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

By Hugh M. Smith, *Assistant in Charge.*

RIVER AND LAKE FISHES OF MAINE.

The fresh-water inquiries in Maine, referred to in previous reports, were continued in 1900 by Dr. William C. Kendall. In the latter part of the summer and early fall the Sebago Lake region was visited, principally with a view to obtain further data on the spawning of the native salmon (*Salmo sebago*). It was observed that there are distinct spring and fall runs of these fish into the streams for feeding and breeding purposes respectively. The spring salmon enter the streams in pursuit of smelts, and at that time will take the hook. They return to the lake with the downward movement of smelts. The fall fish very seldom bite. These facts suggest an explanation of similar habits in the sea salmon. The early sea salmon take the hook, while fall salmon seldom, if ever, do. It is quite possible that the early run is for feeding purposes. The fact that food is seldom found in the stomachs is not proof that the salmon do not feed, for after confinement in traps or when caught in gill nets they naturally get rid of their stomach contents, perhaps by disgorging, but more likely by digestion.

Some interesting notes were obtained on the habits of fresh-water smelt in Sebago and Little Sebago lakes. Later Lake Auburn was visited and a collection of the native fishes was made. Here Hon. H. O. Stanley, one of the State fish commissioners, rendered assistance in various ways. A short trip was made to the Rangeley Lakes, in order, if possible, to study and collect the blueback trout (*Salvelinus oquassa*), but only one specimen was obtained. The fish have become scarce almost to extinction, but in the last ten years they seem to have changed their habits to some extent and have increased in size. Formerly a fish 10 inches long was the largest, and a weight of one-fourth of a pound was probably the heaviest. The specimens now caught on fly or spoon, or by bait-fishing at the bottom, weigh as much as 2½ pounds This increase in size is ascribed to the abundance of smelts, the result of the plants made about 1891.

Sebec Lake, one of the original landlocked-salmon lakes, was also visited. It was learned that there the salmon had the same migratory habits as the Sebago fish. From there Dr. Kendall went to Matagamon or Grand Lake, near the headwaters of the east branch of the Penobscot. A few years ago a gentleman from New York called at the Fish Commission Office in Washington to ascertain the identity

of some small trout or salmon-like fish that he had caught at the upper end of the east branch below the foot of Grand Lake. He reported that they ran from 6 to 10 inches long and were sexually mature at that size. These interesting fish seemed to be identical with the small salmon found in the Presumpscot River below Sebago Lake. A specimen of a ripe male only 6 inches long was obtained. No adult salmon were observed there, though it was learned that not longer than four years ago they were plentiful on the spawning-grounds within 2 miles of the dam at the foot of Matagamon Lake.

At least 17 species of fishes inhabit Matagamon Lake and neighboring waters. At one haul of a 12-foot seine in the mouth of a small brook 12 species were obtained. Of these, 3 were previously unknown from Maine waters, and the recorded range of 4 more was extended. The most interesting feature of this collection scientifically was the discovery of 2 unrecognized species of the minnow *Leuciscus* and the occurrence of the minnow *Notropis muskoka*, previously recorded only from Muskoka Lake, Ontario, together with the finding of the "shore-fish" (*Fundulus diaphanus*), the stickleback (*Gasterosteus atkinsii*), and the chub (*Semotilus atromaculatus*) in these new localities.

Incidental to the clam-planting experiments on Casco Bay, a number of interesting observations were made in the Harraseekett River, a tidal estuary. The usual littoral fishes of the region were found in abundance. Young blue-fish (*Pomatomus*) were very common, and some had been seen the previous season, when they were supposed by fishermen to be butter-fish (*Poronotus*). Their presence in such large numbers is remarkable, since adults of this species have not been noticed in these waters, and only now and then has one been caught in pound-nets in the outer waters of Casco Bay. In October young menhaden (*Brevoortia*) from 3.75 to 4.75 inches long were seined, and were also observed in brush weirs. The young of this species had not before been positively known to occur on the Maine coast. White perch (*Morone*) were uncommonly numerous, and the fishermen, owing to their unfamiliarity with the species because of its previous scarcity, identified it as the sea bass. On October 21 a jumping mullet (*Mugil cephalus*) was taken in a weir, this being the first record of the occurrence of this southern species in Maine waters.

MODEL STUDY OF AN INDIANA LAKE.

In the summer of 1899 the Commission began a physical and biological survey of Lake Maxinkuckee, Indiana, the desire being to make such a study of this lake as would serve as a model for the investigation of all similar lakes. The objects and scope of this inquiry are indicated in the report for 1900. It very early became manifest that satisfactory data concerning many of the problems that came up for consideration could be secured only by carrying on the observations throughout at least one entire year. Therefore, when the

work was resumed July 1, 1900, it was with the intention to continue as many of the lines of observation as possible until July, 1901.

The investigations were again placed under the direction of Dr. B. W. Evermann, who, during the summer months, had the following assistants: Dr. J. T. Scovell, teacher of biology, Terre Haute, Ind., High School, whose time was devoted chiefly to a study of the plants of the lake and its immediate shores; Mr. Leonard Young, teacher of biology, Evansville, Ind., High School, who was put in charge of the plankton investigations; Mr. Millard Knowlton, student, Indiana State Normal School, and Mr. H. W. Clark, of Fort Wayne, Ind., general assistants, and Mr. W. F. Hill, assistant engineer, U. S. Fish Commission, who, with Prof. R. G. Gillum, teacher of physics and chemistry, Indiana State Normal School, and Mr. T. B. Evermann, student, Cornell University, made the survey for accurately mapping the lake.

This survey was completed early in September, and the volunteer assistants returned to their respective school and college duties about the first of September, leaving only Dr. Evermann and Mr. Clark to continue the investigations during the fall. When the former returned to Washington Mr. Clark remained at the lake and carried on the observations during the winter and spring.

The results of Mr. Clark's observations are important and interesting. They cover a period of the year during which but little study has been given to any American lake, and it is believed that they will add materially to a knowledge of the physics and œcology of small lakes. Perhaps the more important series of observations made during the winter pertained to the behavior of various species of fishes, mollusks, turtles, and aquatic plants, the feeding of coots and other water birds, the series of temperature records, and the action of the ice in its relation to the life in the lake and in modifying the shore line. In spring the observations regarding the breeding times, habits, and places of the different species of fishes, turtles, frogs, crustaceans, and mollusks, the growth of the aquatic plants of the lake, and the development of the plankton were of much interest and value.

The report on these investigations is now in preparation, and when published will constitute a fairly complete monograph of Lake Maxinkuckee.

BIOLOGICAL SURVEY OF THE GREAT LAKES.

This work, which had been in progress for several years, was continued under the direction of Professor Jacob Reighard, of the University of Michigan. The plan of operating a central laboratory at Put-in Bay, which should serve as the headquarters of the survey, was temporarily abandoned, and a number of independent inquiries were taken up by field parties.

One of the most important of the fundamental biological investigations which must be undertaken in lakes is the nature, abundance,

and distribution of the minute floating organisms comprehended under the general name of plankton, for it is on these that all the fishes and other large forms are ultimately dependent for their food supply. Besides the mere determination of the species of animals and plants which comprise the plankton, it is desirable to ascertain, by means of specially devised apparatus, its volume and its vertical distribution. Since 1898, Professor Reighard, in association with Prof. H. B. Ward, had been at work on a net which would register automatically the volume of water from which a given amount of plankton had been abstracted; and this subject was continued in 1900. During the summer of 1899, it had become evident that, in order to determine the amount of water passing through a plankton net when in use in the lake, it would be first necessary to "rate" in a laboratory the meter placed in the net opening for the purpose of indicating the rate of flow of the water through the opening. It was required to measure the volume of water passing through the net opening at different net velocities in a unit of time, and to determine the number of revolutions of the meter corresponding to such volume for each velocity. This could be done only in a hydraulic laboratory, and after investigation it was decided to make use of the facilities of the hydraulic laboratory of the Ohio University at Columbus, Ohio. The Commission had the services of Prof. William T. Magruder, of the Columbus laboratory, and the rating was carried out under the joint direction of Professor Magruder and Professor Ward.

The work of practically testing the efficiency of plankton nets was then transferred to Put-in Bay. Here four nets were constructed of bolting cloth of four different degrees of fineness. Each of these nets was then hauled repeatedly in the open lake from the steamer *Shearwater*, and about seven hundred such hauls were made. The automatic record of each haul showed the time occupied by the haul (recorded in fifths of a second) and the number of revolutions of the meter during the haul. From the curve constructed from the laboratory tests it was possible to determine the amount of water filtered by each net during the entire haul, as well as during each fraction of the haul. The results so far obtained may be stated as follows:

1. All of the nets experimented upon become clogged during the haul, so that they filter less water toward the end of the haul than at its beginning. This clogging is so serious as to make it doubtful whether such nets can be, in any way, made to yield quantitative results of value.

