XLI.—THE STATUS OF THE U. S. FISH COMMISSION IN 1884.

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ANALYSIS.

1. INTRODUCTORY NOTE.

In an essay entitled "Epochs in the History of Fish Culture," published in the Transactions of the American Fish Cultural Association for 1881 (tenth meeting, pp. 34–59), in a paper on "The First Decade of the United States Fish Commission," read before the American Association for the Advancement of Science in 1880 (proceedings Boston meeting, pp. 563–574), in the article "Pisciculture," in the forthcoming Volume XIX of the "Encyclopædia Britannica," in a paper not yet

published upon "The Aims and Limitations of Modern Fish Culture," recently presented to the Biological Society of Washington, and in an address upon "The Fishery Industries of the United States," delivered June 25, 1883, at the London Fisheries Exhibition, the writer has considered from various points of view the history of fish culture in America, and, what constitutes a very considerable part of this topic, the history of the United States Fish Commission. It is proposed in this essay to bring the discussion down to the present time, and to show, by quotations from recognized Old-World authorities, that the opinions which the writer has expressed in the past and now reaffirms are shared by others who have better right to opinions than he.*

2. THE ESTABLISHMENT OF THE U. S. FISH COMMISSION.

On the 9th of February, 1871, 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 in-

* It has been the good fortune of the writer to be intimately acquainted with the work of the United States Fish Commission ever since its organization, and to have served in its ranks as a volunteer upon many occasions. In 1871 a private natural history excursion on the coast of Southern Massachusetts afforded the opportunity of inspecting the work, then in its first year's organization, from the outside. In 1872 and 1873, at Eastport and Portland, as an officer of a New England college; in 1874, at Noank; in 1875, at Wood's Holl, working in behalf of the Government Board of the Centennial Exhibition; in 1877, as statistical expert in behalf of the State Department, at Halifax; in 1878, in behalf of the National Museum, at Gloucester, he was one of the party at the coast stations, taking more or less active part in the marine explorations, according as his other engagements would permit. From 1879 to the beginning of 1881 he was in the employ of the Superintendent of the Tenth Census, in charge of the division of fishery statistics. Since 1875 the Commissioner of Fisheries has from time to time intrusted him with the conduct of special investigations, the results of which have been published in the official reports. In 1880 at the International Fisheries Exhibition in Berlin, and in 1883 upon a similar occasion at London, it was his privilege, through Presidential appointment, to represent in the capacity of United States commissioner the fishery interests of the nation, including the work of the United States Fish Commission and the fish commissions of the several States. During these fourteen years of relationship to the work he has never held any direct official relationship to the Commissioner of Fisheries, nor, so far as he can remember, has he ever received a week's salary from the Fish Commission appropriation; his connection with the work having always been that of a volunteer, except so far as his duties in connection with the National Museum, Census, State Department, or the various international exhibitions have carried him into the routine of the Commission work.

These facts are mentioned simply to explain the stand-point from which it is proposed in this review, to consider the career of the Commission, this stand-point being that of an outside observer, whose work for some time past has been entirely separate from that of the Commission, but who, by reason of his familiarity with the history and interior workings of the service, is an enthusiastic supporter of, and believer in, the work, and who has had opportunities to observe what European Governments have done in their efforts to grapple with the fisheries problem, and how the operations of our Government are looked upon by the statesmen and economists in other lands.

vestigations 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 protection, prohibitory or precautionary measures should be adopted in the premises, and to report upon the same to Congress."

The resolution establishing the office of Commissioner of 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 Baird, then Assistant Secretary of the Smithsonian Institution, was appointed and entered at once upon his duties.

I think I may say without fear of challenge that very much of the improvement in the condition of our fisheries has been due to the wise and energetic management of our Commissioner. Himself an eminent man of science, for forty years in the front rank of biological investigation, the author of several hundred scientific memoirs, no one could realize more thoroughly the importance of a scientific foundation for the proposed work.*

His position as the head of that most influential scientific organization, the Smithsonian Institution, given by an Englishman to the United States "for the increase and diffusion of useful knowledge among men," enabled him to secure at once the aid of a body of trained specialists.

Pure and applied science have labored together always in the service of the Fish Commission, their representatives working side by side in the same laboratories; indeed, much of the best work both in the investigation of the fisheries and in the artificial culture of fishes has been performed by men eminent as zoologists.

The principal activity of the Commissioner, however, has been directed to the wholesale replenishment of our depleted waters. The success of fish culture is well recognized in the United States, but it was especially gratifying to its advocates that in 1880 the grand prize of the International Fisheries Exhibition at Berlin was awarded to Professor Baird as "the first fish-culturist in the world."

3. THE SCOPE OF ITS WORK.

The work of the Commission 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 philo-

*See the recently published "Biblography of the writings of Spencer Fullerton Baird" (Bulletin 20, United States National Museum), in which are enumerated the scientific papers of this investigator, not a small number of which relate directly to fishery economy.

sophical 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. A 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 in 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 fishes 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 an increasingly 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.

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 I should be glad to review the peculiar features of the work of each investigator, the limits of this paper will not allow me even to mention them by name.

4. METHODS AND RESULTS OF THE COAST INVESTIGATION.

Since the important sea fisheries are located along the North Atlantic, the coast of this district has been the seat of the most active operations in marine research. For twelve 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 North Carolina 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.

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 a few days. In the laboratory are carried on the usual structural and systematic studies; the preparation of museum specimens and of reports.

In addition to what has been done at the summer station, more or less exhaustive investigations have been carried on by smaller parties in every important position of the coast and interior waters.

For several years steamers were lent for the work for a greater or less period of time by the Coast Survey and the Revenue Marine services, and in and subsequent to 1873 by the Navy Department.

In 1880, however, a steamer of 450 tons, the Fish Hawk, was built for the fish-hatching purposes of the Commission. Another larger steamer, of 1,000 tons, the Albatross, was built and put into commission in 1883 for special service in connection with the sea fisheries.

Through the courtesy of the Secretary of the Navy and in direct compliance with the law of Congress, naval officers have been detailed to attend to the technical details of the deep-sea work—a course mutually beneficial to the two services, since the appropriation of the Fish Commission is thereby husbanded, and an efficient staff of navigators is insured, while active employment and training in scientific methods of work is provided for several naval officials.

One of the important features of the work done by the Commission has been the preparation of life histories of the principal fishes, great quantities of material having been accumulated relating to almost every species. A portion of this has been published, biographical monographs having been published on the bluefish, the scup, the menhaden, the salmon, the whitefish, the shad, the mackerel, the swordfish; and the others will make up the first volume of the forthcoming illustrated special report upon the fisheries and fishery industries of the United States, now in the hands of the Public Printer.

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, the silver gars, the clam, and the oyster have been obtained under the auspices of the Commission.

Many other problems have been worked out by specialists for the Commission, the details of which are described in the reports. One of these, for instance, has been the determination of the cause of the reddening of salt codfish, so injurious to commerce. Professor Farlow found this to be due to the presence of a species of alga in the kind of salt in common use, and gave instructions by which the plague has been greatly lessened.

An investigation into the chemical composition and nutritive value of fish as compared with other food is still in progress, and all American food-fishes are being analyzed by Professor Atwater.

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 has for several years been made under the direction of the Chief Signal Officer of the Army and with the hearty co-operation of the Light-House Board at light-houses, light-ships, life-saving and signal stations, carefully chosen, along the whole coast. A number of fishing schooners and steamers have kept similar records. 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 two thousand persons were thrown out of employment; and a similar course of study recently developed by Colonel McDonald seems to explain the recent fluctuations in the shad fishery.

A most remarkable series of contributions has been received from the fishermen of Cape Ann. When the Fish Commission had its headquarters at Gloucester, in 1878, a general interest in the zoological work sprang up among the crews of the fishing vessels, and since that time they have been vieing 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 were carrying collecting-tanks on every trip, until it became necessary to recall them because no more specimens were required, and many of the fishermen, with characteristic superstition, had the idea that it insured good luck to have a tank on board, and would not go to sea without one. The number of specimens acquired in this manner is at least 50,000 or 60,000, most of them belonging to species unattainable by other means.

The success of the incidental efforts of these men would seem to indi-

cate that much of the coast work of the Fish Commission could be more effectively accomplished by small vessels navigated by skillful fishermen than by large steamers with their more complicated routine.

5. RESULTS OF INQUIRY INTO CAUSES OF FISHERY DETERIORATION.

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 England 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.

Each year increasing attention has been paid to this subject. The Commissioner has never advised any legislation on the part of the General Government, each State government having control over the fisheries in its own waters. Certain general conclusions concerning the effect of the fisheries upon the abundance of aquatic animals, seem to meet with general acceptance in the United States.

The important distinction between *the extermination of a species*, even in a restricted locality, and *the destruction of a fishery*, should be noticed. The former is somewhat unusual, and seemingly impossible in the case of oceanic species, while the latter, especially for limited regions, is almost of yearly occurrence.

1. Aquatic mammals, like seals, may be entirely exterminated, especially when, like the fur-seals, they forsake the water and occupy the land for breeding purposes. The fur-seals of our Pacific coast are nearly gone, except upon the Prybilov Islands of Alaska, where they are protected by the General Government, the islands being leased to a company, which is allowed to kill only 100,000 each year, these being non-breeding males, and the permanence of this fishery thus being perfectly secured.

2. Aquatic mammals which do not leave the water, such as whales and manatees, conspicuous on account of their size, and not capable of rapid multiplication, may be practically exterminated when they breed near the shore. As examples, may be cited the cases of the Arctic sea-cow of the North Pacific, *Rhytina Stelleri*, and the Pacific gray-whale, or devil-fish, *Rhachianectes glaucus*, the tale of whose destruction in the lagoons of California may be found in Scammon's Marine Mammals of the Pacific Coast.

3. In the case of fixed animals, like the sponge, the mussel, the clam, and the oyster, the colonies or beds may be practically exterminated, exactly as a forest may be cut down. The destruction of the oyster beds of Pocomoke Sound, in Maryland, a large estuary, formerly very productive, is an example—the destruction being due more directly to the choking of the beds by the rubbish raked over them by the dredges, and the destruction of the ledges suitable for the reception of the young

spat, than to the removal of all the adult oysters, which was, of course, never effected.

The preservation of the oyster-beds is a matter of vital importance to the United States, for oyster fishing, unsupported by oyster culture, will, within a short period, destroy the employment of tens of thousands, and the cheap and favorite food of tens of millions of our people.

Such transfer has already come to pass in France and Holland, and England, but there appear to be almost unsurmountable difficulties in the way of protecting the property of oyster culturists from depredations—difficulties apparently as formidable in England as in America. Professor Huxley, who views these vexed problems with a vision whose clearness is all the more conspicuous from being brought into juxtaposition with the hazy generalizations of other European fishery officials, has pointed out the fallacy of close-time legislation. "Suppose," he remarks, "that in a country infested by wolves you have a flock of sheep; keeping the wolves off during the lambing season will not afford much protection if you withdraw shepherd and dogs during the rest of the year. * * * Surely nothing is more obvious than this—that the prohibition of taking the oysters from an oyster bed during four months in the year is not the slightest security against its being stripped clean (if such a thing be possible) during the other eight months."

