

II.—THE FIRST DECADE OF THE UNITED STATES FISH COMMISSION: ITS PLAN OF WORK AND ACCOMPLISHED RESULTS, SCIENTIFIC AND ECONOMICAL.

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There are nine departments of the government devoted, in part or wholly, to researches in pure and applied science—the Geological Survey; the Coast and Geodetic Survey; the Naval Observatory; the National Museum; the Department of Agriculture; the Entomological Commission; the Tenth Census, with its special agencies for the study of the natural resources of the country; the Smithsonian Bureau of Ethnology, and the Commission of Fish and Fisheries. The Smithsonian Institution, established upon an independent foundation, should also be mentioned, as well as the Medical Museum of the Army, and the various laboratories under the control of the Army and Navy Departments.

The Geological Survey is not now carrying on any of the schemes of zoölogical and botanical investigation engaged in by its predecessors.

The work of the Entomological Commission and that of the Census, though of extreme importance, are limited in scope and duration, while that of the Agricultural Department is necessarily, for the most part, economical.

The work of the National Museum is chiefly confined to the study of collections made by government surveys or individual collectors and sent in to be reported upon.

The work of the Fish Commission, in one of its aspects, may perhaps be regarded as the most prominent of the present efforts of the government in aid of aggressive biological research.

On the 9th of February, 1874, Congress passed a joint resolution which authorized the appointment of a Commissioner of Fish and Fisheries. The duties of the Commissioner were thus defined: "To prosecute investigations on the subject (of the diminution of valuable fishes) with the view of ascertaining whether any and what diminution in the number of the food-fishes of the coast and the lakes of the United States has taken place; and, if so, to what causes the same is due; and also whether any and what protective, prohibitory, or precautionary meas-

ures should be adopted in the premises, and to report upon the same to Congress."

The resolution establishing the office of Commissioner of Fish and Fisheries required that the person to be appointed should be a civil officer of the government, of proved scientific and practical acquaintance with the fishes of the coast, to serve without additional salary. The choice was thus practically limited to a single man, for whom, in fact, the office had been created. Professor S. F. Baird, at that time Assistant Secretary of the Smithsonian Institution, was appointed and entered at once upon his duties.

The summer of 1880 marks the tenth season of active work since its inception in 1871. The Fish Commission now fills a place tenfold more extensive and useful than at first. The present essay aims to show, in a general way, what it has done, is doing, and expects to do—its purposes, its methods, its results.

The work is naturally divided into three sections :

1. The systematic investigation of the waters of the United States and the biological and physical problems which they present. The scientific studies of the Commission are based upon a liberal and philosophical interpretation of the law. In making his original plans the Commissioner insisted that to study only the food-fishes would be of little importance, and that useful conclusions must needs rest upon a broad foundation of investigations purely scientific in character. The life-history of species of economic value should be understood from beginning to end, but no less requisite is it to know the histories of the animals and plants upon which they feed or upon which their food is nourished ; the histories of their enemies and friends, and the friends and foes of their enemies and friends, as well as the currents, temperatures, and other physical phenomena of the waters in relation to migration, reproduction, and growth. The necessary accompaniment to this division is the amassing of material for research to be stored in the National and other museums for future use.

2. The investigation of the methods of fisheries, past and present, and the statistics of production and commerce of fishery products. Man being one of the chief destroyers of fish, his influence upon their abundance must be studied. Fishery methods and apparatus must be examined and compared with those of other lands, that the use of those which threaten the destruction of useful fisheries may be discouraged, and that those which are inefficient may be replaced by others more serviceable. Statistics of industry and trade must be secured for the use of Congress in making treaties or imposing tariffs, to show to producers the best markets, and to consumers where and with what their needs may be supplied.

3. The introduction and multiplication of useful food-fishes throughout the country, especially in waters under the jurisdiction of the general government, or those common to several States, none of which might

feel willing to make expenditures for the benefit of the others. This work, which was not contemplated when the Commission was established was first undertaken at the instance of the American Fish-Cultural Association, whose representatives induced Congress to make a special appropriation for the purpose. This appropriation has since been renewed every year on a more bountiful scale, and the propagation of fish is at present by far the most extensive branch of the work of the Commission, both in respect to number of men employed and quantity of money expended.