2. The records show that the pitching of the boat affects the amount of water passing through the net, a downward motion of the boat decreasing the amount and an upward movement increasing it.

3. The records show that currents in the water or the drifting of the boat noticeably increase the amount of water passing through the net.

4. It was rendered probable that the nets filter a much larger part of the water through which they are drawn than the work of Hensen has indicated.

This work yields the first direct measurement of the water passing through a plankton net, and when completed will show under what conditions, if at all, such nets may be used. The conclusions stated

above involved the careful tabulation of all the meter records, a tedious operation involving a large amount of calculating. This work was completed in December. Upon discussing the results with competent physicists and engineers it seemed best, in order to avoid all possible sources of error, to continue the work for a short time during the summer of 1901. By making slight alterations in the apparatus it is hoped to reduce to a minimum some of the unavoidable errors.

The work on the biology of the plankton algæ of Lake Erie was continued by Dr. Julia W. Snow in the botanical laboratory of the University of Michigan. Material collected at Put-in Bay was frequently forwarded to Dr. Snow in the living condition and was used in preparing cultures. The results of Dr. Snow's work during the summers of 1898, 1899, and 1900 have been embodied in a paper, with numerous colored figures, which is an important contribution to the subject.

Mr. R. H. Pond continued his investigation on the source of nutrition in the larger aquatic plants. This work was carried on chiefly at Ann Arbor by means of aquarium experiments. Mr. Pond also visited Put-in Bay at intervals and there conducted experiments in which large numbers of aquatic plants were cultivated under various conditions. Briefly stated, Mr. Pond's work shows that in the case of several species of the larger aquatic plants there is, contrary to the usual opinion, undoubted dependence on the soil for nutrition.

In April, 1901, an investigation of the breeding habits of the sturgeon in the rivers of western Michigan was undertaken by Prof. S. O. Mast, of Hope College, Holland, Mich. A study was made of the ascent of western Michigan rivers by this fish, with a view to determining where fish might be obtained for artificial propagation. Mr. Mast collected a considerable body of facts by correspondence and made some observations in person. The observations show that the sturgeon still ascends these rivers (Kalamazoo, St. Joseph, Grand, and Manistee) in small numbers, but it is not apparent that artificial propagation on a profitable scale could be undertaken there.

In May and June Professor Reighard maintained, under the auspices of the Commission, an observation camp on the Huron River, Michigan, for the purpose of studying the breeding habits of various fishes. Among the species to which special attention was given was the dogfish (*Amia calva*), which was under constant observation from the time the young fish, attended by the males, left the nests in swarms until they had attained a length of 3½ inches. The adult fish also came in for study. Other species which were studied in some detail were the common sun-fish (*Eupomotis gibbosus*), the bullhead (*Ameiurus nebulosus*), and the black bass (*Micropterus*).

The large collections of invertebrate animals of Lake Erie obtained since the beginning of the survey have been distributed as follows for study and report: Mollusks, to Mr. Bryant Walker, of Detroit; nemertine worms, to Dr. C. M. Child, of the University of Chicago; leeches and oligochætes, to Dr. J. P. Moore, of the University of Pennsylvania;

bryozoa, to Dr. C. B. Davenport, of the University of Chicago; cladocera, to Prof. E. A. Birge, of the University of Wisconsin, and flat-worms, to Mr. Raymond Pearl, of the University of Michigan.

NATURAL HISTORY OF THE CALIFORNIA SALMON.

Mr. Cloudsley Rutter, scientific assistant, has continued his studies of the salmon of the Sacramento basin. His field observations on the migrations, habits, food, diseases, etc., of the adult and young salmon have been supplemented by laboratory work addressed to the embryology, anatomy, and histology of the species. Much new information has been acquired, and additional or confirmatory data have been obtained on subjects previously considered.

Among the topics to which special attention was given, conclusive evidence has been obtained as to the essential completeness of natural spawning and of natural fertilization. It has also been shown that the death of the female salmon after spawning is not due to exhaustion incident to the spawning process, and that the fish remain on the spawning-grounds even after all the eggs are extruded and continue the spawning exertions until death. Some interesting observations were made on the diseases to which the spawning fish are subject, fungus and gill parasites being very destructive in September, but of only slight effect in November. Some additional facts in regard to the migrations of adults and fry were secured; but the rate of migration of adults is still an unsettled question and should be further investigated. It would be useful for the fish-culturists on the upper waters of the Sacramento to know definitely when to expect a run of salmon that had passed a given point in the lower river—say, Sacramento—at a certain time.

It has been appreciated that by tagging or branding much light may be thrown on the growth and movements of salmon that could not be obtained in any other way. Accordingly, tests have been made of the relative advantages of tagging fish, of marking numbers or characters on their cheeks and opercles, and of mutilating non-vital parts in various ways. Some 10,000 eggs were set aside with a view to holding the resulting fry until the fall of 1901 and liberating them after marking.

A complete study of the circulatory system of the salmon, with drawings, has been made; a full set of drawings has been prepared, showing the changes in the alimentary tract of the salmon during migration, and material has been preserved for histological study of the various organs and tissues. Series of specimens for a full embryological study have been prepared.

In the course of the work along the river a new stream was found affording special facilities for artificial propagation, especially in dry seasons, like 1900, when many of the fish fail to reach the upper courses of the river. This stream, Mill Creek, is already provided

with a dam, and in 1900 would probably have yielded three or four million eggs.

At times from July to December, 1900, Mr. F. M. Chamberlain, assistant of the Commission, was engaged in an investigation which had its origin in the continued reports of a periodic mortality among the fishes of the Sacramento River between Keswick and Redbluff, this mortality being chiefly noticeable among the salmon at the time when they were ascending that part of the river in abundance on their way to the spawning-grounds. These reports were current topics of conversation among the citizens of Redding, Anderson, and neighboring communities, and, owing to the undoubted veracity of the people who claimed to have personally noted this mortality, it became necessary for the California State Fish Commission to take the matter in hand. As this remarkable death rate had not been noticed previous to the extensive operation of the copper works at Keswick, and as those works are known to dump their waste into an affluent of the river, popular rumor at once assigned the mortality to this cause.

During the summer of 1899 Mr. N. B. Scofield, an assistant of the California Fish Commission, was detailed to make an examination of the conditions existing in the river at the affected point. He carried on a series of experiments mainly directed to the effect of the drainage from the works upon the salmon fry. The matter of the supposed injurious effect of the smelter refuse was first officially brought to the attention of the U. S. Fish Commission by the superintendent of the Baird station in 1899. As this was a matter that ordinarily comes wholly within the province of the State authorities, and affected the government only through the diminution and eventual destruction of the hatchery operations at Baird and Battle Creek in case the noticeable decrease of the salmon run was traceable to the alleged causes, no investigation was then undertaken by the U. S. Fish Commission and the matter was dropped for the time being, though verbal reports of numbers of dead salmon in the river continued from time to time to reach the station. In June of the following year, however, the testimony of reputable citizens of Redding so strongly substantiated reports of a remarkable and unnatural mortality among the salmon then ascending to their spawning-grounds, that the superintendent was impelled to again lay the matter before the Washington office, at the same time suggesting that an investigation be made. Accordingly, Mr. Chamberlain was directed to begin an examination of "the physical, chemical, and biological conditions of the various parts of the river where the fish are affected."

Personal inspection of the river in the vicinity of the copper works disclosed (1) the presence of many dead fish, not only salmon, but trout, suckers, carp, etc., either in the water or on the banks near the water line, and (2) the discharge of particles of slag and chemicals into the Sacramento from the turbid creek on which the smelter is

located. On sand bars in the creek there was found an abundant deposit of copper salts, and a preliminary test demonstrated the presence of large quantities of acid, copper, and iron in the creek water discharged into the river. It was thought advisable to take advantage of the run of adult salmon at the Baird and Battle Creek hatcheries for the purpose of conducting a series of tests as to the susceptibility of fish to the materials in the water.

Careful experiments properly controlled established the fact that copper sulphate in solution is decidedly injurious to fish life, and even in amounts as small as one part to 582,000 parts of water caused the death of salmon in a few hours. Other copper salts and free sulphuric acid, the product of mining and allied operations, were also injurious, but not so markedly as copper sulphate. The manner of death resembled that of the death of fish from simple asphyxiation from the products of their own respiration. Questions are raised as to the exact rôle of the salts in causing death (whether absorption and resulting poisoning of nerve centers, or peripheral irritation at gills and skin, or a destruction of the osmotic function of gills and consequent asphyxiation), and whether the metal or acid component of the salt is the more active agent.