Something may be effected by laws which allow each bed to rest for a period of years after each season of fishing upon it. It is the general belief, however, that shell-fish beds must be cultivated as carefully as garden beds, and that this can only be done by leasing them to individuals. This is already the practice in the Northern States, where oysters are planted in new localities. There is difficulty, however, in carrying out this policy in the case of natural beds, to which the fishermen have had continued access for centuries. It is probable that the present unregulated methods will prevail until the dredging of the natural beds ceases to be remunerative, and that the oyster industry will then be transferred from the improvident fishermen to the care-taking oyster culturists, with a corresponding increase in price and decrease in consumption.

4. Fishes in ponds, lakes, or streams are quickly exterminated unless the young fish are protected, the spawning season undisturbed, and wholesale methods of capture prohibited. Many of our older States now have excellent laws for the preservation of game and fish, which are enforced, not by fishery wardens, but by the agency of societies and anglers' clubs, whose members are expected to prosecute offenders against the public interest.

5. A river may quickly be emptied of its anadromous fishes, salmon, shad, and alewives by overfishing in the spawning season, as well as by dams which cut off the fish from their spawning grounds. Examples of this may be found in dozens of American rivers.

In the same way sea fishes approaching the coasts to spawn upon the

shoals or in the bays may be embarrassed, and the numbers of each school decimated, particularly if, as in the case of the herring, the eggs are adhesive and heavy.

Sea fishes spawning in the estuaries are affected by wholesale capture with stake nets, much in the same manner, though in a less degree, than salmon in the rivers. An example is apparently found in the temporary depression in the scuppaug or porgy fishery of Narragansett Bay.

Our shad and alewife fisheries are protected by an economic code of laws, different in the different States, and in the different rivers of each State. The most satisfactory laws are those which regulate the dates at which fishing must begin and close, and prescribe at least one day in the week, usually Sunday, in which the ascent of the fish must not be interrupted. Massachusetts regulates its stake-net fisheries along the coast in a similar manner.

Migratory, semi-migratory, or wandering fishes, ranging in schools or singly over broad stretches of ocean, mackerel, herring, menhaden, bluefish, bonito or squeteague, are apparently beyond the influence of human agency, especially since they spawn at a distance from the coast, or since the adults, when about to spawn, cannot be reached by any kind of fishery apparatus. Their fecundity is beyond comprehension, and in many instances their eggs float free near the surface, and are quickly disseminated over broad areas. The conclusions gained by Professor Baird tally exactly with those of Professor Huxley, that the number of any one kind of oceanic fish killed by man is perfectly insignificant when compared with the destruction effected by their natural enemies.

Their movements are no more to be anticipated than those of the atmosphere, and in many instances, with no intelligible cause, some of the most abundant species, the bluefish, the chub-mackerel, the little tunny, the scuppaug, and the bonito have absented themselves for considerable periods of years.

The chart showing the history of the mackerel fishery for the past eighty years, hanging in the fisheries gallery of the National Museum, is an illustration of this statement. The variations in abundance cannot be explained by any facts in our possession, and the yield in 1882 was greater than ever before notwithstanding the fact that the fisheries of the past ten years have been prosecuted with unusual vigor. The remarkable change in the habitat of the menhaden, occurring in 1880, and promising to be permanent, was certainly not the effect of overfishing, though fifteen years ago it would have been regarded as such. When the production of a region falls in two successive summers from 617,000 to 550 barrels, it is evident that nature, not man, is the cause.

The variations in the abundance of cod and haddock along the coast and on the banks within the last half century have been equally inexplicable,

Almost any piece of water, be it a bay or sound, or be it the covering of a ledge or shoal at sea, may be overfished to such a degree that fishing becomes unprofitable, especially if fishing be carried on in the spawning season. This statement refers, of course, only to the fishes which feed near the bottom. A familiar example is the abandonment of Massachusetts Bay by the halibut and the extension of the fishery into very deep water.

Protection to the local fishermen may therefore require the regulation by law of definite fishing-grounds near the coast. There can be no doubt that the extensive fisheries prosecuted by menhaden steamers in the gulf of Maine, though probably not so injurious to the fishery interests in general as is usually supposed, were prejudicial to the shore fishermen by driving the fish they formerly caught for bait out to sea and beyond the reach of their nets. There is also reason to believe that our great purse-seine fisheries for menhaden and mackerel, though perhaps not causing a decrease in the numbers of the fish, have kept them farther from the shore.

6. METHODS TO BE ADOPTED FOR THE IMPROVEMENT OF THE FISHERIES.

We have briefly reviewed the character of the various destructive influences which man brings to bear upon the inhabitants of the water, and noticed in passing some of their effects. We now are confronted by the question, What can be done to neutralize these destructive tendencies? There are evidently three things to do:

1. To preserve fish waters, especially those inland, as nearly as it may be possible in their normal condition.
2. To prevent wasteful or immoderate fishing.
3. To put into practice the art of fish breeding:
   a. To aid in maintaining a natural supply.
   b. To repair the effects of past improvidences, and
   c. To increase the supply beyond its natural limits rapidly enough to meet the necessities of a constantly increasing population.

The preservation of normal conditions in inland waters is comparatively simple. A reasonable system of forestry and water-purification is all that is required; and this is needed not only by the fish in the streams but by the people living on the banks. It has been shown that a river which is too foul for fish to live in is not fit to flow near the habitations of man. Obstructions, such as dams, may, in most instances, be overcome by fish ladders. The salmon has profited much by those devices in Europe, and the immense dams in American rivers will doubtless be passable even for shad and alewives if the new system of fishway construction, devised by Colonel McDonald, and now being applied on the Savannah, James, and Potomac, and other large rivers, fulfills its present promises of success.

The protection of fish by law is what legislators have been trying to effect for many centuries, and we are bound to admit that the success of

their efforts has been very slight indeed. Great Britain has at present two schools of fishery economists, the one headed by Professor Huxley, opposed to legislation, save for the preservation of fish in inland waters, the other, of which Dr. Francis Day is the chief leader, advocating also a strenuous legal regulation of sea fisheries. Continental Europe is by tradition and belief committed to the last-named policy. In the United States, on the contrary, public opinion is generally antagonistic to fishery legislation, and our Commissioner of Fisheries after carrying on for fourteen years investigations upon this very question has not yet become satisfied that laws are necessary for the perpetuation of the sea fisheries, nor has he ever recommended to Congress enactment of any description.

Just here we meet the test problem in fish culture. Many of the most important commercial fisheries of the world, the cod-fishery, the herring-fishery, the sardine-fishery, the shad and alewife fishery, the mullet-fishery, the salmon-fishery, the whitefish-fishery, the smelt-fishery, and many others, owe their existence to the fact that once a year these fishes gather together in closely swimming schools, to spawn in shallow water, on shoals, or in estuaries and rivers. There is a large school of *quasi* economists who clamor for the complete prohibition of fishing during spawning time. Their demand demonstrates their ignorance. Deer, game, birds, and other land animals may easily be protected in the breeding season, so may trout and other fishes of strictly local habits. Not so the anadromous and pelagic fishes. If they are not caught in the spawning season, they cannot be caught at all. I heard a prominent fish culturist recently advocating before a committee of the United States Senate the view that shad should not be caught in the rivers because they came into the rivers to spawn. When asked what would become of our immense shad-fisheries if this were done, he said that doubtless some ingenious person would invent a means of catching them at sea.

The fallacy in the argument of these men lies in part in supposing that it is more destructive to the progeny of a given fish to kill it when its eggs are nearly ripe, than to kill the same fish eight or ten months earlier.

We must not, however, ignore the counter-argument. Such is the mortality among fish that only an infinitesimal percentage attains to maturity. Professor Möbius has shown that for every grown oyster upon the beds of Schleswig-Holstein 1,045,000 have died. Only a very small proportion, perhaps not greater than this, of the shad or the smelt ever comes upon the breeding grounds. Some consideration, then, ought to be shown to those individuals which have escaped from their enemies and have come up to deposit the precious burden of eggs. How much must they be protected?

I quote from the Commissioners Report for 1882, the following memoranda of what the Fish Commission hopes to accomplish in time, in connection with this department of its work.

"1. *In the department of investigation and research there is yet to be carried out an exhaustive inquiry into the character, abundance, geographical distribution, and economical qualities of the inhabitants of the waters both fresh and salt.* The subject is practically unlimited in extent, and, so far as the ocean is concerned, has scarcely been touched. With the powerful apparatus, however, at the command of the Commission, it is expected that much progress will be made year by year, and the publication of the results and the distribution of duplicate specimens to colleges and academies in the United States be carried out on a large scale, so as to meet the increasing demand.*

"2. *The second object in connection with the sea fisheries is the improvement of the old methods and apparatus of fishing and the introduction of new ones.* The work of the Commission in bringing to the notice of American fishermen the importance of gill-nets with glass ball floats for the capture of codfish has already revolutionized the winter codfishery industry in New England. Looked upon almost with ridicule by the Gloucester fishermen when first brought to their notice by the Commission, these nets have come rapidly into use, until at the present time they represent the most important element in the winter fisheries, the number of fish taken being not only much greater but the fish themselves of finer quality."

Between eight and nine millions pounds of codfish were taken in the winter of 1883–'84 about Cape Ann by a fleet of 25 to 30 sail, this being nearly three times what was formerly taken by Cape Ann fishermen in a winter's work of trawl-line fishing, and comparing favorably with the renowned gill-net codfishery of Norway.

"3. *Another important point for consideration is that of the improvement in the pattern of fishing vessels.* There is annually a terrible mortality in the fishing crews of New England, especially those belonging to

*The Commission has made very large collections of aquatic animals, especially of fishes, shells, corals, crustaceans, star-fishes, &c., and after submitting them to a careful investigation for monographic research, and setting aside a full series for the National Museum, the remainder has been made up into well-identified and labeled sets for distribution to colleges, academies, and other institutions of learning throughout the United States. The educational advantages of this last measure have proved to be of the utmost value, and are thoroughly appreciated by teachers throughout the country. Applications for these sets are being continually received, and several hundreds of them have already been supplied, a number of persons being employed for a good part of the time in preparing to meet additional calls. There is nothing which so much increases the interest in natural history as the opportunity of examining actual specimens of rare and usually unprocurable species, instead of depending upon descriptions and drawings; and as the possibility of obtaining these series becomes the better known it is quite likely that all the resources of the Commission for making collections, great as they are, will be fully taxed * * *. There is no nation that does so much as the United States in the way of co-operation with teachers and students, advancing theoretical and practical natural history through its distributions of duplicate specimens and of official documents. (Report of Commission for 1882, p. 1, *et seq.*)

Gloucester, to say nothing of the total loss and wreck of the fishing vessels and their contents. There has gradually developed in connection with the mackerel and cod fisheries of New England a pattern of vessel which, while admirable for speed and beauty of lines and of rig, is less safe under certain emergencies than the more substantial vessel used abroad, especially in England and Scotland. The subject of the best form of fishing vessel has been intrusted Captain Collins, of the Commission, himself a most experienced fisherman, and after a careful study of the boats of all nations he has prepared a model which is believed to combine the excellencies of both English and American vessels. An appropriation will be asked from Congress for means to construct an experimental vessel and test its qualities; but until this successful experiment is made it will be difficult to induce the fishermen to change their present form of construction."

Since this was written some progress has been made to the accomplishment of this end. The model of the "New Era," exhibited at the London Fisheries Exhibition, met with the approval of many experienced builders, yachtsmen, and fishermen, and a tendency is manifesting itself among the New England fishermen to heed the warnings of Captain Collins; a number of somewhat deeper vessels having already been built. It is much to be regretted that Congress failed to make the desired appropriation before their summer adjournment.

