

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

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OYSTER INVESTIGATIONS.

LYNNHAVEN RIVER, VIRGINIA.

During this year the oyster-fattening experiments at Lynnhaven River, Virginia, have been continued with encouraging results. The special objects have been to secure by artificial means a more abundant growth of the minute plants on which the oyster feeds in order that the oysters may more readily and surely attain a marketable condition. The use of commercial fertilizer as a pabulum for the diatoms was continued with increasing success. The *claire*, wholly shut off from the influence of the tides, was refilled in August with water having a density of 1.012, and a good quality of fertilizer was applied at the rate of 400 pounds to the acre, the *claire* having a mean depth of 2½ feet. The oysters, introduced at intervals between October and January, ultimately became as fat as any market requires, and some sent to Washington in March were exceptionally fat. It was found, however, that the time required for oysters to attain the desired condition was too long for practical purposes, probably because the processes of respiration, feeding, etc., are not sufficiently active on account of the absence of tidal motion. The next step in the experiments will be the artificial production of currents throughout the *claire*, so that the water will be aerated and the vital processes in the oysters stimulated at the same time that the food organisms are being regularly supplied.

NORTH CAROLINA.

In pursuance of the general policy of the Commission to assist the States in the development of their fishery resources, the steamer *Fish Hawk* was detailed for a thorough survey of certain oyster-grounds of North Carolina, the special object in view being the devising of methods for promoting the oyster industry and the determination of the factors which underlie the failure of oyster-culture in the State during the past ten or twelve years. A consideration of these points involved a complete study of the biological and physical characters of the oyster-grounds. The extent of the North Carolina waters adapted to the existence of oysters prevented an examination of more than a small part of the grounds in one season, and the work was therefore restricted to certain areas of special interest.

In September, 1899, the investigations were begun in the vicinity of Beaufort and Morehead, and included Newport and North rivers, the Straits, Jarrett Bay, and Back Sound, which waters were completed in December; then the *Fish Hawk* moved into Pamlico Sound, where it was engaged until March, 1900, in work on several important areas, including Swan Quarter Bay, the most productive oyster section in the State.

The general examination of the oyster-beds was under the immediate charge of Mr. James A. Smith, the commanding officer of the vessel, who was assisted by Mr. W. F. Hill and Mr. O. F. Bellows, who were detailed from the office at Washington as surveyors and draftsmen, and by Dr. Caswell Grave, of Johns Hopkins University, who gave particular attention to the biological features of the inquiry. Prof. J. A. Holmes, director of the North Carolina geological and natural-history survey, took great interest in the work and his suggestions as to the especial regions to be examined were followed. The State Oyster Commission, at the request of Professor Holmes, detailed their steam launch to assist in the survey in Pamlico Sound. Special reports on the work have been submitted by the commander of the vessel and Dr. Grave, and large detailed charts delineating the natural and planted oyster-beds have been prepared in the office by Mr. Hill from data obtained in the field.

EASTERN OYSTERS ON THE PACIFIC COAST.

Although the eastern oyster has been acclimatized in the Pacific States for a number of years, it is only in California that natural reproduction is known to have taken place. If the oysters in Oregon and Washington have reproduced, the young have not survived the free-swimming stage. This matter is naturally engaging the attention of the State fishery authorities. References to the studies of the eastern oysters planted in Yaquina Bay, Oregon, have been made in previous reports of the division. In 1899 the condition of the oysters in Willapa Bay, Washington, received attention. The Commission had planted 80 barrels of eastern oysters in this place in 1894, with the understanding that they would be properly guarded and left to multiply. The absence of recent reports from this lot, together with requests from the State that the physical conditions in the bay be considered with reference to oyster propagation, led the Commission to undertake a preliminary examination in the present fiscal year. Dr. H. F. Moore, naturalist on the *Albatross* and an oyster expert, having been detailed to visit the bay in August, 1899, while en route to join the vessel, made the following report:

Pursuant to orders, I have visited Willapa Bay for the purpose of examining the eastern oysters planted there by the Commission and "to determine whether natural spawning has taken place, and if not, whether there are physical conditions which prevent it." I have found that the oysters planted there by the Commission have been almost exterminated, a somewhat lengthy search resulting in finding

but five. The reasons for this are not to be defined from the brief examination which it was possible for me to make. They may have become buried by shifting of the bottom or by the deposit of silt, but from the condition of the shells found I am inclined to think that neither explanation is adequate, and I suspect that some, at least, of the transplanted oysters have found their way to market. I understand that these oysters were bedded rather thickly, and if they and the dead shells have not become buried they have certainly been carried off through some agency. I have learned from the oystermen that at the end of the first year a large proportion of those planted had survived and were on the beds, but after that they became gradually fewer. It would appear, therefore, that they had withstood the vicissitudes of transportation with a fair degree of success.

During the last two or three years several private beds of eastern oysters have been established in different parts of Willapa Bay and they are reported to be doing well, possibly because it is somebody's interest to protect them from deprivations of unprincipled persons.

In this connection I should counsel against further plantings of oysters on this coast by the Commission unless satisfactory guarantee can be offered that they will be protected from theft. A general assurance from the oystermen of a given locality is not sufficient, as then no one feels the responsibility and no one wishes to assume the onus of prosecuting the offenders even if they be detected.

In two of the five oysters found the ovaries were well developed and apparently ripe eggs could be squeezed from the oviduct. The other three were not sexually mature, and as no males were found the possibility of fertilizing the eggs could not be tested. I understand, however, that Professor Doan, of the State Agricultural College, succeeded in fertilizing some eggs earlier in the summer. He is said to be carrying on experiments on the line of artificial fecundation as a solution of the difficulties in establishing self-sustaining beds.