Copper sulphate is produced at the ore deposits by natural causes, and leaches into the drainage of the region. This process has been in operation continuously, and is increased upon opening the deposits by the greater oxidation permitted. The extensively practiced process of roasting ores produces large quantities of copper sulphate and of sulphuric acid, both of which find their way into the drainage, which is acid in the immediate vicinity and so heavily charged with copper that efforts are made to save it by precipitation in tanks. The smelting yields the slag which is turned into the streams and which has been popularly supposed to be the chief factor in the mortality of salmon. It is comparatively unimportant, however, and the smelting process adds but little to the pollution from mining and roasting. While the small tributary which carries the drainage from the mines investigated is acid and has no fish life whatever, the Sacramento itself is mainly alkaline.

There has been for three seasons an undoubted falling off in the salmon on the hatching-grounds, while there is not apparent a corresponding diminution in the fish entering the river at its mouth.

The case against the mining and allied operations is not proven, as it does not yet appear certain that the mortality known to occur is due to artificial conditions; and if so due, that these conditions consist in the products of mining, roasting, and smelting thrown into the stream.

Mr. Chamberlain's summary of the results of his observations and experiments is as follows:

It is well known that during the past three seasons the salmon run at the spawning-grounds has fallen off to a point where the suspension of the fish cultural work is threatened. At the same time the fishing at the entrance of the river

ington. This, with similar material from other waters taken at various seasons, will, when studied, be sufficient to establish the food of the carp—a question about which conflicting opinions are held—and also afford a basis for comparison of the food of other fishes with similar habits found in the same waters.

Some cursory observations on the food of carp and buffalo-fish were made incidentally to the collecting and preserving of their viscera. The season was apparently the least favorable for finding large quantities of food, but this was anticipated; and the material probably shows adequately the food for the season. The stomachs were usually empty. The food was largely microscopic and contained in what was apparently a mass of mud passed on into the intestine, where, rather than in the stomach, doubtless the digestion of such nutritive elements as the mud contained occurred. Food portions recognizable macroscopically were rarely seen. In a few cases fragments of higher water plants, such as *Ranunculus*, were found in the œsophagus and may have been taken in accidentally. The color of the small amount of fluid contents often found in the stomach indicated that green algæ had been fed upon. In the Maumee River carp fed constantly and largely upon whole wheat lost in the river a season or two previously by a grain elevator fire.

Observations carried on from Central Station in the Potomac River near Washington, D. C., during the spawning time of the shad have shown that the carp is not at all destructive to shad spawn, the carp not frequenting that part of the river bottom where the shad resort for reproduction.

Cat-fish are known to consume immense quantities of the spawn of shad and other river fishes, and, with the eel, must be reckoned among the most destructive of the natural enemies of the shad in all the streams of the Atlantic coast. A seine haul on Albemarle Sound, North Carolina, witnessed by the writer in April, strikingly exemplified the spawn-eating proclivities of the cat-fish. A large shad seine was hauled in the early evening over a ground where a school of shad had apparently just spawned. Many shad and alewives were caught, but the principal part of the catch consisted of about 5,000 cat-fish (*Ameiurus albidus*), ranging in length from 6 to 18 inches, every one of which, so far as observation went, was gorged with shad eggs.

EXAMINATION OF WEST VIRGINIA STREAMS.

The examination of the general physical and biological characters of the streams of West Virginia, and more especially the nature and abundance of the fish life, was continued in the summer of 1900 by a party in charge of Mr. W. P. Hay. Field work began at Hinton in July, and was carried on for two months, during which time numerous streams in the southwestern part of the State, tributary to the Ohio, were visited, and extensive collections of fishes and other water animals were made.

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The rivers in whose basins most time was spent were the New and Greenbrier branches of the Great Kanawha, and the Guyandotte and Big Sandy, independent affluents of the Ohio. All of these are fine streams, flowing through picturesque mountain sections. The water averages slightly warmer than in the Monongahela basin; and the beds are for the most part rocky, but in places there are stretches of mud, sand, and gravel. Within very recent times the fish life of this region was extremely abundant, but is now becoming scarcer each year. The influences which are here proving inimical to the fishes are the same as those operating in the northern parts of the State, mining and lumbering. Thus the fish throughout almost the entire length of the Bluestone River have been greatly diminished by coal-mining. In some counties logging and coal-mining have together wrought the complete destruction of fish and fishing in fine streams that were formerly celebrated for their abundance of excellent fish. The employment of dynamite for fishing purposes has been common in places and has resulted in much useless destruction of fish life. The conditions in this State call for action and energetic measures on the part of the local authorities if it is intended to preserve the remaining food and game fishes.

EXPERIMENTS IN REARING LOBSTERS AND CLAMS.

The special lobster and clam investigations begun in the previous year were continued during the summer and fall of 1900, and substantial progress was made in devising methods for carrying on the cultivation of these important food animals on a large scale. The work was under the direct supervision of Dr. H. C. Bumpus, who was assisted by Dr. William C. Kendall, of the U. S. Fish Commission; Dr. A. D. Mead, of the Rhode Island Fish Commission; Prof. J. L. Kellogg, of Williams College; Mr. George H. Sherwood, Mr. J. E. Wells, and Mr. Thomas B. Gould. Experiments were conducted at Woods Hole, Gloucester, and Duxbury, Mass., at Wickford, R. I., and at several points on Casco Bay, Maine. At Wickford the Commission had the active cooperation of the Rhode Island fishery authorities and was much aided thereby. Some remarkable results were achieved in the planting of clams, and it may be said that the feasibility of private clam-culture has been established, and that the business of growing clams for market gives promise of rich pecuniary returns on many parts of the east coast. The problem of rearing lobsters in large numbers is still receiving attention, with prospect of ultimate success. In June, 1901, arrangements were being made to renew the lobster and clam experiments at several favorable points.

OYSTER-FATTENING EXPERIMENTS.

During the year the experiments in fattening oysters on artificially nourished food have been continued at Lynn Haven, Va., with more favorable results than have heretofore been attained. Each year

since the beginning of the experiments a nearer approach has been made to the end in view, namely, the perfecting of a sure means of putting poor oysters in a condition of the highest possible perfection for market, and it is now believed that the result is almost within reach of attainment. The aim has been, from the beginning, to furnish a method which would have the merit of being purely practical from a commercial standpoint, with all of the problems worked out which would confront the oyster-grower in applying it to his own purposes. During the preceding fiscal year many of the oysters introduced into the claire had become very fat, but certain irregularities were manifested which would have militated against the adoption of the process by practical men. These irregularities appeared to arise from the absence of tidal or other currents such as are necessary for the aeration of the water and the transport of the food within reach of the oyster, and at the beginning of the fiscal year certain changes were made in the plant with the object of supplying this need. A canal was constructed of sheet piling, through which currents were induced by the action of a propeller driven by a windmill erected for the purpose. To reduce the expense of handling the oysters, they were placed in the canal on shallow trays which could be raised or lowered by means of a simple type of windlass.

The construction was finished in the fall, but, certain alterations being found necessary, no oysters were introduced into the canal until February 15. They were in very poor condition, but on March 5, eighteen days later, they were reported fit for shipment. During March the results were much better, and two lots which were placed in the canal in an entirely unmerchantable condition were excessively fat at the end of eight days. Other lots fattened almost as quickly, but it was found that during many days the velocity of the wind fell below that required to move the propeller, and there was a consequent lack of circulation in the claire. It may be necessary to correct this by the use of a motor not dependent upon an uncertain power. A peculiarity in the flavor of the oysters developed in the course of the experiment, but the cause appears to be now understood, and it is thought possible to obviate it during the coming season.

SPONGE-PLANTING EXPERIMENTS.

The increasing scarcity of sponges on the Florida coast, due to the extensive fishery carried on there, induced the Commission to begin, during the present year, a series of experiments in sponge-culture. The field is not a new one, several previous experimenters having met with a measure of success, but the experiments have never reached a stage of practical utility. Sponges may be grown either from cuttings or from the egg, but the former method is so much more direct and under control that it appears to offer the more promising field for the establishment of a new industry.

In January, 1901, Dr. H. F. Moore began experiments at Sugar

Loaf Key, about 25 miles east of Key West, and at several places in Biscayne Bay. Several thousand sponge cuttings were planted at these places under a variety of environmental conditions and according to a number of different methods. The chief problem confronting the experimenter in this field is to find some ready means of attaching the cuttings to a durable support, capable of resisting the action of salt water and the ravages of the teredo and animals having similar destructive habits, and which, at the same time, will not have an injurious effect upon the growing sponge. The cuttings live and their cut surfaces heal without difficulty. About six weeks after the plants were made they were examined, and, under favorable conditions, it was found that about 95 per cent of the sheepswool cuttings were alive, healed, and apparently healthy. In several cases, where the plants were made in places exposed to very strong currents, many of the pieces were torn loose from their supports, while others had been killed by rough action of the currents. The cuttings from yellow sponges suffered a much greater mortality than those made from the sheepswool sponge, but whether this be due to the more delicate nature of the animal or to the accidental conditions under which they were planted is not yet determined. So far as has been determined the more valuable sheepswool sponge seems to be possessed of greater hardiness than its cogener. The experiments will be continued and extended during the coming season, and will have for their primary object the development of a practical method of sponge-rearing.