"4. *The fourth object of the Commission is to determine the extent and general character of the old fishing localities and to discover new ones.* There is no doubt whatever that there still remains many important areas, even in the best known seas, where the codfish and halibut will be found in their old abundance. There has never been any formal investigation on this subject, and the banks that are known have been brought to light purely by accident. It is believed that by a systematic research and a careful survey, the area of known grounds can be greatly extended. There is even more reason to hope for successful results from this inquiry of the South Atlantic coast and in the Gulf of Mexico. These regions, the latter especially, may be considered as practically unknown, the few established localities for good fishing being in small proportion to what must exist."

A preliminary discussion of the fishing grounds, prepared by Messrs. Rathbun and Collins is now going through the press, and this will give us a foundation for future expansion. It may be mentioned incidentally that during the London exhibition, members of the American staff were enabled to point out from their knowledge of the habits of these fish in the Western Atlantic, the locations of what are no doubt excellent fishing ground for halibut and mackerel along the European coasts which have never been tried by European fishermen.

"5. *There is also much to be learned in the way of curing and packing fish for general and special markets.* The American methods have grown up as a matter of routine, and are adapted to only one class of demand,

There are, however, many modes of preparations which can be made use of to meet the wants of new markets, and thus enter more efficiently into competition with European nations for European trade, as well as for that of the West Indies and Central America. A great advance has already been made toward this desired improvement since the Centennial Exhibition of 1876, where many methods of curing and putting up fish were shown in the foreign sections that were almost entirely unknown in America. Notably among these were the preparation of sardines and other species of herring in oil as well as in spiced sauces. Quite recently this industry has been well established in Maine, amounting to a value of millions of dollars, and there are many other parts of the country where the same work can be done with other kinds of fish."

The fisheries exhibitions of Berlin and London greatly promoted this department of the work. An extensive export trade with the continent was inaugurated at the close of the Berlin exhibition, but was not continued, because of the indifference of our fish merchants to the advantages of a foreign market, their entire capacity being required to manage to supply the home demand. The members of the American staff at these exhibitions have prepared an elaborate report upon the methods of preparing fish for European markets and the opportunity for extending our commerce in this direction.

7. THE SCOPE AND PROVINCE OF ARTIFICIAL PROPAGATION.

Here the fish culturist comes in with the proposition "that it is cheaper to make fish so plenty by artificial means, that every fisherman may take all he can catch, than to enforce a code of protection laws."

The salmon rivers of the Pacific slope and the shad rivers of the East and the whitefish fisheries of the lakes are now so thoroughly under control by the fish-culturist that it is doubtful if any one will venture to contradict his assertion. The question now is whether he can extend his domain to other species.

Fish culture in its more restricted sense, or fish breeding, must sooner or later be resorted to in all densely populated countries, for with the utmost protection nature, unaided, can do but little to meet the natural demand for fish to eat. Pond culture, *Teichwirthschaft*, has been practiced for many centuries, and the carp and the goldfish have become domesticated like poultry and kine. The culture of carp is an important industry in China and in Germany, though perhaps not more so than it was in England three and four centuries ago; the remains of ancient fish-stews may be seen upon almost every large estate in England, and particularly in the vicinity of old monasteries. Strangely enough not a single well-conducted carp-pond exists in England to-day to perpetuate the memory of the tens of thousands which were formerly sustained, and the carp escaping from cultivation have reverted to a feral state, and are of little value. Carp culture can never be made to succeed in

England until improved varieties of carp are introduced from Germany, as they have been in this country.

A kind of pond culture appears to have been practiced by the ancient Egyptians, though in that country, as in ancient Greece and Rome, the practice seems to have been similar to that now practiced in the lagoons of the Adriatic and of Greece, and to have consisted in driving the young fish of the sea into artificial inclosures or vivaria, where they were kept until they were large enough to be used.

The discovery of the art of artificially fecundating the ova of fish must apparently be accredited to Stephan Ludwig Jacobi, of Hohenhausen, in Westphalia, who, as early as 1748, carried on successful experiments in breeding salmon and trout.

The importance of this discovery was thoroughly appreciated at the time, and from 1763 to 1800 was a fruitful subject of discussion in England, France, and Germany. George III, King of England, in 1771 granted to Jacobi a life pension. Upon the estate of Jacobi, by the discoverer and his sons, it was carried on as a branch of agriculture for nearly eighty years—from 1741 to 1825—though it was nearly one hundred years before public opinion was ripe for a general acceptance of its usefulness, a period during which its practice was never entirely abandoned by the Germans.

The establishment in 1850 at Huningue, in Alsace, by the French Government of the first fish-breeding station, or "piscifactory," as it was named by Professor Coste, is of great significance, since it marks the initiative of public fish culture. To this establishment the world is indebted for some practical hints, but most of all for its influence upon the policy of governments. The fortunes of war and conquest have now thrown Huningue into the hands of the German Government. The art discovered in Germany was practiced in Italy as early as 1791 by Bufalini; in France in 1820; in Bohemia in 1824; in Great Britain in 1837; in Switzerland in 1842; in Norway, under Government patronage, in 1850; in Finland in 1852; in the United States in 1853; in Belgium, Holland, and Russia in 1854; in Canada about 1863; in Austria in 1865; in Australasia, by the introduction of English salmon, in 1852, and in Japan in 1877.

Sponges have been successfully multiplied by cuttings, like plants, in Austria and in Florida.

Oysters have long been raised in artificial inclosures from spat naturally deposited upon artificial stools. The eggs of the American and Portuguese oysters have at last, however, been artificially fecundated and the young hatched, and in July, 1883, Mr. John A. Ryder, an assistant in the United States Fish Commission, solved the most difficult problem in American oyster culture by devising a mechanical device for preventing the escape of the newly-hatched oysters while swimming about prior to fixation.* The English oyster, being hermaphrodite, or

* Bulletin United States Fish Commission, pp. 17-31, 1884.

moncœcious, cannot be artificially propagated from the egg like the diœcious American species.

8. THE METHODS OF ARTIFICIAL PROPAGATION.

The fertilization of the fish egg is the simplest of processes, consisting, as every one knows, in simply pressing the ripe ova from the female fish into a shallow receptacle and then squeezing out the milt of the male upon them. Formerly a great deal of water was placed in the pan; now the "dry method," with only a little, discovered by the Russian, Vrasski, in 1854, is preferred. The eggs having been fertilized, the most difficult part of the task remains, namely, the care of the eggs until they are hatched, and the care of the young fry until they are able to care for themselves.

The apparatus employed is various in principle, to correspond to the physical peculiarities of the eggs. Fish culturists divide eggs into four classes, viz: (1) Heavy eggs, nonadhesive, whose specific gravity is so great that they will not float, such as the eggs of the salmon and trout; (2) heavy, adhesive eggs, such as those of the herring, smelt, and perch; (3) semi-buoyant eggs, like those of the shad and whitefish (*Coregonus*); and (4) buoyant eggs, like those of the cod and mackerel.

Heavy, non-adhesive eggs, are placed in thin layers, either upon gravel, grilles of glass, sheets of wire cloth, or perforated tin, in receptacles through which a current of water is constantly passing. There are numerous forms of apparatus for eggs of this class, but the most effective are those in which a number of trays of wire cloth, just deep enough to carry single layers of eggs, are placed, one upon the other, in a box or jar into which the water enters from below, passing out at the top.

Heavy, adhesive eggs are received upon bunches of twigs or frames of glass plates, to which they adhere and which are placed in receptacles through which water is passing.

Semi-buoyant eggs, or those whose specific gravity is but slightly greater than that of the water, require altogether other treatment. They are necessarily placed together in large numbers, and to prevent their settling upon the bottom of the receptacle it is necessary to introduce a gentle current from below. For many years these eggs could be hatched only in floating receptacles placed in a river with wire-cloth bottoms, placed at an angle, the motion of which was utilized to keep the eggs in suspension. Later an arrangement of plunging buckets was invented, cylindrical receptacles, with tops and bottoms of wire cloth, which were suspended in rows from beams which were worked up and down at the surface of the water by machinery. The eggs in the cylinders were thus kept constantly in motion. Finally the device now most in favor was perfected; this is a receptacle, conical, or at least with a constricted termination, placed with its apex downward, through which passes from below a strong current, keeping the eggs

constantly suspended and in motion. This form of apparatus, of which the McDonald and Clark hatching jars are the most perfect developments, may be worked in connection with any common hydrant.*

Floating eggs have been hatched only by means of rude contrivances for sustaining a lateral circular eddy, or swirl of water, in the receptacle and in floating boxes constructed to utilize the action of the waves.

The use of refrigerators, to retard the development of the ogg until such time as it is most convenient to take care of the fry, is now extensively practiced in the United States, and in Germany.

The history of fish culture in this country is so familiar to every one who has the slightest interest in the subject that it seems unnecessary to refer to it in this place, except to show that it was largely to the growth of popular interest in the subject that the Fish Commission has owed its original and since increasing support.

The transplanting of fish was practised and advocated in the United States by General Lincoln, Benjamin Franklin, and others at the close of the last century, and Jacobi, the father of artificial culture, had correspondents in the United States as early as 1770.

For fifteen or twenty years prior to the establishment of the Commission popular interest in the fisheries, and a desire for their maintenance had been on the increase, the state of public opinion being doubtless under stimulation from the action of the French Government in fostering the still infant art of fish culture, which, although discovered before the middle of the previous century in Germany, and never really abandoned in Europe, had not been considered worthy of government aid until the successes of the French peasants, Remy and Géhin, about 1850, had been popularized by the brilliant genius of M. Coste, under whose direction was established the first governmental fish cultural establishment, that at Huningue in Alsace, now the official center of fish culture in the German Empire.

The publications and experiments of Garlick, Fry, Atwood, Lyman, Green, Stone, Ainsworth, Roosevelt, Atkins, Slack, and others, awakened everywhere a sense of the fact that our rivers and streams were being rapidly cleared out, and the feeling that a similar state of affairs was probably existing in the adjoining ocean. Measures were set on foot for restoration and protection as early as 1865, when Massachusetts appointed the first commission, and prior to 1870 this example was followed by several other States. Nearly all the States and Territories now have similar organizations. In the accompanying table, prepared by Mr. C. W. Smiley, are shown the dates of organization of the several State commissions, together with the appropriations up to 1882:

* Trans. Amer. Fish Cultural Association. 1883.

Appropriations for the work of the State Fish Commissions, arranged in the order of their organization.

