REPORT OF THE COMMISSIONER.

The present report embraces two distinct subjects: first, the result of inquiries entered upon for the purpose of ascertaining whether any decrease has taken place in the food-fishes of the sea-coast and lakes, as alleged, and, if so, what are the causes and what legislative and other measures may be necessary to remedy the evil; secondly, the history of the measures adopted, up to July, 1873, for multiplying the food-fishes of our rivers and lakes and for transferring them to new localities, with a view of increasing the food-resources of the United States and cheapening the price of provisions.

A—INQUIRY INTO THE DECREASE OF FOOD-FISHES.

1.—PRELIMINARY STEPS.

For some years past it has been alleged that the food-fishes of the eastern coast of the United States have been decreasing in number, and the attention of the General Government was called to the subject, with a view, if possible, of ascertaining the causes and suggesting a practicable remedy.

Responding to the appeals made from numerous quarters, and for the purpose of settling the question as to the facts, a resolution was passed by Congress on the 9th of February, 1871, directing the President to appoint some one of the civil officers of the Government competent to the task, to serve, without salary, as Commissioner of Fish and Fisheries.

The resolution further directed that it should be the duty of the Commissioner to prosecute the necessary inquiries, with a view of ascertaining whether any and, if so, what diminution in the number of food-fishes of the coast and lakes of the United States had taken place; and to determine what were the causes of the same, and to suggest any measures that might serve to remedy the evil. The heads of the Executive Departments of the Government were instructed at the same time to render the Commissioner such assistance as might lie in their power.

2.—INVESTIGATION IN 1871.

Having been appointed, by the President, Commissioner of Fish and Fisheries under this law, in the spring of 1871 I proceeded, by permission of Professor Henry, Secretary of the Smithsonian Institution, to carry out the inquiry thus authorized and directed, spending the summer of 1871

in this research, and establishing my headquarters at Wood's Hole, Mass., in Vineyard Sound, one of the regions most interested in the inquiry. With the assistance of several eminent specialists, particularly of Prof. A. E. Verrill, Prof. Theodore Gill, and Mr. S. I. Smith, I made an exhaustive inquiry into the subject, with all the means at my command. The results of my labors and of those of my associates have been presented to Congress in the form of a voluminous report, to which reference is suggested for further particulars.

The fish to which attention was more particularly directed during this first year were the blue-fish, scup, tautog, sea-bass, striped bass, and menhaden.

The opportunities furnished by the possession of a very perfect outfit of apparatus for the research in question were embraced to prosecute a general inquiry into the natural history of the deep seas along the coasts of the United States, as it was thought that the history of the fishes themselves would not be complete without a thorough knowledge of their associates in the sea, especially of such as prey upon them or constitute their food. It is well known that the presence or absence of particular forms of animal life in certain localities determines the occurrence of many kinds of fish; and it was thought best to make an exhaustive inquiry in this direction.

The temperature of the water taken at different depths, its varying transparency, density, chemical composition, percentage of saline matter, its surface and under currents, and other features of its physical condition, were also carefully noted, as likely to throw more or less light upon the agencies which exercise an influence upon the presence or absence of particular fishes; in other words, the object in view was to make as complete explorations of the physical, natural, and economical features of the sea as those which have been attempted for the Western Territories, under successive congressional appropriations, by Doctor Hayden, Lieutenant Wheeler, and others; the same warrant for an exhaustive research being thought to exist for the one as for the other, especially in view of the fact that the economical results to flow from a satisfactory solution of the various problems connected with the fisheries, might safely be considered as even more profitable in their immediate yield and availability than those to arise from the territorial survey.

Finally, large collections of specimens of natural history were gathered for the National Museum, embracing duplicates in great number for distribution to the various scientific and educational establishments of the country.

3.—INVESTIGATIONS IN 1872.

In arranging for the work of the Commission in 1872, it was thought best to spend the season on the Bay of Fundy, for the purpose of making an especial study of the fish and fisheries belonging to that portion of Maine and the British provinces; and, the necessary leave of absence

having again been obtained from Professor Henry, I proceeded to Eastport, in Maine, as a convenient point from which to prosecute my inquiries, arriving there on the 19th of June. I carried with me all the apparatus necessary for my work, and as soon as possible entered upon the investigation as to the present condition of the fisheries.

I succeeded in obtaining a great deal of information from persons resident in the town and vicinity, connected more or less with the fisheries; especially from Capt. U. S. Treat, of Treat's Island, Mr. William J. Odell, Mr. C. H. Dyer, Mr. Bucknam and others, of Eastport, Capt. Robinson Owen, of Campobello, &c.

It gives me very great pleasure to acknowledge the courtesies of the Department of Marine and Fisheries of the Dominion of Canada during the investigations prosecuted in the time mentioned. Before proceeding to Eastport, I addressed the Hon. Peter Mitchell, minister of the department, stating my objects, and asking for some form of document by which I might be accredited to the official fishery authorities of the Dominion, not only to prevent any interference on their part, but to secure their co-operation and assistance. This was promptly supplied, and authority granted to capture fish by any desired method, whether in accordance with the laws of the dominion or not, all the subordinate officers of the department being at the same time required to render me whatever help I might demand.

From this document, as well as from personal letters furnished by Mr. William F. Whitcher, commissioner of the Dominion fisheries, and by Mr. William H. Venning, inspector of fisheries, Saint John, New Brunswick, I received much benefit. I am also under obligations for assistance to Mr. W. B. McLaughlin, fishery-overseer at the Southern Head, Grand Manan, especially in connection with the investigation of the herring-fisheries in that vicinity.

Desirous of making a complete collection of the different *Salmonidæ* of America, for the purpose of more accurately defining their geographical distribution and of determining their comparative character, I made my wishes known to the Department of Marine and Fisheries, and instructions were at once forwarded to its officers throughout the Dominion to meet my wants. In accordance with these instructions I have already received numerous specimens of great importance to the inquiry, and which will aid considerably in accomplishing the object referred to. Several interesting communications from these officers will be found on pages 80, 81, and 82.

Here, as at Wood's Hole, I had the co-operation of Prof. Verrill, of Yale College, who kindly undertook the supervision of the investigations into the invertebrate fauna of the Bay of Fundy, with the assistance especially of Mr. S. I. Smith, Mr. O. Harger, Professor Todd, Professor Rice, &c., while Prof. D. C. Eaton took charge of the subject of the algæ. The labors connected with the fishes of the region were prosecuted with the help more especially of Prof. Theodore Gill, Mr.

G. Brown Goode, and Dr. E. Palmer. The facilities I was able to furnish at Eastport, as at Wood's Hole, induced a large number of scientific gentlemen to spend the greater part or the whole of the active season with the Commission. Among those who were present during some portion of this period may be mentioned the following:

BRITISH POSSESSIONS.....*W. H. Venning*, of Saint John; inspector of fisheries of New Brunswick and Nova Scotia.

Capt. N. B. Beckwith, of Hantsport, Nova Scotia.

Walter B. McLaughlin; overseer of fisheries, Southern Head, Grand Manan.

George A. Boardman, of Saint Stephen, New Brunswick.

MAINE..... .....*E. M. Stilwell*, of Bangor; fish-commissioner of Maine.

O. C. Stanley, of Dixfield; fish-commissioner of Maine.

Charles G. Atkins, of Bucksport; in charge of United States salmon-breeding establishment.

Charles H. Fernald, of Orono; professor of natural history in the Maine State College.

NEW HAMPSHIRE.....*Livingston Stone*, of Charlestown; in charge of United States salmon-hatching establishment on the McCloud River, California.

MASSACHUSETTS .....*N. S. Shaler*, of Cambridge; assistant in the Museum of Comparative Zoology.

T. Sterry Hunt, of Boston; professor of geology, Massachusetts Institute of Technology.

Gurdon Saltonstall, of Boston; collector for the Boston Society of Natural History.

James H. Emerton, of Boston; assistant in the Boston Society of Natural History.

CONNECTICUT.....*N. S. Rice*, of Middletown; professor of natural history, Wesleyan College.

G. Brown Goode, of Middletown; curator of the Museum of Wesleyan College.

A. E. Verrill, of New Haven; professor of zoology, Yale College.

Daniel C. Eaton; professor of botany, Yale College.

W. D. Whitney; professor of Oriental literature, Yale College.

S. I. Smith, *J. K. Thatcher*, assistant teachers of zoology in Yale College.
O. Harger; assistant in Yale Museum.
John B. Isham, *George W. Hawes*, *T. Mitchell Prudden*, students of Yale Scientific School.
Talcott H. Russell, of New Haven.

NEW YORK.....*H. E. Webster*, of Schenectady; professor of natural history, Union College.
Charles Pond; student of natural history, Union College.
H. A. Ward, of Rochester; professor of natural history, Rochester University.

OHIO.....*Rev. J. G. Fraser*, of East Toledo.

Robert Brown, jr., *John Davis, M. D.*, *Rev. A. E. Taylor*, *Richard Folsom*, committee on marine aquaria for the Cincinnati Industrial Exposition, September and October, 1872.

IOWA.....*J. E. Todd*, of Tabor; professor of natural science, Tabor College.

DISTRICT OF COLUMBIA ..*Theodore Gill*, Smithsonian Institution, Washington.
Edward Palmer, of Washington.
A. G. Seaman, Agricultural Department, Washington.

Among these visitors, Mr. Robert Brown, Dr. John Davis, Rev. A. E. Taylor, and Mr. Richard Folsom came for the purpose of obtaining living specimens of marine zoology with which to stock an aquarium at the Cincinnati Industrial Exposition.

In the course of the summer, the fish-commissioners of Maine, E. M. Stilwell and O. C. Stanley, spent several days with me, in company with Mr. Atkins, during which time the subject of restocking the waters of the State with salmon was discussed, and an understanding entered into with them in regard to hatching such eggs of this fish as I might be able to allot to the State from the stock owned by the United States. Mr. Livingston Stone also, prior to his departure for California for the purpose of securing eggs of the Sacramento salmon, visited me in order to arrange the details of his operations.

In continuation of the courtesies previously extended, the Treasury Department instructed Capt. D. B. Hodgden, in command of the revenue-cutter Mosswood, to render me such assistance as he could without interfering with his regular duties; and to him and his officers I am under many obligations for the cordiality and readiness with which they carried out these orders. Without the help of the cutter, I should have been able to make a few only of the researches

and investigations which have proved of great service in the inquiry intrusted to my charge.

In the course of the summer I visited the British provinces, passing through Saint John, Digby, Annapolis, Halifax, Pictou, Prince Edward Island, Shediac, and Fredericton, with a view of ascertaining the present condition of the fisheries, the nature of the regulations concerning them, as well as the various methods for carrying them on, and I am particularly indebted for valuable assistance and information to Mr. William Jack, of Saint John; to Dr. J. B. Gilpin and Mr. J. Matthew Jones, of Halifax; and to Mr. Dunn, the United States consul, and Mr. J. C. Hall, merchant of Charlottetown.

My inquiries in reference to the herring and other fisheries of the coast would not have been complete without a visit to Grand Manan, and especially, the southern extremity, known as Southern Head, and well known to be the great spawning-ground of the majority of the herring entering the Bay of Fundy. With the aid of a letter from Mr. William F. Whitcher, the Commissioner of Fisheries at Ottawa, to Mr. Walter B. McLaughlin, in charge of the spawning-grounds, I was enabled to obtain a great amount of very valuable information in regard to this interesting locality. To Mr. Simeon F. Cheney, of Nantucket Island, Grand Manan, I am also much indebted for services rendered.

The fact that particular portions of our sea-coast are frequented by the herring during their spawning-season, while others, apparently equally eligible, remain unvisited by them, induced me to undertake a careful investigation of ocean temperatures; and, with the assistance of Captain Hodgden, of the revenue-cutter, I was enabled to secure, through the use of the Casella-Miller deep-sea thermometer, many records of the temperature of the bottom waters at different parts of the Bay of Fundy, as well as of the surface. These are considered of very great importance in solving the various problems referred to. *

*A movement in the same direction was subsequently undertaken by the Scottish Meteorological Society, having for its object the determination of the question as to how meteorological conditions of air and water influence the herring-fishery, an industry of the first importance to the inhabitants of Scotland; the inquiry having been suggested by the Marquis of Tweeddale, president of the society, in a letter transmitted on the 30th of January, 1873.

A committee was appointed, and on the 2d of July reported the progress made, when, although no very positive results were announced, enough was adduced to show the eminent propriety of the investigation and the probability of attaining important generalizations. (Journal of the society, July, 1873, 60.)

The inquiry was restricted at first to the east coast of Scotland, and to pond-fishing districts therein, viz, Wick, Buckie, Peterhead, and Eyemouth, the last including the fishing-ports of Dunbar and Eyemouth, Berwick, and North Sunderland. Copies of the weekly returns sent to the fishery-board from these districts during July to September, the season of the herring-fishing for that part of Great Britain, for six years, beginning with 1867 and ending with 1872, giving the catch per week, the number of

Having been so fortunate as to interest Professor Peirce, of the Coast-Survey, in the general inquiry intrusted to me by Congress, I received, under his instructions, from Captain Patterson the proffer of the aid of that branch of the service in pursuing such investigations as related in any way to its own objects; and as the physical and natural history of the various banks off the New England coast constituted a common bond of interest, it was determined by the Superintendent to fit out the steamer Bache to make surveys on George's Banks, one of our best fishing-grounds. I was authorized to put on board two experts in the line of marine zoology, for the purpose of prosecuting the necessary inquiries; and having selected Mr. S. I. Smith and Mr. Harger, these gentlemen presented themselves at Provincetown, as the place of rendezvous, at the appointed time. While certain needed repairs of the vessel were being completed, these gentlemen in the interval visited Eastport and entered into the general inquiries prosecuted in the Bay of Fundy. They, however, returned to Provincetown when the Bache was ready to take them on board; and although beginning their work so late in the season, as to be interfered with by storms and unfavorable weather, they succeeded in securing many valuable results, a report of which will be presented hereafter.

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boats out in each district, were extracted from the reports, and an average of these six years calculated at several of the stations. These were finally compared day by day with two series of sea-temperatures; one taken off Harris, and the other near Edinburgh.

The temperature of the sea was found to rise very rapidly about the middle of July; and to keep oscillating slightly about a uniform temperature of 56° until the 13th of August, when it rapidly rose to the annual maximum, namely, 57°.2, and ranged relatively high until the first of September. This period of highest annual temperature, namely, from the middle of July to the first of September, was found to be coincident with the fishing-season in the northern districts of Scotland; and the period when the temperature rises to the absolute maximum is further coincident with the date of the largest catches during the fishing-season. The committee, however, consider it premature to lay great stress on the striking coexistence of these facts, since it is impossible, without further statistics, to say whether these relations are of a permanent character. The fishing-season did not begin until the sea-temperature had risen to about 55½° in July, nor did it continue after it had fallen below 55½° in September.