So far as I could learn, there is no evidence that the eastern oyster has ever naturally spawned here, or, rather, that there has ever been a set of spat. I think that the cold water here will prevent that under ordinary conditions, but I believe that in shallow ponds suitably constructed, and with proper precautions against the deposit of silt on the cultch, spat may be raised for subsequent planting in the open bay. If the Commission is to attempt oyster-culture on this coast, it seems to me that this line of research is the one indicated as most reasonable and most likely to yield results of value. The water during my stay was about 61° F., 8 or 9 degrees lower than usually suffices for the development of oyster fry.

We have no series of temperature and density observations extending throughout the year on this coast, and I have left a set of salinometers with Mr. Bush, who will make and record observations.

Concerning the native oyster, I made the interesting observation that, like its European relative, the eggs undergo a very considerable development in the gill chamber of the mother. When discharged they are, in fact, about at the stage of fixation. The eggs and embryos are very much larger than the eggs of the eastern oyster. I do not remember to have seen this fact mentioned by those who have called attention to the hermaphroditism of the species.

The failure of the eastern oyster to reproduce in the colder waters of Oregon and Washington has suggested the desirability of transplanting to our west coast some of the fine large oysters found in northern Japan, notably in Akishi Bay, on the eastern side of Hokushu Island. This step has been recommended by the Commission to some of the oyster-planters of Washington, and it is understood that negotiations are now under way for the shipment of a cargo for transplanting in Willapa Bay and other waters of Washington.

WORK AT THE BIOLOGICAL LABORATORIES.

WOODS HOLE, MASSACHUSETTS.

From the report of Dr. H. C. Bumpus, the director of the biological laboratory of the Commission at this place, the following outline of the work there carried on has been taken:

The year has been characterized by general improvements in the equipment of the laboratory, increased facilities for collecting material, enlarged library accommodations, and a gratifying increase in the amount of scientific work accomplished. The Commissioner was at the station during the greater portion of the summer, and through his advice many needed changes were made in and about the laboratory.

The steamer *Fish Hawk* was at the station at the beginning of the fiscal year and remained until September 6. During the summer the trawl was lowered 71 times, and Mr. J. D. Milligan kept a careful record of all the animals taken. The efficiency of the *Fish Hawk* as an instrument of biological research was largely due to the skill, interest, and experience of the commanding officer, James A. Smith, mate, U. S. Navy.

The *Grampus* made three trips to the Gulf Stream, and Captain Hahn secured valuable data respecting the distribution of the tile-fish. The steam launches *Blue Wing*, *Cygnel*, and *Merganser* were in daily use during July and August.

At the close of the summer of 1899 Commissioner Bowers recommended that a large room, heretofore used as a museum, be repaired and made into a library. Nothing during the year has occasioned more general approval from men of science than the furnishing of this room for the growing library and as a resort for those who wish to study. The card catalogue shows a gratifying increase in the number of contributions to the library, and already the list of acquisitions numbers over 3,000 volumes and pamphlets. The librarian of Brown University has kindly loaned sets of the more important scientific journals, and the authorities of the Marine Biological Laboratory have extended the use of their library to those working at the Commission.

The number of those who pursued investigations at the laboratory is somewhat larger than in the previous year, and while it includes many who worked on problems solely of economic importance, the director did not hesitate to call upon any or all for advice or assistance when the interests of the Commission could be thereby subserved. Indeed, the following list represents a body of able and willing volunteers: Warren E. Babcock, M. D., Ogdensburg, N. Y.; Barton A. Bean, U. S. National Museum; James E. Benedict, Ph. D., U. S. National Museum; R. P. Bigelow, Ph. D., Massachusetts Institute of Technology; Maurice A. Bigelow, M. S., Harvard University; R. E. Blount, A. B., Chicago, Ill.; H. C. Bumpus, Ph. D., Brown University; R. S. Breed, M. S., Harvard University; T. J. Burrage, A. B., Brown University; H. L. Clark, Ph. D., Amherst College; H. A.

Childs, B. S., University of Iowa; F. P. Drowne, Brown University; W. H. Dudley, Wisconsin State Normal School; G. W. Field, Ph. D., Rhode Island Agricultural College; W. W. Francis, Johns Hopkins University; Peter Frandsen, A. B., Harvard University; Erik H. Green, A. M., Massachusetts Institute of Technology; C. W. Hargitt, Ph. D., Syracuse University; Harold Heath, Ph. D., Leland Stanford University; C. J. Herrick, M. S., Denison University; S. J. Holmes, Ph. D., University of Michigan; Freeland Howe, jr., A. B., Harvard University; J. M. Johnson, Harvard University; R. H. Johnson, Harvard University; J. L. Kellogg, Ph. D., Olivet College; C. R. Knight, American Museum of Natural History; T. G. Lee, M. D., University of Minnesota; A. B. Lewis, A. M., University of Nebraska; Edwin Linton, Ph. D., Washington and Jefferson College; C. G. Maywood, A. B., Albion College; A. D. Mead, Ph. D., Brown University; P. Calvin Mensch, M. D., Ursinus College; E. C. McKibben, Denison University; W. J. Moenkhaus, Ph. D., Harvard University; C. C. Nutting, A. M., University of Iowa; G. H. Parker, D. S., Harvard University; H. F. Perkins, A. B., Johns Hopkins University; Charles W. Prentiss, A. M., Harvard University; Herbert W. Rand, A. M., Harvard University; Jonathan Risser, Grinnell College; Porter E. Sargent, A. M., Harvard University; H. Sherwood, A. M., Brown University; Arthur J. Stewartson, Washington and Jefferson College; Myron W. Stickney, A. M., Worcester Academy; R. M. Strong, A. B., Harvard University; Oliver S. Strong, Ph. D., Columbia University; C. F. Sylvester, Princeton College; G. W. Sylvester, Princeton College; Millett T. Thompson, A. M., Brown University; Edward L. Thorndike, Ph. D., Columbia University; R. W. Tower, A. M., Brown University; E. E. Tyzzer, A. M., Harvard Medical School; Ira Van Gieson, M. D., Pathological Institute of the New York State Hospitals; H. E. Walter, A. M., North Division High School, Chicago; L. B. Walton, A. M., Brown University; F. E. Watson, A. M., Brown University; W. A. Willard, A. M., Harvard University; W. M. Wheeler, Ph. D., University of Texas; S. R. Williams, A. M., Harvard University; G. M. Winslow, Ph. D., Auburndale, Mass.; R. M. Yerkes, A. B., Harvard University.