In the account of the operations of the steamer *Fish Hawk* will be found a reference to the work done by that vessel in beginning a survey of the sponge-grounds of Florida. As a preliminary to rational legislation for the improvement of the sponge industry, a knowledge of the extent of the grounds, their exact location, their present and past productivity, and the distribution of the commercial sponges in the different sections is indispensable. It is proposed to continue this work of the vessel, in conjunction with the sponge-planting experiments.

FISHES AND FISHERIES OF HAWAIIAN ISLANDS.

The act of Congress approved April 30, 1900, providing a government for the Territory of Hawaii, contained the following provision (section 94):

> That the Commissioner of Fish and Fisheries of the United States is empowered and required to examine into the entire subject of fisheries and the laws relating to the fishing rights in the Territory of Hawaii, and report to the President touching the same, and to recommend such changes in said laws as he shall see fit.

Early in the spring of 1901 the Commission made plans for such an inquiry as was contemplated by this act. It was decided to make the investigations comprehensive and thorough, so that the fishes and fisheries of this group of islands might be as fully understood as possible in both the biological and commercial aspects. The investi-

gations were placed under the direction of Dr. David Starr Jordan, president of Leland Stanford Junior University, and Dr. Barton W. Evermann, ichthyologist of the Commission, with the following assistants: Mr. John N. Cobb and Mr. E. L. Goldsborough, of the Fish Commission, as statistician and general assistant, respectively; Dr. Oliver P. Jenkins, of Stanford University, as volunteer scientific assistant; Mr. A. H. Baldwin and Mr. C. B. Hudson as artists.

The party sailed from San Francisco May 30 and landed at Honolulu June 5. With Honolulu as headquarters, the investigation was begun of the commercial fishes and fisheries of the island of Oahu and was well under way at the close of the fiscal year.

DISEASES OF FISHES.

During the year the study of the diseases of wild and domesticated fish has received increased attention. Mr. M. C. Marsh, the assistant who has been assigned to this branch, has devoted most of his time thereto, and for the purpose of better fitting himself for the consideration of this intricate subject, has taken special laboratory instruction in human pathology and in bacteriological methods.

Owing to the newness of the subject there is very little reliable published information on the etiology, pathology, and treatment of fish diseases, and a great deal of pioneer and preliminary work must be done in order to be in position to interpret the phenomena of disease and devise measures for its amelioration. It has already been determined that bacteria are the most potent factors in the causation of fish diseases, and the thorough study of these organisms and the perfection of cultural methods applicable to the special class of animals under consideration are of fundamental importance. As the study of fish pathology has progressed it has become more and more evident that accurate descriptions of the normal functions and structure of the various species of food-fishes are necessary, and the absence of comprehensive information of this character is strongly felt. There is scarcely one of our food-fishes which has been the subject of a systematic physiological and anatomical examination, and until this is done the interpretation of diseased conditions and the institution of remedies therefor can not be intelligently undertaken.

The diseases demanding and receiving most attention during the year were epidemics affecting the brook trout at the Manchester, Iowa, and Northville, Mich., stations of the Commission. Several weeks in July, 1900, were spent at the former station in studying a trout disease, apparently the same as that which was found at Northville in the previous year and which reappeared in the spring of 1901. The investigation of the Northville epidemic continued through June and was in progress at the close of the year.

Prof. Gary N. Calkins has recently described * a disease affecting the brook trout on Long Island, N. Y., and attributable to a newly

* Report of Commissioners of Fisheries, Game, and Forests of the State of New York for 1900.

discovered protozoan parasite (*Lymphosporidium truttæ*) to which the disease at the Commission stations bears a close resemblance in many respects. It was therefore thought that an examination of the pathological material from Northville and Manchester would probably reveal the same parasite. A careful search, however, failed to disclose it, and the evidence pointed to the original diagnosis of bacterial infection, which was confirmed in the summer of 1901. It thus appears that the brook trout is subject to both bacterial and protozoan infection, the two very similar in their external lesions.

Studies were made of various minor cases of apparent parasitism or malformation in trout and of the blisters or air blebs of the mucous membrane of trout afflicted with pop-eye. Microscopic sections of the latter showed merely the method in which the superficial layer of epithelium had been uplifted by a gas pressure beneath it, and gave evidence of no more antecedent cause. As in the case of pop-eye among fishes in the Woods Hole aquarium, no parasite appeared in the immediate neighborhood of the gas accumulation, although this does not exclude, of course, bacteria difficult of demonstration or not demonstrable by ordinary methods.

Of the other cases the most interesting was one of scarcely elevated black areas upon the skin of a brook trout, these having every appearance of parasitic cysts. On section, the black color appeared to be an increase in the normal pigment of the skin, while the elevation contained no parasites, many cocci-like bodies proving to be merely pigment granules. The slight elevation seemed to be caused by a new growth of normal tissue, and the most likely explanation is that the black spots are small neoplasms of uncertain classification. The same trout had a small polyp or projection from the skin of the belly, which upon section appeared also to partake of the nature of a tumor. Pigment was absent from it, but is also absent from that portion of the belly. There is a possible relation between this process and the black cyst-like bodies upon the sides and back of the trout.

Studies were made of the brain of salmon fry from the Pacific coast, which had died as so-called "crazy" fry, there being no external lesions or any circumstance whatever to account for the mortality. As brain pathology is of especial difficulty, and as but little is known of the microscopic features of the normal fish brain, not much was expected from this examination; but there was some evidence of brain lesions to account for the peculiar death of fry. These were not degenerations, but lack of complete development of important portions. If cases of this sort continue to arise, an important field is opened for study.

An annoying fungus attack in the Commission aquarium at the Pan-American Exposition received some attention in June. The lake water was found to be charged with fungus spores, and the quantity used was too large to admit of a filtration that would remove these spores. It was concluded that the fungus could be kept in check

only by careful attention to the individual fish as fast as they showed the slightest signs of being affected. Nothing proved to have decided advantages over the use of salt for this purpose. A permanganate of potash solution, reported as almost a specific for fungus in England, was a failure. It could not be introduced into the water continually on account of the color imparted, and especially because the fish would not endure, save for a comparatively short time, even a very weak solution. The short dip in stronger solutions was impracticable, as there was no safe margin between a strength of solution which was fatal to the fungus and harmless to the fish. Formalin was expected to give better results, but according to the report of the superintendent of the exhibit did not do so, and at best nothing would improve very much upon salt, for there remains in any case the necessity of attention to the individual. Salt is moderately successful as a remedy when the attack has not proceeded very far.

Some bacteriological work was undertaken in connection with the Lynn Haven experimental oyster claire. The so-called "muddy" taste of oysters from this claire can not be attributed to bacterial infection or pollution, although the colon bacillus was obtained from the stomach of some oysters. It was not obtained, after test for it, from the claire water or fertilizer, and its presence in the oysters is not constant. Observations are too few to show the significance of its presence in the few cases recorded.

Mr. Marsh devoted the last half of the year chiefly to work in the bacteriological and pathological laboratories of Johns Hopkins University, where an exhibit of bacteria related to fishes and fish diseases was arranged for the Commission's display at the Pan-American Exposition. Over twenty species were prepared, each represented by a plate culture and two tube cultures. They consisted of water bacteria, the pus cocci, bacteria obtained from diseased fishes, a chromogen from the disease known as "pop-eye," a phosphorescent bacillus, and the bacillus of tuberculosis in fishes. The cultures were usually killed and the medium hardened by formalin, and the tube or plate sealed with paraffin.

The necessity for carrying on microscopic and bacteriological work in the field led to the preparation of an outfit to serve as a portable laboratory. The extensive traveling outfit of the Marine-Hospital Service furnished a precedent and in a general way a model for the plans of a similar but much smaller one adapted to the needs of the Commission. It consists of the smallest quantities of apparatus and material consistent with usefulness and efficiency for performing the more ordinary bacteriological and microscopic manipulation, exclusive of incubation at body temperature and anaërobic culture. The essential idea in the gathering together of the apparatus as a unit was to do work which could be done only in the field, and which was to be continued in a more complete and permanent laboratory.

The bacteriological researches of the Fish Commission were greatly

advanced by again receiving from the Secretary of the Treasury permission to use the facilities of the Hygienic Laboratory of the Marine-Hospital Service at Washington. The director of the laboratory and his staff aided these studies by their courteous assistance in various ways.

WORK OF THE BIOLOGICAL LABORATORIES.

WOODS HOLE, MASSACHUSETTS (H. C. BUMPUS, DIRECTOR).