Although activity in this direction may be regarded in the light of applied rather than pure scientific work, it is particularly important to the biologist, since it affords opportunities for investigating many new problems in physiology and embryology.

The origin of the Commission, its purposes, and methods of organization, having been described, it now remains to review the accomplished results of its work. In many departments, especially that of direct research, most efficient services have been rendered by volunteers; in fact, a large share of what has been accomplished in biological and physical exploration is the result of unpaid labor on the part of some of the most skillful American specialists. Although it would be interesting to review the peculiar features of the work of each investigator, the limits of this paper will not allow me even to mention them all by name.

Since the important fisheries center in New England, the coast of this district has been the seat of the most active operations in marine research. For ten years, the Commissioner, with a party of specialists, has devoted the summer season to work at the shore, at various stations along the coast, from Connecticut to Nova Scotia.

A suitable place having been selected, a temporary laboratory is fitted up with the necessary appliances for collection and study. In this are placed from ten to twenty tables, each occupied by an investigator, either an officer of the Commission, or a volunteer. From 1878 to 1879, important aid was rendered by the Secretary of the Navy, who detailed for this service a steamer to be used in dredging and trawling, and this year the steamer built expressly for the Commission is employed in the same manner.*

* The number of dredging and trawling stations on record is as follows:

1871. Wood's Holl.....	345
1872. Eastport, 200 by hand, 35 by steamer.....	235
1873. Portland.....	149
1874. Noank.....	223
1875. Wood's Holl.....	169
1877. Salem.....	} 378
Halifax.....	
1878. Gloucester.....	
1879. Provincetown.....	
Total in round numbers.....	1,500
The number of seine hauls is about 600.	

The regular routine of operations at a summer station includes all the various forms of activity known to naturalists—collecting along the shore, seining upon the beaches, setting traps for animals not otherwise to be obtained, and scraping with dredge and trawl the bottom of the sea, at depths as great as can be reached by a steamer in a trip of three days. In the laboratory are carried on the usual structural and systematic studies; the preparation of museum specimens and of reports. Since the organization of the Commission, the deep-sea work and the investigation of invertebrate animals has been under the charge of Professor Verrill, who had, for many years before the Commission was established, been studying independently the invertebrate fauna of New England.

In addition to what has been done at the summer station, more or less exhaustive investigations have been carried on by smaller parties on many parts of the coast and interior waters. The fauna of the Grand Banks, and other off-shore fishing grounds, has been partly explored. In 1872, 1873, and 1874 dredging was carried on from the Coast Survey steamer *Bache*, by Professor Packard and Mr. Cooke, Professor Smith, Mr. Harger, and Mr. Rathbun. In 1879 Mr. H. L. Osborn spent three months in a cod-schooner collecting material on the Grand Banks, and Mr. N. P. Scudder as long a time on the halibut grounds of Davis' Straits.

A most remarkable series of contributions have been received from the fishermen of Cape Ann. When the Fish Commission had its headquarters at Gloucester, in 1878, a general interest in the zoölogical work sprang up among the crews of the fishing vessels, and since that time they have been vying with each other in efforts to find new animals. Their activity has been stimulated by the publication of lists of their donations in the local papers, and the number of separate lots of specimens received, to the present time, exceeds eight hundred. Many of these lots are large, consisting of collecting-tanks full of alcoholic specimens. At least thirty fishing vessels now carry collecting-tanks on every trip, and many of the fishermen, with characteristic superstition, have the idea that it insures good luck to have a tank on board, and will not go to sea without one. The number of specimens acquired in this manner is at least fifty or sixty thousand, most of them belonging to species unattainable. Each halibut vessel sets, twice daily, lines from 10 to 14 miles in length, with hooks upon them 6 feet apart, in water 1,200 to 1,800 feet in depth, and the quantity of living forms brought up in this manner, and which had never hitherto been saved, is very astonishing. Over thirty species of fishes have thus been added to the fauna of North America, and Professor A. E. Verrill informs me that the number of new and extra limital forms thus placed upon the list of invertebrates cannot be less than fifty.

A permanent collector, Mr. Vinal N. Edwards, has been employed at Wood's Holl and vicinity since 1871, and many remarkable forms have also been discovered by him.