No.	State.	1865.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	Total.
1	Massachusetts	—	$7,000	$10,000	$12,500	$2,500	$4,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$95,500
2	Vermont	—	—	106	100	231	680	321	415	531	1,335	775	761	545	1,000	1,000	1,000	1,000	1,000	10,800
3	Connecticut	.....	—	—	4,000	4,000	3,000	3,000	3,000	5,000	5,000	5,000	1,528	1,809	1,000	3,000	2,500	5,000	5,000	53,300
4	New Hampshire	.....	100	1,000	2,071	1,429	1,231	1,364	1,300	2,443	1,950	1,999	776	1,528	3,204	2,077	2,000	2,000	.....	26,462
5	Pennsylvania	.....	—	—	—	—	—	—	—	18,080	18,080	5,470	15,000	8,000	10,000	15,000	10,000	7,500	7,500	114,630
6	Maine	.....	.....	1,000	1,000	3,000	2,000	2,000	2,500	3,500	4,500	1,500	2,500	3,700	3,700	—	6,075	5,000	5,000	46,975
7	New York	.....	.....	.....	1,000	10,000	10,000	15,000	15,000	15,000	10,000	29,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	210,000
8	Rhode Island	.....	.....	.....	—	—	1,000	2,500	1,500	1,500	1,500	1,000	500	—	—	—	1,000	1,000	.....	11,500
9	California	.....	.....	.....	.....	.....	2,500	2,500	2,000	2,500	2,500	5,000	5,000	5,000	4,000	5,000	5,000	5,000	5,000	52,000
10	New Jersey	.....	.....	.....	.....	.....	—	—	1,500	1,500	2,000	3,000	2,500	5,000	4,000	5,000	5,000	4,000	.....	33,500
11	Alabama	.....	.....	.....	.....	.....	.....	—	—	—	—	—	—	—	—	—	—	—	—	.....
12	Utah	.....	.....	.....	.....	.....	.....	—	—	—	—	—	—	—	—	—	—	—	850	850
13	Michigan	.....	.....	.....	.....	.....	.....	.....	.....	7,500	7,500	7,000	7,000	7,000	7,000	5,000	5,000	8,000	7,500	68,500
14	Ohio	.....	.....	.....	.....	.....	.....	.....	.....	500	500	5,000	5,000	4,000	5,000	—	9,000	5,000	5,000	39,000
15	Wisconsin	.....	.....	.....	.....	.....	.....	.....	.....	500	360	2,000	10,000	8,000	8,000	8,000	2,000	7,000	7,000	52,860
16	Iowa	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,500	1,500	4,375	5,575	4,200	4,200	3,700	3,700	3,700	32,450
17	Maryland	.....	.....	.....	.....	.....	.....	.....	.....	.....	6,500	6,500	13,000	13,000	13,000	13,000	11,500	10,000	10,000	96,500
18	Minnesota	.....	.....	.....	.....	.....	.....	.....	.....	.....	500	1,000	1,000	5,000	5,000	5,000	5,000	5,000	5,000	32,500
19	Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	—	2,500	2,500	2,500	2,500	4,000	2,500	2,500	2,500	21,500
20	Illinois	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—	—	—	—	—	2,000	1,000	2,500	5,500
21	Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—	—	—	—	—	—	—	.....
22	Georgia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500	500	500	500	500	500	500	3,500
23	Kentucky	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,500	1,500	1,500	1,500	2,500	2,500	2,500	13,500
24	Colorado	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	200	200	1,000	1,000	6,000	3,250	11,650
25	Kansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500	500	500	500	—	1,000	3,000
26	Missouri	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500	500	3,000	3,000	3,500	3,500	14,000
27	Nevada	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500	500	2,000	2,000	1,000	1,000	7,000
28	North Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—	—	—	—	3,214	8,012	11,226
29	Tennessee	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—	—	—	—	—	—	.....
30	Washington	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—	—	—	—	—	—	.....
31	West Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,500	1,500	1,000	1,000	2,000	500	8,100
32	South Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—	800	—	3,156	2,286	6,242
33	Nebraska	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500	500	3,700	3,700	8,400
34	Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—	800	800	750	2,350
35	Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—	—	—	5,000	5,000
36	Oregon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—	.....	.....
37	Arizona	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	250	250	500
38	Delaware	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	150	150	300
39	Indiana	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,000	1,000	2,000
	Total	.....	7,100	12,106	20,171	21,160	24,411	31,635	32,215	63,554	68,725	83,235	94,912	95,848	97,804	101,677	105,075	120,470	120,948	1,101,996

9. WHAT THE COMMISSION HAS DONE IN ARTIFICIAL PROPAGATION.

It has been stated that no legislative action has ever been recommended by the Commissioner of Fisheries. The statutes of the various States contain numerous laws for the protection of fish and fishermen, generally worse than useless, though there are many definitions of close time which appear to be beneficial. To enforce these laws would, however, render necessary a large force of fish wardens.

The policy of the United States Commissioner has been to carry out the idea *that it is better to expend a small amount of public money in making fish so abundant that they can be caught without restriction, and serve as cheap food for the people at large, rather than to expend a much larger amount in preventing the people from catching the few that still remain after generations of improvidence.*

The discussion of what the Fish Commissioner has done in the direction of fish culture has been reserved to the last, since it is so much the most extensive and, at present, practically valuable part of the work.

The relative extent of the three branches of the service may be indicated by the apportionment of the appropriation during the first ten years of the work. From $5,000 to $7,500 was annually given for the investigation into the causes of the decrease of the fisheries; for the collection of statistics nothing was specifically allotted, while the entire remainder was assigned to the stocking of inland waters. Of late years no specific allotment of the appropriation has been made, though of course the sum given for the support of the steamers is in large part to be accredited to the department of coast investigation. An examination of the accounts from 1871 to 1883 shows that from 75 to 85 per cent of the money granted has been used for propagation, and that fully one-third of the appropriations has been invested in the form of permanent appliances for present and future work.

I am indebted to Mr. Earll for the following statistics of the work of the United States Commission:

"As the operations of the Commission have increased, and the propagation of additional species has been undertaken, it has been found desirable to increase the number of hatching stations. These are of two kinds, known as collecting and distributing stations. The former are located near the spawning grounds of those species for which they are especially intended. The eggs are secured at these stations, and enough having been reserved to stock the waters of that region, the remainder are sent to distributing stations, usually located at some central point, to be hatched and shipped to the waters for which they are intended.

"The following is a list of the hatching stations operated by the United States Fish Commission in 1883:

1. Grand Lake Stream, Maine, station for collecting eggs of the Schoodic salmon (*Salmo salar*.var. *sebago*).

2. Bucksport, Me., station for collecting and hatching eggs of the Atlantic salmon (*Salmo salar*), and for hatching eggs of whitefish (*Coregonus clupeiformis*) to be distributed in the waters of the State.
3. Wood's Holl, Mass. Permanent coast-station, which serves as a base of operations for the scientific investigations of the Commission and as a hatching station for eggs of the cod (*Gadus morrhua*) and other sea-fishes.
4. Cold Spring Harbor, Long Island, New York. Station for hatching eggs of various species of salmonidæ for distribution in New York and vicinity.
5. Havre de Grace, Md. Station located on Battery Island, in the Susquehanna River, for the purpose of collecting and hatching eggs of the shad (*Clupea sapidissima*).
6. Washington, D. C.
   a. National carp ponds. Ponds for the propagation of the three varieties of the carp (*Cyprinus carpio*), and the goldfish (*Carassius auratus*), the golden ide (*Idus melanotus* var. *auratus*), and the tench (*Tinca vulgaris*).
   b. Arsenal ponds. Ponds for the propagation of carp (*Cyprinus carpio*).
   c. Navy-yard. Station for collecting and hatching eggs of the shad (*Clupea sapidissima*).
   d. Central hatching station. A station fully equipped for scientific experiments connected with the propagation of fishes. The station is also provided with apparatus for hatching the eggs of all of the more important species, including light, heavy, and adhesive eggs. It is the principal distributing station of theFish Commission for both eggs and young fish to all portionsof the United States.
7. Wytheville, Va. A station for hatching eggs of brook trout (*Salvelinus fontinalis*) and California trout (*Salmo irideus*).
8. Saint Jerome's Creek, Point Lookout, Md. A station for the artificial propagation of the oyster (*Ostrea virginiana*), the Spanish mackerel (*Scomberomorus maculatus*), and the banded porgy (*Chætodipterus faber*).
9. Avoca, N. C. A station on Albemarle Sound, at the junction of Roanoke and Chowan Rivers, for collecting, hatching, and distributing eggs of the shad (*Clupea sapidissima*), alewife (*Clupea vernalis* and *æstivalis*), and striped bass (*Roccus striatus*).
10. Northville, Mich. A hatching station for the development and distribution of eggs of the whitefish (*Coregonus clupeiformis*). This station is also provided with tanks and ponds for the spawning, hatching, and rearing of brook trout (*Salvelinus fontinalis*) and California trout (*Salmo irideus*).
11. Alpena, Mich. A station for the collection and development of the eggs of the whitefish (*Coregonus clupeiformis*).

12. Baird, Shasta Co., California.
    a. Salmon station. A station on the McCloud River for the development and distribution of eggs of the California salmon (*Oncorhynchus chouicha*).
    b. Trout ponds. A station near Baird, for collecting, developing, and distributing eggs of the California trout (*Salmo irideus*.)
13. Clackamas River, Oregon. A station on Columbia River for collecting and hatching eggs of the California salmon (*Oncorhynchus chouicha*).

"The following is a list of the principal species artificially hatched in the United States, with the date when, and the person by whom, the experiments were made:

1. Brook trout, *Salvelinus fontinalis*, by Dr. T. Garlick in 1853.
2. Whitefish, *Coregonus clupeiformis*, by Müller and Brown in 1857.
3. Lake trout, *Salvelinus namaycush*, by Müller and Brown in 1857.
4. Pike perch, *Stizostedium americanum*, by Müller and Brown in 1857.
5. Atlantic salmon, *Salmo salar*, by J. B. Johnston in 1864.
6. Shad, *Clupea sapidissima*, by Seth Green in 1867.
7. Land-locked salmon, *Salmo salar*, var. *sebago*, Robinson and Hoyt in 1867.
8. California salmon, *Oncorhynchus chouicha*, Livingston Stone in 1872.
9. Striped bass, *Roccus striatus*, M. G. Holton in 1873.
10. Oquassa trout, *Salvelinus oquassa*, by C. G. Atkins in 1874.
11. Sea bass, *Serranus atrarius*, by Fred Mather in 1874.
12. Grayling, *Thymallus tricolor*, by Fred Mather in 1875.
13. Sturgeon, *Acipenser sturio*, by Seth Green in 1875.
14. Smelt, *Osmerus mordax*, by James Ricardo in 1876.
15. Herring, *Clupea harengus*, by Vinal N. Edwards in 1877.
16. Alewife, *Clupea vernalis*, by T. B. Ferguson in 1877.
17. Oyster, *Ostrea virginiana*, by W. K. Brooks in 1877.
18. Cod, *Gadus morrhua*, by James W. Milner in 1878.
19. Haddock, *Melanogrammus æglefinus*, by R. Edward Earll in 1879.
20. Carp, *Cyprinus carpio*, by Rudolph Hessel in 1879.
21. Spanish mackerel, *Scomberomorus maculatus*, R. Edward Earll in 1880.
22. Cero, *Scomberomorus regalis*, by R. Edward Earll in 1880.
23. Moon-fish, *Chætodipterus faber*, by R. Edward Earll in 1880.
24. Silver gar, *Belone longirostris*, by Marshall McDonald in 1881.
25. Gold-fish, *Carassius auratus*, by Rudolph Hessel in 1881.
26. Tench, *Tinca vulgaris*, by Rudolph Hessel in 1881.
29. Soft-shelled clam, *Mya arenaria*, by J. A. Ryder, 1881."

10. PUBLIC VERSUS PRIVATE FISH CULTURE.

In the discussion of fish-cultural economy, the distinction between PRIVATE FISH CULTURE and PUBLIC FISH CULTURE must be carefully observed, and it must also be borne in mind that the art of fish culture (*pisciculture*, *fischzucht*) as it is at present cultivated is not limited to

those animals which are grouped by zoologists in the class *Pisces*. "Fishery" is now understood to signify the exploitation of all products of sea, lake, and river; the capture of whales, turtles, pearls, corals, and sponges, as well as of salmon, mackerel, and sardines. The purpose of fish culture, or *aquiculture*, as it is in France more appropriately named, is to counteract by reparative, and also by preventive measures, the destructive effects of fishery.