Dr. James L. Kellogg, assisted by Mr. George H. Sherwood, has conducted a series of experiments to test the rate of growth of the clam and the feasibility of clam cultivation. The results of these experiments will be published in a special report.

Mr. George H. Sherwood has carried on a series of observations for the purpose of determining the cause of the migrations of fish. Mr. Vinal N. Edwards's valuable records of the times of arrival and departure of various species of fish visiting the Woods Hole region have proved of great service in this work.

In 1898 Professor McClure, assisted by Mr. C. F. Sylvester, began a comparative study of the circulatory system of fishes, which has been continued during the present year. The nets and traps of the Commission have provided him with material for this work.

Mr. E. H. Green has made a chemical examination of the connective tissue of the ocean sun-fish to determine its value as a glue-producing material; and has begun an analysis of the chitin of the lobster for the purpose of finding for it some commercial use.

Mr. E. E. Tyzzer, of Harvard Medical School, and Dr. Cushing, of Jefferson Medical College, have begun investigations on the diseases of fishes, in which they have had the assistance of Dr. Edwin Linton, who for many years has confined his studies to the entozoa of fishes.

During July and August, 1899, Dr. J. E. Benedict was given opportunity to collect material for the U. S. National Museum, and in August and September Mr. Barton A. Bean collected fishes for the same institution. In August Mr. Freeland Howe, jr., accompanied the *Fish Hawk* on a dredging excursion to the Gulf Stream. His account of the biological results will appear in an early paper of the Bulletin.

For many years workers at Woods Hole have needed papers of general reference in which they might find descriptions of the numerous animals which occur in this region. The publications of Professor Verrill on the invertebrates of Vineyard Sound have been for a long time out of print, and it has been decided to issue a series of faunistic papers which will ultimately embrace all of the invertebrate groups. The copepods and hydroids, two groups of invertebrates contributing largely to the general food supply of fishes, have been given special attention during the past year. Prof. W. M. Wheeler, of the University of Texas, has already prepared a paper on the former group, which will appear in the Bulletin for 1899, and Prof. C. C. Nutting, of the University of Iowa, has a paper on the latter group, which will be ready for the printer at an early date.

Prof. Hubert L. Clark, of Olivet College, Michigan, has in preparation a paper on the general anatomy of the star-fish, and Thomas J. Burrage, of the Harvard Medical School, has contributed an anatomical paper on the alimentary tract of the flounder.

Excellent photographs of living fish have been taken by Mr. M. W. Stickney, and sketches of living marine animals have been made by Mr. Charles R. Knight, of the American Museum.

Much interest has been manifested in recent years in the photography of living fishes and other animals in the water. While considerable difficulties are encountered, they are more than counterbalanced by the satisfaction in securing illustrations that actually represent the form and attitude of the live animals. In the United States great success in this line has been attained by Dr. R. W. Shufeldt, to whom the Commission extended facilities at the aquaria in Washington, and whose paper entitled "Experiments in Photography of Living Fishes" was printed in 1899 as a part of the Bulletin for that year. The plates in this paper, and also the text, have been extensively reprinted, both here and abroad. Working along independent lines, Mr. M. W. Stickney has achieved some creditable results in the photography of marine fishes at the Woods Hole laboratory.

BEAUFORT, NORTH CAROLINA.

The opening of a laboratory at Beaufort, N. C., on June 1, 1899, was noticed in the last report, which contained an outline of the operations during the last month of the fiscal year. The laboratory remained open until September 15, and was occupied by Prof. W. K. Brooks, Dr. Caswell Grave, and Mr. A. M. Reese, all of Johns Hopkins University; Prof. E. W. Berger, of Baldwin University; Prof. J. I. Hamaker, of Trinity College (N. C.); Prof. T. G. Pearson, of Guilford College; Prof. J. Y. Graham, of the University of Alabama; and Mr. C. A. Shore, of the University of North Carolina, in addition to Prof. H. V. Wilson, of the same institution, who was in charge. The laboratory reopened under the same direction on June 1, 1900, during which month tables were taken by Prof. E. B. Wilson, Dr. H. E. Crampton, Mr. H. B. Torrey, and Mr. J. C. Torrey, of Columbia University; Dr. Grave; Professor Hamaker; Prof. R. E. Coker, of the Goldsboro (N. C.) public schools; and Mr. J. W. Turrentine, of the University of North Carolina.