An important omission in these tables is, that they do not show whether they indicate the surface or bottom temperature of the sea; the difference in this respect being very appreciable. Another omission is, as to the relation between the spawning-season of the herring and their shoreward movement. Along the coast of the United States, the great spawning-ground of the sea-herring is off the southern end of Grand Manan, where the surface and bottom temperatures sometimes differ at the spawning-season by as many as five or six degrees.

An important relation was also observed by the committee between the exceptional atmospheric temperatures and the migrations of the herring, the fishing-season beginning much later in the year, when the summer-temperatures are low, than when they are high. As regards the relation between barometric observations and the fisheries, it appears that during the periods when good or heavy catches were taken, in a great majority of cases the barometer was high and steady, the winds light or moderate, and electrical phenomena wanting; when the captures were light, the observa-

4.—CORRESPONDING RESEARCHES OF OTHER NATIONS.

A few years previous to the movement on the part of the United States in the establishment of a commission for the investigation of the fish and fisheries of its coast, the *Fischerei-Verein*, an association composed of several eminent naturalists, physicists, and statisticians of Germany, warmly urged upon its government the importance of prosecuting similar researches, recognizing equally with the United States that the only way of securing definite and practical results in the way of protecting and improving the fisheries was to initiate a series of thorough inquiries into the general physical and natural history of the seas.

A commission was accordingly appointed by the German government to report upon the best method of securing the desired object. A report of what was needed was presented by the commission, which invited careful inquiry into the following points: first, the depth, and character of the water, the peculiarities of the bottom, the percentage of salt and gas in the water, and the nature of its currents and temperatures; secondly, a minutely-detailed determination of the animals and plants found in the sea; and, thirdly, the distribution, mode of nourishment, propagation, and migration of the useful fishes, shells, crustaceans, &c. While this programme embraced the primary physical condi-

tions often indicated a low barometer, strong winds, unsettled weather, and thunder and lightning.

In conclusion, the committee recommend that, in further elucidation of the subject, steps should be taken to obtain information which may lead to a solution of the following queries:

1. What determines the time of the commencement of the fishing?
2. What determines the fluctuations in the catches of herring in different districts, or in the same district on different days?
3. What causes the absence of herring during some seasons from certain districts of the coast?
4. What determines the ending of the fishing-season?

The information required demands—

1. An extension of the area examined, so as to include the Moray Firth, the Shetland, Orkney, and Hebrides Islands, and the west coast of Scotland.
2. Daily returns of the number of boats fishing and the catch.
3. The erection of self-registering sea-thermometers at different points on the coast, similar to those now in operation at Peterhead Harbor.
4. Thermometric observations taken by the fishermen themselves over the grounds fished; as it is only by the observations of numerous thermometers in continuous immersion that we can hope to obtain accurate information regarding those currents of cold and warm water round our coasts which are often found to interpenetrate each other, and which are supposed, with apparently good reason, to influence greatly the migration of the herring. It is said that the Dutch fishermen derive valuable practical advantages from a system of this kind, and there can be no doubt that favorable results might confidently be looked for if a similar system were generally adopted by our fishermen.

It is an interesting fact in the natural history of the herring that, while the season or their capture is quite definite and generally uniform at any one point, it varies on different parts of the coast; thus, on the east of Great Britain, from Shetland in the north to Flamborough Head in the south, it occurs in July, August, and September,

tions of organic life in the sea, and their variations, the final object, of course, was a practical one, namely, the determination of the facts embraced under the third head. As, however, very little was known in reference to the natural laws of distribution, &c., of the useful animals, it became necessary to investigate them from a scientific point of view; so that the primary inquiries were strictly scientific, the deductions therefrom leading to the practical end.

The initiation of the Franco-German war interfered very materially with this programme, and it was not until 1871, and nearly at the same time with the American investigations, that operations were actually commenced. The commission consisted of Dr. H. A. Meyer, Dr. K. Möbius, Dr. G. Karsten, and Dr. V. Hansen, each gentleman having charge of some special branch, and all co-operating toward the common result. Fixed stations were established at various points for the purpose of observing the variations of atmospheric conditions, the daily changes of temperature of the water, and the occurrence of special phenomena of animal and vegetable life; and for several months in the year the commission, with its assistants, was engaged in researches at sea, prosecuted upon the government steamer Pommerania, placed at its disposal, under Captain Hoffmann. Upon this work the commission has been engaged for three successive seasons, and has just published a report of its operations during the year 1871.

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and a little earlier in the north than in the south. At Yarmouth the herring-season is in October and November; off the Kentish coast, in November and December; along the south coast of England, from October to December; off Cornwall, in August and September; in the North Channel, in June and July; and in the Hebrides, May and June.

It is suggested by the Scottish committee in their report that when the periods of migration on all parts of the British sea-coast will have been calculated as closely as in Scotland, these will be found to bear a critical relation to the annual epochs of the temperature of the sea. This gives a renewed importance to the inquiries undertaken by the United States Signal-Service and the Fish Commission, on the American coast, in the way of determining of the sea-temperature, &c., as connected with a very important branch of our domestic industries.

In this connection we may state that the spawning-season of the herring, and the time of its catch, vary remarkably in different portions of our own coast. Thus, in parts of the Bay of Fundy and in the Gulf of Saint Lawrence, it takes place in May and June, as in the Hebrides; at the Southern Head of Grand Manan, the great spawning-ground, it occurs in September, commencing possibly in August, and extending into October; taking place later and later in the season as we proceed south. At the most southern point at which the herring is positively known to spawn, namely, off Noman's Land and possibly Block Island, this does not occur until December and January.

From this we may draw the inference that a certain minimum of temperature, rather than a maximum, is needed for the operation in question; and this occurring in the autumn, that the proper temperature is reached later and later as we proceed southward.

It is to be hoped that the temperature-observations now being made by the United States Fish Commission and by the Signal-Service may enable us to solve these problems and to co-operate with our Scottish scientific brethren in getting at the true relation between physical conditions and the movements of such important food-fishes as the herring, mackerel, cod, &c.

5.—CONCURRENT ACTION OF THE UNITED STATES SIGNAL-SERVICE.

So far the only nations that have undertaken investigations into the fish and fisheries of their coasts in a thoroughly scientific manner are Norway, Germany, and the United States; and it is with much satisfaction that we can claim at least an equal degree of completeness, in the inquiry, to the others. While no permanent stations have been established on the coast directly under the authority of the United States Fish Commission, the hearty co-operation of General Myer, the Chief Signal-Officer, has rendered this unnecessary. Meteorological observations are, of course, made regularly at all the signal-stations along the coast and on the lakes, and in addition to these the Chief Signal-Officer has directed that a daily record be made of the temperature of the water at the surface and at the bottom, and that copies be sent to the Fish Commission. The examination of these records has already developed many interesting facts, and promise important generalizations of direct practical application to the fisheries.

It is well known that in Europe the fisheries are under the immediate control of the authorities, and that in Norway, especially, such is the attention given to the fullest development of this interest, that the government causes information to be furnished by telegraph of the approach of the herring and cod to the shores, and in regard to their subsequent movements, by this means enabling the entire fishing-fleet at a given point at once to take advantage of the facts, instead of depending upon casual information, which is frequently incorrect, moreover the facts are frequently willfully suppressed by parties who desire to enjoy a monopoly.

General Myer, the chief Signal-Officer of the Army, in charge of the Government system of weather telegraphy, desirous of rendering his department serviceable in the highest degree to the interests of the country, in a letter dated November 21, 1872, invited suggestions in regard to the utilization of the system of telegraphic signals for the benefit of the fisheries. It gave me pleasure to call his attention to the points just referred to in connection with the Norwegian government, and to suggest that much might be done by instructing the signal-officers to keep watch of the facts in regard to the occurrence of herring, mackerel, cod, and other coast-fishes off the shores, and to cause these facts to be promptly communicated to the newspapers.

I also urgently advised the establishment of a signal-station at Eastport, in Maine, as being the center of the United States herring fisheries, and a place where the information which could be furnished by such a station would be of the utmost value. This includes not only the announcement as to impending changes of the weather generally, such as any seaman would desire to be made acquainted with for the purpose of determining his movements, but has especial reference to the trade in frozen herring. During the winter-season, herring of the finest quality are captured in Passamaquoddy Bay and adjacent portions of the coast,

Of late the attention of the legislatures of the New England States has been called to this fact, and to the importance of restoring their fisheries, and a great deal has been already accomplished toward that end. Unfortunately, however, the lumbering interest in Maine, and the manufacturing in New Hampshire and Massachusetts, are so powerful as to render it extremely difficult to carry out any measures which in any way interfere with their convenience or profits; and notwithstanding the passage of laws requiring the construction of fish-ways through the dams, these have either been neglected altogether, or are of such a character as not to answer their purpose. The reform, therefore, however imperatively required, has been very slow in its progress, and many years will probably elapse before efficient measures will be taken to remedy the evils referred to.

It would, therefore, appear that while the river-fisheries have been depreciated or destroyed by means of dams or by exhaustive fishing, the cod-fish have disappeared in equal ratio. This is not, however, for the same reason, as they are taken only with the line, at a rate more than compensated by the natural fecundity of the fish. I am well satisfied, however, that there is a relation of cause and effect between the present and past condition of the two series of fish; and in this I am supported by the opinion of Capt. U. S. Treat, of Eastport, by whom, indeed, the idea was first suggested to me. Captain Treat is a successful fisherman, and dealer in fish on a very large scale, and at the same time a gentleman of very great intelligence and knowledge of the many details connected with the natural history of our coast-fishes, in this respect worthily representing Captain Atwood, of Provincetown. It is to Captain Treat that we owe many experiments on the reproduction of alewives in ponds, and the possibility of keeping salmon in fresh waters for a period of years. The general conclusions which have been reached as the result of repeated conversations with Captain Treat and other fishermen on the coast incline me to believe that the reduction in the cod and other fisheries, so as to become practically a failure, is due, to the decrease off our coast in the quantity, primarily, of alewives; and, secondarily, of shad and salmon, more than to any other cause.

It is well known to the old residents of Eastport that from thirty to fifty years ago cod could be taken in abundance in Passamaquoddy Bay and off Eastport, where only stragglers are now to be caught. The same is the case at the mouth of the Penobscot River and at other points along the coast, where once the fish came close in to the shore, and were readily captured with the hook throughout the greater part of the year. That period was before the multiplication of mill-dams, cutting off the ascent of the alewives, shad, and salmon, especially the former. The Saint Croix River was choked in the spring with the numbers of these fish, endeavoring to ascend; and the same may be said of the Little River, the outlet of Boynton's Lake, about seven miles above Eastport. The lake in question is one of considerable size, and was visited by

immense numbers of alewives, which could be dipped out, to any extent, on their passage upward, while the waters of the adjacent bay were alive with the young fish on their return.

The fish themselves enter the waters of the streams in May or June, and return almost immediately after spawning, to the sea. But they may be taken by the drift-nets along the shores as early as March and April; and, indeed, it is quite probable that the whole period of their abode in the salt-water is spent adjacent to the rivers in which they were born. The young come down from the ponds in which they are hatched, from August to October, keeping up a constant stream of the young fish. In this way a supply of alewives was to be met with throughout the greater part of the year, and nearer the coast they furnished every inducement for the cod and other ground fish to come in-shore in their pursuit.

It is true that the sea-herring is also an attraction to these fish, and probably but for their presence our pollack, haddock, and hake-fisheries would be greatly diminished. Nevertheless, the alewife appears to be more attractive as a bait, and furthermore the sea-herring are less constantly on the coast, especially in-shore, occurring as they do at stated intervals, when they come in from the deep sea to spawn. It is possible, too, that they are less easily captured by the cod, since they swim nearer the surface than the alewives. Corroboration of this idea is furnished in the testimony of Mr. W. B. McLaughlin, of Southern Head, Grand Manan. This gentleman informs me that the only stream in the island which ever furnished alewives to any extent was Seal Cove Creek, which discharges to the east of the southern extremity of Grand Manan, and into which these fish entered in immense numbers in the spring. At that time cod, haddock, and pollack, as well as halibut, were taken in great abundance in Seal Cove Sound, between Hardwood Cove, on Wood Island, and Indian or Parker's Point, on the main island. They were to be met with during the greater part of the year especially from May to January; and the fishery in the channel-way within a quarter of a mile of the shore was really more productive than on the banks much farther out to sea.

Although still a young man, Mr. McLaughlin recollects the capture of these fish; and, indeed, as a mere boy enjoyed the sport within a very short distance of his father's house. Soon after that time a dam was built across this stream about 200 yards above its mouth, cutting off entirely the upward passage of the alewives, and by a remarkable coincidence, if it be nothing more, the cod-fishery in question diminished very soon after, and in a few years ceased almost entirely, so that up to the present time there are not enough cod in those waters to repay the experiment of attempting to catch them. A few alewives still find their way up to the foot of the dam, but in such small numbers as to make it often doubtful whether there are any there or not.

The other fishing-grounds about Grand Manan are farther out to sea,

at the northern end of the island, where there are no alewives, and where herring appear to be the principal food, although the variation in the abundance of these in different seasons appears to have an important bearing upon the number of hake and cod.

If these conclusions be correct—and I am quite satisfied of their general validity—we have, for the efforts made to establish fish-ways in the rivers of Maine, New Hampshire, and Massachusetts, a much more weighty reason than that of merely enabling a few salmon to enter the streams in order to permit their capture while on their way.

Whatever may be the importance of increasing the supply of salmon, it is trifling compared with the restoration of our exhausted cod-fisheries; and should these be brought back to their original condition, we shall find, within a short time, an increase of wealth on our shores, the amount of which it would be difficult to calculate. Not only would the general prosperty of the adjacent States be enhanced, but in the increased number of vessels built, in the larger number of men induced to devote themselves to maritime pursuits, and in the general stimulus to everything connected with the business of the sea-faring profession, we should be recovering, in a great measure, from that loss which has been the source of so much lamentation to political economists and well-wishers of the country.

As the observations in regard to the marine animals and plants of the Bay of Fundy will not be complete without referring to and including those found on the remaining shores of Maine, I defer, for the present, any report upon them such as has been made for Wood's Hole. It is proposed to devote the summer of 1873 to researches in Casco Bay and the adjacent waters, and also, with the aid of the United States Coast-Survey steamer Bache, to examining the waters between the Maine coast and Cape Cod; and it will be more satisfactory to present the results of the two years' work in one account.

7.—INVESTIGATIONS IN 1871 AND 1872 ON THE GREAT LAKES.

The act of Congress specially directed that investigations should be conducted on the great lakes, of the same kind as those ordered for the coasts of the United States; and, under this provision, Mr. James W. Milner was appointed assistant commissioner, with instructions to collect as reliable data as possible on the following points: the evidences of decrease in the numbers of the food-fishes; and, this fact established, to ascertain its causes, and what practicable methods may be applied for their restoration. It was determined to confine the inquiry for the first season to one lake, and to give it a thorough examination. Lake Michigan, having the longest line of shore within the United States and the largest number of fisheries, was selected as the region for the investigation.