The administration of the work of the biological laboratory at Woods Hole was continued under the direction of Dr. H. C. Bumpus, professor of comparative anatomy in Brown University.

The opportunity to pursue studies at the laboratory was accorded to an unusually large number of biologists, whose names follow arranged under the respective institutions with which they were connected:

Brown University: George H. Sherwood, A. M.; Millett T. Thompson, A. M.; R. W. Tower, A. M.; Lee Barker Walton, A. M.; L. W. Williams, Ph. D.

Denison University: Charles Bawden; H. A. Green, B. S.; C. Judson Herrick, Ph. D.

Harvard University: Robert S. Breed, S. M.; Freeland Howe, jr., A. M.; J. M. Johnson, A. B.; J. H. McMurray; T. Ordway, A. B.; George H. Parker, Sc. D.; Herbert W. Rand, Ph. D.; M. E. Stickney, A. M.; R. M. Strong, Ph. D.; William A. Willard, Ph. D.; Robert M. Yerkes, A. M.

Indiana University: William H. Dudley, Ph. D.; C. H. Eigenmann, Ph. D.; W. J. Moenkhaus, Ph. D.

University of Iowa: W. B. Bell; H. A. Childs, B. S.

Johns Hopkins University: Caswell Grave, Ph. D.; Henry F. Perkins, A. B.

Massachusetts Institute of Technology: R. P. Bigelow, Ph. D.; George W. Field, Ph. D.; Erik H. Green, M. A.

University of Michigan: S. J. Holmes, Ph. D.; Raymond Pearl, A. B.

University of Nebraska: Albert D. Lewis, A. B.; Frank E. Watson, A. M.

Princeton University: Ulric Dahlgren, Ph. D.; C. W. F. McClure, A. M.; C. F. Silvester; G. W. P. Silvester.

Stanford University: R. P. Cowles, A. B.; Harold Heath, Ph. D.

University of Texas: Charles T. Brues; Axel L. Melander; W. M. Wheeler, Ph. D.

Washington and Jefferson College: Edwin Linton, Ph. D.; Charles W. Stone.

Williams College: James L. Kellogg, Ph. D.; Roy Spencer Richardson, Ph. M.

Miscellaneous: F. M. Chapman, American Museum of Natural History, New York; Wesley R. Coe, Ph. D., Yale University; George Ellett Coghill, M. S., University of New Mexico; Herbert H. Cushing, M. D., Woman's Medical College of Pennsylvania; Winfield A. Denny, Anderson High School, Anderson, Ind.; Charles W. Hargitt, Ph. D., Syracuse University; Charles A. Holbrook, A. B., Melrose, Mass.; Ernest Ingersoll, New York City; Porter Edward Sargent, A. M., Browne Nichols School, Cambridge, Mass.; M. W. Stickney, A. M., Worcester Academy; Francis B. Sumner, Ph. D., College of the City of New York; Ernest E. Tyzzer, A. M., Harvard Medical School; F. C. Waite, New York University Biological Station, Hamilton, Bermuda; Herbert E. Walter, A. M., North Division High School, Chicago; Charles B. Wilson, A. M., State Normal School, Westfield, Mass.

Besides the usual full equipment for the collection of all forms of marine life and their preservation and microscopic study, the laboratory had a number of accessories which contributed to the facilities. A large fish-trap, operated by the Commission in Vineyard Sound, furnished a great abundance and variety of material for study. The

steamer *Fish Hawk* and the schooner *Grampus* were attached to the station during most of the summer; the former made a number of dredging expeditions to the neighboring waters, and the latter made a successful trip to the off-lying tile-fish grounds. The steam yacht *Phalarope*, which had been purchased for this station in the previous year, proved of great assistance, and the steam launches *Blue Wing*, *Cygnet*, and *Merganser* were in general use.

The laboratory assistants were Prof. R. W. Tower, Mr. George H. Sherwood, Mr. Vinal N. Edwards, Mr. L. B. Walton, Mr. David Robinson, and Mr. H. A. Green.

The library, which had been greatly improved during the previous summer, was in constant use for reading and reference. The librarian of Brown University courteously loaned to the Commission a number of scientific periodicals and standard books of much usefulness to the laboratory workers. Biologists in all parts of the world have sent copies of their papers to the library. The accessions during 1900 numbered about 500.

Among those who conducted work in the special interest of the Commission the following may be mentioned:

Prof. C. H. Eigenmann made a study of the early life of the squeteague, one of the most abundant and important of the summer food-fishes of southern New England. His inquiries were addressed to the spawning time and grounds; the movements, habits, and food of the young; the rate of growth of the young, and the changes in their form and color incident to growth.

Prof. R. W. Tower carried on certain physical and physiological investigations regarding the air-bladder of fishes, and the chemical nature of chitin, the basis of the shells of lobsters, crabs, and other crustaceans.

Prof. Edwin Linton continued and completed his studies of the internal parasites of the fishes of the region.

Prof. W. M. Wheeler, who in the previous season had studied the free-swimming copepods of the adjacent waters, continued his consideration of this group, and began a systematic study of the pelagic copepods of the east coast. A large amount of material, which the Commission had for years been accumulating, was placed in Professor Wheeler's hands.

Prof. S. J. Holmes began the preparation of a descriptive list of the amphipods of the region.

Mr. George H. Sherwood experimented with new methods of rearing lobster fry, and, together with Mr. V. N. Edwards, made observations on the phenomena of fish migration and its relation to the physical and meteorological conditions.

Prof. J. L. Kellogg continued his experiments in clam-culture begun in the previous year.

A biological subject of more than ordinary interest to scientists and the general public is the reproduction of eels. During the summer of

1900, some observations were made at the laboratory which materially contributed to the knowledge of the spawning of eels in American waters. On July 31 the schooner *Grampus* collected a number of eel eggs at the surface, about 30 miles south of South Shoal light-ship. The eggs reached the station on August 1 and were placed in charge of Professor Eigenmann. Inasmuch as no eel eggs had before been taken in our waters, the progress of these was watched with much interest. The development was rapid, and many eggs hatched during the night of August 2–3. The last larvæ died on August 14. A preliminary note on these eggs and larvæ was published by Professor Eigenmann in Science for September 14, 1900, and a full account of his observations was prepared for publication in the Bulletin of the U. S. Fish Commission for 1901. The latter article first reviews the modern work on the development of the eel by Raffaele, Grassi, Cunningham, and other European biologists, and then describes in detail the eggs, embryos, and larvæ in hand, many drawings accompanying the text. The identification of the eggs as those of the conger eel—not previously described—is based on strong circumstantial evidence.

In the last week in August, 1900, information was received at the laboratory that for two or three weeks previous there had been streaks of reddish water in Priests Cove, Buzzards Bay, near the Fairhaven shore. It was stated that the "streaks" varied in width from 50 yards to one-half mile, and those who conveyed the information said that when fishing they had caught no fish within the limits of these areas. According to the report, thousands of dead or dying fish were seen on the shore, among them minnows, chogset, tautog, eels, etc. The tautog ranged in length from 6 inches to 1 foot, and the eels from 1 to 2 feet. There was a bad stench from the red water, and the fish washed ashore were bloated.

Upon learning of the appearance of the red water, the director of the laboratory suggested to Prof. C. H. Eigenmann and Mr. Vinal N. Edwards that they visit the region of New Bedford and examine into the matter, and this they did on August 29. Professor Eigenmann reported that reddish-brown water in a band about 100 yards wide was found extending from Fort Phoenix eastward toward Egg Island, and that the red water had been noticed during ten days previous to his visit. It appeared that the period of discoloration of the water must have culminated on August 25, for during the following night a number of dead eels, tautog, cunners, minnows, and squeteague were cast on shore, and none were cast up later. Squeteague had been abundant in the bay previous to the appearance of the red water, but none had been taken since it appeared, and fish were generally absent in its neighborhood. Some of the water placed in glass jars was found to contain great numbers of minute bodies which gave the water a yellowish tinge; many settled to the bottom, forming a yellowish flocculent layer. The bodies were found to be globular unicellular

organisms (*Peridinium*), either single or in strings of two to six, and measuring 32 to 40 μ in diameter. The red water had a density of 1.025 and a temperature of 76.75°.

It is interesting to note that this occurrence of *Peridinium* resembled that in Narragansett Bay in 1898, investigated and described by Dr. Mead (Science, vol. VIII, p. 707, 1898). The red water in Narragansett Bay was noticed during the latter part of August, September, and part of October, the maximum being reached on September 8 and 9. Fish and crustaceans tried to escape from the water, and thousands of dead fish, crabs, and shrimps were found strewn along the shores or even piled up in windrows. No fish were killed after the latter date, but the red color in the water remained, and fish were scarce in its vicinity. The water was cleared by a heavy rain, but the red color was somewhat in evidence for a time afterwards.