Among the numerous special inquiries conducted by the laboratory corps, the following may be mentioned: Prof. H. V. Wilson, assisted by Mr. Shore, gave attention to the breeding conditions of certain fishes, sponges, and crustacean parasites, among the last being a small barnacle (*Dichelaspis*) on the gills of the common edible crab (*Callinectes*). Professor Coker and Mr. Turrentine, under Professor Wilson's supervision, investigated the spawning habits of various fishes, including the following edible forms, from all of which eggs were artificially taken and fertilized: Weak-fish (*Cynoscion regale*), spotted squeteague (*Cynoscion maculatum*), hog-fish (*Orthopristis*), porgy (*Chalodipterus*), and king-fish (*Menticirrhus*). The eggs of the silverside (*Menidia notata*), important as an article of food for the other fish, were also obtained, and some interesting and valuable observations on another small species, a blenny (*Hyppleurochilus*), were made. The character of the food of the hog-fish and croaker (*Micropogon*) was studied. The former species is regarded by many persons as having a distinctly unpleasant flavor and hence much less valuable as food than the same fish taken in the vicinity of Norfolk; one cause for the inferiority in flavor has been found to be a large species of the peculiar worm-like animal (*Balanoglossus*), which is very abundant on the flats in Beaufort Harbor and is freely eaten by the hog-fish. Dr. Grave studied the life-history of the brittle-stars (*Ophiurans*), and during the spring of 1900, while attached to the *Fish Hawk*, used the facilities of the station in connection with his examination of the oyster-grounds of the region. Dr. Crampton was occupied in investigating the effects of abnormal conditions on the development of the eggs of the oyster and other mollusks. Mr. Torrey considered the early development of one of the most abundant annelid worms (*Axiothea*), an important article of diet for some of the bottom-feeding fishes.

In the course of an extended article on "Marine Biology at Beau-

fort" in the American Naturalist for May, 1900, Professor Wilson, director of the laboratory, makes the following statements concerning the studies of the various animal forms of the region:

It is planned that the record of each species shall include mention of the localities in which it is fairly abundant, most convenient collecting methods, time of year during which breeding goes on, brief natural-history notes on habits of adult (food, enemies, parasites, rate of growth, time and extent of migration, etc.), and on the life-history (character of eggs, where and how deposited, possibility of artificial fertilization, period of embryonic development, character of larva and period of larval development, habitat, food, and enemies of larva). The economic value of such a knowledge of the natural history of the region will be readily understood, and it is equally obvious to what an extent it will aid naturalists engaged in the study of abstruse problems of morphological and physiological embryology, of comparative anatomy and physiology. Its value in connection with similar results of the work at other coast stations, to the study of the variability of organisms, may be here alluded to.

To carry out such a scheme of work for a rich fauna like that of Beaufort will require years. An excellent basis has, however, been built up, and profitable lines of study marked out by the members of the Johns Hopkins marine laboratory and by other naturalists. At the Fish Commission laboratory many of the previously known facts, some recorded, some unrecorded (in the possession of former workers at Beaufort), have been brought together and confirmed, and important additions have been made. The forms actually collected during the season of 1899 include 238 species of marine invertebrates, some 70 fishes, 50 birds, a number of reptiles, amphibia, insects, and arachnoids, and a very considerable number of land plants and algæ. In the case of a good number of species, notes along the lines indicated above were made. In another season's work doubtless all the recorded forms will have been taken and identified. Further progress can only be made by a formal division of labor among the members of the laboratory. With the great awakening of interest, which is so apparent to-day in the phenomena exhibited by animals and plants regarded as living units, it should not be difficult to find naturalists who will gladly work up the local natural history of the groups embracing the particular forms on which they may be investigating problems of a morphological or physiological character.

The variety of fishes that may be taken in a short time in Beaufort Harbor and adjoining waters is so great as to make it evident that the number recorded (Jenkins gives 134) for the region will be greatly increased when systematic collecting has been carried on for a few years. Some 9 miles from Beaufort inlet the coast line makes a sharp right-angled bend, with Cape Lookout at the angle. From the end of the cape a narrow line of shoals extends much farther out. The cape and its submerged continuation form a wall, as it were, reaching seaward for 15 miles. Cape Lookout itself is so shaped as to embrace a bay, a quiet and beautiful sheet of water, Lookout Bight. The coast configuration thus forms a remarkable natural trap into which fish migrating northward fall. It is doubtful whether a better place can be found anywhere on our coast for the carrying out of observations on oceanic species and on bay and river species during the oceanic period of their life. The seining at Cape Lookout has been extremely interesting and successful, both as regards the variety of forms and the number of individuals taken.

It is a source of great satisfaction to the Commission and to biologists that at the last session of Congress an act was passed providing for the establishment of a permanent station on the coast of North Carolina, at which the biological problems connected with the marine-fishery interests of the South Atlantic region may be investigated.

MISCELLANEOUS MARINE AND FRESH-WATER INQUIRIES.

SPECIAL LOBSTER AND CLAM INVESTIGATIONS.

In the urgent deficiency bill approved February 9, 1900, provision was made for special investigations having for their object the institution of measures for the arrest of the serious decline in the lobster and clam fisheries, which has been referred to in previous reports of the Commission. The intelligent consideration of the condition of these important fisheries and the steps needed to reverse the present downward tendency involve a comprehensive study of their history, methods, regulation, etc., but it has been apparent that the chief aid which can be rendered by the General Government lies in the direction of increased production through artificial means.

The hatching of lobsters on a large scale is a comparatively simple matter; but the rearing of the young to a point where they leave their defenseless free-swimming stage and assume the habits of the adult is a difficult problem which has heretofore not been successfully solved. With regard to the clams—more especially the soft-shell species (*Mya arenaria*)—it has seemed clear that the future of the industry depended largely on the inauguration of planting methods similar to those so successfully adopted with the oyster. This procedure presents few difficulties and gives promise of large returns in a short time, at a very small cost.

In April, 1900, the following special commission was created by the Commissioner for the prosecution of the investigations authorized by Congress: Dr. H. C. Bumpus, chairman; Mr. W. de C. Ravenel, Capt. E. E. Hahn, and Dr. H. M. Smith, secretary. It is chiefly to the biological and cultural problems involved in the development of practicable rearing methods that the commission will give attention. Already some important and significant results have been attained.