Instructions were also given him to make full collections of all forms of life found in the waters, and to take as full notes as possible on the

habits of the species; making the white-fish, the most valuable food-fish of the lakes, the principal object of attention and efficient action for their restoration.

On the 13th of April, 1871, the first visit to the fishing-shores was made, and it became evident from the first, that to obtain any definite knowledge of the amount of decrease, it would be necessary to make the entire circuit of the lake. The migratory habits of the fish and the tendency to entirely change their locality after a term of years, at least in the opinion of the fishermen, made it evident at once that the condition as to numbers could not be understood from any circumscribed area of shore, but that a collection of accurate statistics through a term of years for all the fishing-regions must be gathered to give satisfactory evidence as to their condition.

The southern end of the lake was visited from point to point by steamer and rail before the middle of summer, and, at the northern end, where no steamers plied, the tour was made in an open boat, the trip lasting about five weeks, the sum of the distances traveled from point to point being about six hundred miles. Seventy-one stations were visited, embracing nearly the entire number of fisheries.

Though recorded statistics in the fishing localities were rare, still good evidences were obtained of the decrease and its causes, and many interesting notes of the habits of species and their mutual relations procured. Information was constantly sought and obtained, from fishermen, dealers, and residents, on the subject of the fisheries, which was noted for use in preparing a report on the subject of the inquiry.

As on several other occasions, very important assistance was rendered by the Secretary of the Treasury, the revenue-steamer Andrew Johnson, Capt. David Evans, being instructed to afford facilities for examination of the bottom fauna of the lake. In September Mr. Milner went on board with a dredging outfit, and remained during a cruise of two weeks dredging in depths of from 30 to 144 fathoms, obtaining a full collection of invertebrate forms from the bottom and some knowledge of the temperature at those depths. The species collected were examined by Dr. William Stimpson; but soon after they were received at the Chicago Academy of Sciences, they were lost in the great fire of October.

The dredge was also used from a small boat in Torch Lake, of the Grand Traverse Region, Michigan, in 40 fathoms, and the same forms of *Mollusca*, *Mysidæ*, and *Gammaridæ* were found as in Lake Michigan.

The inquiry was renewed in the latter part of June, 1872; the region of Lake Superior was explored, collections and notes ware obtained, and similar inquiries were made with reference to numbers of fishes. Much less evidence of decrease in this lake was the result, though a marked diminution was ascertained to have taken place in certain localities.

In the autumn of 1872 nearly a million of white-fish eggs were obtained by Mr. Milner and placed in Mr. N. W. Clark's hatching-house at Clarkston, Mich., from which in the winter a large number were for-

warded to California for the waters of Clear Lake. Arrangements were also made for the hatching of salmon for the waters of Michigan and Wisconsin.

At the close of the field-work of the season, Mr. Milner visited all the prominent dealers on the chain of lakes, and obtained the amounts of their receipts of lake-fish for the year.

After the close of the distribution of the shad in 1873, Mr. Milner visited the shores of Lake Huron, and obtained a collection of its fishes. The inland locality in that region inhabited by the grayling was also examined, notes relating to its habits were obtained, and a knowledge of the facilities for obtaining the spawn acquired.

Later he proceeded to Lake Erie, and made a large collection of fishes in the vicinity of Sandusky, Ohio; and afterward at Cincinnati the species of the Ohio River were obtained.

Full details of Mr. Milner's labors will be found on page 1 of the appendix to the present report.

B—ACTION IN REGARD TO PROPAGATION OF FOOD-FISHES.

8.—INTRODUCTORY MEASURES.

It will be observed that the labors thus referred to, as authorized by the original resolution of Congress, relate only to the investigations of the facts as to an alleged decrease of the food-fishes of the sea-coast and the lakes of the United States, an inquiry into the causes of the same, and the best methods of remedying the evil.

At a meeting of the American Fish-Culturists Association, held in Albany February 7, 1872, it was for the first time suggested that measures be taken to induce the United States to take part in the great undertaking of introducing or multiplying shad, salmon, and other valuable food-fishes throughout the country, especially in waters over which its jurisdiction extended, or which were common to several States, none of which might feel willing to incur expenditures for the benefit of the others.

A committee, of which Mr. George Shepard Page was chairman, was accordingly appointed to present the subject to Congress, and to do whatever was in its power to secure the desired object. This gentleman visited Washington, and appeared before the Committee on Appropriations to urge the measure and secure its favorable action. A clause appropriating $10,000 was accordingly put into the appropriation bill for the purpose in question; but this was rejected by the House. Subsequently, however, the subject was considered by the Senate committee, who took an equally favorable view of it with the House committee, and an amendment appropriating $15,000 was introduced and carried successfully through Congress; its disbursal being placed under my charge. To the action of the association in question, therefore, the credit of the original idea and the consequent favorable action of Congress is emphatically due.

On the 13th of June a meeting was held in Boston, three days after the passage of the act, composed of the fish-commissioners of the New England States and of members of the Fish-Culturists Association, at which the general problem as to the best method of carrying the act of Congress into effect was presented. After full deliberation, it was recommended that the services of Messrs. Green and Clift be secured for the planting of shad in the Mississippi River and its tributaries, and that means be furnished to Mr. Atkins, of Bucksport, Me., to enable him to enlarge his operations on the Penobscot River, and to Mr. Stone for similar labors on the Sacramento.

In reference to shad, it was thought that they might even live comfortably the whole year round in the great lakes, with the exception of a short run up the tributary rivers for the purpose of spawning. As to whether they would push their way up from the Gulf of Mexico to the headwaters of the main tributaries of the Mississippi River was, of course, a problem which could not be solved without experiment.

The proceedings of this meeting will be found in the appendix to the present volume.

9.—PROPAGATION OF SHAD IN 1872.

Little time was to be lost in carrying out the suggestions with reference to shad, as the appropriation was not available until the 1st of July, and the season during which the eggs could be successfully hatched lasted but a few days beyond that period.

Both Messrs. Green and Clift, however, undertook to do what they could, and worked with great energy. In addition to the large number of eggs introduced by Mr. Green, in behalf of the State of New York, into the Hudson River, Oneida Lake, Lake Champlain, and Genesee River, he furnished 50,000 fish for Lake Champlain to the commissioners of Vermont, and, in behalf of the United States Government, placed 30,000 in the Alleghany River at Salamanca, N. Y., and 25,000 in the Mississippi River, a few miles above Saint Paul, Minn.

The later period at which the shad spawn in the Connecticut enabled Mr. Clift to secure a larger margin of time for his arrangements; and, by the kind assistance of the commissioners of the State of Connecticut, he succeeded in procuring, from the State hatching-house at Holyoke, Mass., a sufficient number for his purpose. Mr. Clift started, on the 2d of July, with several hundred thousand young fish, filling nine eight-gallon cans. Of these, a portion, estimated at 200,000, were placed in the Alleghany at Salamanca, and a like number in the Cuyahoga, in the White River at Indianapolis, Ind.; the remainder were carried direct to Denver, in Colorado; and, on the 7th of July, introduced 2,000 in number into the Platte.

Very valuable assistance was rendered in this experiment by the

express companies, especially the Adams and the American and Merchants' Union. Without the help, of special instructions to their agents to assist Messrs. Green and Clift, it would have been difficult to accomplish the object in view.

Acknowledgments are also due to the commissioners, both of New York and Connecticut, for placing their hatching-establishments at the disposal of the United States in order to furnish the necessary number of eggs.

Concurrently with the operations on the part of the United States, the commissioners of both New York and Connecticut were industriously engaged during 1872 in continuing experiments previously instituted in regard to stocking the waters of their respective States with shad, and incredible numbers of young fish have been introduced. Thus in New York, under the efficient direction of Mr. Seth Green, nearly 7,000,000 shad were released in the waters of the State, while the extraordinary number of 92,065,000 young fish is reported by Dr. Hudson to have been turned into the waters of the Connecticut. Dr. Edmunds, commissioner of Vermont, also obtained 50,000 young fish from Mr. Green, which were placed inBurlington Bay, Lake Champlain.

Whether shad can live permanently in fresh water, and maintain those characteristics of flavor and size which give them such a prominence, and whether they can be established in the Mississippi Valley are problems not yet solved; but the results to be obtained, in the event of its possibility, are of such transcendant importance in relation to the food-supply of the country, and the cost of the experiment so very trifling, that it would be inexcusable not to attempt it.

11.—PROPAGATION OF MAINE SALMON IN 1872.

More time was allowed for satisfactory arrangements in regard to the propagation of salmon than of shad, because of the much later period in the year when they spawn; this in the common salmon (*S. salar*) not taking place until the end of October or the beginning of November, and varying with the locality.

In compliance with the suggestion of the meeting at Boston, I had an interview with Mr. Charles G. Atkins at Bangor, and ascertained the probable degree of expansion that he could give to his operations at Bucksport, on the Penobscot River, with additional funds.

The method devised by him consists in obtaining mature fish as they come up the river and are taken by the fishermen, placing them in a pen situated in a large pond of about 150 acres, and keeping them there until the season of reproduction, and then securing the spawn, and, after impregnating it, hatching it in a suitable hatching-house.

The only method of obtaining salmon in sufficient numbers was to offer the full market-price to the fishermen for all they may deliver alive to the hatching-establishment. About six hundred fish were thus obtained during the summer. But little mortality occurred among these fish, and, on the 28th of October, Mr. Atkins and his assist-

ants commenced taking the spawn, securing about 1,560,000 eggs. These were brought forward in the hatching-house at Bucksport until February. During that month and March they were distributed to other hatching-houses in different parts of the country in order there to be fully developed.

The experiment in regard to the Bucksport salmon-hatching establishment was initiated in New York on the 17th of April, 1872, by an agreement of several parties to contribute funds to a given amount, the division of the spawn to be made in the same ratio. The subscriptions were as follows:

E. M. Stilwell and H. O. Stanley, jr., for the State of Maine.....	$500
E. A. Brackett, for the State of Massachusetts.....	1,000
I. H. Barden, for the State of Rhode Island.....	400
W. M. Hudson, for the State of Connecticut.....	1,000
W. Clift, for Poquonnoc Fish Company.....	300

These gentleman kindly consenting, I supplied, from the funds at my disposal, the means to greatly enlarge the scale of operations, and received a pro-rata share of the eggs. The full history of the entire enterprise connected with the taking of the eggs in 1872, and their distribution in 1873, will be found in Mr. Atkins's report, beginning page 226 of the present volume.*

11.—PROPAGATION OF THE RHINE SALMON IN 1872.

The possible contingency of failure in Mr. Atkins's experiment induced me to look to other sources for an additional supply of eggs; but I was unable to make any arrangement in America for that purpose. In consequence of the scarcity of fish, it was impossible to organize upon other salmon-rivers of Maine the experiment that Mr. Atkins had begun on the Penobscot; and the regulations of the Dominion authorities in regard to gravid salmon and their eggs are such as to preclude the idea of looking across the borders for assistance.

The Canadian government has, it is true, a hatching-establishment at Newcastle, on the north side of Lake Ontario, near Toronto, and has occasionally allowed a surplus, left after it has supplied its own wants, to be sold to parties in the United States. The charge, however, being $40 a thousand, (in gold,) was considered excessive, and the only alternative left was to look to Europe, where the streams emptying into the North Atlantic abound in precisely the same species. Under these circumstances, and after much consideration, I decided to obtain what I wanted from the Rhine, the fish of that river being famous for their excellence and size. I accordingly applied to the secretary of the *Deutsche Fischerei-Verein* at Berlin, inquiring whether any eggs could be procured from the government fish-breeding establishment at Hüningen. To my gratification, I was informed that, on the represen-

*On the Salmon of Eastern North America and its Artificial Culture, p. 226.

tation of the *Verein* to the German government, it had been decided that 250,000 eggs should be presented to the United States at the proper time, all packed and ready for transmission, provided I would agree to have them transported to a point of shipment under the care of an experienced operator. To this, of course, I gladly agreed, and named Mr. Rudolph Hessel, of Offenburg, an eminent fish-culturist and highly esteemed correspondent, from whom I had already derived much valuable information, to take charge of that duty. Articles by this gentleman upon the salmon of the Danube River, (*Salmo hucho*,) the breeding of the cyprinoid fishes, &c., will be found in the appendix to his report.*

The following letters on this subject were received from the authorities in Germany:

[Translation.]

BUREAU OF THE DEUTSCHE FISCHEREI-VEREIN,
Berlin, June 11, 1872.

In consequence of your letter of the 15th of May, addressed to Professor Peters, of this city, in reference to the acquisition of salmon-eggs for your Government, we have applied to the superintendent of the fish-culture establishment at Hüningen, and have received his reply, of which we inclose a copy.

Placing you thus in possession of the facts in the case, we beg that you will favor us as speedily as possible with a reply as to whether your Government is ready to assume the cost of the transportation of 250,000 salmon-eggs.

MANARD.

DR. SPENCER F. BAIRD, *Washington.*

[Translation.]

HÜNINGEN, *June* 7, 1872.

On receipt of your letter I placed myself immediately in communication with the circle president in reference to the conditions under which the establishment could supply salmon-eggs to the American Government. On my proposition, it was agreed that, in any event, the eggs should be furnished free of expense, although it is not possible to supply "several millions." As the salmon-eggs are intended, in the first place, for Germany alone, the establishment could not pledge itself to supply more than 250,000 at most, and this only on the condition that the necessary care be exercised in their transportation. It is an indispensable condition that the eggs shall be taken from here by a special messenger to Havre or Cherbourg, so that they may be secured against heating during the journey. Arrangements must also be made for their preservation on the steamer in a uniformly cool place, and for their reception in New York by an expert in such matters. The doublepacking of a quarter of a million of salmon-eggs will require at least thirty boxes, each weighing about fifteen pounds; so that the whole will weigh nearly five hundred pounds and occupy a considerable space.

HAACK, *Director.*

HERR MANARD.

[Translation.]

IMPERIAL FISH-BREEDING INSTITUTION,
Hüningen, near St. Louis, Alsace, August 13, 1872.

HONORABLE SIR: I have been asked by the Bureau of the German Fishery Association to write directly to you in reference to the Rhine salmon-eggs to be sent to America.

*The Salmon of the Danube, or the Hucho, (*Salmo hucho*,) and its Introduction to American Waters, p. 161; also Method of Treating Adhesive Eggs of Certain Fishes in Artificial Propagation.

The first eggs are usually obtained by the middle of November, but in such small numbers that it would be impossible to make up a quarter million for one transmission. This is one of the most difficult points for large transports. The institution receives from 20,000 to 30,000 eggs per day, and, taking into account the considerable loss in the incipient hatching, [*Anbrüten,*] it requires from twelve to fifteen days to collect a quarter of a million. With so great a difference in time of collecting, the eggs are, of course, not ready for transportation at the same time. It is true, at the very height of the season we obtain occasionally 80,000 to 100,000 eggs a day, and we have to arrange that such days be reserved for the intended large collection. These days mostly occur about the middle of December, and the eggs to be sent to America could not leave our place before the middle of January, since about five weeks are necessary for the incipient hatching. Besides, the day of sailing of the steamers has to be taken into consideration, and I believe there are only two trips per month during the winter-season. These are difficulties, to meet and to overcome which we have only the power in part; still I hope for good success. I consider it an affair of honor, and mention the many difficulties only to explain a possible mishap.

