there carefully examined. In 11 cases there was no doubt of the cause of death, in 2 the cause was not positively made out, and in 1 it could not be determined. Cerebral meningitis, due to hook wounds, was responsible for the death of 5 fish; the same condition, resulting from injuries to the eye, led to the death of 2 others; cerebro-spinal meningitis, induced by a blow on the side, caused the death of 1 fish; marked degeneration of the heart muscle was found in two cases, and inflammation of the heart or pericardium existed in 2 fish, being complicated with meningitis, due to hook wound in one of them. In one of the doubtful cases there was slight meningitis traceable to a hook wound, and in the other there seemed to be a rupture of the abdominal aorta.

The inflammation resulting from the hook wounds could easily be traced to the membranes of the brain, which were in most instances highly congested and surrounded by considerable bloody serum. While such injuries are often unavoidable, it is probable that some might have been less severe had more care been exercised in extracting the hooks. In the cases of meningitis due to injuries to the eyes, there is ground for suspicion of rough handling. Fishermen have a practice of thrusting the forefinger and thumb into the eyes of cod and other fish in order to secure a firm hold in removing the hook, and in this way displacement of the lens, rupture of the eyeball, and other injuries may result. The cases of degeneration and inflammation of the cardiac muscle and of rupture of the aorta might be occasioned by heavy pressure on the ventral region between the gills. Fishermen, while removing the hook, often grasp fish in the place stated, squeezing the heart and related structures with sufficient force to produce serious lesions. The fish whose death depended on cerebro-spinal meningitis was clearly the victim of rough handling; the wound in the side was such as might be produced by a swinging blow on the thwarts or gunwale of a boat.

Subsequent examinations of many cod at the station showed conditions similar to those mentioned. There seems no reason to believe that the fish received rougher treatment this season than formerly. The high mortality may have depended on special physical surroundings, such as high-water temperature, which promoted inflammation, perhaps septic, that under other conditions would not have ensued. The experience, however, demonstrates the necessity for great care in handling cod that are to be kept in confinement for several months.

TAGGING COD AT WOODS HOLE.

During December, January and February 560 cod, weighing from 3 to 17 pounds, were tagged at Woods Hole and released in adjacent waters. These fish had been caught with hand-lines on the southern Massachusetts coast and retained at Woods Hole for brood purposes. After their use in the fish-cultural work, they were liberated with a small tin or copper tag attached to one fin by silver or copper wire. Complete data were kept for each fish tagged, including its weight, length, sex, and when and where released. A printed circular calling attention to the experiment and soliciting certain information regarding the fish was extensively circulated in the coast towns of Massachusetts, Rhode Island, and Connecticut, and also in New York and New Jersey. Within a few weeks after the fish were released tagged fish began to be caught, and by the close of the fiscal year about 25 tags had been received, while the taking of other fish was reported; these were mostly from southern Massachusetts, but some came from Rhode Island, Connecticut, and New York, and one from a point on the middle New Jersey coast. It is expected that the experiment may throw some light on the rate of growth of the cod, the frequency of its spawning, the extent to which individual fish migrate, etc.

COLLECTIONS AND REPORTS.

A small collection of fishes obtained by the *Albatross* on the coast of southern California in April, 1897, was transferred to Dr. Charles H. Gilbert, of Stanford University, for examination and report. The collecting was done in the neighborhood of Santa Catalina Island and Monterey Bay, with dredge, gill net, trawl line, hand line, and shore seine. The greatest depth at which trials for fish were made was 581 fathoms off Monterey Bay with gill net and beam-trawl; another trial with these appliances in the same region was in 278 fathoms; all the other collecting was in water less than 100 fathoms deep. Dr. Gilbert's report, which appears in the appendix to this report (pp. 23–29), shows that 62 species of fish were secured, one-third of which are rockfishes (*Scorpænidæ*), while most of the others are the common shore species. Off Santa Catalina Island, at depths of 47 fathoms and 80 fathoms, respectively, two undescribed species were obtained, one an agonoid (*Averruncus sterletus*), the other a cottoid (*Radulinus boleoides*).

The interest of late manifested in the fish and fisheries of Florida has suggested the need of a comprehensive report on the fish fauna of that State. The preparation of such a report has been begun by Drs. Evermann and Kendall, based on extensive collections made by the Commission, and on previously published lists of Florida fishes. About 600 species are now known from Florida waters, and the fish fauna is consequently more varied than that of any other State. Some additional field investigations in certain sections are desirable; these will doubtless considerably augment the list.

In conformity with the established custom, natural-history objects obtained by the field parties and vessels of the Commission have been transferred to the United States National Museum. The large collections of aquatic animals sent to the Museum during the year included reptiles, batrachians, mollusks, crustaceans, and other invertebrates, besides rare fishes and types. These collections are studied and reported on by specialists connected with the National Museum and Smithsonian Institution.

Arrangements have been made to supply to the leading educational institutions of the country sets of named marine and fresh-water fishes in alcohol. After collections have been reported on, and complete series of specimens have been reserved for the Government, the best use to which they can be put is to donate them to universities, colleges, and schools having biological courses, and to State museums.

The various papers pertaining to the functions of this division which have appeared during the year have been mentioned in the foregoing report of the Commissioner.