MACKEREL.

The question of the existence of different races of mackerel (*Scomber scombrus*) on the east coast of North America was studied by Mr. M. C. Marsh in continuation of inquiries begun in the preceding year. For the purpose of securing ample material, Mr. Marsh in July and August visited several places in New England, and in Boston was able to examine large series of specimens from the Canadian provinces. Special facilities were extended by Mr. J. R. Neal and Messrs. Potter and Wrightington, of Boston, and Capt. A. W. Rich, of Provincetown. In May Hon. E. G. Blackford, of New York, forwarded 200 mackerel caught off New Jersey. About 2,000 specimens have now been examined, and their detailed study justifies the following conclusions:

(1) The existence of a marked racial distinction between American and British mackerel, as indicated by the studies of Mr. Walter Garstang, is strongly confirmed.

(2) The evidence thus far accumulated fails to disclose the existence on the American coasts of distinct bodies of mackerel, charac-

terized by color or structural features, such as are found on the shores of the British Isles. The examination of further material from extreme southern and northern localities is desirable, however, before the question can be considered settled.

Certain minor points in the relations of the characters have been determined. Thus a decrease in the number of dorsal spines with the growth of the fish, as shown by Garstang's material, holds good for American fish, as does a correlation between the dorso-lateral spots and the size of the fish, not exhibited by British mackerel. A preponderance of male fish, in the ratio of 2 to 1, is shown. No selective process, so far as known, would account for this disparity in the material examined.

COBBOSSÉECONTEE AND SEBAGO LAKES, MAINE.

The study of the fish fauna of Sebago Lake by Dr. W. C. Kendall, referred to in the last report, was continued during July and part of August, 1899. Hon. L. T. Carleton, chairman of the State board of fish commissioners, having expressed a desire that the character of the fish life of Lake Cobbosseecontee be determined, Dr. Kendall devoted the last two weeks of August to this investigation.

Cobbosseecontee is the largest of a connected group of lakes in Kennebec County, the other important ones being Amabessacook and Maranacook. It is irregular in shape, about 9 miles long, 0.5 to 2.8 miles wide, and consists of two wide areas connected by a narrow portion. The shores are mostly rocky, with a few sandy beaches and a swamp at the southern end, through which several inlets pass. The lake discharges into Kennebec River through a small stream.

The fishes of the lake are not numerous as to species, but are as to individuals. Among the most abundant are the small-mouthed black bass (*Micropterus dolomieu*) and the white perch (*Morone americana*). The latter are protected by law and reach a large size, some weighing 3 pounds having been caught. Schools containing thousands of the season's young, from 3 to 6 inches long, were noticed along the sandy shores, where the black bass were feeding on them. Trout (*Salvelinus fontinalis*) are fairly common, reach a weight of 8 pounds, and afford good fishing in spring. Salmon (*Salmo sebago*) have been planted in the lake, but not with much success, as but few have been caught. The character of the lake water seems to be well suited to the salmon, whose apparent inability to maintain itself naturally may be due to restricted spawning-grounds and the abundance of predaceous fishes. An interesting ichthyological discovery is the existence in the lake of the brook stickleback (*Eucalia inconstans*), which has not heretofore been known from Maine waters. Other fishes found in the lake are the hornpout (*Ameiurus nebulosus*), sucker (*Catostomus commersonii*), chubs (*Semotilus corporalis* and *S. atromaculatus*), roach, locally called herring (*Abramis crysoleucas*), eel (*Anguilla chrysypa*), smelt (*Osmerus abboti*), pickerel (*Lucius reticulatus*), long-eared sunfish (*Lepomis*

auritus), common sun-fish (*Eupomotis gibbosus*), yellow perch (*Perca flavescens*), and five other minor species, which raise to twenty-one the list of forms known from the lake.

SENECA LAKE, NEW YORK.

This is one of the largest of the interior lakes of New York. No critical examination of its fish fauna appears to have been made, although it is extensively resorted to by anglers, has certain ichthyological features of special interest, and at one time or another has supported commercial fisheries of some importance. It also appears to be a field in which fish-cultural work may profitably be conducted. In August, 1899, a brief visit to the lake was made by Dr. H. M. Smith for the purpose of determining the nature and abundance of the fish life, and arrangements were made by which the fishes were collected throughout the year. When the extent of the fauna has been fully determined, a special report on the fishes of the lake will be issued. Meanwhile, a few notes on the principal species will here be given.

Seneca Lake is about 36 miles long and 1 to 4 miles wide, with a maximum depth of 500 to 600 feet. The lake, whose surface is about 450 feet above sea level, occupies an eroded valley flanked by bold hills. It is fed by small streams and discharges into Lake Ontario by means of Seneca River, Cayuga Lake, and Oswego River.

Various forms of commercial fishing are permitted in the lake, as shown by the following extract from the fishery law of New York:

It shall be lawful to fish in waters of Seneca Lake with nets or seines, the meshes of which shall not be less than a 2-inch bar, from the 15th day of April to the 15th day of August, both inclusive. It shall also be lawful to fish with spears in the waters of Seneca Lake for all fish except black bass from the 15th day of April to the 15th day of June, both inclusive.

The number of species of fishes known to inhabit Seneca Lake is small in comparison with the number recorded from the neighboring Cayuga Lake by Dr. Meek,* although further inquiry will doubtless show the existence of a considerable number of other species. The occurrence in the lake of about 50 species has thus far been determined by the writer, of which about a third are food-fishes.