By *public fish culture*, or *modern fish culture*, I mean fish culture carried on at public expense and for the public good. Public fish culture, to be efficient, must be conducted by men trained in scientific methods of thought and work.

The distinction between private and public fish culture must be carefully observed. The maintenance of ponds for carp, trout, and other domesticated species, is an industry to be classed with poultry raising and bee keeping, and its interest to the political economist is but slight.

The proper function of public fish culture is the stocking of the public waters with fish in which no individual can claim the right of property.

The comparative insignificance of the private fish culture of Europe is perhaps what has led to the recent savage attack upon fish culture in general by Professor Malmgren, of the University of Helsingfors, in Finland, which has caused so much consternation among continental fish-breeders. European fish culturists have always operated only with small numbers of eggs. The establishment of Sir James Maitland, at Howieton, near Stirling, Scotland, is the finest and largest private establishment in the world, and yields a handsome addition to the revenues of its proprietor. A description of this hatchery is published as one of the conference papers of the International Fisheries Exhibition, and that the distinction between public and private enterprise in fish culture may be understood, it should be compared with the following statement by Mr. Livingston Stone, the superintendent of one of the seventeen hatcheries supported by the United States Fish Commission, that on the McCloud River, in California:

"In the eleven years since the salmon-breeding station has been in operation 67,000,000 eggs have been taken, most of which have been distributed in the various States of the Union. Several million, however, have been sent to foreign countries, including Germany, France, Great Britain, Denmark, Russia, Belgium, Holland, Canada, New Zealand, Australia, and the Sandwich Islands.

"About 15,000,000 have been hatched at the station, and the young fish placed in the McCloud and other tributaries of the Sacramento River. So great have been the benefits of this restocking of the Sacramento that the statistics of the salmon fisheries on the Sacramento show that the annual salmon catch of the river has increased 5,000,000 pounds each year during the last few years."

In the two Government hatcheries at Alpena and Northville, Mich., there have, in the winter of 1883–'84, been produced over 100,000,000 eggs of the whitefish, *Coregonus clupeiformis*, and the total number of young fish to be placed in the Great Lakes this year by these and the various State hatcheries will exceed 225,000,000. The fishermen of the Great Lakes admit that but for public fish culture half of them would be obliged to abandon their calling.

Instances of great improvement might be cited in connection with nearly every shad river in the United States. In the Potomac alone the annual yield has been brought up by the operations of the Fish Commission from 668,000 pounds, in 1877, to an average of more than 1,600,000 in recent years.

In 1882 carp bred in the Fish Commission ponds in Washington were distributed in lots of 20 to 10,000 applicants in every State and Territory, at an everage distance of more than 900 miles, the total mileage of the shipments being about 9,000,000 miles, and the actual distance traversed by the transportation cars 34,000 miles.

Public fish-culture is only useful when conducted upon a gigantic scale; its statistical tables must be footed up in hundreds of millions. To count young fish by the thousands is the task of the private propagator. The use of steamships and steam machinery, the construction of refrigerating transportation cars, and the maintenance of permanent hatching stations, seventeen in number, in different parts of the continent, are forms of activity only attainable by Government aid.

Equally unattainable by private effort would be the enormous experiments in transplanting and acclimatizing fish in new waters; California salmon in the rivers of the east; landlocked salmon and smelt in the lakes of the interior; such as the planting of shad in California and the Mississippi Valley; and German carp in thirty thousand separate bodies of water, distributed through all the States and Territories in the Union; the two last-named experiments, carried out within a period of three years, have met with successes beyond doubt, and of the greatest importance to the country; the others have been more or less successful, though their results are not yet fully realized.

It has been demonstrated, however, beyond possibility of challenge, that the great river fisheries of the United States, which produced in 1880, 48,000,000 pounds of alewives, 18,000,000 pounds of shad, 52,000,000 pounds of salmon, besides bass, sturgeon, and smelt, and worth "at first hands" between $4,000,000 and $6,000,000, are entirely under the control of the fish culturist to sustain or destroy, and are capable of immense extension.

There still exists in Europe some skepticism as to the beneficial results of fish culture. Such doubts do not exist on our own side of the Atlantic, if the continuance from year to year of grants of public money may be considered to be a test of public confidence.

11. THE AIMS AND LIMITATIONS OF MODERN FISH CULTURE.

Having now attempted to define the field of modern fish culture, and to show what it has already accomplished, it remains to be said what appear to be its legitimate aims and limitations.

The aims of modern fish culture, as I understand them, are:

1. To arrive at a thorough knowledge of the life history from beginning to end of every species of economic value, 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.

2. To apply this knowledge in such a practical manner that every form of fish shall be at least as thoroughly under control as are now the salmon, the shad, the alewife, the carp, and the whitefish.

Its limitations are precisely those of scientific agriculture, and animal rearing, since, although certain physical conditions may constantly intervene to thwart man's efforts in any given direction, it is quite within the bounds of reasonable expectation to be able to understand what these are, and how their effects are produced.

An important consideration concerning the limitations of fish culture must always be kept in mind in weighing the arguments for and against its success. It is simply *this : That effort toward the acclimation of fishes in new waters is not fish culture, but is simply one of the necessary experiments upon which fish culture may be based.* The introduction of carp from Germany was not fish culture, it was an experiment; the experiment has succeeded, and fish culture is now one of its results. The introduction of California salmon to the Atlantic slope was an experiment. It has not succeeded. Its failure has nothing to do with the success of fish culture. If any one wants to see successful fish culture in connection with this fish let him go to the Sacramento River. The introduction of shad to the Pacific coast was an experiment. It succeeded. Shad culture can now be carried on without fear of failure by the fish commission of the Pacific States.

Shad culture is an established success; so is whitefish culture in the Great Lakes. The experiments with cod and Spanish mackerel were not fish culture, though there is reason to hope that they may yet lead up to it.

12. PUBLIC OR MODERN FISH CULTURE TYPIFIED IN THE WORK OF THE UNITED STATES FISH COMMISSION.

Public fish culture, then, scarcely exists except in America, though in Europe many eminent men of science appreciate its importance and are striving to educate the people up to the point of supporting it.

This doubtless seems like a very sweeping statement, and since I do not like to appear in the attitude of one who boasts of American supremacy and is not able to substantiate his position I shall endeavor to support my position by evidence.

Let us take first the prize list of the *Internationale Fischerei-Ausstellung* in Berlin.

Here is a tabulation of the prizes in fish culture:

	Gold medal.	Silver medal.	Bronze medal.	Honorable mention.
United States	6	1	1	2
Germany	3	1	3	11
Russia	1	1	1	1
Norway	.....	1	.....	1
Sweden	.....	1	.....	.....
Austria	.....	.....	1	.....
Switzerland	.....	.....	1	.....

Here also is a tabulation of the general prize list at the International Fisheries Exhibition, London, 1883:

INTERNATIONAL FISHERIES EXHIBITION, LONDON, 1883.

Jury awards to foreign and colonial countries.

No.	Countries.	Gold medals.	Silver medals.	Bronze medals.	Diplomas.	Total.
1	United States	50	47	30	24	151
2	Norway	29	70	40	7	146
3	Sweden	27	86	40	19	122
4	Canada	17	15	6	4	42
5	New South Wales	11	9	4	1	25
6	Newfoundland	10	9	4	3	26
7	Spain	9	17	13	3	42
8	Netherlands	8	11	6	5	30
9	Russia	7	21	19	6	53
10	India	4	5	4	2	15
11	Italy	4	3	2	.....	9
12	France	3	6	8	3	20
13	Denmark	3	2	9	2	16
14	China	2	3	.....	1	6
15	Tasmania	1	4	.....	.....	5
16	Greece	1	3	.....	.....	4
17	Bahamas	1	1	1	1	4
18	Chili	.....	2	2	.....	4
19	Germany	.....	1	.....	1	5
20	Belgium	.....	1	3	1	5
21	Jamaica	.....	1	2	5	8
22	Straits settlements	.....	1	2	.....	3
23	Austria-Hungary	.....	1	.....	.....	1
24	Tunis	.....	1	.....	.....	1
25	Ceylon	.....	1	.....	.....	1
26	Japan	.....	.....	2	1	3
	Total	187	271	200	89	747

In a dispatch to the Secretary of State, dated May 19, the American minister, Mr. James Russell Lowell, wrote:

"I have the honor to report that the International Fisheries Exhibition promises to be far more successful than even the most sanguine of its projectors had ventured to hope. The wisdom of Congress in making so liberal an appropriation in furtherance of its object is entirely

justified both by the substantial encouragement given to the enterprise at its inception, by this proof of interest on the part of the United States, and by the fact that the section devoted to our country is more valuable than that of any other, and valuable for reasons of which we may very properly be proud.

"I have the highest authority for saying that, quite apart from any consideration of intrinsic interest or curiosity, our share in the Exhibition is superior to all others in virtue of the scientific intelligence shown in its arrangement and classification, thus rendering it more instructive than any other. This is especially gratifying because it is a triumph of a far higher kind than could be won by any ingenuity in our contrivances for the breeding or mechanical perfection in our implements for the taking of fish, though in these also we may safely challenge and in some cases defy comparison.

"I shall naturally have occasion to write again and more fully on this topic when more perfectly informed, but could not deny myself the pleasure of reporting to you the impression already made in this international competition by the genius for organization of which our countrymen have here given proof, a faculty certainly not the lowest among those that distinguish the social and civilized man."

13. EUROPEAN OPINIONS OF AMERICAN FISH CULTURE.

Still more impressive are the expressions of opinion on the part of public officials and the press in various parts of Europe. I may add that it was my daily pleasure and pride, while in attendance upon the European fisheries exhibitions, to observe with what appreciative eagerness the collection sent over by our Government was studied by people of every class, by monarchs, statesmen, merchants, manufacturers, fishermen, and by the public generally. In order that the readers of this essay, who are, I take it for granted, equally interested in the matter, may share these pleasurable feelings, I will quote somewhat at length from what has already been printed, and to which they cannot well have access.

GREAT BRITAIN.—Kind words of approval from British authorities might be quoted almost without limit. The writer has in his possession a series of scrap-books, in which are arranged hundreds of quotations from English papers upon the course of the Fish Commission as illustrated at the late Fisheries Exhibition. I will only refer to the testimony of a very few. Prof. Cossar Ewart, of the Edinburgh University, in the preliminary report of the investigation committee of the fishery board of Scotland, says:

"The example set by America, Germany, and other continental states, we must follow. We have as a nation at last made a liberal acknowledgment of our ignorance, and at the conferences of the International Fisheries Exhibition expressed regret."

At the close of the late Exhibition His Royal Highness the Duke of Edinburgh, remarked: "The example of the United States is well worthy of imitation by the European nations which have large stakes in the fisheries;" and H. R. H. the Prince of Wales stated that "he was pleased to admit that in very many things pertaining to the fisheries England was far behind the United States."