No dredging has yet been attempted by the Commission south of Long Island, though much has been done in shore work, especially among the fishes, by special agents and friends of the Commission, and by the parties stationed here and there in the work of fish-culture. Mr. E. G. Blackford, of Fulton Market, New York, by carefully watching the market slabs, has added at least ten species of fishes to the fauna of the United States. Mr. Fred. Mather is studying the fish of Long Island and the Sound. Dr. Yarrow, Mr. Earll, and others, have collected from Cape May to Key West. The Gulf States coast was explored last winter by a party conducted by Mr. Silas Stearns, who spent nine months in studying the food and the census. The entire Pacific coast has been scoured by Professor Jordan for the Commission and the census, and the ichthyology of that region has been enriched by the discovery of sixty species new to the fauna, forty of them being new to science. A similar investigation on the great lakes has been carried over a period of several years by Mr. J. W. Milner and Mr. L. Kumlien. The ichthyology of the rivers of the country has received much attention from the many experts employed by the Commission in fish-cultural work.

In addition to these local studies may be mentioned the general explorations such as are now being carried on, for the oyster by Mr. Ernest Ingersoll and Mr. John A. Ryder, for the shad by Colonel M. McDonald, for the smelt and the Atlantic salmon by Mr. C. G. Atkins, and the Quinнат salmon by Mr. Livingston Stone.

A partial indication of what has been accomplished may be found in the number of species added to the various faunal lists. Take, for instance, the cephalopod mollusks of New England. In Professor Verrill's recently published monographs, twenty species are mentioned, thirteen of which are new to science. Ten years ago only three were known.

I am indebted to Professor Verrill for the following estimate of the number of species added within the past ten years to the fauna of New England, mainly by the agency of the Commission :

	Formerly known.	Additions.	Now known
Crustacea.....	105	193	298
Pycnogonida.....	5	10	15
Annelida.....	67	238	305
Vermea.....	80	100	180
Mollusca.....	317	109	426
Echinodermata.....	47	41	88
Anthozoa.....	20	35	55
Tunicata.....	20	25	45
Polysoa.....	59	91	147
Brachiopoda.....	5	0	5
Sponges.....	10	80	90
Acalephæ.....	102	78	180
Totals in round numbers.....	800	1,000	1,800

It is but just to say that many of these species were obtained by Professor Verrill in the course of his independent explorations in Maine and Connecticut previous to 1871.*

A similar estimate for the fishes indicates the discovery of at least one hundred species on the eastern Atlantic coast within ten years; half of these are new to science. Forty species have been added to the fauna north of Cape Cod; sixteen of these are new and have been found within three years; seventeen have been described as new from the Gulf of Mexico; sixty and more have been added upon the western coast. The results of the summers' campaigns are worked in winter by the specialists of the National Museum, and under the direction of Professor Verrill, in New Haven.

One of the important features of the work is the preparation of life-histories of the useful marine animals of the country, and great quantities of material have been accumulated relating to almost every species. A portion of this has been published, more or less complete biographical monographs having been printed on the bluefish, the scup, the menhaden, the salmon, and the whitefish, and others are nearly ready.

Another monograph which may be referred to in this connection is that of Mr. Alexander Starbuck on the whale fishery, giving its history from the earliest settlement of North America.

The temperature of the water, in its relation to the movements of fish, has from the first received special attention. Observations are made regularly during the summer work, and at the various hatching stations. At the instance of the Commissioner, an extensive series of observations have for several years been made under the direction of the Chief Signal Officer of the Army, at light-houses, light-ships, life-saving and signal stations, carefully chosen, along the whole coast. This year thirty or more fishing schooners and steamers are carrying thermometers to record temperatures upon the fishing grounds, a journal of the movements of the fish being kept at the same time. One practical result of the study of these observations has been the demonstration of the cause of the failure of the menhaden fisheries on the coast of Maine in 1879—a failure on account of which nearly 2,000 persons were thrown out of employment.

Another important series of investigations carried on by Commander Beardsley, of the Navy, shows the error of the ordinary manner of using the Casella-Miller deep-sea thermometer; still another series, made by Dr. Kidder, of the Navy, and to be carried out in future, had for its object the determination of the temperature of the blood of marine animals.