The alewife (*Pomolobus pseudoharengus*) is one of the most abundant fishes of the lake. The presence of this anadromous species has given rise to much speculation, such as has been indulged in with regard to the alewife in Lake Ontario and other New York lakes. It is generally believed that this species was introduced into Seneca Lake by Seth Green about 1872, but there is evidence to prove that as early as 1868 it had, probably unassisted, reached the lake. The chief interest now attached to the species is the annual mortality to

* Notes on the Fishes of the Cayuga Lake Basin, Annals N. Y. Academy of Sciences, 1889.

which it is subject, as in Lake Ontario, large numbers dying each summer and causing much annoyance by decaying on the lake shores.

The lake trout (*Salvelinus namaycush*) is rather common, reaches a large size, and is caught with lines and spears. Several species of white-fish exist here. The common white-fish (*Coregonus clupeiformis*) was formerly numerous, but for about 15 years has been comparatively scarce. Another species, locally known as the "greenback," is rather abundant. A rare species is the "smelt" (*Argyrosomus osmeriformis*), known only from this lake and Skanateles Lake.

The small-mouthed black bass (*Micropterus dolomieu*) is very abundant, as are also the rock bass (*Ambloplites rupestris*) and the sun-fish (*Eupomotis gibbosus*). The yellow perch (*Perca flavescens*) is numerous and reaches a large size, examples from deep water weighing 2 pounds. The wall-eyed pike was formerly abundant, but disappeared about the time the common white-fish became scarce, and is now practically absent. The remaining species include pickerel (*Lucius*), eel (*Anguilla chrysypa*), two or three suckers, about eight kinds of minnows, all of which are abundant, two species of cat-fish, and several darters. A very destructive species is the lamprey (*Petromyzon marinus unicolor*), which attacks cat-fish, pickerel, black bass, and other species, and kills many of them.

WEST VIRGINIA.

Investigations begun in West Virginia in 1899 had for their object the determination of the character of the fish life of the several large river basins draining into the Atlantic Ocean and into the Mississippi River. A party in charge of Mr. W. P. Hay entered the State in July and remained for a little more than two months, during which time numerous streams were examined in the basins of the Monongahela, Potomac, Greenbrier, and Elk rivers. Special attention was given to the Monongahela, of which about sixty tributaries were visited, chiefly by team, including the Cheat, Blackwater, Buckhannon, and other rivers. Large collections of the fishes of each stream were made, and extensive notes on the nature of the fish fauna were taken.

As a rule the streams of the Monongahela basin are swift, cool, with rocky beds and numerous falls, and naturally well adapted to sustain fish life. It appears that within comparatively recent years they have been able to sustain large numbers of the finest kinds of food-fishes, but at present the fishes are far from abundant and are becoming scarcer each year. The agencies which have cooperated to destroy the fishes are clearing of forests, reduction of food supply by changes in the character of the banks, pollution of the water in various ways, logging operations, dynamiting and damming to fit the streams for log "running," and several others, mostly incident to the industrial development of the country.

It is the purpose to continue the exploration of the streams of this State, giving special attention to those of the southwestern part tributary to the Ohio.

LAKE ERIE.

The systematic study of the biological features of Lake Erie was resumed on July 1 and actively prosecuted for two months under the direction of Prof. Jacob Reighard, of the University of Michigan. Those assisting in the work were Prof. H. B. Ward, of the University of Nebraska; Dr. H. S. Jennings, of Dartmouth College; Dr. Julia Snow, of the University of Michigan; Mr. R. H. Pond, of the University of Michigan; Mrs. H. S. Jennings, Mr. J. H. McClellan, Dr. Charles Hill, and Mr. A. B. Lewis. The hatching station of the Commission at Put-in Bay was used as a laboratory as heretofore, and was the headquarters of the party. Those who pursued studies at Put-in Bay were Dr. Jennings, Dr. Snow, and Mr. Pond.

Dr. Jennings resumed the studies in which he was engaged in the previous year, namely, experimental investigations of the reactions of the protozoa of the lake to stimuli. The principles underlying the movements of these small organisms are probably applicable to the higher animals, including young fishes. Three papers of Dr. Jennings, based on this work, have appeared in the American Journal of Physiology for January and April, 1900, and the American Naturalist for the latter month.

Dr. Snow continued the investigations of the previous season, identifying numerous species of algæ and determining the life-histories of several, especially those occurring in the plankton. The nature of Dr. Snow's investigations are thus stated by Professor Reighard:

In order to have any permanent knowledge of the plankton algæ it is necessary that they be cultivated in the same manner as bacteria in culture media of different sorts. When so cultivated, it is found that algæ assume different forms. The different forms of the same algæ also occur in nature, and have been in many cases described as distinct species. We can not know what species are present in the lake until the life-history of each has been worked out so that we may know the various forms that it assumes.

Mr. Pond considered the question of the nutrition of the larger aquatic plants, conducting some work at the University of Michigan after the close of the Lake Erie work. The nature and importance of the subject studied by Mr. Pond are thus stated by the director:

It is the purpose of this investigation to find out whether the rooted aquatic plants use their roots chiefly as anchors, as has been hitherto supposed, and draw their nutrition wholly from the water, or whether they are nourished like other plants largely through the roots. In order to determine this point Mr. Pond cultivated one of the species of plants common at Put-in Bay under two sets of conditions—i. e., so that the roots were in the soil and so that the roots were unable to reach the soil. Some of the plants were grown in aquaria in the laboratory, while others were grown in the lake. The results in both cases were very striking, and showed that in a comparatively short time plants that were rooted in the soil made a gain of about 80 per cent over those that were not thus rooted. If this rule holds for other species of plants it is a matter of considerable practical importance. If rooted plants draw their nourishment only from the water they add nothing to the sum total of the primary food supply of the water. They take certain materials from the water for their growth and return these materials to

the water again when they decay. If on the other hand the rooted plants draw nourishment from the soil, when they decay this material or a part of it passes into solution in the water. Thus the plants would serve as a continual go-between between the soil and the water, extracting from the soil and adding to the water plant food materials. These food materials would then serve for the nutrition of the aquatic algæ, upon which all of the animals of the water depend either directly or indirectly for their food.