"If there be," wrote, in 1879, Sir Rose Price, author of The Two Americas, "any race of people who exhibit more shrewdness than others in their ability to grasp and manipulate the apparently indistinct elements of what may lead to a commercial success, or be of ultimate benefit to their nation, those people are the Americans. No Government throws away less money in useless expenditures, and no representative assembly more narrowly criticises waste, yet the Americans subsidize considerable sums of their national revenue for the purpose of restocking the rivers of the Eastern States by artificial culture, and with praiseworthy considerations their Government supports several ably conducted establishments from which fish ova are distributed gratis to all those who choose to apply. The very railroads assist this enterprise, and some by moderating their tariff, and others by generously conveying the ova free of charge, give every possible encouragement to what their common sense tells them must lead to so much national good. To expect an English Government to exhibit the same amount of foresight, or to practice a similar generosity, would be to credit them with virtues which have yet to be developed. The American example, however, should not be lost sight of." *

Professor Huxley, commenting upon an address delivered at the conferences of the London exhibition by the present writer, said:

"The great moral of the United States contribution to this Exhibition, and especially of the contribution which Mr. Brown Goode had just made to the conferences, was that if this country, or any society which could be formed of sufficient extent to take up the question, was going to deal seriously with the sea fisheries, and not to let them take care of themselves as they had done for the last thousand years or so, they had a very considerable job before them; and unless they put into that organization of fisheries the energy, the ingenuity, the scientific knowledge, and the practical skill which characterized his friend Professor Baird and his assistants their efforts were not likely to come to very much good. One of his great reasons for desiring that the subject which Professor Goode had put before them should be laid distinctly before the English public was to give them a notion of what was needed if the fisheries were to be dealt with satisfactorily; *for he did not think*, speaking with all respect to the efforts made by Sweden, North Germany, Holland, and so forth, *that any nation at the present time had comprehended the question of dealing with fish in so thorough, excellent, and scientific a spirit as that of the United States.*

* The Fishing Gazette, London, III, p. 65.

The Rev. W. S. Lach-Szyrma, of Newlyn, England, in a lecture upon the late Exhibition, made the following comparison:

"At the Paris Exhibition he considered Europe as a man in full vigor, Asia as a decrepit old man, America as a boy, Australia as a baby. In the present Fishery Exhibition the case was different. * * * America was the gem of the Exhibition."

The London "Shipping World" (June, 1883) remarked: "Foremost in practical value, as in interest, is the court occupied by the United States. Not only are the fisheries of the States of great importance, but that importance is fully recognized and fostered by the Government. The United States Fish Commission was intrusted by Congress with £10,000, and the task of preparing a complete and systematic representative exhibition of the fisheries of the United States. The work has been most admirably performed. * * * *We are quite safe in saying that we have not a single Government department in this country, in any branch of industry, which, with the help of double the money, could produce anything so representative and instructive as we find here.*"

Major-General A. Pitt Rivers, one of the vice-presidents of the Anthropological Institute of Great Britain, in a letter to the London Times, expressed the following opinion as to the methods by which the fishery resources of the country were displayed, which I quote as showing how the character of the work of the Commission is regarded by such high scientific authority:

SIR: In confirmation of the praise you justly bestow on the arrangement of the United States department in the Fisheries Exhibition, I beg to draw attention to the fact that in the whole exhibition it is the only one which is arranged historically. In the Chinese, Japanese, Scandinavian, and Dutch courts there are objects which the scientific student of the arts of life may pick out and arrange in the proper order in his own mind; but in that of the United States * * * following the method adopted in the National Museum in Washington [there has been] attempted something more, to bring [the] department into harmony with modern ideas. * * * This gives to the Exhibition an interest which is apart from commerce, and an interest which is beyond the mere requirements of fish culture, and it may be regarded as one out of many indications of the way in which the enlightened Government of the United States mark their appreciation of the demands of science.

I have the honor to be, sir, yours obediently,

A. PITT RIVERS.

The Pall Mall Gazette, June 8, 1884, remarks:

"The United States section is a department whose importance grows upon the inquiring visitor at every inspection. With fisherman and angler alike it holds the supreme position in the entire Exhibition. The section forms a very flattering manifestation of international courtesy upon the part of the Government at Washington; for by far the largest part of the exhibits are from the National Museum at Washington, and from the storehouses of *the United States Fish Commission—an institution for which it would be rather difficult to find an English counterpart*—the private exhibitors, particularly trading exhibitors, being very few.

Of the comprehensiveness and completeness of this really national exhibition, it is impossible to speak too highly."

"The part of the Exhibition I like above all others," wrote the editor of "Engineering," "is the United States section. The collection of exhibits is so well chosen and completely labeled that one can always be sure of obtaining valuable information on some point or another connected with fishing at a small expenditure of trouble. It is a great relief, after wrestling in vain with the bloated, useless official catalogue in the main building, to find oneself in a compact, well-arranged department, nearly every exhibit in which bears a fully descriptive label."

The London "Field" of July 21 remarked: "It is impossible to enumerate all the objects of interest in connection with the northern whale fishery, but I would especially call attention to the beauty of the United States lay figures for exhibiting the use of the implements displayed. * * * The same care and completeness is visible in every department of the United States exhibit, and their masterly collection of reports and memoirs on the industries, products, and natural features of their country, as well as the liberality with which the results are distributed to students of other nations, speak volumes for the enlightenment and progress of a great people, as well as for the ability of those who have charge of the various scientific departments."

"The Thames," of July 13, said: "We would advise the visitor to make the United States exhibit the starting-point in his survey. He will here find an epitomized museum of angling appliances, arranged in historical developmental order. The United States exhibit is a model as to the arrangement of any economic museum."

Said the "Yorkshire Post" of June 1: "It is really hopeless, save at very great length, to give an adequate idea of the comprehensiveness of these American exhibits. The exhibition does immense credit to the United States Government. It is not only the largest but the most systematically arranged of any of the foreign contributors."

Said the "Glasgow Herald" of May 19: "A leading, if not *the* leading place must be given to the United States. * * * It is an exceedingly comprehensive collection, illustrating in the fullest manner the various branches of fish culture and capture as carried on in the United States. Each department is under the charge of a skilled person, whose duty it is to give information to visitors. These officials are always at hand, and are as ready and fluent in conveying information as if instead of coming from America, they had been nurtured in Paris, the city of politeness. It may be as well to add that what they have to communicate is marked by greater terseness and exactness of statement than could be expected in the case of a Frenchman."

Says the "Birmingham Post" (May 30, 1884): "The leading place indisputably belongs to the United States, whose participation is in accordance with an act of Congress by which the Commissioner of Fisheries was instructed to prepare a complete, systematic, and representative exhibition."

Said the London "Standard" (September 17, 1883): "There is no other country which contributed such large and well-defined collections on such an important and adequate scale as the United States. The display of these vast stores of material in an accessible form, and with scientific knowledge as well as skillfulness of arrangement for effect, does great credit to those to whom the interests of the American exhibit have been intrusted. * * * To describe the American contribution thoroughly would take more than a volume, for there is not an admissible subject that is not fully illustrated by models, drawings, books, photographs, and actual specimens."

"England" (June 30, 1883), remarked: "The United States court is certainly the most instructive in the Exhibition. It represents such a vast industry, and has been arranged in so methodical and intelligent a fashion."

Said the London "Evening News" (June 22, 1884): "It is only natural that the exhibits from the great Republic should hold a very prominent place both as regards importance and number. * * * So large indeed is the court, and so very varied and interesting, are the things there shown, that it would be quite a hopeless task to try and even give a faint description of them in one article."

NORWAY.—In a report to the Norwegian Government, after his return from a visit to the United States in 1876, Mr. F. M. Wallem, one of the principal fishery authorities of that country, wrote: "In a book on trout culture, written by a practical breeder, it is said * * * that 'it pays better to rear trout than hogs,' and every one knows what the pork business is for America. All that I have learned indicates that this assertion has gained general acceptance, both among the common people and the learned; and it is said to be admitted that *in the art of rearing fish the Americans surpass all others.* Partly to control the fisheries themselves, and partly to carry on hatching operations, there were appointed in eighteen different States, taken together, fifty-two commissioners, besides a regular staff of subordinate officials. There was established by the United States Government, besides, a Fish Commission, whose chief is the well-known Prof. Spencer F. Baird. With this complement of special, practical, cultivated officials, and talented, scientific men, the effort was untiring to produce and distribute young fishes. * * * From what I have communicated it will presumably be evident that *the American example contains a stirring invitation to Norway to develop her fresh-water fisheries, which are now greatly neglected.*

THE NETHERLANDS.—I quote a few sentences from a recent essay on the London Fisheries Exhibition, by Prof. A. A. W. Hubrecht, of the University of Utrecht, one of the Dutch Commission of Fisheries.

"Whilst in Europe fish culture, if not exclusively, at any rate principally occupies itself with the *Salmonidæ*, America also raises artificially other kinds of fish, * * * fish belonging to the *Clupeidæ* and the *Cyprinidæ*, and even codfish. As regards the last-named species

this seems almost incredible. Whenever I have taken the trouble to protect a codfish, when still in the egg, and as a young fish, I found that in that condition it was worthless for us, because to make it grow as it should it must return to its own element, the sea; and there to find it again at a later period seems just as hopeless as the desire of Polycrates that the waves of the ocean should return to him his golden ring. And still, correct as this reasoning may appear, the Americans will prove the whole thing to us in dollars and cents; whilst the delighted fishermen of Gloucester would soon convince you of the contrary if you were to tell them that their increased codfisheries were simply caused by accidental circumstances and not by the energetic work of Professor Baird and the United States Fish Commission. * * * The head of the American commission to London said to me: 'In our country we would as little think of leaving fish culture to private effort as of taking from the hands of the Government the care of the light-houses.' Well said, but not very pleasant for the ears of true adherents of the Manchester school. These words should be taken to heart in Europe, and especially in the Netherlands. *It is to our immediate interest that * * * we may be the first to reap the fruits of American teaching and to take the front rank in the European fish markets, which belongs to us rather than to other countries which, owing to their location, are not able to imitate the example set by America as well as we can.*"

"Of the nine Government institutions, which are either wholly or in part intended for making investigations on the field of pure and applied science,* the United States Commission of Fish and Fisheries is at this day, to quote the words of its historian, '*the most prominent of the present efforts of the Government in aid of aggressive biological research.*' Every person in Europe who has followed its career and who has studied its reports, will cheerfully subscribe to the truth of the words quoted above, which in such terse form expresses the deep interest which the Government of the Union takes in these researches; and we must not fail to mention that the energetic American mind did not only invent this term ('aggressive research'), but that it has also understood to make the aggression in such a manner as to conquer all opposition.

"Perhaps the time is near—and would that the London Fishery Exposition might hasten it—when the eyes of our representatives will be opened to the great importance to the welfare of our country of 'aggressive research.'

"*After briefly mentioning material aids, we must not forget to refer to the intellectual aid placed at the disposal of the Commission. Under the supervision of the Commissioner there is a full staff of experienced and skillful naturalists, which works into a whole all the various observations, and orders the new investigations called for by such observations. Their ranks*

* *Een verwaarloosd Volksbelang.* "A neglected public interest," in a reprint from "de Gids," No. 7. Utrecht, 1883.

are filled by young men who, after having completed their education at some college, desire to devote themselves to the science of zoology, more especially in a field where that science not only promises to supply many of the daily wants of the masses, but where it has already accomplished a great deal. They are the men who use for investigations in the field of embryology the exceedingly valuable scientific material furnished by the numerous stages of development of fish which may be observed in practical fish culture. We may doubtless look for important communications relative to the results of these scientific investigations.