The sending of one-quarter million of eggs will require twenty-five single parcels, each consisting of two double boxes. Each parcel weighs about 10 pounds, and thus the whole 250 pounds, or 2½ hundred-weight. Believing it to be absolutely necessary that an expert should accompany the transport to Hamburg or Bremen, and direct the suitable packing there, the expenses will be quite considerable, scarcely less than 100 thalers per hundred-weight.

Since our institution furnishes the eggs gratis, and no funds are available to me for defraying expenses, I respectfully ask to have by the end of the year a sum of money of the above amount placed at my disposal, so that no delay may be caused by its want.

Accurate accounts will be rendered in time.

HAACK, *Director.*

Prof. S. F. BAIRD.

As a still larger number of eggs was considered desirable, at the suggestion of Mr. Hessel, I applied to Oberbürgermeister Schuster, of Freiburg, and ordered from him half a million eggs, which he agreed to furnish at the very reasonable price of two thalers per thousand, (their actual cost amounted to $1.67 currency per 1,000,) guaranteeing them to be taken from large healthy fish. These were also placed in charge of Mr. Hessel for shipment, who finally agreed to accompany the two sets of eggs to New York for the greater certainty of their reception in good condition.

As is well known, the best period for transporting salmon-eggs is when they are about half hatched, or when the eyes are visible through the envelope. They are then put up in damp moss in shallow boxes, and inclosed in other dampened receptacles. In this condition they may be kept out of water for a long time. Indeed, the eggs are not infrequently hatched out in the moss itself, if kept long enough, without being placed in water at all. Mr. Norris gives an instance of this kind in regard to some eggs which had been shipped from the Wilmot establishment at Ontario, a portion of them, that had been thrown aside with the damp moss having subsequently hatched, and this has since been confirmed by the experience of the commission.

Owing to the fact that the water at the Hüningen establishment was warmer than that at Freiburg, the eggs presented by the German gov-

ernment were developed first, those at Freiburg requiring some further time, so that it involved considerable effort to combine the two sets so as to prepare them for shipment to the United States at the same time.

Mr. Hessel, in accordance with the agreement, took charge of the eggs at Hüningen, as also those at Freiburg, and brought them to Bremen, where they were to be shipped on board one of the steamers of the North German Lloyd's. Unfortunately several circumstances concurred to render it doubtful to Mr. Hessel whether these eggs would come safely through. In the first place, the weather was exceptionally warm throughout Germany, no cold weather being experienced up to the middle of January, so that the eggs were developed in their shells much too fast for their welfare. It was impossible to retard these by the application of ice, as the stock in Bremen was very low, and supplies were only to be had at an enormous expense.

Again, the steamer upon which the eggs were first placed broke down, and was obliged to return to port. Mr. Hessel's packages were thus delayed and exposed to the continuous heat for another week. The consequence was that on his arrival in New York, to his great distress he found that the eggs had in large part been prematurely hatched, and the gases resulting from their putrefaction had destroyed many more of the eggs.

Application had been previously made to the Secretary of the Treasury for permission to land the packages containing the salmon-eggs without delay, and every facility was offered by the inspector of customs and other authorities. The boxes, sixty in number, occupying nearly 300 cubic feet of space, were transferred to the hatching-houses of Dr. Slack, near Bloomsbury, N. J., and the contents immediately assorted, but of the 750,000 eggs only four or five thousand were sound. These were successfully hatched out, and ultimately introduced into the Musconetcong, a tributary of the Delaware, and on which Bloomsbury is situated.

Much help was rendered in this experiment by the authorities of the North German Lloyd's, who gave up a special house on deck for the accommodation of the eggs, and assisted in various other ways, especially by advancing all the funds needed for the expenses in Germany and allowing the settlement of the account in New York. I had the assistance, also, in the reception and transfer of the eggs, of Dr. William M. Hudson, fish-commissioner of Connecticut, and of Mr. Seth Green, of New York, the whole party, with the exception of Dr. Hudson, proceeding to Bloomsbury with Dr. Slack, for the purpose of giving the eggs the best attention. I have no doubt that with a winter of average severity, which would not carry the eggs forward so rapidly as happened in this very exceptional instance, the transfer of salmon-eggs can be made from Europe without the slightest uncertainty as to their safe arrival. Perhaps a somewhat different method of packing would be required, and the inclosure of the eggs in smaller boxes would tend to promote their safety. In the ex-

treme probability that hereafter there may be obtained from American waters all the eggs that can be properly handled, I think it will be unnecessary to repeat the experiment.

The entire cost of the enterprise, including the purchase of the Freiburg eggs, the freights, the traveling-expenses and salary of Mr. Hessel, and every other outlay, amounted to $1,969.83, or to about $2.62½ per 1,000.

The value of this donation of eggs from the German government is not to be estimated by its worth in money, but is to be appreciated as an evidence of kind feeling on its part toward the United States, especially as there is a very great demand for salmon-eggs throughout Europe, and as the supply received from Hüningen is entirely insufficient to meet the calls from Germany alone.

12.—PROPAGATION OF THE CALIFORNIA SALMON IN 1872.

The propriety was strongly urged, at the Boston meeting, of sending some experienced fish-culturist to the west coast for the purpose of securing a large amount of spawn of the California salmon. This was the more proper, as the resolution originally introduced into the House by Mr. Roosevelt looked especially to the securing of a supply of eggs by means of hatching-houses on the Columbia River or elsewhere in the West; and I felt it incumbent to carry out the intention, although the law making the appropriation, as actually passed, contained no restriction.

Although considerable diversity of opinion exists with reference to the California salmon, most of those familiar with both species consider it nearly, if not quite, equal to the eastern salmon, and in some respects superior to it. At any rate, it possesses the advantages of existing in great abundance in our country, and of thriving in water, the temperature of which might not admit of the existence of the eastern species.

Accordingly, at the suggestion of the meeting, Mr. Livingston Stone was engaged to undertake this work, and proceeded to California as soon as he could arrange his affairs for the purpose. The experiment was of course uncertain, in the entire absence of any reliable information bearing upon the natural history of the species. It was not even known at what period they spawned, although Mr. Stone was assured by professed experts, on his arrival in California, that this occurs late in the month of September. This was thought the more probable, since the other salmon usually deposits its eggs in the end of October or the beginning of November. Mr. Stone left on the 1st of August, and arrived in due time in California, where, at my request, he reported to Mr. Throckmorton and the other fish-commissioners of the State, as well as to the president of the California Fish-Culturists' Association. By all of these gentlemen he was received with the utmost courtesy and kindness, and every assistance was rendered him. His instructions authorized him to select any point on the Sacramento or the Columbia River

that promised to answer best the purposes of his mission. Quartermaster-General Meigs had supplied him with letters of recommendation to the officers of his department in the West; but, to his regret, Mr. Stone found no military post sufficiently near to render him any particular assistance during the present season.

After much fruitless inquiry, Mr. Stone at last learned, chiefly through Mr. B. B. Redding, fish-commissioner of California, and through the chief engineer of the Central Pacific Railroad, that the Indians speared salmon on the McCloud River, a stream of the Sierra Nevada, emptying into Pitt River three hundred and twenty miles nearly due north of San Francisco. Proceeding to this station, in company with Mr. John G. Woodbury, of the Acclimatization Society, Mr. Stone immediately set to work in erecting the necessary hatching-establishment, although, on account of the distance from any settlement and the absence of special facilities, he found the undertaking both difficult and expensive. The efforts of Mr. Stone and his party were prosecuted unintermittingly, day and night, for a sufficient length of time to prove that the season had almost entirely passed, and that but few spawning fish remained. Many thousands of spawn were secured, however, and placed in hatching-troughs; but the extraordinary heat of the season, rising day after day to 110° and 112° in the shade, finally accomplished the destruction of the greater portion.

The surviving eggs collected by Mr. Stone (30,000 in number) were packed by him in moss and forwarded October 26 by express, addressed to his establishment at Charlestown, N. H., this designation being selected in the failure to reach him, of a letter directing their transmission to Dr. Slack, at Bloomsbury, N. J. On receiving a telegraphic dispatch announcing the shipment, I immediately telegraphed to Charlestown, directing the packages to be forwarded at once to Dr. Slack, and sent also a telegram to the office of Wells, Fargo & Co., at Albany, requesting that, if the eggs had not already passed that point, they might be intercepted there and returned at once to New Jersey. This dispatch came too late, as the eggs had passed when it was received; but the superintendent of Mr. Stone's establishment forthwith sent the eggs to New Jersey, with a skilled assistant to take charge of them and deliver them at their destination. Unfortunately, in consequence of the warmth, and through a miscalculation of the rapidity with which they accomplished their changes, the eggs were in large part hatched out on the journey, so that of the 30,000 originally shipped all but about 7,000 were hatched. The remainder were immediately picked out and placed in the hatching-house by Dr. Slack. The brood proved to be unusually hardy, very few dying, and all manifesting an extraordinary voracity for the food supplied to them.

By the advice of the various State commissioners and fish-culturists at a meeting in New York in October, it was concluded to place this stock of young fish in the Susquehanna; Mr. James Worrall, late commissioner

of fisheries for Pennsylvania, undertaking to do everything possible for their proper care. It had been the intention to transfer them from the hatching-house to the river as soon as the yolk-bag had become absorbed and the young fish were able to shift for themselves; but in consequence of the very cold weather which occurred during the winter, Dr. Slack was requested by Mr. Worrall to keep them until later in the season. They were therefore retained in the hatching-house and amply fed, from time to time, until the 3d of March, when they were taken to Harrisburgh and placed in the Susquehanna, being between five and six thousand in number. Only about one hundred perished on the journey, the rest being vigorous and in good condition. It is much to be hoped that some important result may follow this enterprise, especially if it be at all possible to add largely to the number in the course of the next few years. At the time of their introduction they were from 2 to 2½ inches long, showing the banded side very distinctly. They were much larger than the young of the *Salmo salar* at the same age, in this respect agreeing with the egg, which, in the Sacramento species, is fully twice the capacity of that of its congener.

The surprise of Mr. Stone at finding the extraordinarily high temperature in the Sacramento Valley, just referred to, was all the greater from the fact that he had been warned against being blockaded with snow during the same period. It is, therefore, probable that, as the season of 1872 was exceptionally warm, this obstacle to success will not continue on a subsequent occasion.

From Mr. Stone's experiences in 1872 he concluded that it will be necessary to commence operations as early as the 20th of July, and to have the breeding salmon caught and confined as early as the 20th of August. The hatching-water he proposes to take from the McCloud River, which is of so even a temperature that, notwithstanding the great heat, it does not rise above 54°. He would have used this water for hatching-purposes in 1871 but for fear of its rising by sudden freshets so as to destroy the establishment. He found, however, that the water altered only about two inches during his stay, and should operations be continued another season he proposes to employ it for the purpose, continuing operations at the same station. No better place is, indeed, to be had in California than the McCloud, as it is a very clear, cold, swift-running stream, full of salmon, and probably embraces the principal spawning-ground of that fish.

The spawning-beds lower down the river have been almost entirely destroyed by the washings of gravel and sand from the gold-diggings, which have exercised an unfavorable influence upon the supply.

According to Mr. Stone there are no white settlements on the river; but the Indians are numerous. The nearest highway is the Oregon stage-road, four miles from the river. Mr. Stone's party endeavored to enlist the Indians in their service, but were unable to communicate intelligibly with them, and were obliged to rely upon their own resources. As it was, their operations were somewhat delayed by the non-arrival of a

salmon-net which had been sent for. Mr. Stone had been assured that there would be no difficulty in securing aid from the Indians, which, however, he found to be entirely impossible.

We do not know enough of the natural history of the *Salmonidæ* of the West to decide as to the relationship of the Sacramento salmon to those of the waters farther north, especially of the Columbia and Frazer Rivers. Dr. Suckley and others are, however, of the opinion that the same species extends from California to Alaska; but that, while there are additional species in the northern waters, only one inhabits the Sacramento. Its flesh is much more highly colored than that of the eastern salmon, being almost of a dark-red, and its flavor is said to be fully equal, if not superior; although about this there is a great diversity of opinion. In its proportions it differs, being shorter and thicker, so that one of them weighs considerably more than a fish of the same length taken from the East. Further considerations as to its value and adaptability to eastern waters will be found farther on.

13.—PROPAGATION OF WHITE-FISH IN 1872.

The white-fish breeding was begun in the fall of 1872. Over half a million of eggs were placed in the troughs of Mr. N. W. Clark, an experienced breeder of Clarkston, Mich. These were obtained at Ecorse, on the Detroit River, through the liberality of Mr. George Clark of that place, with but little expense. On the 20th of January, 1873, about 200,000 eggs, partially developed, were shipped to the fish-commissioners of California, but did not arrive in good condition, having either smothered from the thick bed of sawdust in which the case containing them was placed or been killed by the excessive cold. A second lot of one-half the number was shipped to the same destination with excellent success. These were placed by the commissioners in a hatching-house provided for their reception, and the young fish soon after were put into the waters of Clear Lake.

The white-fish is of great value, because of the excellent flavor of the flesh, both fresh and salted, its fecundity, and the fact that it feeds on crustacea and other invertebrate forms. It is adapted to the larger and cooler lakes of the interior, and like the rest of the salmonoids is easily propagated artificially.

14.—PROPAGATION OF SHAD IN 1873.

As shown in the first part of the present report, the shad-hatching season was so far advanced at the time of the passage of the act making an appropriation for the service in 1872 that little could be done. The appropriation itself was not available until the 1st of July; and as the appropriation bill containing the item was passed just before the adjournment of Congress, on the 10th of June, it was necessary to make sure that the item was included therein before taking any measures that might involve any expense. An account of the work actually accomplished in 1872 is given on p. xvi.

Owing to the earlier date at which the necessary appropriations were made by Congress for the propagation of food-fishes, especially of the shad, in 1873, I was enabled to take timely steps looking toward this great interest, the plan adopted being to hatch out the fish in the rivers of the Atlantic coast, and to transfer a suitable portion of them to western waters, beginning in the south, and conducting operations farther and farther toward the north as the season advanced.

Entirely ignorant of the best points where this work could be carried on, I dispatched Dr. Yarrow on a tour of reconnaissance, and was very much surprised to learn from his report (page 396) that, in consequence of the scarcity of fish, it would be extremely difficult to get enough to experiment upon, farther south than the Neuse. This conclusion was found to be correct, by the subsequent experience of the parties entering upon the work.