Observations have also been made by Mr. Milner upon the influence

*A few days after the reading of this paper a new fauna was discovered about one hundred miles southeast of Newport, and several hundred numbers might now be added to this enumeration.

of a change from sea water into fresh water and from fresh water into sea water upon the young of different fishes.

Mr. H. J. Rice carried on a series of studies upon the effect of cold in retarding the development of incubating fish eggs.

A series of analyses have been made by Professor W. O. Atwater to determine the chemical composition and nutritive value of fish as compared with other articles of food. This investigation is still in progress.

In connection with the work of fish culture much attention has been paid to embryology. The breeding times and habits of nearly all of our fishes have been studied, and their relations to water temperatures. The embryological history of a number of species, such as the cod, shad, alewife, salmon, smelt, Spanish mackerel, striped bass, white perch, and the oyster, have been obtained under the auspices of the Commission by Messrs. Brooks, Ryder, Schæffer, Rice, and others.

The introduction of new species, in water in which they were previously unknown, is of special interest to the student of geographical distribution. Through the agency of the Commission, the German carp has already been placed in nearly every State and Territory, although the work of distribution has only just begun, and the tench (*Tinca vulgaris*) and the golden orfe (*Idus melanotus*) have been acclimated; the shad has been successfully planted in the Mississippi Valley and on the coast of California, and the California salmon in the rivers of the Atlantic slope. The maræna, or lake whitefish, of Europe, has been introduced into a lake of Wisconsin. It is not my purpose to speak of the great success in restocking with shad and salmon several rivers in which the supply was almost exhausted, and in planting the Schoodic salmon in numerous lakes. By an act of international courtesy, California salmon have been successfully introduced into New Zealand and Germany. The propagation work has increased in importance from year to year, as may be seen by the constant increase in the amount of the annual appropriation. A review of the results of the labors of the Commission, in increasing the food supply of the country, may be found in the annual reports; the rude appliances of fish culture in use ten years ago have given way to scientifically devised apparatus, by which millions of eggs are hatched where thousands were, and the demonstration of the possibility of stocking rivers and lakes to any desired extent has been greatly strengthened. This work was for six years most efficiently directed by the late Mr. James W. Milner, and is now in charge of Maj. T. B. Ferguson, also commissioner for the State of Maryland, by whom has been devised the machinery for propagation on a gigantic scale, by the aid of steam, which is now so successfully in use, revolutionizing the art of fish culture.

The investigation of the statistics and history of the fisheries has perhaps assumed greater proportions than was at first contemplated. One of the immediate causes of the establishment of the Commission was the dissension between the line and net fishermen of Southern New Eng-

land with reference to laws for the protection of the deteriorating fisheries of that region. The first work of Professor Baird, as Commissioner, was to investigate the causes of this deterioration, and the report of that year's work includes much statistical material. In the same year a zoölogical and statistical survey of the great lakes was accomplished, and various circulars were sent out in contemplation of the preparation of monographic reports upon the special branches of the fisheries, some of which have already been published.

In 1877, the Commissioner and his staff were summoned to Halifax to serve as witnesses and experts before the Halifax Fishery Commission, then charged with the settlement of the amount of compensation to be paid by the United States for the privilege of participating in the fisheries of the Provinces. The information at that time available concerning the fisheries was found to be so slight and imperfect that a plan for systematic investigation of the subject was arranged and partially undertaken. The work was carried on for two seasons with some financial aid from the Department of State. In 1879 an arrangement was made with the Superintendent of the Tenth Census, who agreed to bear a part of the expense of carrying out the scheme in full. Some thirty trained experts are now engaged in the preparation of a statistical report on the present state and the past history of the fisheries of the United States. This will be finished next year, but the subject will hereafter be continued in monographs upon separate branches of the fisheries, such as the halibut fishery, the mackerel fishery, the shad fishery, the cod fishery, the herring fishery, the smelt fishery, and various others of less importance.

Hundreds, and even thousands, of specimens of a single species are often obtained. After those for the National Museum have been selected, a great number of duplicates remain. These are identified, labeled, and made into sets for exchange with other museums, and for distribution to schools and small museums. This is in accordance with the time-honored usage of the Smithsonian Institution, and is regarded as an important branch of the work. Several specialists are employed solely in making up these sets, and in gathering material required for their completion. Within three years fifty sets of fishes in alcohol, including at least ten thousand specimens, have been sent out, and fifty sets of invertebrates, embracing one hundred and seventy-five species and two hundred and fifty thousand specimens. One hundred smaller sets of representative forms intended for educational purposes, to be given to schools and academies, are now being prepared.