"*Round this staff of scientists there has gradually been formed an entire corps of officers who are thoroughly versed in the more mechanical work of fish culture and fish transportation. The catching of mature fish, the impregnation of the eggs, the care of them during their development, and the raising of the young fish can only be intrusted to experienced persons, although a scientific education is not required for this work.*

"In what manner can the Netherlands derive the greatest possible benefit from the lessons taught by the American exhibit at the London Fishery Exposition? Certainly not by leaving fish culture, in the future, principally in the hands of private individuals. In this way we may get a number of establishments which may be placed on a line with establishments for raising chickens and pigeons, but the public interest is not advanced thereby. For this purpose it is absolutely necessary, as has been mentioned above, that the Government take the matter in hand and follow out a carefully prepared programme."

GERMANY.—The verdict of Germany bears no double interpretation when we examine the trophy awarded to our Commissioner of Fisheries at the Exhibition of 1880, and remember the words of Herr von Behr, the president of the Deutscher Fischerei Verein, that it was given to him as "the first fish culturist in the world."

It will do no harm, however, to quote also from the report of Director Haack, the head of the imperial hatching establishment at Hüningen, the paragraph relating to the American section at Berlin.

"Everything which America had sent was on a magnificent scale. We shall therefore only * * * admit the truly superb scientific collection, filling several rooms, and finally devote some time to the department of pisciculture. Much of the apparatus was already known to us, as for about three years we have imitated the Americans in this respect. * * * Lost in astonishment, we stand before the large model of the Fish Hawk, a large steamship specially constructed by the American Government for purposes of pisciculture. * * * With all our piscicultural efforts we must confess that we felt very small when viewing this grand American exhibit, and the magnificent results obtained in America are a sufficient guarantee that this is no 'American humbug.' For the present we can certainly do no better than to strain every nerve and imitate the example set us by the Americans."

The juries of the Fishery Exhibition of Berlin in their official report remark:

"*We must thank America for the progress which fish culture has made during the past decade*, and the new inventions through which this progress has been accomplished were very fully shown at the Exhibition. The American section was therefore in the highest degree instructive and interesting to every practical fish-culturist."

BELGIUM.—The Hon. E. Willequet, in a speech before the Belgian Chamber of Deputies recently, remarked:

"Heretofore there has been no thought except regarding the fishery in our rivers and their tributary streams. There is another fishery * * * which is carried on in the lowest parts of our rivers, in the Escaut and in the Meurs. Now, this is a source of wealth which is most completely slighted and yet is exceedingly valuable. I could attest by statements emanating from the highest authorities that with a slight expense these water-courses could be peopled at will with excellent fishes. In America this is done every day, *The great Commission of Fisheries established by the United States Government has led to positive results which can be verified at any time.*"

FRANCE.—M. C. Raveret-Wattel, the principal French authority on pisciculture, in a recent essay writes:

"*To this day pisciculture has nowhere produced results which can be compared with those obtained in the United States.* In no other country has this industry attained to the same degree of development, perfection, and success. But it must also be said that perhaps no other nation has so fully understood the great importance of pisciculture and that in no other country have such great efforts been made. *Nowhere, certainly, has so much been accomplished by private enterprise; nowhere has the Government given so much enlightened care to the rational cultivation of the waters, and afforded such efficient protection and generous encouragement.*"*

SPAIN.—Capt. Andres A. Comerma, of the Spanish navy, commenting on the methods of fishing and fish culture as shown at the London Exhibition, wrote:

"It would be necessary to write a voluminous work were I to attempt to discuss in detail the exhibition of these methods, which are unequaled elsewhere in the world, and which show how *this young and vigorous nation, the United States, is pressing forward in competition with Europe, surpassing in many things even England, Germany, and France, who together formed the vanguard of progress in olden days.*"

ITALY.—In the official report of the Italian commission to the Berlin Exhibition it is remarked:

"The juries very justly awarded the first prize of honor to Prof. Spencer Baird, Secretary of the Smithsonian Institution and head of the United States Fish Commission, a man of most indefatigable energy,

* Bulletin mensuel de la Société nationale d'acclimatation de France, 3, IX, 1882, p. 69.

who, although absorbed in important public duties, has found time to devote a part of his life to science."

14. THE CAUSES OF THE SUCCESS OF THE UNITED STATES FISH COMMISSION.

To what elements of strength does the United States Fish Commission owe its long-continued success? It may seem a waste of paper to try to answer this question, but at the risk of seeming verbose I venture to make the attempt.

(1) *The work of the United States Fish Commission owes its value solely and entirely to the fact of its being based upon an extensive and long-continued system of scientific investigations*, for the purpose of discovering unknown facts, the knowledge of which is essential to the welfare of the fisheries, the economical management of the national fishing resources, the success of fish culture, and the intelligent framing of fishery laws.

The resolution establishing the Commission requires that its head shall be a civil officer of the Government, whose services shall be at the command of the President, and who possesses proved scientific and practical acquaintance with the fishes of the coast, thus formally fixing its scientific character.

The work of the Commission is and has always been under the direction of eminent and representative scientific specialists acting as heads of its several divisions, and the employés, with the exception of a very limited number of clerks, are trained experts, usually scientific students—so exact and special is the training required even for subordinate positions, that in a majority of cases each man employed is the only man in the country who understands and can perform his own individual work.

The character of the scientific work has been determined from the start by the intimacy of its affiliation with the Smithsonian Institution, famous throughout the world as a nursery of scientific enterprises. No organization in the United States not so affiliated, could by any ordinary means have secured the co-operation of so many master-workers, whose aid has been so important to the success of its plans.

(2) *The successful application of scientific methods of work has always depended upon the entire freedom of the service from departmental routine.**

* Since the preparation of this paper has been begun the writer has been informed that there is a feeling in some official circles in favor of the subordination of the Fish Commission to some one of the Executive Departments of the Government.

The chief argument in favor of such a change is said to be based upon the idea that every branch of governmental work should be in some way under the surveillance of a Cabinet officer. Without attempting to antagonize this view, I shall attempt to show that this policy is by no means a general one, and that the Fish Commission is one of the branches of the service which would lose more by such transfer than it could possibly gain.

In the first place, let us review the status of the offices of the Government which are not subordinated to any Executive Department.

Chief among them is the Agricultural Department. This is simply a bureau or

Much of the work is now done by volunteers, in addition to duties elsewhere in colleges, scientific institutions, and other departments of government, and in their own time. This is especially true of the heads of scientific departments, whose services money alone would not secure, and not less so of many of the best younger workers, who serve the Commission at extremely low rates of pay for the sake of the advantages they have for preparing themselves to hold scientific positions elsewhere. No regular force outside of the staff is kept up throughout the year, and at certain seasons four times as many men are employed as at others. With the departmental system of regular appointments and graded salaries the cost would probably be twice as great as it now is.

Furthermore, the system of appointments necessarily in vogue in an executive department, with the periodical changes of assignment, which are customary in some of them, would prevent the greatest efficiency in work. We are accustomed to consider the English civil service to be one of the best in the world, to praise its efficiency, and to hold it up for emulation. Efficient it may be in departments where routine work is the chief occupation of the officials, but it sometimes falls short in the matter of organizations requiring special qualifications in

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commission corresponding in every essential respect to the United States Fish Commission. It is proposed to make it a cabinet office, but this has not been done. Other offices of a similar character are the National Board of Health, the Civil Service Commission, the United States Tariff Commission, the United States Fish Commission, the Government Printing Office, the Library of Congress, the District Government, Congress itself, the Smithsonian Institution, National Academy of Sciences, &c. All these bodies are distinct and separate in their organization and responsible in part to the President and in part to Congress, but they are not related in any way to a Cabinet officer. The United States Fish Commission exactly corresponds to its title, and *is* a commission to do certain things ordered by Congress. The Commissioner is appointed by the President, and makes his report directly to Congress, and may be in a certain way considered a Congressional official. There is a Senate Committee on Fish and Fisheries which is related to the United States Fish Commission, and I presume in time there will be a committee of the same character in the House having direct relationship to it. The Civil Service Commission is related in a similar manner directly to the President, and very properly is not placed in immediate connection with any Department, as it regulates and controls them all.

The Fish Commission, as has been stated, is authorized by Congress to call upon any Department for aid in its work, which has always been readily and promptly granted. To place it under one Department rather than another would be to confine its relationships entirely to that Department, as the others would no longer render the same ready assistance.

If the Fish Commission is to be subordinated to any Department, it should be by all means to the Smithsonian Institution, which is the only branch of the Government to which it is akin in purpose and method. That it is scientific and not executive in its methods has already been shown. Departmental subordination always dampens the enthusiasm and stifles the energy of scientific workers, though many Department officers in their individual capacities do excellent work. Especially unfortunate would be subordination to a division of the Government whose interests, so far as science is involved, are naturally and necessarily in lines quite at variance with the biological investigation for which the Fish Commission was organized.

their membership. Let me quote a few words from "Fairplay," a London journal of considerable prominence. After discussing the make-up of our Fish Commission somewhat at length, the editor, speaking of the head of one of the divisions, continues: "Such is the man our practical cousins across the Atlantic have put on a public commission; his sole recommendation being that he is thoroughly fitted for the post. In England we should have given the post to a Government clerk, or ex-private secretary who had established a claim upon some minister, a troublesome M. P., or perhaps a "younger son." Whether all or either of these had the remotest knowledge of fishery matters would be probably the last consideration that would have been considered a recommendation for the post." ("Fairplay," October 5, 1883, p. 490.)

The usefulness of the Commission depends in great measure upon the rapid dissemination of knowledge concerning fish, fisheries, and fish culture, through its reports and bulletins. Delay would undoubtedly result from subordination to an executive department, and supervision by a purely executive head would cramp the movements and dampen the enthusiasm of the contributors to these serials, and reduce them to the uninteresting level of the ordinary executive report, such, for instance, as that of the Canadian Fishery Commission, which consists chiefly of financial statements and files of official correspondence.*

The methods of a scientific commission cannot be replaced by those

*Although the publications of the Fish Commission are undoubtedly highly appreciated, it seems to me doubtful whether their importance to science and to technology is thoroughly understood. I would advise those interested to examine carefully the classified list of Fish Commission papers recently published by Mr. Smiley in the Bulletin of the Fish Commission, for 1883, pp. 1–84. From this list it appears that as a result of ten years' work 968 separate contributions have been printed.

Having quoted the opinions of European authorities upon the other branches of the Fish Commission work, I cannot refrain from repeating here what has been said about one of its recent publications by "Nature," the leading scientific weekly of England.

"UNITED STATES COMMISSION OF FISH AND FISHERIES.

"Part vii. Report of the Commissioner for 1879.

"The contents of the present volume, embracing details of the work done by the United States Fishery Commissioner for the year 1879, are quite as varied and even of greater interest, if that be possible, than the preceding reports. The specific objects of the methodical inquiry which has now been going on for over twelve years has for its object to report progress in regard to the propagation of food-fishes in the waters of the United States, as also to afford information as to the decrease in stock of food-fishes. As has been already stated in the columns of Nature, in which previous reports have been reviewed, the inquiry which has been so long in progress is being conducted in a thorough and searching way; it embraces the consideration of every topic calculated to throw light on the economy of the American fisheries. Nothing that can be deemed illustrative is neglected—the literature devoted to the natural history of food-fishes, or to descriptions of the fisheries of other countries, especially those of Europe, has been largely utilized in preparing the reports, with the result of making the volumes which have been issued a perfect encyclopædia of fishery information. Among the distinctive articles contributed to the present volume are some of rare importance; we may refer to that by Professor Farlow on 'The Marine Algæ of New England,' which is both interesting and exhaustive; it extends to 210 pages of the volume now before us, and is illustrated by a series of well-

of one of the bureaus of an executive department. Except in the divisions of records and accounts routine is reduced to a minimum; and, indeed, the amount of clerical work is very small. Any kind of departmental routine would be prejudicial to the service, particularly of that kind which would trammel the action of its presiding officer.