Desirous of utilizing the practical experience in shad-culture of Mr. Seth Green, I made arrangements with him to devote his whole attention to the business of hatching shad in behalf of the United States, or at least until it became necessary for him to commence operations on the Hudson River for the State of New York. He accordingly reported himself in Washington on the 17th of April, with his trained assistants, Mr. H. M. Welsher, Mr. Jonathan Mason, Mr. M. G. Holton, and Mr. Chester K. Green. As agreed upon, he proceeded first to the Savannah River at Augusta, Ga., but, to his disappointment and my own, was unable, as already explained, to find enough spawning shad to make the experiment worth the cost.

New Berne on the Neuse, and Weldon on the Roanoke were next fixed upon as stations. Unfortunately the unprecedented rise in the rivers prevented anything like the success we had hoped for; the streams being many feet above high-water mark, rendering it impossible either to catch the shad, or to hatch out the spawn properly had it been possible to procure it. The most important result of the experiment at Weldon was the discovery by Mr. Holton that the striped bass or rock-fish could be propagated in the same manner as the shad. Several spawning fish were stripped of their eggs, which were fertilized and placed in the shad-boxes. They were found to develop in rather less time than the shad, and to be capable of quite a similar treatment generally.

As this fish has diminished equally with the shad, and is much more valuable on account of its greatly superior size, we have here the warrant as to further operations, which it is proposed to carry into effect hereafter.

The operations at Weldon were under the charge of Mr. M. G. Holton and Mr. C. K. Green; and on the 17th of May a camp was established on the Potomac River by Messrs. Mason and Welsher, and the first work of any magnitude commenced. About one hundred hatching-boxes were prepared according to Mr. Green's pattern, and anchored above the western end of the Long Bridge opposite Washington, and advantage

was taken of an adjacent fishery belonging to Messrs. Knight & Gibson to secure the spawning fish. Here about 1,400,000 young shad were placed in the river, increasing the supply to that amount. It was now for the first time possible to make a transfer of fish to the West; and having placed Mr. Milner, an assistant of the commission, in charge of this branch of the work, he succeeded, with the assistance of Mr. Welsher, in introducing about 70,000 fry into the headwaters of the Kanawha River on the 6th and 9th days of June. A supply was also furnished to Mr. N. W. Clark for the Michigan commissioners.

The season having closed at this point in consequence of the heat of the water, and the fact that the spawn taken from the fish invariably failed to develop, two new stations were established; one under Mr. Welsher, at Marietta, in Pennsylvania, and the other under Mr. Holton and C. K. Green, at Bull's Island Ferry, on the Delaware. The business arrangements of this branch of the work were placed in charge of Dr. J. H. Slack, who, as fish commissioner of New Jersey, had certain privileges in regard to the capture of the shad, which were important to the success of the enterprise. The fish hatched at this point were principally placed in the Delaware River, although 15,000 were transferred by Dr. Slack to Jack's Run, at Greensburgh, for the purpose of stocking the Monongahela.

About the time of the starting the camp at Marietta, the Pennsylvania commissioners began another at Newport on the Juniata, where a considerable number of fish were hatched and placed in the river.

The operations on the Delaware were closed in July, mainly in consequence of certain obstructions introduced by the canal company above the hatching-camp, and the regular parties proceeded to the camp on the Hudson, at Castleton, where the New York commissioners have a station, and where a considerable supply of spawn was to be expected. Here the hatching was prosecuted entirely at the expense of the State of New York; her fish commissioners, however, very kindly giving the United States such spawn as was required for its purposes. Mr. Milner assisted by Mr. Mason was actively engaged for several weeks in transferring young shad from Castleton to various points in the West, becoming so well skilled as to involve a very slight mortality.

At the same time Mr. Livingston Stone, in behalf of the United States Fish Commission, received 80,000 fish from the establishment of the New York commissioners, none of which reached their destination; the attendant who carried them through to Chicago, where they were to meet the aquarium-car, failing to success in keep them alive during their journey.

The attempt to transfer valuable food-fishes from the Atlantic slope to the Pacific slope in the so-called aquarium-car, as well as the unfortunate accident by which the car was precipitated from a trestle-work into the Elkhorn River of Nebraska not far from Omaha, have become widely known through the newspapers. The enterprise was a joint affair

between the United States and the State of California, through her commissioners, Messrs. Throckmorton, Redding, and Farwell.

The car, in charge of Livingston Stone, assistant United States commissioner, was ingeniously and very completely fitted up in every detail of necessity and convenience required for the successful transfer of fishes, obsters, and oysters. It contained in all nearly 300,000 fishes, representing the following species: The tautog, (*Tautoga onitis;*) the black bass, (*Micropterus salmoides;*) the rock-fish or striped bass, (*Roccus lineatus;*) the perch, (*Perca flavescens;*) the wall-eyed pike, (*Stizostedion americana;*) the brook-trout, (*Salmo fontinalis;*) the bull-head, (*Amiurus atrarius;*) the cat-fish, (*Ictélurus cœrulescens;*) the eel, (*Anguilla bostoniensis;*) besides minnows, (*Cyprinidæ,*) to serve as food for the larger individuals *en route.* One hundred and seventy lobsters and a barrel of seed-oysters were also in the car.

To accommodate these, one very large tank, and ten smaller ones, besides hogsheads, barrels, and tin cans, were required.

A large amount of ice, and reserves of sea and fresh water, were provided, as well as supplies of food and apparatus for aerating water and regulating temperature. Sleeping and feeding accommodations for attendants were arranged within the car.

By the accident, the car was thrown into the Elkhorn River, and the fishes had an opportunity of escape from the tanks. It is not likely that the lobsters, oysters, or the tautogs were able to sustain life in the fresh waters of the river for any great length of time. The rock-fish and the shad are anadromous fishes, spending a portion of each year in fresh waters, and both have proved their ability to sustain life in fresh waters through several years. The other species are fresh-water fishes, and some of them will be valuable acquisitions to the system of waters where fate has consigned them.

A full account of this expedition and of the accident which interrupted it so suddenly, and from which Mr. Stone and his companions barely escaped with their lives, will be found in the body of the report.

Mr. Stone, having lost the first installment of shad, was directed to return to Albany for the purpose of taking an additional supply; and he again started on the 25th of June, with about 40,000 fish, accompanied as far as Omaha by Mr. Welsher. I am happy to state that they experienced scarcely any mortality on the way, and after placing 5,000 fish in the Jordan River, a tributary of the Great Salt Lake, on the 30th of June, he deposited 35,000 in the Sacramento on July 2, in the presence of the California commissioners, and to their very great satisfaction. This number of young fish in the Sacramento River, to be increased, I hope, hereafter, will very probably result in supplying that stream with this useful food-fish, and will furnish a point of departure from which to stock the Columbia and other more northern rivers, as contemplated by act of Congress. Experience has shown that it will be impossible to take young shad from the east over a greater distance than the Pacific

Railroad will carry them; and until the northern line, or the coast-line from California to Oregon, is completed, it will hardly be worth while to spend our efforts in that direction.

In order to have a still greater supply of young shad for the purposes of the commission, an arrangement was made with the Connecticut commissioners to enlarge their operations at Hadley Falls, the increased expense being borne out of the appropriation made by the United States. This was accordingly done, and Mr. Milner and Mr. Mason were enabled, after the season had closed farther south, to obtain all the young shad they could attend to during the remainder of the season.

A deposit in the Mattawamkeag, a tributary of the Penobscot, was made at the urgent request of the commissioners of Maine.

Mr. Milner and Mr. Mason next proceeded to Topsham, Me., on the Androscoggin, with a view of ascertaining whether ripe eggs could be obtained in sufficient number for shad-hatching purposes. They found, however, that, owing to the lateness of the season and the scarcity of the fish themselves, nothing could be done; and it is thought not improbable that the restoration of shad to the rivers of Maine will be done most easily by transferring the spawn from the Connecticut, or from the Merrimack, should the commissioners of Massachusetts exhibit the same liberality that has been shown by those of Connecticut. Returning from Maine, they proceeded again to the Connecticut and the Hudson, continuing their labors in the way of transferring of young fish. Their work finally closed on the 24th day of July.

An accompanying table gives the statistics of the work actually accomplished in transferring shad to western waters. The aggregate of nearly a million is certainly likely to produce a marked effect; and if similar efforts are made in successive years, which I trust will be the case, there is every reason to expect the accomplishment of the object in view. The information in this and other tables, as to the entire number of shad and salmon hatched in the United States to date will not be without interest.

The accompanying very valuable report by Mr. Milner, (page 419,) gives the details of his operations, and embraces numerous very valuable suggestions in regard to the transportation and treatment of shad, which will serve an important purpose in future operations.

I append reports from Mr. Green, of his labors south of Washington, (p. 406;) from Dr. Slack, upon work on the Delaware, (p. 409;) and from Mr. Stone, (p. 413,) upon his transfers to the Jordan and Sacramento.

During the present season, as in the past, I have great pleasure in acknowledging the help rendered by many persons, not only by the State commissioners, (especially those of New York and Connecticut,) in supplying young fish from States where the United States had no hatching-house, but also by the part of officers of railroad and express companies. Most of these are mentioned hereafter.

It had been contemplated to carry on hatching-operations on the Rappahannock River, where the shad were believed to be very abun-

dant, and where, it was thought, a large number of eggs might be obtained and transferred to the West. The most suitable point on this river was some distance below Fredericksburgh; and at Mr. Green's suggestion I applied to the governor of Virginia, asking the loan of one of the State fishing-steamers for my aid, which was promptly acceded to, and I was informed that the steamer Tredegar, in command of Capt. Orris A. Browne, would be at my service at any time after the 1st of May. It, however, was found impossible to occupy more than two stations at a time, owing to the small force at my command, and when the experiment at Weldon was given up, and Messrs. Welsher and Green proceeded to the Rappahannock, they found the season had passed, and that no success was possible. Another year it may be expedient to commence operations on this river, especially in view of the fact that it affords a convenient point from which to transfer the young fish to West Virginia, Kentucky, and Tennessee.

C—MULTIPLICATION OF FISH IN GENERAL.

15.—GENERAL HISTORY OF FISH-CULTURE.

Having presented in the introductory portion of the present report a general account of the measures taken to carry out the intention of Congress in establishing the Commission of Fish and Fisheries, I now proceed to give in more detail a statement of what has been done generally in regard to the multiplication of the species of fish considered of most importance, and the various interests connected with the fisheries, to which a brief sketch of the theory and practice of so-called fish-culture may not be an unacceptable preliminary.*

The subject of securing from the fresh waters and the sea a larger supply of fish than they would spontaneously afford has attracted the attention of various nations from a very remote period; one of the simplest methods consisting in the collection of fish into natural or artificial ponds or reservoirs, and by allowing them to prey upon each other, or else by supplying food to them artificially. This was in vogue among the Romans especially, and it is asserted that not unfrequently the food thus supplied consisted of the flesh of slaves, which it was claimed imparted to the fish a delicate flavor, especially to the lampreys and other favorite species. This method of treating fish is, however, scarcely to be regarded as a branch of fish-culture in its restricted sense.

According to Soubeiran, in a recent and very complete summary of the history of fish-culture†, the first essays made in this direction in

*A fuller account of this will be found in the History of Fish-Culture, page 465.

†La pisciculture et la pêche en Chine par P. Dabry de Thiersant, consul de France, membre honoraire de la Société d'acclimatation; ouvrage accompagné de 51 planches, représentant les principaux instruments de pisciculture et engins de pêche employés par les Chinois et quelques nouvelles espèces de poissons recueillies en Chine par P. D. Thiersant, précédé d'un introduction sur la pisciculture chez les divers peuples par le Dr. J. L. Soubeiran, professeur agrégé à l'École de pharmacie de Paris, secrétaire de la Société d'acclimatation.

Europe were by Dom Pinchon, in the fifteenth century, at the abbey of Reôme, near Montbard, in France, and in a manuscript dated A. D. 1420, belonging to the Baron de Montgaudry, describing his process, it is said that it is necessary to have long wooden boxes, with solid bottoms, but with wicker-work at the ends, open above, and covered with a willow grating. At the bottom of the box is to be placed a bed of fine sand, and a slight groove is to be made in the sand, in which to deposit the eggs, which have previously been fertilized. The trout is to be kept in a gentle current of water; and as soon as the discharge of ova has taken place, (the period of which is carefully watched for,) and these are fertilized by the milt of the male, the eggs are to be removed to the boxes referred to, and allowed to remain until hatched out.

About the middle of the eighteenth century the subject of fish-culture was again brought into notice by the experiments of Lieutenant Jacobi, of Hoenhausen. An account of his labors forwarded to Count de Goldstein was translated into Latin by that gentleman, and later into French by Duhamel du Monceau. The method adopted by Jacobi was that of modern times, namely, the squeezing of the ripe eggs from the body of the female into a dish partly filled with water, discharging upon this the milt of the male, stirring them well together, and afterward placing them in the boxes for hatching.

According to Adanson, as early as 1772 some form of artificial fecundation, of trout especially, was made use of on the borders of the Weser, in Switzerland, in the Palatinate of the Rhine, and in many of the more elevated regions of Germany.

The methods of Jacobi, and his results, seemed for many years to have passed into oblivion, although various experiments were made for some time after, in one country or another, looking more particularly toward the increase of the salmon and the trout. No material progress seems to have been made, however, until the time of Joseph Rémy, a simple fisherman of Bresse, a village in the Vosges, who by his own ingenuity discovered the general theory of artificial fecundation, and again carried into effect, but much more efficiently, the methods of Jacobi. To him is due the fuller appreciation of the importance of artificial fecundation, and of protecting the eggs and young fish during the period of greatest danger. It is well known that there is no more attractive food for aquatic animals than the roe of fish, even the very parents of the eggs in many cases devouring them greedily. It is not too much to claim that, as a general rule, 60 per cent. of all eggs are devoured before the young are hatched; and it is also certain that of the latter, three-fourths are probably eaten while in their helpless condition, with the yolk-bag attached, and before they are able to feed themselves and to take the natural precautions for their safety.

Again, a serious loss is experienced in the uncertainty of natural fecundation, many of the eggs failing to receive the spermatic fluid, and of course remaining inert. The estimate has repeatedly been made that

if 5 per cent. of the number of eggs laid under natural conditions by the parent become young fish, able to feed for themselves, it is rather more than a usual occurrence. Of course, subsequent to this stage they are exposed to numerous dangers before the perils of immaturity are passed. On the other hand, if more than 10 per cent. or even 5 per cent. of those artificially hatched fail to reach the same period of existence, especially in the case of the eggs of the salmon and trout, which are large, and are usually more carefully manipulated, it may be considered as unsuccessful management. This fact, which is one of the most important features in the success of artificial hatching of fishes, was appreciated by Rémy, and provided for in his various methods. These he practiced with only one associate, named Gehin, for several years; but it was not until 1849 that they became known to the scientific world through Haxo and Professor de Quatrefages. The subject was taken up by the French government, and the final result was the erection, at Hüningen on the Rhine, of a great French national establishment for the artificial cultivation of fish, and their distribution to the adjacent waters, under the direction of Professor Coste, of the College of France.