The following publications, based on or relating to the work of the laboratory, were issued during the fiscal year:

The gas-bubble disease of fish and its cause. By F. P. Gorham.
Some chemical changes in the developing fish egg. By P. A. Levene.
The free-swimming copepods of the Woods Hole region. By W. M. Wheeler.
Observations on the life history of the common clam, *Mya arenaria*. By James L. Kellogg.
The natural history of the starfish. By A. D. Mead.
On the movements of certain lobsters liberated at Woods Hole. By H. C. Bumpus.
Improvements in preparing fish for shipment. By R. W. Tower.
Report of a dredging expedition off the southern coast of New England, September, 1899. By Freeland Howe, jr.
Fish parasites collected at Woods Hole in 1898. By Edwin Linton.
Biological Notes No. 1.
The chemical composition of the subdermal connective tissue of the ocean sun-fish. By Erik H. Green.
The hydroids of the Woods Hole region. By C. C. Nutting.
Parasites of fishes in the Woods Hole region. By Edwin Linton.

BEAUFORT, NORTH CAROLINA (H. V. WILSON, DIRECTOR).

The Beaufort laboratory, which had opened on June 1, 1900, was closed on September 10. It was reopened on May 1, 1901, and was in operation at the close of the fiscal year. The laboratory occupied the same temporary quarters as in previous years, and Dr. H. V. Wilson, professor of biology in the University of North Carolina, continued in charge. The steam launch *Petrel* and several small boats were attached to the station during the summer.

Those who availed themselves of the facilities of the station were as follows:

Johns Hopkins University: Dr. Caswell Grave, Mr. R. P. Cowles, Mr. J. A. E. Eyster, Mr. O. C. Glaser, Mr. D. H. Tennent.
Columbia University: Dr. H. E. Crampton, Mr. H. B. Torrey, Mr. J. C. Torrey, Dr. E. B. Wilson.
University of North Carolina: Dr. H. V. Wilson, Mr. J. W. Tarrentine.
University of Missouri: Dr. W. C. Curtiss.
University of Alabama: Dr. John Y. Graham.
Bryn Mawr College: Dr. T. H. Morgan.
Trinity College (N. C.): Dr. J. I. Hamaker.
Goldsboro (N. C.) Schools: Mr. R. E. Coker, principal.

The following accounts of some of the investigations here carried on are extracted from Dr. Wilson's report:

Mr. Coker and Mr. Tarrentine, who during June had made a study of the food of certain edible fish, spent the greater part of July in studying the life-history of a small nonedible fish, one of the blennies very common about wharf piles, where sheepshead feed. The eggs of this fish are deposited in layers, adhering to old barnacle shells, ascidians, or rocks. The eggs were hatched in the laboratory. The striking characteristics of egg, old embryo, and just-hatched larva were worked out in sufficient detail to permit recognition of these stages wherever met. The notes on this investigation, together with those on the food study, will be handed in as soon as certain figures are completed. Mr. Coker spent the remaining part of the summer in studying the life-history of a small goose barnacle parasitic on the gills of two edible crabs, the blue crab and stone crab. About 70 per cent of the blue crabs are infested. The parasite is sometimes so abundant in individual crabs as to fill the gill chamber, the number running up to about 1,000. Certain simple experiments indicate that the parasite unquestionably weakens the crab. The systematic points of the form were carefully worked out. The form differs from previously described species of this interesting genus, and must be recorded as a new species.

Dr. Grave devoted most of his time to his economic investigation of the conditions favorable to oyster-culture. Constant watch was kept upon an experimental oyster bed, which included many small areas planted at different times from April to August, 1900, inclusive, on some of which steamed shells were scattered broadcast; on others similar shells were laid down in rows; on still others, steamed and fresh shells were hung on wires. The catch of spat was abundant on all areas, there being no difference between steamed and fresh shells, contrary to the opinion and practice of local oystermen; but where shells were planted in rows there is a much better catch of spat than where they are scattered broadcast. In this locality the breeding season of the oyster extends from March to December, inclusive. The spat deposited on the bed has grown well. Many of the oysters on June 1, 1901, measured about 2½ inches in length, others only 1 to 1½ inches; larger oysters, 3 inches long, were occasionally taken.

Dr. Grave also continued his investigations upon the feeding of oysters, both on natural beds and beds composed of planted adults, and upon the physical factors affecting the growth of oysters. His study of the influence of shore line, bottom, and current on the shape taken by natural beds, an account of which has already been published in the Johns Hopkins University Circular (April, 1901) bears upon the shape and direction which should be given to planted beds in the North Carolina sounds.

During the summer Dr. Grave collected material and data for a proposed report upon the Beaufort echinoderms from the systematic

and natural-history points of view. He has now complete accounts of the life histories of the southern sand-dollar and the most abundant of the Beaufort ophiurans. His signal success in rearing these forms from the unfertilized egg to the adult condition has been due to his employment of a particular method of feeding. Muddy sand, rich in diatoms, is dredged, and is kept in proper light, in laboratory aquaria, until the number of diatoms has vastly increased. Such diatomaceous sand is used as stock food. A supply of it is added to each aquarium jar in which the larvæ are kept; the water in the jar is not changed, and the jar is kept covered.

Dr. Hamaker carried on observations on the natural history of the Beaufort actinians, studying their characteristic features in the living state, both in their natural habitat and when kept in the laboratory aquaria. Their variability and individual color changes make this study from life essential to a successful systematic treatment. Notes were made on the breeding, food, etc. Material was prepared for careful histological work, and the study of this material was continued during the year.

Mr. H. B. Torrey studied the early development of an annelid (*Axiothea*), one of the most abundant worms on the sand shoals. Mr. Torrey's attention was concentrated upon the "cell lineage," or the origin of particular layers and organs from particular segments of the egg. Incidentally observations on the general natural history were made. The eggs are laid in jelly masses, very frequently at any rate, in the early morning. The eggs emerge from the mouth of the burrow already fertilized. The larva is an opaque modified trochophore, free-swimming in the jelly. It emerges from the jelly in from two to twelve days, and then has a structure adapted for bottom life. *Axiothea* is a common article of food for several bottom-feeding fish (hog-fish, croaker, sea mullet).

Dr. E. B. Wilson and Dr. Crampton made studies of the early development of the eggs of the various invertebrates. The former gave special attention to the development of the unfertilized eggs of the white sea-urchin, which are made to develop parthenogenically under the stimulus of magnesium chloride. Dr. Crampton studied the behavior of the eggs of the oyster and other mollusks when submitted to unusual chemical and physical conditions.

BIOLOGICAL LABORATORY ON THE GULF OF MEXICO.

For a number of years the establishment of a biological laboratory on the Gulf coast of the United States has been under consideration and has been urged by members of Congress and private citizens of the Gulf States. During the Fifty-sixth Congress unusual attention was given the matter and a number of bills providing for the station were introduced. In order to put the Commission in possession of full information regarding the available sites, it was determined to have the entire Gulf seaboard canvassed in advance of any action

Congress might see fit to take. Accordingly, during the fall and winter of 1900–1901 Dr. H. F. Moore was detailed to visit Texas and Louisiana for this purpose; Dr. W. C. Kendall went to all suitable localities on the shores of Mississippi and Alabama, and Dr. H. M. Smith made an examination of points on the Florida coast between Tarpon Springs and Key West. Reports on these investigations have been submitted.

SCIENTIFIC INQUIRY EXHIBIT AT PAN-AMERICAN EXPOSITION.

An exhibit illustrating the functions and work of this division, and forming a part of the general exhibition of the Commission at the Pan-American Exposition, was collated by Dr. H. F. Moore, Mr. M. C. Marsh, and the writer.

The collection, which was one of the most complete and instructive of the kind ever brought together by the Commission, included the following objects: (1) Models of the steamers *Albatross* and *Fish Hawk*, to whose investigations most of the knowledge of the deep-water life of our coasts is due; (2) samples of the beam trawls, dredges, rakes, tow nets, tangles, seines, gill nets, and other apparatus used in making collections of water animals; (3) samples of the vessels used for the preservation and transportation of collections; (4) a sounding machine and its accessories, for determining the depth of water, the bottom temperature, and the nature of the bottom; (5) a map showing where the Commission has carried on scientific investigations, and plates used in illustrating the reports of the Commission.

As pertinent to the functions of this division of the Commission, there were also shown series of specimens illustrating the aquatic resources of the country, including the economic mollusks, crustaceans, and other invertebrates of the United States and Porto Rico. Special exhibits of this nature were the commercial sponges of Florida; the pearl-bearing mussels of the Mississippi basin, many of which are used in button-making; the oysters of all coastal regions, displayed with reference to their growth, life-history, and enemies. Ten charts showing the geographical distribution of the most important food-fishes of the Great Lakes were also prepared.