In support of this statement, let us examine the condition of affairs in England. The fishery interests of the nation, so far as inland waters are concerned are assigned to the home office, and Her Majesty's inspector of salmon fisheries occupies a desk in one of the imposing departmental structures at Whitehall. Following the example of the United States an eminent zoologist, the president of the Royal Society, Professor Huxley, occupies this position, which corresponds, in England, more nearly than anything else, to our Commissionership of Fisheries. Bound hand and foot by departmental routine, Professor Huxley, whom no one can accuse of lack of originality in conception and enterprise in execution, has, during his three years of office, done nothing in any wise different from what was done by his predecessor, who was not a man of science—nor could he if he were to try.

Holland, Germany, and Norway, are the only European nations which exhibit intelligent enterprise in the consideration of fishery questions in general, although fair work is done by Sweden and other countries in the treatment of limited special branches of this industry. These three countries are, it should be noted, the ones in which special commissions, independent, in a measure, of administrative control, have been organized.

In Germany, which leads the van, the functions of the German Fishery Union (*Deutscher Fischerei Verein*), and of the commission for the in-

executed drawings. Another paper of importance, full of curious information, is that of Mr. A. E. Verrill, 'On the Cephalopods of the Northeast Coast of America;' it is also profusely illustrated with fine drawings. 'The Propagation of the Eel' is a contribution which is sure to attract attention; the article is by Dr. Otto Hermes, and was read before the German Fishery Association. Although brief it contains many features of interest in connection with the natural history of the curious animal of which it treats, and describes most distinctly the differences of the two sexes. The author of this paper announces that the old eels, both males and females, die soon after the spawning season; 'the extraordinary rapid development of their organs of generation exhausts them to such a degree that they die soon after having spawned.' This is the reason why they are never seen to return to the rivers. Among the miscellaneous contents of the present report will be found instructive essays on the food of marine animals, by Prof. K. Möbius. In the appendix will be found a very readable account of the herring fisheries of Iceland, as also a short treatise on the fisheries of the west coast of South America. One of the most important scientific papers which is given is one containing a reprint of a series of extracts from the investigations of the Commission for the Scientific Examination of the German Seas; it contains much that will prove of interest both to naturalists and economists. *It may be safely said alike of the present and the preceding reports, that they contain a mass of information on fish and fisheries of a kind which has never been before brought to a focus, and in issuing such a guide to all interested the United States Government has set us an example which we ought at once to follow.* The volume is published at Washington, and is printed at the Government Printing Office."

vestigation of the German seas (*Ministerial-Kommission zur wissenschaftlichen Untersuchung der deutschen Meere zu Kiel*), taken together represent practically the two divisions of the work of the United States Fish Commission, namely: "Propagation and investigation."

The latter body is composed of a commission of scientific men, whose head is appointed by the Government; is carried on with Government funds, but is not in any way subjected to Government control, the central headquarters being at Kiel instead of Berlin.

The Fischerei Verein is a private body, under the patronage of the Emperor, and with funds partly furnished by the Government, and having also the general direction of the National Fish Cultural Society at Huningue. This, also, is not a bureau of any Government department, but managed entirely by its own officers. It is the only European fisheries established that has so far constituted a thoroughly successful experiment.

The Netherlands Commission of Sea Fisheries (*Collegie voor de Zeevisscherijen*) is a body of fifteen men, chiefly workers in science, occupying a responsible position in the national economy, their function being "to advise Government in all subjects connected with the interest of the fisheries." During the twenty-five years of its existence, says its historian, "the commission has constantly been consulted by Government on the different measures that might be beneficial, or on the abolition of others that were detrimental, to the fisheries."

The Society for the Development of Norwegian Fisheries (*Selskabet for de Norske Fiskeriers Fremme*) is an organization independent of the Government, and electing its own officers, but receiving large grants from Government to carry on work precisely similar to that of our own Commission. In 1882–'83 these grants amounted to 49,000 kroner.

(3.) *Co-operation with organizations and individuals outside of the organization itself has been carried on to the very great advantage of this work*, and has enabled the Commissioner to accomplish very much more than would otherwise have been practicable with the means at his disposal.

This policy, which has been carried out by the Fish Commission to a very much greater extent than by any other governmental organization save the Smithsonian Institution, is an extension of the time-honored policy of the Smithsonian Institution, and applied by means of experience gained in its service by those who have been employed interchangeably in the two establishments.

This co-operation is varied in character. In some instances it is reciprocal, being carried on with persons who are interested in accomplishing the same end, and who share in the benefits of its accomplishment. Of this character has been the affiliation of the Commission to scientific institutions and individual investigators, who, as has already been stated, are willing to aid in the work for the sake of the opportunities for study and publications which they receive. Of this character

also has been the relation of the Commission to the National Museum, both establishments being equally concerned in the acquisition of material illustrating the natural history of our waters and the methods of the fisheries; the former for purposes of immediate study, the latter for permanent preservation and exhibition.

Of this nature, too, has been the relation of the Commission to similar organizations abroad, resulting in the interchange of publications and experience, and the exchange of native species of fishes for experiments in acclimatization and fishery apparatus for introduction. Co-operation of this kind has been and is sustained with every nation in Europe.

The moral influence of such international comity is not to be slighted. I am tempted in this place to quote from a speech recently delivered in the Belgian Chamber of Representatives by one of its prominent members, M. Willequet:

"On the subject of the fisheries," he remarked, "new relations have recently sprung into being between different Governments. We notice a kindness and disinterestedness and eagerness to oblige, which have not hitherto been a characteristic feature of these reciprocal relations. There are being carried on to-day between the United States, France, Switzerland, Italy, and England exchanges of fish eggs and fry which attest a cordiality most remarkable and most profitable. Not a year passes that the North Americans do not make important shipments of fish in every direction, and they not only make presents of them to other countries, but send persons to accompany each lot in order that they may arrive in the best condition."

Of this character, too, has been the relation to the Interior Department in connection with the census work upon the statistics of the fisheries, with the Department of State in connection with the conduct of international exhibitions abroad, with the Navy Department in affording training in scientific methods for young Naval Academy graduates detailed for that purpose.

In co-operation of another kind the Commission has received more than it has returned.

According to the provisions of its law of organization the Commissioner is empowered to call upon any of the Executive Departments for assistance, and very much has been done every year through the aid of the several Departments which would otherwise have been impracticable.

Important relations of this kind have in past years, and are still from time to time, kept up (1) with the Treasury Department, in connection with its Bureau of Statistics, in connection with its life-saving stations and light-houses, where temperature observations are kept for the use of the Commission, and observations made upon the movements of marine animals; also in the occasional facilities afforded by

the Secretary in connection with the use of revenue cutters and coast-survey vessels, and in the occupation for many years by the Commission of a portion of the wharf of the buoy station at Wood's Holl; (2) with the War Department, and in the military guard supplied to the hatching station on the Sacramento River, and in the supply of thermometers for the use of coast observers of the Fish Commission; (3) with the Navy Department, in the facilities afforded for the use of naval vessels in the coast work in past years; also in facilities afforded by the Navy Department in fitting out Fish Commission steamers with officers and men.

Important benefits have been derived also from the courtesy of transportation companies, by whom eggs, young fish, and other property of the Government have been carried from place to place at greatly reduced rates, the charges being in many instances entirely remitted. In the fiscal year of 1884 concessions of this kind amounted to more than $12,000.

Finally, the Commission co-operates in many enterprises in which the benefit is entirely that of the other partner. Pre-eminent in this class has been its relations to the various State commissions. By reference to the table above on page 18 it will be seen that the various State governments had appropriated for fish propagation, up to 1882, over $1,101,000, a sum considerably exceeding that appropriated by the Federal Government for the same purpose, the total amount to the middle of 1883 having been $1,190,955, of which about one-fourth must be credited to the account of the ocean fisheries inquiry and the construction of the steamer Albatross, leaving a balance of from $750,000 to $800,000 expended in fish propagation.

The success of the propagation work of the several States has for ten years past depended in a large degree upon a long-established system of co-operation between the Commissioner of Fisheries and the several State fish commissions, some thirty in number, by whom the General Commissioner is regarded as a general advisory and executive head. The United States Commission cannot operate in waters belonging to an individual State, but can supply that State with fish to be planted by its local authorities, and has already accomplished very much in this manner. Co-operation of this kind would not be easily practicable under the direction of an Executive Department whose Secretary and whose policy are frequently changing.

Relations of this kind have also been kept up with the Department of State, in connection with the conventions and other deliberations for the construction of fishery treaties, in which the staff of the Commission have served as experts, with the Treasury Department in preparing opinions upon the character of supposed dutiable articles of import, and with the War Department in connection with the erection of fish ways by the Engineer Bureau, also with the Navy Department

in the loan of the steamer Albatross for the work of the Hydrographic Office.

15. CONCLUSION.

As early as 1869 all the essential features of the work, except that of the propagation division, were put into operation by the present Commissioner, at Wood's Holl, on the southern coast of Massachusetts, at his own private expense. The following year his own resources were re-enforced by a grant of $100 from the secretary of the Smithsonian Institution. In 1871 Congress allowed him $5,000 for current expenses in an investigation of the fishery dispute then existing in Southern New England.

From this beginning has grown up the Fish Commission, an institution peculiarly American in its conception, and without a parallel in any other governmental organization.

It has achieved a world-wide reputation for its enterprise and originality of method. Its work is better appreciated abroad than in the United States, and at the International Fisheries Exhibitions at Berlin and London—at the former with eighteen sister Governments competing; at the latter with thirty-five—carried away a majority of the prizes for supremacy both in scientific method and practical results. Throughout Europe the Fish Commission is being held up as one of the most striking evidences of the public spirit, intelligence, and liberality of the American nation.

"It is a matter of peculiar gratification," remarked the Hon. Samuel S. Cox, of New York, in a recent speech in the United States House of Representatives, "that even as late as the 9th of February, 1871, Congress passed a general and generous law providing for investigations as to the diminution of our food-fishes; and that at the same time it took measures for their increase and distribution. It is also a matter of congratulation that the resolution establishing the office of Commissioner of Fish and Fisheries led the way to the selection of Professor Baird, who has not only assisted as Secretary of the Smithsonian Institution in the increase and diffusion of knowledge among men, but who has also increased and diffused both fish and the knowledge thereof among men, women, and children in forty States and Territories, not to speak of what he has done in the way of international exchange.

"That he carried off the highest of the honors at the Berlin exhibition, that our country won the highest prizes in London, and that these glories have inured to the general welfare, is not the least among the benefactions which science in its practical application has showered upon the people of this country, and which they have gladly shared with the millions of other lands. Let the good work go on! Let Congress appropriate its generous aid to the hatching stations and ponds where

science is doing this grand and useful work! Let the eulogy of Professor Huxley upon the ingenuity, energy, and scientific knowledge of Professor Baird and his assistants find a general echo in our homes, as well as here and now, to the end that something of that praise which comes after our labors are done may greet these fishers in the waters of science while they are in full hope, faith, and life to enjoy our laudations!"*

* Congressional Record, May 12, 1884.

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[NOTE.—The references are to page-figures in brackets.]