During August a 90-foot steam yacht was hired and used in transporting from point to point a camping party in charge of Dr. Hill, engaged in collecting animal forms along the shores of the lake. Mr. Lewis gave special attention to the parasites of the lake fishes. All the organs of each fish examined were systematically searched for parasites, the results recorded, and the parasites preserved. Mr. McClellan collected bryozoa, flatworms, and leeches, and Dr. Hill and Dr. Jennings the remaining invertebrates. The material preserved, which is without doubt the most complete invertebrate collection from the region, has been distributed to well-known specialists for identification, including Prof. E. A. Birge, of the University of Wisconsin; Dr. J. P. Moore, of the University of Pennsylvania; Dr. C. M. Child and Dr. C. B. Davenport, of the University of Chicago, and Mr. Raymond Pearl, of the University of Michigan.

The hired vessel was also employed in work on the plankton, under the immediate charge of Professor Reighard and Dr. Ward, and many deep-water hauls were made. The steamer *Shearwater*, belonging to the Commission, was likewise used to a limited extent.

Mrs. Jennings was engaged as artist and gave her time to making pen-and-ink and water-color drawings of algæ and living animals, especially those which do not retain their colors in the ordinary preserving fluids. Mrs. Jennings's work, which is of a high grade, has been placed in the hands of those who are studying the various groups.

WABASH BASIN, INDIANA.

In the summer of 1899 the Commission entered on a systematic study of the physical and biological features of the Wabash River and its tributary lakes and streams, under the direction of Prof. B. W. Evermann. Some inquiries were made in behalf of the Commission by members of the biological station of the Indiana University at Winona Lake, at Bass Lake in Starke County, and Bruce Lake and Tippecanoe River in Fulton County, and several other waters were also examined; but the principal work of the season was addressed to Lake Maxinkuckee, in Marshall County. In view of the intimate relations which exist between the fishes, other animals, and plants of a lake, it seemed desirable for the Commission to make a comprehensive survey of some small body of water representative of the numerous lakes of glacial origin in the Upper Mississippi Valley. Maxinkuckee was selected as being typical of that class, and, in addition, is conveniently located, is a popular resort for fishermen, and has a rich fauna and flora.

Investigations were begun July 1 and continued until the latter part of October. Professor Evermann was assisted by Dr. J. T. Scovell, Prof. C. H. Eigenmann, Messrs. T. B. Evermann, R. S. Gillum, C. Juday, Leonard Young, and T. Large. Both the biological and physical conditions of the lake were carefully studied, and much useful information was collected for the period mentioned. Many lines of soundings, with conjoint temperature observations, were run across the lake, and the location and extent of the bars and deep holes were determined. A sounding machine adapted for use from a rowboat was especially designed and constructed for this work. Material for cataloguing most of the groups of animals of the lake was collected, and many data were obtained regarding the habits, distribution, food, growth, abundance, etc., of the various animals, the fishes naturally receiving most attention. The species of plants in the lake were determined, together with the maximum and minimum depth at which each is found; many of the patches of vegetation on the bottom were mapped out, and the animals associated with each kind of plant were noted. It is proposed to continue the investigations and provide for observations at other seasons of the year.

LAKE MATTAMUSKEET, NORTH CAROLINA.

In the winter of 1899-1900, while the *Fish Hawk* was engaged in surveying the oyster-grounds of Pamlico Sound, Dr. John D. Milligan, of the vessel, was detailed to visit Lake Mattamuskeet and determine the nature of its fish fauna and the fisheries therein prosecuted. A number of trips were made, specimens were collected by means of a fine-meshed seine, and information was obtained by personal observation and from the people living near the shores. Although the winter is an unfavorable time for examining the lake, much information was gathered and a good idea of the character of the fish life was obtained.

The following account is taken from Dr. Milligan's report:

This, the largest lake in North Carolina, is situated in Hyde County; its length is 14 miles and its greatest width 7 miles. The water is very shallow, being only 2½ feet deep over a large part and having a maximum depth of 7 feet in the middle of the western end. In winter and early spring the lake is muddy and roily, owing to strong winds stirring the bottom and to the suspension of light soil and vegetable matter brought from the swamps and farm lands; but in summer the water is generally clear, with a brownish color, and is what is known as "juniper water." The bottom is mostly of fine sand mixed with mud, and is fairly hard.

This section was at one time inhabited by a tribe of Indians, and the lake has received the tribal name of Mattamuskeet. The Indian tradition as to the origin of the lake—which is the popular one to-day—is that it was due to a fire which burned many months, affecting a far larger area than is now covered by the lake. In support of this theory the people point out the blackened and water-worn cypress stumps everywhere abundant near the shores, and argue that the surrounding territory, being swampy and peaty and covered with cypress trees, is even now liable to have just such another fire. Prof. J. A. Holmes, of the North Carolina Geological Survey, states that this tradition is untenable and that Mattamuskeet, like others with the same story of origin—Lake Drummond, in the Dismal Swamp, for instance—is a natural lake.

The lake is fed by draining from swamps and farm lands and discharges through a canal which begins near Lake Landing on the southeast shore and ends in Yeosocking Bay, Pamlico Sound. The northern and western shores are swampy and marshy, while on the south and east there are extensive farms, generally dry and very fertile. Cypress and willow trees form an almost continuous border around the lake and grow far out into it.