This took place in 1851, and the work was carried on by the French with varying success until the capture of Alsace and Lorraine by the Germans. The Hüningen station, being now within the German limits, is still maintained as a piscicultural establishment, and is under the immediate charge of Dr. Haack, one of the most eminent pisciculturists in Europe. The *Salmonidæ* receive chief attention at this establishment, although some species of other families are cultivated. It was from this place that the salmon-eggs already referred to as presented by the German government to the United States were supplied.

At the present day there are few countries of Europe where fish-culture in some form is not prosecuted. There are numerous establishments in France, Germany, Great Britain, Norway, Sweden, Russia, Denmark, Holland, Belgium, Italy, Spain, &c., while even in India, Java, and Australia more or less attention is given to the subject.

The claim has been raised in behalf of China as having earliest practiced pisciculture. But if by this we mean the artificial fecundation of fishes, and raising them in limited spaces, the assertion cannot be sustained. It is very true that great ingenuity is expended in China in securing the fertilized eggs of fishes after they have been already deposited by them, and in rearing the young, as well as in stocking waters with the most approved varieties. In this respect, indeed, they may be said to have prosecuted the art of aquiculture as well as of agriculture from a period far antedating the practice of the same by any other nation. They, however, as far as the eggs of the fishes were concerned, confined their efforts to finding the localities where these had already been laid, or else to straining them out of the water by means of fine nets, mats, or gratings, and then they either hatched them out on the spot or carried them to great distances throughout the empire. It is,

however, for the United States that we may claim the fullest development of the art of pisciculture, both as to the perfection of its methods and the extent of its operations.

On the authority of the Southern Cultivator, the Rev. Dr. John Bachman, of Charleston, S. C., as early as 1804, at the age of fourteen, impregnated and hatched the eggs of trout and other fishes. This has been questioned by some; but Dr. Slack, in his work on trout-culture, well remarks that Dr. Bachman's reputation as a Christian and a naturalist is too well established to permit us to doubt his word. It is not pretended, indeed, that the idea was original with him, but he probably found in the work of Duhamel du Monceau the account of the methods of Jacobi and imitated them.

In 1853 Dr. Theodatus Garlick and Professor Ackley established a fish-farm near Cleveland, Ohio; the result of their experiences being published in Dr. Garlick's work, entitled "A Treatise on the Artificial Propagation of Certain Kinds of Fish; Cleveland, Ohio, 1857."

In 1859, Mr. Stephen H. Ainsworth, of West Bloomfield, N. Y., began his experiments, and has continued them up to the present time. Since then, numerous establishments have been started, more particularly devoted to the culture of the brook-trout, meriting and meeting a greater or less degree of practical and pecuniary success.*

I am indebted to Mr. Stone for a list, brought up to 1872, of persons at that time known by him to have been engaged in the practical work of fish-culture, or more or less interested in itssuccess. Although necessarily incomplete, I have given it in the appendix as the basis of a fuller enumeration hereafter. Among the more prominent names in this connection we may mention the world-renowned Seth Green; Dr. J. H. Slack; Livingston Stone; William Clift; S. H. Ainsworth; A. S. Collins; N. W. Clark, &c.

16.—ACTION OF STATE AND NATIONAL GOVERNMENT.

The recent establishment of the American Fish-Culturists' Association, a society designed to bring together those interested in the subject, promises to be of great benefit in advancing a correct knowledge of the best theory and practice of the science of fish-culture. It is to this body, under the presidency of Mr. George Shepard Page, that we owe the first movements which resulted in the recognition, by Congress, of the national importance of fish-culture, and in the appropriations for the multiplication of useful food-fishes in the national waters.

As already stated, (page xvi,) it was in 1872 that the subject was presented to Congress and favorably acted upon; the result being an appropriation of $15,000 "for the introduction of shad into the waters of the Pacific States, the Gulf States, and of the Mississippi Valley, and

* Fuller details in regard to American fish-culture are given farther on in the article by Mr. Milner, page 523.

of salmon, white-fish, and other useful food-fishes, into the waters of the United States, to which they are best adapted," for the fiscal year of 1872–'73, with a supplementary appropriation of $10,000 for the same year, having special reference to the propagation of shad. A further appropriation of $17,500 was subsequently made for the same object during the fiscal year of 1873–'74. This action on the part of the United States was the natural culmination of what had already been done by many of the States, accelerated by the action of the American Fish Culturists' Association. (See page xvi.)

At an early period the subject of protecting the fishes, if not, indeed, of their actual multiplication, was brought before the legislatures of certain States, and various laws were enacted, and commissioners appointed to attend to their enforcement. In many instances their efforts were restricted to preventing injurious, unseasonable, and excessive fishing; but in others they were also instructed to take such measures as lay in their power to increase the supply. This has already been done to a greater or less extent in the States of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island; Connecticut, New York, New Jersey, Pennsylvania, Virginia, Alabama, Ohio, Michigan, Utah, and California, as well as in the Dominion of Canada; and as year by year the number of States taking action in this matter and extending operations therein is increasing, there is little doubt that before long nearly all the members of the Union will have fish commissioners duly appointed and qualified to act in reference to this important branch of our internal resources.

A list of the States which to the present time have appointed commissioners, with the names of the officers themselves, will be found in the accompanying appendix, and also a bibliography of the reports published by them. While, however, the action of the commissioners of the several States has reference to restricted localities, and to introducing new varieties, or increasing the supply in ponds, small lakes, and streams, they have not been disinterested enough to take charge of waters which constitute State boundaries, or where the benefits are likely to be shared, if not entirely reaped, by citizens of other States. For this reason some of the more important rivers, and the entire system of the great lakes, the best subjects for the experiment, have been entirely neglected; and as these constitute the common waters of the United States, it was thought desirable for Congress to take charge of them, and to do whatever was possible within a moderate cost to increase the supply of food to be derived from them. Thus, it was impossible to secure State action, in stocking the Mississippi with the anadromous fishes, or those that run up from the ocean to the headwaters of the streams to spawn, the shad for instance, which it is believed can be made as abundant in that river and its tributaries as it now is in any other waters. Wherever the young fish may be introduced, after reaching a certain size they will descend to the Gulf of Mexico, returning in the course of three or four years, if permitted, to the spot

from which they originally started. Supposing a locality in Ohio to have been their first abode, there will be nothing to prevent the citizens of all the States intervening between that place and the Gulf of Mexico from arresting the upward returning run, and capturing a portion, if not the entire body of the fish, so that little or no benefit would inure to the parties through whose instrumentality this result was rendered possible.

As far as the United States is concerned, however, it is a matter of no consequence who take the fish, since the great object is to increase the supply of food to the nation at large, and every capture, whether in Ohio or Louisiana, will tend to accomplish the same general result.

After any species of fish has become permanently established in a given body of water, their continuance therein will depend in great measure upon the enactment of suitable laws, securing their access to suitable spawning-grounds, and protecting them during the critical period of their existence, from capture or unnecessary destruction. Otherwise the methods of artificial propagation must be resorted to indefinitely. The various measures required for the protection of fish will be referred to hereafter.

17.—COMPARATIVE VALUE OF ANADROMOUS AND OTHER FISHES.

In reference to the fresh-water fishes most worthy to attract the attention of the General Government or of the States, the distinction between resident species and those that are anadromous, or which spend a part only of their life in the fresh waters and the remainder in the ocean, must be clearly borne in mind. The species which belong exclusively to fresh water, such as the brook-trout, the lake-trout, the land-locked salmon, the white-fish, the black bass,* &c., are well worthy of attention, and by judicious treatment can be introduced into new waters, or their numbers greatly increased in any particular locality. But, after all, there is a direct relationship between the number of any kind of fish of a given weight and the amount of water needed to furnish a supply sufficient to add definitely to that weight of food; and when the limit has been reached, we cannot, without feeding artificially, advance upon the proportion. Where the waters are pure and constantly renewed, and a suitable supply of healthful food is furnished regularly, large numbers of fish may be kept and cultivated, where not one in ten thousand would find an ample supply of natural food; but, as a general rule, the expense of feeding is such as to render the sale at comparatively high prices necessary for a satisfactory result.

It must be remembered, too, that however rapidly certain fish, especially the black bass, multiply in new waters, there is a limitation to their increase, as shown by the experience of the Potomac River.

* All these species are able to live for a time in salt-water, and, indeed, if no obstacle intervene, may run down to the sea for a time; but by far the greater number belong to the interior waters of the country, and have no opportunity for such experiences.

This fish was introduced into this stream in 1854 by Mr. William Shriver, of Wheeling;* several mature fish having been transported

*As an important contribution to the history of the black bass and of the measures taken to introduce it into new waters I reproduce a letter by John Eoff from the report of the Smithsonian Institution for 1854:

"On my return from a small hunting expedition to the headwaters of Sand Creek, Jackson County, Virginia, I found your kind letter of November 26, 1854; and, in order to comply best with your wishes and views therein expressed, I will give you such a description of one particular species of fish, (which I consider the most valuable, on account of their quality as a pan-fish and their quantity,) in our western streams, viz, the bass, (called by the early settlers in the western country yellow or black perch.) They are a remarkably active and voracious fish, with a large and hard mouth, and vary in size, according to their age, from three-quarters of a pound to three pounds, and occasionally have been caught to weigh as high as six pounds or seven pounds. Their food, when small, appears to be all kinds of insects, (flies, worms, &c.;) when larger, though not entirely leaving off their earlier habits, their principal food is the smaller fish of other kinds. In the winter-season they retire to deep and still water, and apparently hide under rocks, logs, &c., and remain there until the first of April, when they come out and begin to ascend the streams, apparently to find a convenient place for spawning, which commences about the 15th of May, varying some little according to the warmth of the season, &c. When that event is about taking place, they appear to separate into pairs, male and female, and hunt out some retired place, or nook, where the water is about eighteen inches deep, and still, but adjoining deeper water, to which they can escape if alarmed; they there commence making their nests, that is, washing all the mud, &c., off the bottom, so as to leave it perfectly clean, in a circular form, the diameter of the circle (or nest) being about twice the length of the fish; after which the female begins depositing her eggs, which appear to become glued to the bottom, or small stones, in rows, after the deposit has taken place. She remains night and day, either on her nest, or swimming round about it, apparently guarding the eggs, and driving every other smaller fish away. This watching or guarding continues until the eggs are what is called *hatched*, which occurs in from eight to ten days, according to the temperature of the water. The young fish at first remain near the bottom, and appear like a gauze vail floating. In two or three days they gradually rise and spread, the old one leaves them, they separate, and each one shifts for itself, *i. e.*, hides under leaves, small sticks, and stones.

"I, as yet, have had no positive means of determining the precise time for a young bass to arrive at *maturity*, but suppose it to be three years, from the following facts: In the spring of the year (April) you may find large numbers of young bass about two or two and a half inches in length, rather in company with other minnows; in the following autumn and fall of the year you will find very few of that size, but congregating together, and alone, you will find a number from three to four inches in length; while during the same fall you may catch young bass of about eight inches long, with the formation of the young egg within them, preparatory for spawning the following spring. In the spawning-season you will find a large number of nests of small bass, the bass being ten or eleven inches long, which I have always concluded were three years old. Hence, from the above facts, you will perceive that the bass of our western country are valuable, and, at the same time, can be easier transferred, and in greater quantities, from one stream to another, than almost any other fish. All that is necessary to supply a pond with any quantity would be to examine their nests at the time they are spawning, and to pick up the small gravel out of their nests, with the eggs attached thereto, and put them in a bucket of water, and place them in your pond, in such a position that smaller fish could not devour the eggs; and in a short time they would hatch, and the young ones would help themselves. Or, to secure a larger quantity in a short time, wait until the young are hatched, and are in innumerable quanti-

in the water-tank of a locomotive from the Ohio River, at Wheeling, to Cumberland on the Potomac. Not many years after, the young fish began to distribute themselves in numbers, and in time the entire river became thoroughly stocked with the new game. Starting at the head-waters of the river, the bass found immense numbers of *Cyprinidæ*, such as chubs, minnows, suckers, &c., as also of crawfish, insect-larvæ, and the like, which had been previously, for the greater part, undisturbed, except, perhaps, by the pickerel, and, having an ample supply of food, in accordance with the theory of natural selection, they multiplied to a prodigious extent. Year by year they extended their limits toward the mouth of the Potomac, until at the present time they are found in great abundance near Washington, and form a very attractive object of sport.

I am, however, informed by residents on the Upper Potomac and its tributaries that the bass are becoming scarce, and that their numbers are much less than a few years ago, while, as a concomitant, the immense schools of smaller fry, formerly so abundant, have disappeared, a minnow in some localities being a rare sight. This is a very natural consequence, and must produce its result. In the increasing scarcity of herbivorous fish, the bass will be driven to feed more and more upon each other, and after a time a certain average will be established, perhaps the same as that existing in the waters of the Mississippi Valley and elsewhere, where, although indigenous, they are in proportion fewer than in the Potomac River.

An entirely different condition of things prevails with the anadromous fish, among which we may enumerate as best known the shad, the alewife, or the fresh-water herring, the salmon, the smelt, and probably the striped bass. These fish spend the greater part of their existence

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ties suspended over the nest; then, with a piece of gauze net, dip them up and empty them into a vessel containing as much pure water as will sustain them until you can convey them to your pond; and then, as I before observed, they can support themselves, while young, on insects, &c. Or, early in April or May, if you are fond of angling, you can go to a stream in which they are plenty, and, in catching fifteen or twenty, will almost always get nearly one-half the number smaller ones. Put these into your pond unhurt; and, as they have not spawned that season, they will soon stock the water. Then all that remains to be done is to supply your pond with other small fish, minnows, &c., for food for the large bass, and they will increase in quantity just in proportion to their supply of food. Hence I am satisfied that if a farmer would convert one acre of his land into a pond, well supplied with fresh water, that acre would raise and support more fish yearly (the value of which would be more) than any other two acres cultivated in any other manner—the expense of cultivating deducted from each.

"Mr. William Shriver, a gentleman of this place, and son of the late David Shriver, esq., of Cumberland, Md., thinking the Potomac River admirably suited to the cultivation of the bass, has commenced the laudable undertaking of stocking that river with them; he has already taken, this last season, some twenty or more in a live box, in the water-tank on the locomotive, and placed them in the canal-basin at Cumberland, where we are in hopes they will expand and do well, and be a nucleus from which the stock will soon spread."

in, and derive their chief growth from, the sea. At certain seasons of the year, when fat and plump, they enter the rivers and proceed usually as far as the obstructions will permit, or until they find their proper spawning-ground; here the eggs are discharged, fertilized, and hatched. The adults either return immediately to the ocean or after a certain interval. The young fish spend a certain period in the fresh waters, feeding, it is true, but on minute organisms, which are always procurable in abundance.