The arrangement of the invertebrate duplicates is in the charge of Mr. Richard Rathbun; of the fishes, in that of Dr. T. H. Bean.

Facilities have also been given to many institutions for making collections on their own behalf.

Six annual reports have been published, with an aggregate of 5,650 pages. These cover the period from 1871 to 1878. Many papers relat-

ing to the work have been published elsewhere—particularly descriptions of new species and results of special faunal exploration.

AN EPITOME OF THE HISTORY OF THE COMMISSION.

1871.

The Commissioner, with a party of zoölogists, established the first summer station at Wood's Holl, Mass., other assistants being engaged in a similar work at Cape Hatteras and the Great Lakes. He also personally investigated the alleged decrease of the fisheries in southern New England, taking the testimony of numerous witnesses.

1872.

This year the summer station was at Eastport, Me., particular attention being paid to the herring fisheries. The survey of the Great Lakes was continued. Dredging, under the direction of Professor Packard, was begun on the off-shore banks. At the instance of the American Fish-Cultural Association, Congress requested the Commissioner to take charge of the work of multiplying valuable food-fishes throughout the country. Work was begun on the shad, salmon, and whitefish, and the eggs of the European salmon were imported.

1873.

The summer headquarters were fixed at Portland, Me. The opportunities for research were greatly increased by the aid of the Secretary of the Navy, who granted the use of an eighty-ton steamer.

Explorations in the outer waters between Mount Desert and Cape Cod were carried on in the United States Coast Survey steamer *Bache*. Operations in fish culture were carried on upon an extensive scale.

1874—1875.

In 1874 the zoölogical work centered at Noank, Conn. The attempt was made to introduce shad into Europe. In 1875 the station was for a second time at Wood's Holl, where a permanent seaside laboratory, with aquaria, was now established. The number of investigations this year was about twenty. The increase in the propagation work was proportionately much larger.

1876.

This year the Commissioner was unable to take the fishes and useful invertebrates in behalf of the Commission field for fishery investigations, having been instructed to exhibit, in connection with the Philadelphia International Exhibition, the methods of fish culture and the American fisheries. Much, however, was accomplished by single investigators in various localities. The propagation work continued. This year the first carp were introduced from Germany.

1877.

The field of investigation was resumed at Salem, Mass., and later at Halifax, N. S. A larger steamer of 300 tons made deep-sea research possible. The Commissioner and his staff served as experts before the Halifax Fishery Commission. The propagating work was on the increase, and the government carp ponds were established in Washington.

1878—1879.

In 1878 the summer station was at Gloucester, Mass.; in 1879 at Provincetown. These centers of the fishing interests were selected that more attention might be devoted to studying the history, statistics, and methods of the sea fisheries; a plan for the systematic investigation which seemed yearly more necessary in view of the dissensions between the Governments of the United States and Great Britain. In 1879 a combination was formed with the Superintendent of the Tenth Census, by which the Commissioner was enabled to carry more rapidly forward this branch of the work. Specialists were dispatched to all parts of the country to study the biological, statistical; and practical aspects of the fisheries. In 1878 the breeding of cod and haddock was accomplished at Gloucester. In 1879 the propagation of the oyster was accomplished, by co-operation with the Maryland commission, under the direction of Major Ferguson, and the distribution of the carp throughout the country was begun.

1880.

The summer station is at Newport, R. I. The Fish Hawk, a steamer of 484 tons, constructed expressly for the work of the Commission, lies at the wharf, now equipped for scientific research, later to be employed in the propagation of sea fish such as the cod and the mackerel. Over fifty investigators are in the field in the service of the Commission. The season was opened by the participation of the commission in the International Exhibition at Berlin. The first-honor prize, the gift of the Emperor of Germany, was awarded to Professor Baird, not alone as an acknowledgment that the display of the United States was the most perfect and most imposing, but as a personal tribute to one who, in the words of the President of the Deutscher Fischerei Verein, is regarded in Europe as the first fishculturist in the world.