INTERNATIONAL CONGRESS OF AQUICULTURE AND FISHERIES.

In conjunction with the Universal Exposition at Paris in 1900, there was held, under the direction of the French government, an international congress of aquiculture and fisheries, under the presidency of Prof. Edmond Perrier, member of the Institute and director of the Museum of Natural History of Paris. The congress convened on September 14, in the Palais des Congrés, and was formally opened by the French minister of commerce. Professor Perrier then delivered an able introductory address, and the congress resolved itself into sections for convenience in considering the various subjects that came before it. About 100 delegates from Europe and America were in attendance, most of the countries of Europe being represented by

persons distinguished in the lines of fish-culture, the commercial fisheries, or biological science. The United States Fish Commission was officially represented by Dr. H. M. Smith. Other members from the United States were Dr. T. H. Bean, director of forestry and fisheries on the staff of the United States Commission to the Paris Exposition, and Lieut. Commander A. C. Baker, U. S. N.

Papers and discussions covering a wide range of topics were presented in the sections and the general séances. The subjects considered came under the heads of scientific studies of the salt and fresh waters, the methods of the sea fisheries, marine fishing considered as sport, practical aquiculture and fishing in fresh waters, oyster-culture and mussel-culture, the utilization of fishery products, and the social and hygienic relations of the fishermen. Dr. Fabre-Domergue, the inspector-general of marine fisheries, gave an illustrated lecture on "The character and limitations of man's influence on the productivity of the seas." The proceedings of the congress included visits to the fishery palace of the exposition and to the museum of natural history, and a number of social features, concluding with a banquet on September 19 at the Palais D'Orsay, given by the French minister of marine.

Before adjourning the congress took action on a number of resolutions and propositions that had been brought up in the course of the meeting. Among the numerous formal views expressed, the following have special application or interest to the United States:

(1) Investigations of lacustral biology are important for both their scientific interests and practical value, especially as they bear upon fish-culture, and should everywhere be encouraged as far as possible.

(2) In small and unimportant streams line fishing only should be permitted, the use of nets or other apparatus being limited as much as possible.

(3) The introduction of exotic species of fishes into international streams and lakes, or the planting of the eel in waters still free from the species, should be undertaken only after obtaining the sanction of all States interested.

(4) The success attending shad-culture in the United States and the important economic results therefrom indicate that similar operations in this country (France) would be apt to prove of substantial benefit.

(5) Each government should be urged to take the most effective measures for facilitating the free movements of migrating fishes (especially salmon) in ascending streams, to foster the study of improved systems for the passage of fish, and to provide for fishways in all industrial and agricultural dams having a greater height than 0.80 meter. Water-tight dams should not be built with a vertical face downstream, but with both surfaces sloping at an angle of about 30°.

(6) The governments should promote the study of means of detecting poisoned fishes, just as in human criminology, and all poisoned animals should be seized and the holders thereof prosecuted so as to put an end to this nefarious practice.

(7) As to the pollution of streams by various factories, it is declared to be the duty of the manufacturers to devise the means necessary to the purification of the waste products of their works, while the part of the government consists in seeing that the water be turned back to the rivers in a condition not injurious to useful plant and animal life.

(8) Where previous permission is necessary for the locating of industrial works upon streams, this permission should be granted only after the deposit by those

interested and the study by competent experts of specimens of waste analogous to that which would be discharged by the projected factory.

(9) Maritime nations should, as soon as possible, reach an international agreement for the regulation of lights on fishing vessels.

(10) The powers should close to navigation, by restrictive laws promulgated by each government, certain defined zones resorted to by marine fishermen.

(11) The governments represented at the congress should encourage by bounties the destruction of injurious marine animals, such as sharks and porpoises, and should also promote investigations leading to the utilization of such animals.

(12) The various governments should encourage experiments in freezing fish, with the following purposes in view: (*a*) The benefit of marine fishermen by the safe and regular marketing of a commodity which naturally is eminently perishable. (*b*) Securing a more uniform price for fish. (*c*) Supplying laboring people with a cheap article of food.

(13) The different governments should encourage the construction of steam vessels designed for the collection of fishing products at sea in order to insure the better utilization of such products.

(14) In order to facilitate the introduction of fishing products into regions where at present they are but little used, railroad companies should adopt uniform freight rates and should expedite the transportation of these products as much as possible.

(15) The governments should provide subsidies to promote the study of the best methods of preparing fish upon the fishing-grounds, and the packing of fresh fish in a manner to secure their transportation in the best possible condition.

(16) New fishing schools should be established which would extend maritime instruction and give to the pupils practical experience at sea. Special courses should be founded for instructing men and women in the preparation and utilization of sea products. Diplomas should be granted to marine fishermen who pursue the course of study at these schools, and who can pass a creditable examination before a competent commission.

(17) Earnest efforts should be made in fishing ports to instruct marine fishermen in the care of their health on board as well as on shore. The necessity for this has been pointed out by previous congresses.

(18) The fishing industry and marine fishermen should be considered as neutral in time of war.

(19) The congress directs the formation of a permanent international committee to have charge of the organization of future fishery congresses, such committee to be selected by joint action of officers of the congress together with the official delegates of the different powers and of the learned societies here represented.

(20) The next international congress of aquiculture and fisheries shall be held in 1902, in St. Petersburg.

(21) The congress orders the periodical publication of international comparative fishery statistics on the basis of The Hague Statistical Congress of 1869, including full statistics of accidents on fishing vessels. This publication shall be intrusted to a permanent international committee or, in default of this, to the St. Petersburg committee of organization.

(22) Recognizing the importance of having an organ of international fishery congresses, the proposition of the Russian Society of Fisheries and Fish Culture is accepted, and the Revue International de Pêche et de Pisciculture is designated as such organ.

EUROPEAN BIOLOGICAL STATIONS.

The writer's presence in Europe, in connection with the International Congress of Aquiculture and Fisheries, afforded an opportunity to visit some of the great biological stations, for the purpose of making observations on their management, construction, equipment, and methods of study. The time available permitted the visiting of only

two such stations, but these were the foremost in Europe, namely, the Marine Biological Laboratory at Plymouth, England, and the Zoological Station at Naples, Italy.

Marine Biological Laboratory, Plymouth.—The laboratory occupies a bluff 110 feet above Plymouth Harbor, and affords a strikingly fine view of this historic roadstead, with Eddystone light-house in the distance. The building, which, with its equipment, cost about £12,000, is constructed of gray sandstone, and consists of a two-story central part with two square three-story wings or towers. The lower floor contains an aquarium, the second floor is occupied by the main laboratory and rooms opening therein, and the upper story is devoted to a library, general rooms, etc. Water for the laboratory and aquarium is pumped from the harbor into large cement-lined pools under the building, holding about 100,000 gallons, thence to tanks with capacity for 5,000 gallons at the top of the building, whence it is led by gravity. The vessels and boats belonging to the station are a 7-ton steamer, a 40-ton barge, and two small sailboats.

The laboratory is under the control of the Marine Biological Association of the United Kingdom, of which Prof. E. Ray Lankester is president, and is supported by annual subsidies from the government and the Fishmongers' Company, of London, by annual subscriptions, by fees of investigators, by paid admissions to the aquarium, and by the sale of specimens and publications. The resources of the institution in 1899 were about £2,000. The director receives an annual salary of £200.

The accommodations are rather limited, there being only ten tables for investigators. Those entitled to the privileges of the laboratory are the nominees of the founders of the institution and of the persons who have endowed tables. There are no restrictions as to the subjects which may be studied. The laboratory fees of investigators are 30s. a week, which amount covers all materials and supplies except the more costly reagents. No sleeping or eating accommodations are afforded by the laboratory except to the director, who has an office and private rooms in the building. The laboratory is open throughout the year, but is occupied mostly in summer and during the Easter and Christmas holidays.

The aquarium is small, but attractive, and devoted to the marine species of the vicinity. The general public is admitted from 10 to 6 o'clock daily on payment of an entrance fee of 6d., which is reduced to 2d. on Wednesdays. The disease known as "pop-eye," which is observed in aquarium fish in America, is quite prevalent here.

The Journal of the Marine Biological Association, a quarterly, is the official organ of the laboratory.

The Naples Zoological Station.—This institution, the largest and most noted of its kind, is situated in a spacious park near the shore of the beautiful Bay of Naples. Investigators here have the advantage of climate that is perpetually mild, physical surroundings of great

beauty and interest, a rich historical environment, and a liberal and efficient management, combined with a fauna of the adjacent waters which is extremely rich and varied. Although but little farther south than Woods Hole, the fauna is much more subtropical.

Dr. Anton Dohrn, the accomplished founder and director of the Naples station, together with his assistants, Dr. Lo Bianco and Dr. Meyer, very courteously entertained the visitor. The station occupies a large white stone quadrangular structure, with an aquarium on the ground floor and offices, laboratories, workrooms, and library on the upper floors. To establish the station in 1872 required $100,000, to which considerable sums have been added for permanent improvements and new construction.