Shad and herring enter the rivers and spawn in the spring, and the young return in the autumn. The eastern salmon enter the rivers in spring, and spawn in the autumn, the eggs not hatching until late in the winter. The young remain for one and some of them even for two years, and then go down to the sea. After a certain interval these fish return to their birth-place, the shad, at the age of three or four years, weighing from three to five pounds; the salmon after the same interval, weighing from nine to twelve pounds; this immensely rapid growth having taken place in the ocean, and without requiring anything in the way of human intervention. For this reason it is that the efforts necessary to the multiplication of anadromous fish may be limited to securing a proper passage of the adults to and from their proper spawning-grounds, or, in addition, to the securing of their eggs in numbers, and placing the young when hatched, and after a suitable interval, in the water where they are to pass the period of their infancy. Nothing, therefore, is asked of the waters but the right of way, the adults rarely taking food of any kind while in the rivers. Their sustenance during this period is derived from the surplus of fat in their own bodies, and the exhaustion produced by this period of abstinence, especially with its accompaniment of the development of the eggs and their fertilization, being made up by the voracity of their feeding on returning to the ocean.

The species just mentioned all live in the ocean and run up into fresh water to spawn; the list being capable of considerable addition. Other fishes, again, live in large bodies of fresh water, as lakes, and run into tributary streams or outlets for a similar purpose, and are thus anadromous likewise. The *Coregonus* or white-fish, are almost universally anadromous; also the land-locked salmon, the oquassa-trout, or blue-back, the fresh-water smelt, &c.

In this connection it may be interesting to refer for a moment to the difference in habits between the common eel and the species just referred to. This, like the others, is an anadromous fish, or better, perhaps, *catadromous*, the order of its movements being reversed. The eggs of eels, for the most part, are laid in the sea, and the young, after a short interval, enter the mouths of rivers and streams in early summer and pass up as far as an open passage will permit. The adventurous visitor to the Cave of the Winds, under the water-sheet of Niagara Falls, is struck as much by the immense number of young eels swarming against

the rocks and attempting to climb over their surface as by any other feature, the numbers to be seen being simply incalculable.

After reaching a suitable place of abode, in fresh water, the eels remain, as is supposed, for at least three years, growing to a considerable size. After becoming sufficiently mature, their instinct, probably that of reproduction, carries them seaward again during the autumn; and it is at this time that various forms of fish-dams and fish-weirs are called into requisition. The simplest kind consists of two lines of stone wall, forming the sides of a rude dam, made so as to converge and bring the angle down stream, through which the passing water falls into a sort of basket. This consists of a frame with lattice-work at the bottom, so arranged that, while the water passes through, the fish are forced up over the slats, arranged so as to form a series of slides, and fall into a receptacle beyond, where they are taken sometimes by wagon-loads. The most productive result of this mode of fishing consists of eels intercepted in their seaward movement, although other fish are often taken. It is very destructive to young shad and is very properly interdicted by the laws of Pennsylvania and New Jersey, in their shad-rivers.

The laying of the eggs, it is supposed, takes place in the autumn, or winter, and the young begin to move up in the spring, or early summer.

In further reference to the history of the eel, we may state that its precise mode of copulation and of reproduction was entirely unknown until recently, but that at the present time the view is maintained by very high authority, principally that of Italian physiologists, that the eel is strictly a hermaphrodite; that is to say, that both the male and female organs are found in the same animal. These are said to be developed to the proper degree in winter, and the eggs discharged from the ovary are fertilized by the seminal fluid from the testicles, and leave the body in a condition for further development.

18.—DIFFERENT METHODS OF MULTIPLYING FISH.

We have already indicated in the previous remarks some of the principal methods devised for increasing the number of fish in a given locality, but it may be well to refer again to this in a more systematic manner. Capturing fish in one locality, and transferring them to another, simply for the sake of greater convenience in securing them when wanted, does not come under this head. The fish-ponds of the ancient Romans, and the floating boxes or cars in which living fish are kept by fish-dealers, belong essentially to the same category. As far as the actual multiplication of fish is concerned, we have to deal especially with four principal methods.

The first, and simplest, consists in transferring fish of both sexes, whether still young and requiring further growth, or fully mature, and especially at about the period of their spawning, from one locality to another, where they can make themselves at home, and in due course of time increase and multiply.

This method has been more especially practiced in the United States in the case of black bass, pickerel, * pike-perch, yellow perch, alewife or fresh-water herring, the brook-trout, &c., and to some extent, indeed, the white fish, or *Coregonus albus* † and, indeed, is almost the only method by which it is possible satisfactorily to accomplish the desired object; the efforts of pisciculturists not having been very successful in impregnating the eggs (excepting with the white-fish) and hatching them out, although there would be no particular difficulty in regard to the alewife.

A second method, quite similar to the first, consists in simply collecting and penning up the mature fish in a suitable inclosure at about the time of spawning, and keeping them until the operation of reproduction is accomplished, but without taking any special charge of the eggs themselves.

The third is that especially practiced by the Chinese, of collecting the fertilized spawn, after it is laid, either by gathering it from localities under the water where it has adhered, or by straining it out while floating. The first method is in some instances assisted by introducing bunches of ozier or brush into the water frequented by the gravid fish, so as to furnish convenient objects of adhesion, and such as can be readily handled for the purpose of removing the eggs from them. The

* From a very early time in the settlements of the different States, the transfer of live fishes has been attempted. One of the first species that attracted what was really a most mistaken interest was what is known as the pickerel, and represented by at least two species, the *Esox reticulatus* in the streams of the Atlantic slope, and the *Esox lucius* west of the Alleghanies. This must not be confounded with the so-called pickerel (the *Lucioperca americana*) of the Lake Erie shores.

This genus (*Esox*) is among the most ravenous of predacious fishes. They have a wide mouth, with a formidable armature of long, sharp teeth, and are long, slender, clipper-like creatures, swift in the water, where they are able to run down ordinary fishes, or, lying concealed, as is their habit, in the sedge and rushes at the edge of the clear channel, dart suddenly upon the passing fish. They are very bony, of indifferent flavor, and it is only where people are undiscriminating in their choice, from the lack of opportunity to compare them with better food-fishes, that they consider them desirable. They attain considerable size and take the hook eagerly, but their destructiveness of much superior fishes should condemn every effort to propagate them or to extend their distribution.

It is a singular coincidence that in earlier times in portions of Europe the same species as our western one (*Esox lucius*) was introduced into new waters rather extensively, and it is now acknowledged to be a most mistaken enterprise.

The commissioners of Maine have expressed their regret at the misguided enterprise of citizens of that State in introducing the pickerel into certain rivers and water-systems.

† One of the earliest experiments in the transfer of fish, other than pickerel and black bass, to new waters, was made by Governor L. J. Farwell, of Wisconsin. In 1854 he had one hundred fine, large white-fish carried alive to Madison and deposited in good condition in Lake Mendota in Dane County. A careful examination a few years later showed that they had increased rapidly, and occupied the deepest part of the water. In 1858 they appeared on the northeastern side of the lake, where they were caught in considerable numbers. A concurrent transfer of brook-trout into a tributary of the lake was not so successful.

eggs thus secured may then be transferred to any given locality and allowed to hatch naturally; or else beds are artificially prepared and attended until the birth of the young, when these are either allowed to escape into the water at once, or else they are fed for a short time, and then consigned to the ponds or streams which it is desired to stock.

All these methods are inferior in convenience as well as in economical results to the fourth, which is adopted by most fish-culturists throughout the world. This consists in taking up the fish when ripe, and, by suitable manipulation, in pressing out eggs from the body of the female into a dish, and then by repeating the operation with the male, so as to force the seminal fluid into the same vessel. In some cases the eggs and milt are stirred together in a certain amount of water; in others, what is called the dry method is adopted, a discovery usually credited to a Russian, M. Vrasski, in which no water is used with the eggs, but the milt is slightly diluted with water and poured upon them. By this method a much larger proportion of eggs is impregnated.* The movements preliminary to this treatment of the eggs taken from the living fish are also very varied. In many instances a careful watch is kept over localities where the fish are likely to spawn; and when the experienced observer notices that the operation of spawning is about to take place, he captures the usually inattentive pair by means of nets or other suitably-constructed apparatus, and proceeds with the work of exclusion and fertilization. This is said to be the principal method by which the eggs of the salmon are obtained in Germany and elsewhere for the national and private establishments, and is liable to the disadvantage of great uncertainty, and to a dependence upon conditions of the atmosphere and of the water that may materially interfere with the general result. Most of the doings in connection with the hatching of shad are of this nature; the seine being swept at a suitable locality, and the fertile fish stripped of their eggs and milt. This operation is always fatal to the shad, their delicacy of constitution not enduring such rough handling with impunity. It has also been adopted in some cases for salmon, having been employed by Mr. Livingston Stone in obtaining their eggs during the season of 1872.

The eggs of the white-fish and lake-trout are usually obtained at the fisheries, and the eggs after impregnation sometimes taken to great distances to be hatched. (See Mr. Milner's Report.)

A much more satisfactory and efficient method consists in inclosing the fish in pens or pounds until their eggs and milt are sufficiently matured to allow the process of artificial fecundation to be initiated. With trout

* Although M. Vrasski may have been the first to actually publish this method, Seth Green is said to have discovered it, keeping it a profound secret from his fellow-fish-culturists, who could not understand why so much larger a percentage of Green's eggs should be productive than of their own, although they followed strictly the method advanced in his treatise on fish-culture. This, however, made no mention of the dry process. The claim of priority in regard to the dry process has also been made in behalf of Carl Vogt. (See George P. Marsh on Artificial Propagation of Fish, Burlington, [Vt.,] 1857, p. 35.)

such an inclosure is usually permanent, but for salmon it is generally temporary. This treatment is also adopted with the white-fish which are taken in the Detroit River in the fall of the year, while running up to spawn from the deep water of the lake, placed in inclosures for marketing purposes, and kept there for sale, from time to time, during the winter. Indirectly, under these circumstances, they furnish the opportunity for artificial impregnation and hatching on a very large scale.

The simplest mode of obtaining salmon for the purpose in question is that adopted by Mr. Samuel Wilmot, at New Castle, Ontario. This gentleman, observing a few years ago that a few salmon were in the habit of coming up a small stream to a favorite spawning-ground, conceived the idea of penning them up so as to control them during the period of reproduction. He accordingly built a house over a basin in which they collected, or adjacent to the spawning-ground, and erected a dam below it, so that after they had passed above a gate could be dropped and the fish imprisoned. In this way he has been able to secure a large number of salmon, and with them has carried out, for the most part, his labors in connection with salmon-hatching.

A more feasible method, and one which can be conducted out on a much larger and more efficient scale, is that now practiced by Mr. Charles G. Atkins at Bucksport. This consists in securing the living salmon by any means at his command, the most ready being their purchase at the salmon-weirs at the mouth of the Penobscot River, where they are taken in considerable numbers and kept alive for any length of time. These are brought in suitable floating cars to Bucksport, transported on trucks to the hatching-establishment, and placed in a pond of about one hundred and fifty acres, where they find ample room for their movements.

The various methods of effecting the impregnation of the eggs has been already referred to, and the subject is treated of in detail by Mr. Milner in the appendix.

As already explained, it is not necessary to provide the breeding salmon with food, since they do not take it during the spawning-season; and they exist for the several months necessary to retain them with comparatively little mortality. Mr. Atkins's experiment was initiated in 1871. In 1872 he had nearly six hundred fish by the 1st of July, of which very few were lost. In the months of October and November he took from these fish 1,500,000 eggs, very few of the fish being injured in the process. They were then placed in the water and permitted to return to the sea, the precaution being taken to affix a metallic tag corresponding to the number, weight, and sex of the fish, and the date as recorded, so that if recaptured at any time some idea might be gained of their rate of growth, movements, and migrations.*

The eggs thus obtained, whether of salmon or of trout, are hatched

* For a full account of Mr. Atkins's experiment, see his report, p. 226 of the present volume.

out in contrivances which vary with the kind of fish, and which will be more especially referred to hereafter. Suffice it to say that those of shad are hatched in boxes which float on the water of the stream adjacent to the camp where the fish are captured and fertilized; this being accomplished within a week, and after a further detention of a few days, or until the yolk-bag is absorbed, they are turned into the middle of the stream at night while the predacious fish are most quiet or lying near the shore, and soon find hiding-places for themselves.

The eggs of salmon and trout require a period of from two to four months for development, this being in the winter-season. This process consists in placing them in boxes, with the bottom composed of parallel glass slats or of solid boards, lined with gravel, over which water of uniform temperature is allowed to flow continuously until the exclusion of the young takes place. Sometimes trays are used with wire-gauze bottoms, either singly or in tiers, and the water caused to flow either from above downward or the reverse. After this the young are sometimes transferred to some other receptacle until the yolk-bag is absorbed, when they are either introduced into rivers and streams or else retained in ponds and fed artificially for a greater or less length of time.

The key-note to the treatment of the anadromous fish lies in the now well-established axiom that each will always endeavor to return to spawn, if possible, to the very spot where it was first introduced into the water as a young fish, and that it will make every effort to accomplish this result; sometimes incurring even loss of life by persistent labor to this end. This is fully believed by all who have given attention to the subject, and in this we have the guarantee of success in any attempt to stock a particular body of water. It is true that the labor would in many cases be a profitless task, since the reaper might be, as already explained, and probably would be, a party having no interest in common with the sower. So universal, however, is the principle just enunciated, that we are assured that if three streams empty into the same bay on the coast, or are tributary to the same principal river, and all are equally eligible for the maintenance of anadromous fish, although destitute of them, one of these may be stocked and abound with fish, while the others which have been neglected will be almost entirely unvisited or will possibly become supplied very slowly and after a long period of time.

The existence of obstructions in a river, natural or artificial, is always detrimental in preventing the ascent of fish from the sea. If the young are introduced artificially into the headwaters, they will pass down after the proper period, and will remain in the sea for two or three and possibly sometimes for four years, when they will return, and, as already explained, use every effort in their power to reach their original station. If arrested at any point by an impassable dam, they will become the prey of such fishermen as have the right of access to them, while the upper waters will remain destitute and no captures be possible therein. For

this reason it is that the action of State or general governments in regard to the multiplication of salmon and other anadromous fish may even be carried on without any reference whatever to the existence of dams; and as far as the general interests of the community are concerned, it perhaps may be in many cases much cheaper to continue the artificial fertilization and development of the eggs, and the planting of the young in suitable waters, than to require the inconvenience and expense of removing artificial or natural obstructions or of inserting costly fish-ways. After the preliminary stages have been performed, the expenditure of a few hundred dollars a year will be sufficient to insure the presence of many thousands of shad and salmon in the lower waters of a given stream. Of course, to provide for the natural multiplication of the species and their equal division throughout the entire valley of the stream, the dams or obstructions must be regulated as already referred to.

19.—TREATMENT OF CERTAIN SPECIES.

The hatching of shad.

The boxes most generally in use at the present time for shad-hatching we owe to the ingenuity of Mr. Seth Green, and their introduction constituted an era in the art of pisciculture. The ordinary methods for the development of fish-eggs would not answer the purpose for the shad, and all attempts at hatching in the regular establishments would be practically a failure in consequence of the comparatively small number that could be managed by the usual methods, while an immense aggregate is required to produce even a moderate effect upon the supply in a stream.