The lake supports but little sport fishing and no market fishing, although considerable quantities of fish are taken for local consumption with rod and line and gill net. The turbid and brown water renders the nets less conspicuous and this increases their effectiveness.

While the variety of food-fishes found in the lake is rather small, it embraces a number of first-class species. The most highly prized and the most important from a local standpoint is the white perch (*Morone americana*), which is exceedingly abundant, reaches a large size, and occurs everywhere in the lake and drainage ditches. The yellow perch (*Perca flavescens*), locally called "redfin," is also abundant, but less so than formerly. The blue bream (*Lepomis pallidus*) is very common and ranks next to the white perch in popular estimation. The large-mouth black bass (*Micropterus salmoides*), having the local names of "chub" and "welshman," is present in considerable numbers. The pike (*Lucius reticulatus*) attains a large size and is numerous, and the pickerel (*Lucius americanus*), called "jack," also occurs. Cat-fish (*Ameiurus catus*, and doubtless other species) and eels are abundant. The latter are not much used, although at one time a religious sect called "The Sanctified" made a business of catching eels in the lake and shipping them north.

The only effort to stock the lake seems to have been with carp, about 10 years ago, and was fairly successful, although the fish is not highly regarded in the community. After the West Indian hurricane in August, 1899, a cartload of large carp was found in a hole near the south shore of the lake.

Other species found in the lake are the little sun-fish (*Enneacanthus gloriosus*), the common sun-fish or pumpkin-seed (*Eupomotis gibbosus*), the darter (*Boleichthys fusiformis*), the roach or shiner (*Abramis chrysoleucas*), the stone cat (*Noturus gyrinus*), the dog-fish (*Amia calva*), the hog-choker (*Achirus fasciatus*), the silverside (*Menidia beryllina*), and minnow (*Notropis*).

Besides fishes, shrimp (*Palaemonetes*) and crayfish (*Cambarus*) are abundant, and the blue crab (*Callinectes*) has been found in the canal and in the lake near the outlet. Turtles and terrapin abound, and water snakes are numerous, the "moccasin" (*Tropidonotus*) being most plentiful. Alligators are present, but are not common.

CALIFORNIA, OREGON, AND ARIZONA.

During the first half of the fiscal year Mr. Cloudsley Rutter resumed his special study of the chinook salmon of the Sacramento Basin, and at the same time carried on an investigation of the general fish fauna of the region. He also visited the headwaters of many of the eastern tributaries of the Sacramento River, where no salmon run, and made interesting observations on the fishes and large collections. Between December and July Mr. Rutter was engaged in laboratory work, studying the collections, preparing his reports, and compiling data for an article on the embryology of the salmon as a part of the monograph on the life-history of the species now in course of preparation.

In continuation of the ichthyological examinations of the Pacific coast, referred to in previous reports, a party under charge of Prof. Charles H. Gilbert, of Stanford University, visited the streams between

the northern boundary of California and the Columbia River. The field work began on July 1 and continued until September 27. The results of this season's investigations will be combined with those of 1897, when a similar party explored the coastal streams between San Francisco and the Oregon line. A report on this work is shortly expected from Dr. Gilbert.

Dr. P. H. Kirsch continued his volunteer services in determining the fish fauna of the San Pedro River, devoting a few weeks to the work in the summer of 1899. Only a short stretch of the river now remains to be canvassed, and on its completion a report on the fishes of this interesting tributary of the Colorado will be issued.

AQUATIC FAUNA OF PORTO RICO.

The extensive collections made by the *Fish Hawk* in Porto Rico in the winter of 1898-99 have been distributed among specialists for study and report, with a view to the publication of a comprehensive work on the animals found in the fresh and salt waters of the island. The absence of information regarding the water fauna, the influx of new people, and the inevitable development of the fishing industry, appeared to the Commission to warrant the publication of a work containing descriptions of the animals and illustrations of many of the most important, so that it might be possible for those persons not experts to identify them. The specimens representing the following groups were assigned to the specialists named:

Fishes and other vertebrates, Prof. B. W. Evermann and Mr. M. C. Marsh, U. S. Fish Commission; tunicates, Dr. George Lefevre, Baltimore; mollusks, Dr. W. H. Dall and Mr. Charles T. Simpson, U. S. National Museum; stomatopods, Dr. Robert P. Bigelow, Massachusetts Institute of Technology, Boston; macrurans and brachyurans, Miss M. J. Rathbun, U. S. National Museum; anomurans, Mr. James E. Benedict, U. S. National Museum; isopods, Dr. H. F. Moore, U. S. Fish Commission; leeches, Dr. J. Percy Moore, University of Pennsylvania; polychætes, Dr. A. L. Treadwell, Miami University, Oxford, Ohio; oligochætes, Dr. H. F. Moore; nemertean and planarian worms, Dr. Wesley R. Coe, Yale University; sipunculids and echiurids, Prof. Henry B. Ward, University of Nebraska; holothurians, echini, star-fishes, and ophiurans, Prof. Hubert L. Clark, Olivet College, Olivet, Mich.; crinoids, Prof. W. M. Wheeler, University of Texas; alcyonarians and gorgonians, Prof. C. W. Hargitt, University of Syracuse; corals, Dr. T. Wayland Vaughan, U. S. Geological Survey; sea anemones, Mr. J. E. Duerden, Kingston, Jamaica; sponges, Prof. H. V. Wilson, University of North Carolina; foraminifera, Dr. James M. Flint, U. S. N.; marine algæ, Prof. O. F. Cook, U. S. National Museum.

The study of many of the groups has been completed, and the publication of the reports thereon has begun. It is thought that reports on all the groups will be published during the fiscal year 1901.