The station has a large income, although not in excess of its needs. It is supported by government grants, by the endowment of the tables, by fees for admission to the aquarium, and by the sale of specimens. The most liberal patrons of the institution are Germany and Italy. The German government gives an annual fund of 40,000 marks ($10,000), without any restrictions as to its use. The Italian government gives yearly 5,000 francs ($1,000) for the maintenance of the library. The principal source of income is the endowment of tables, of which 34 were supported in 1900, as follows: Various German provinces, 11 tables; Italian government, 9 tables; Russian government, 2 tables; Austrian government, 2 tables; Hungarian, Swiss, Dutch, and Belgian governments, 1 table each; in England, the University of Oxford, the University of Cambridge, and the British Association for the Advancement of Science, 1 table each; in the United States, the Smithsonian Institution, the Association of American Women, and Columbia University, 1 table each. To endow a table costs $500 per annum, so that the income of the station from this source is $17,000. During each season from 50 to 60 workers from all parts of the civilized world carry on investigations here. Those occupying tables are without any restrictions as to the lines of work they pursue and the publication of results; and, besides being provided with the animals for study, they are supplied with microscope, reagents, individual aquaria, and all other things needful for their work.

Another enterprise which adds $3,000 to $5,000 annually to the resources of the institution is the sale to naturalists and museums of preserved specimens of marine animals for study and exhibition. The reputation of the Naples station for such material is universally recognized, and its output reaches all parts of the world.*

The regular employees of the station number 45. By a provision of the German government a pension fund is established for superannuated employees. There is also a reserve fund maintained to meet extraordinary conditions. Two small steam vessels, one decked and one open, are used in conjunction with the laboratory.

* See Methods Employed at the Naples Station for the Preservation of Marine Animals, by Dr. Salvatore Lo Bianco. Translated by E. O. Hovey. Bull. U. S. Nat. Mus., No. 39, Part M.

The periodical publications of the station are Contributions from the Naples Zoological Station, Fauna and Flora of the Gulf of Naples, and The Zoological Yearbook.

Although this is primarily a station for biological research, an important feature is the aquarium, which is justly celebrated for the beauty of its installation and the healthy condition of the exhibited animals. The aquarium is one of the leading attractions of Naples and is much resorted to by visitors and by the local population. The price of admission to the aquarium is 2 francs, except on Sunday afternoons, when it is 1 franc, and on special occasions, when it is half a franc. The income from this source is about $8,000 annually.

The grotto arrangement of the aquarium is unconventional, and the general impression made on the visitor is novel and pleasing. The 26 large tanks with large glass fronts are skillfully lighted from above, no light reaching the aquarium room except that which comes through the water. As one stands before the tanks and sees the groups of healthy, contented fishes and invertebrates, with nothing neglected that contributes to the naturalness of their environment, one easily fancies he is at home with the animals on the sea bottom.

The salt water required for the aquarium (and laboratory) is retained in large subterranean reservoirs; it is supplied through a closed circulation and is renewed only as needed to replace losses due to evaporation and leakage. Owing to the care exercised in feeding the animals and to the "balance" which has been established, it is rarely necessary to cleanse the aquarium tanks. The water reaches the aquaria from a nozzle with a contracted aperture about a foot above the surface, and the jet carries considerable air with it; this form of aeration is regarded as quite essential for the health of the animals and renders a direct air circulation unnecessary. The water supplying each series or line of tanks runs from one to another by means of a surface gate and discharges into the reservoirs under the building, so that there is a current in each tank, which is considered quite necessary.

Seaside laboratory at Concarneau, France.—Mention should be made of a visit to the laboratory at Concarneau, France—one of the many small seaside laboratories and biological schools maintained by the French marine department. At this institution, in the center of the great sardine fisheries of Brittany, some important biological and fish-cultural work is being done under the direction of Dr. Eugéne Biétrix. An interesting adjunct of this station is a rectangular stone pound or inclosure (*vivier*) constructed many years ago by M. Guillou, for the experimental rearing of lobsters. The pound is very extensive, with eight compartments in which the tide flows; is built of granite and schist, and cost 130,000 francs. It was the first of the kind in France, and is still used in part for the same purpose as lobster pounds are on the coast of Maine. In view of the attention now given to lobster-rearing in the United States, and the

comparatively recent date at which lobster-culture was taken up in this country, it is worthy of note that as early as 1859 M. Guillou, in conjunction with M. Coste, began his successful lobster-rearing experiments. The writer was privileged to examine the collection of artificially-reared lobsters (ranging from the newly-hatched larvæ to examples 10 years old) for which the French government made an award.

MISCELLANEOUS FOREIGN INQUIRIES.

While in Europe the writer investigated a number of fisheries and fishery industries, primarily with a view to possible improvements in similar industries in the United States. The fisheries to which special attention was given were the herring, the sardine, and the lobster. A number of other subjects had been assigned for investigation, but the time available did not permit their consideration.

Immense quantities of the sea herring are imported into the United States annually from England, Scotland, Holland, and Norway, and meet with a ready sale at prices that are uniformly higher than those commanded by the same fish prepared in the same manner on our own coasts. The Commission was in receipt of communications from fishermen, fish-packers, and wholesale dealers in the Eastern States, asking that it investigate the methods of the herring trade in Europe and determine the factors which give to the foreign herring their superiority over the native-prepared fish.

Visits were made to the most important herring centers of England, Scotland, and Holland; and through the courteous assistance of government fishery officials and United States consular officers, much valuable information was obtained. Acknowledgments for assistance are due especially to Mr. Charles E. Fryer, of London, one of the government inspectors of fisheries for England and Wales; Mr. James R. Nutman, of Great Yarmouth; Mr. W. F. Robertson, of Edinburgh, secretary of the Fishery Board for Scotland; Mr. James Ingram, of Aberdeen, one of the Scotch fishery inspectors; Col. S. Listoe, United States consul at Rotterdam, and Mr. E. A. Man, United States consular agent at Schiedam. The observations on the herring fishery of the countries named will be incorporated in a special report now in preparation.

In view of the large consumption of imported sardines in the United States and the relatively high prices commanded by them, the sardine fishery of France and the canning industry dependent thereon were made the subject of a special investigation for the purpose of determining the factors which underlie the general superiority of the French sardines over the native "sardines" prepared from the young of the sea herring. The French sardine industry centers in the province of Brittany, in which one of the most important fishing and canning towns is Concarneau. In this place some time was devoted to a study of the natural history of the sardine, the fishing methods and

appliances, and the canning processes. The manner of preparing cod roe as bait for use in the sardine fishery was fully considered, as a remunerative trade can doubtless be developed in this commodity between the United States and France. These inquiries were greatly facilitated by Mr. Emile Deyrolle-Guillou, to whom special acknowledgments are due for numerous courtesies. A special report on the French sardine industry has been submitted, and will shortly be issued. Some attention was also given to the sardine (i. e., pilchard) fishery in Cornwall, England, and the limited canning of sardines at Mevagissey in that county.

The downward tendency of the United States lobster fishery and the special investigations addressed to the lobster which the Commission has been conducting for several years, made it quite desirable that the actual condition of the lobster fisheries of other countries should be determined, together with the measures which have been adopted abroad for protecting the lobster and promoting the fishery. Accordingly, at various places in England, Scotland, and France, visited in connection with the foregoing inquiries, data on this subject were obtained by personal inspection, and information in regard to several other countries was secured from government officials and others met at the fishery congress at Paris. The history of the lobster fisheries of the different European countries is of decided importance for comparison with that of our own lobster industry.

One current feature of the lobster fisheries of England and France—the most important in Europe—is of special interest as showing the interrelation of aquatic animals and man's possible influence thereon. Owing, in part at least, to the active fishery for the conger eel, this fish has become comparatively uncommon in lobster-fishing regions, where it was formerly very abundant. This is especially the case on the southern coast of England and west coast of France. At the same time these coasts have been visited by enormous numbers of octopus, which have proved very disastrous to the lobster fishery, reducing the number of lobsters on the fishing-grounds and also entering the fishermen's traps and destroying the lobsters after they have been caught, so that in some important districts the lobster fishery has been rendered a total failure. The conger eel is perhaps the most potent natural enemy of the octopus, and according to a widespread and apparently well-founded belief it is to the scarcity of this fish that the present unprecedented scarcity of lobsters is to be attributed.

Another industry to which some attention was given, looking to an extension of the fishery in the United States, was the gathering of seaweed in France. This is one of the leading water products of that country, the value of these marine vegetables taken annually on the west and south coasts being upward of $1,000,000. In the United States, with a vastly longer coast line and a much greater abundance of useful algæ, the yearly production is insignificant.