The idea of a floating box is by no means new, such instruments having been used in Europe for many years, especially for hatching out the eggs of the *Cyprinidæ*, which adhere to whatever they touch, and require careful treatment. Mr. Millet used floating boxes in 1853 for hatching trout and salmon. The difficulty in hatching shad existed in the fact that when the boxes floated in the water so that the bottoms were horizontal, the proper circulation inside of the box was not established, and the eggs would spoil when exposed to the heat of the sun in consequence of their crowded condition. By the simple expedient of nailing two strips of board scantling parallel to each other, one on each side of the box, at an angle inclined to the bottom, the boxes are made to float obliquely in the water, since the strips themselves floated horizontally, and caused the bottom to be tilted up. The boxes are anchored with the inclination up stream, so that the current of water, striking freely against the inclined face of the wire gauze, which constitutes the bottom of the box, passes through it with a constant flow, producing the necessary motion in the eggs. By means of this device it has become possible to hatch shad by millions, where results would necessarily have been limited to thousands.

Several modifications of this box have been made, the most prominent of these being that invented by Mr. Brackett, and used for the first time in 1873. In this the box floats horizontally, but has the up-stream end beveled, and the water striking against it produces an eddy under the box, which causes a gentle agitation of the eggs. The details of this and some other constructions will be found in Mr. Milner's article in the appendix. None of them, however, can compare in simplicity and efficiency with Seth Green's apparatus.

In hatching the eggs of shad, much depends upon the temperature, and when the water is above 80° it is very difficult to bring them forward properly; indeed, the fish appear to experience a loss of vitality, and toward the end of the season apparently sound, ripe eggs fail to develop, notwithstanding every care. When, therefore, the stream reaches the degree of heat in question, the work is considered to be over for the year.

The hatching of white-fish, trout, salmon, &c.

An ingenious device has lately been patented by Mr. M. C. Holton, one of Mr. Green's assistants, for the purpose of securing the development of a large number of eggs from the trout, salmon, and white-fish in a limited space. Instead of placing a single layer of eggs in a long, narrow trough, he has prepared a can or box, of perhaps a foot square and several feet in height. This is filled with shallow trays of about half an inch in depth, with wire-gauze bottoms, on which the eggs are placed, so that with twelve trays, having a surface of one square foot each, he accommodates twelve times as many eggs as by the ordinary method. The box is so arranged that a current of water is carried by a covered pipe down the side of the can to the bottom and allowed to enter at that point. The current in its overflow passes from the bottom to the top, and the water circulates freely over the eggs. This arrangement has the additional advantage that once a day, or oftener if necessary, the trays can be taken out singly, and any diseased or defective eggs removed, thus improving the entire mass.

The eggs of white-fish require a long time for their development, like those of the salmon and trout needing from two to five months, according to the temperature of the water employed. The lower the temperature the longer the period necessary. The general theory of the development of eggs varies very much, according as they are smooth and non-adhesive, or coated with mucus which causes them to attach to each other or to other objects. The latter characteristic belongs to the *Cyprinidæ* in general, such as chubs and suckers, to the yellow perch, and many other kinds, for which reason it is extremely difficult to hatch these out. But little has been done in this country in that direction, and here the European culturists have the advantage of us. I owe to the kindness of Mr. Rudolph Hessel, one of the best of the German pisciculturists,

an account of the method of properly manipulating the adhesive eggs, which will be found in the appendix.

Fortunately the shad, striped bass, and the *Salmonidæ* generally, with perhaps only the exception of the smelt, have smooth or non-adhesive eggs, which permits them to be fertilized and readily manipulated without the inconvenience caused by their sticking together.

It is not my purpose to present here a treatise upon pisciculture in general, as I have nothing to add to the works already published on the subject, and which have been prepared by practical men of great experience. Among the most recent works are those published by Dr. J. H. Slack and Mr. Livingston Stone,* and in them will be found all the best-known methods of treatment, and especially for the trout. I hope, however, to present hereafter some special details in regard to other species that have been developed in connection with the operations of the United States Fish Commission.

The hatching of striped bass.

Nothing was known until recently as to the treatment of striped bass; but Mr. M. G. Holton, already referred to in connection with the improved apparatus for hatching the eggs of the *Salmonidæ*, while in the employ of Mr. Seth Green on account of the United States Fish Commission, at Weldon, N. C., took occasion to experiment with the spawn of several of these fish. To his surprise he found that it was non-adhesive, precisely like that of the shad, and capable of being treated in the same manner. The eggs were hatched out in four or five days, and with a small percentage of loss. They, however, were considerably smaller than those of the shad, requiring the bottom wire of the boxes to be much finer; twenty-two wires to the inch, at least, being needed.

It is unnecessary for me here to go into detail concerning the special method of treating the eggs of such fishes as the salmon-trout, the brook-trout, and other species, as these are discussed in detail by Mr. Milner in this volume, and are also considered at length in the various special American treatises.

Having thus presented a very brief indication of the history of multiplying certain of the food-fishes as practiced in modern times, and having explained the general principles of the method adopted for the purpose, I proceed to discuss more particularly the economical importance and history of the species of fish to which the attention of the commission has so far been more particularly directed, and of some of those which it is proposed to take up hereafter.

* Practical Trout-Culture, by J. H. Slack, M. D. Orange Judd & Co., New York, 1872. Domesticated Trout: how to breed and grow them, by Livingston Stone, A. M. Boston, J. R. Osgood & Co., 1872.

D—FISHES ESPECIALLY WORTHY OF CULTIVATION.

1.—*The shad.*

Among these fishes, the American shad, *Alosa sapidissima* may be considered as holding the chief place, occupying in its distribution as it does the entire eastern border of the United States from the Saint John's River in Florida to the Gulf of Saint Lawrence, and even occurring in limited numbers in the waters emptying into the Gulf of Mexico. Its abundance in the early history of the country was such as to excite the unbounded astonishment of those who beheld it for the first time. With scarcely an exception, every river on the Atlantic coast within the limits mentioned was invaded in the spring by immense schools, which in their upward course furnished an ample supply of the best food, first to the aborigiual inhabitants, and then to their European supplanters and their descendants.

At one time it was imagined that the whole body of American shad, having wintered in the South, started northward with the new year, sending out detachments as they proceeded along the coast, first into one river and then into the next, until the last of the immense school made their way into the Saint Lawrence River. This idea, which attached equally to many other species of fish, is now believed to be in great measure at least incorrect; and it is thought more reasonable to suppose that the young fish, hatched in any particular stream, go out into the sea, and remain within a moderate distance of the coast until the period again recurs for their upward migration.* It may be however that a coastwise movement takes place to some extent.

* As a convenient place for the purpose, I introduce here an important contribution to the natural history of the shad, recently received from Mr. G. Brown Goode and Mr. Joseph Shepard:

"A knowledge of the occurrence of shad in the waters of the Saint John's appears to have been many years before the fishermen make any practical use of their information. Shad were not taken in quantity for the local markets until 1864 and 1865, though I am informed by Colonel Sammis, of Arlington, one of the oldest settlers of East Florida, that he knew of their capture in small numbers as early as the last Indian war (1839) and has since occasionally seen them. At that time the country was but sparsely settled, and there can have been little encouragement, and indeed little need for the use of seines, the inhabitants easily supplying their wants with the cast-net and the line.

"About 1859 or 1860 Mr. P. Waterhouse, a northern fisherman, introduced gill-nets and took shad in large numbers on the bar at the mouth of the Saint John's; these he shipped to northern markets, and it is said that he refused to sell a single fish in Florida, being angry with his neighbors for laughing at his project of catching shad in the Saint John's.

"All fishing was interrupted by the war, but immediately after its close gill-nets were extensively used and the shad were found to be very abundant. There can be little doubt that the species has inhabited the Saint John's for a great many years; the common idea that they are of recent introduction arises from the fact that through want of proper fishing they did not find their way to the markets till about ten years ago. The Saint Mary's River is still thought by many people living on its banks to be destitute of shad,

Nothing but impassable dams or natural falls prevented the fish from making their way to the headwaters of our rivers, and their

though there can be little doubt of their occurrence there also. As there is no market near, there is no object in fishing for shad; but an old fisherman assured me that he found them abundant there many years ago.

"The Saint John's fishermen do not use shad-seines, though small seines are employed along the banks of the river and in creeks to take the smaller species of fish. They do not seem to appreciate the superior advantages of the seine, and aver that the swiftness of the current prevents its use. This is absurd since the current of the Connecticut and other rivers, where seines are used to advantage, is much greater. As the present system fully supplies, and often gluts, the market there seems no immediate necessity for a change in the method of fishing.

"The gill-nets in use vary in mesh from three and one-half to four and one-quarter inches. They are about ten feet wide, and several gangs are fastened together so as to stretch nearly across the river, often a mile or more in width. The net is allowed to 'drive' or drift with the current, entangling in its meshes all the full-grown shad which it meets.

"The principal fishing-stations are near Mayport, on the bar at the mouth of the river, at Yellow Bluffs, and Trout Creek, respectively twelve and fifteen miles above, at Jacksonville, twenty-five miles from the mouth, and at Pilatka, a still greater distance up the river. Several nets are used at the head of the river, in Lakes Harney and Monroe and in Salt Lake, to supply the hotels there. The Pilatka fisheries are small and supply the local market. More than thirty nets are used in the neighborhood of Jacksonville, whence the fish are shipped, packed on ice in barrels, to Central Georgia and Florida, to the interior of South Carolina, and to Alabama. Yellow Bluffs is another extensive market, and sends its fish to Savannah and the northern markets. The estimated total number of nets on the river is seventy-five.

"The largest haul of the past season was at Yellow Bluffs, where six hundred were taken from a single net; at Jacksonvile the largest haul was three hundred and twenty.

"The average price at the fisheries during the past season was 21 cents each.

"The hickory-shad (*Pomolobus mediocris*) usually makes its appearance in the Saint John's the first or second week in November; and as early as the 20th the first shad appear. The shad-fishing begins about the first week in December, and is at its best about the 1st of January. The season ends about the middle of April. At the time of my arrival, April 12, the last shad were in the markets. The herring (*Pomolobus pseudo-harengus*) accompanies the shad in great numbers, but is not caught much after the 1st of March. Two herrings or two hickory-shad count in the market for one 'white shad.' The dates given above are only approximate, taken from the memory of the fishermen and dealers; but as the testimony of the various persons interviewed agrees tolerably well, I believe them to be nearly correct.

"At the time of my visit the shad seemed to be in full spawning condition and were said to be very plentiful in the lakes of Central Florida, where the fishermen believe that most of them deposit their ova. At the time of their first appearance, the ovaries and spermaries are said to be barely distinguishable.

G. BROWN GOODE.

According to Professor Wyman the young shad, even as early as on the 1st of May, are met with in great numbers returning to the ocean and measuring three or four inches in length.

"The shad-season on the Saint John's, according to Mr. C. L. Robinson, of Jacksonville, is from the 1st of December to about the 8th of April.

"The first fishing done here for shad especially was by Captain Waterhouse, of Connecticut, two years before the war. The first year there were three persons engaged in the business as proprietors, working eight men and four nets. The next year there

diffusion was almost universal, so that few portions of the country east of the Alleghany range were destitute of their share.

The fisheries were established on the river banks, and the farmers living at a distance from the streams were in the habit of coming in their wagons to these stations and hauling the fish to their homes, and there preserving such as were not needed at the time, for the winter's use. Sometimes the early settlers in new towns, remote from the rivers, before roads were cut through the forests, having no more convenient mode of transportation, were in the habit of taking their fish in bed-ticks hung across the backs of horses, in some well-authenticated cases for as many as thirty miles.

The fisheries were originally prosecuted almost entirely by the use of seines; and although at any one place very few were taken compared with the numbers now captured in connection with the great modern contrivances employed for the purpose, yet in view of their occurrence in every river and its subdivisions, it is by no means improbable that

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was double that number engaged and some twelve nets, and so increased until a year ago; this last winter there were between seventy and eighty nets and over one hundred men employed from Pilatka down.

"Above Pilatka, particularly in the lakes, there were many more employed, say twenty.

"This last winter the business was about the same as the year before. It is estimated that about 500,000 were shipped from the Saint John's, mostly to Savannah. From Savannah they are distributed to various points north.

"In size those caught here are not as large as those in the Connecticut River.

"Our fishermen use a net of 4⅞ inches mesh; while in the Connecticut they use a 5¼-inch mesh.

"They appear in our river coming in on their way to our upper lakes and creeks to spawn. When they come in they are fat and go into all parts of the river; but on their return, in June and July, they are very poor, and keep low in the deep water and follow the channel.

"Only a small portion of them return. It is thought they die of exhaustion, and are devoured by alligators and larger fish. The young shad go down to salt-water early the summer when they are about 1½ inches long. The fishermen are of the opinion that the shad have always been about as numerous as now in the Saint John's, but that the appliances for capturing them have been improved from year to year, and more persons engaged in it.

"The facts just presented are all from Mr. Robinson, and relate to the Saint John's River. I may say in addition, as regards our own waters, that there are a few shad taken every season in the Saint Mary's and Saint Illa by people living on those rivers for their own use; the net used being simply a hoop, 8 or 10 feet in diameter with handle 8 feet long, and held perpendicularly in the water by one man while another paddles the boat. When the holder of the net feels the fish against it, he brings it to the surface in the same manner as a scoop-net would be handled. From two to three and not unfrequently five or six are caught at one time in this manner. But I do not think that shad are as abundant in the above-mentioned rivers (which are narrow and deep) as they are in the (shoal and broad) river Saint John's

"Very respectfully, yours,

"JOSEPH SHEPARD,
"*Saint Mary's, Ga.*

"Hon. SPENCER F. BAIRD,
"*Commissioner, Washington, D. C.*"

the aggregate actually caught every year was far greater than at present. Seines and scoop-nets being then the only apparatus used, they were, of course, by no means a match for the wholesale devices of seines miles in length, of wire gratings cutting off entirely the upward movement of fish, of slides, &c.

Little by little, impassable dams were erected at different points along our rivers and streams, and this was probably the first thing to check the natural increase of the shad; access to suitable spawning-grounds being an absolute necessity to the function of reproduction. In addition to this, the growth of cities and towns necessitated a larger supply to meet the demand, and more extensive apparatus was called into play, which not only captured a large proportion of each year's supply, but prevented the spawning of the remainder.

We may safely assume that to the exclusion of the fish from their breeding-places, or to their disturbance before reaching them, so as to prevent the discharge of their proper function in this respect, we owe the great decrease, and, indeed, the practical extermination in many localities, of this valuable fish. It is, therefore, sufficiently evident that whatever steps be taken toward the introduction or restoration of shad to our waters, this must be accompanied by appropriate legislation, which shall secure their freedom of access to the upper waters of the streams, and shall prevent the use of nets through the season continuously so as to allow none to escape.

Next to an actually unsurmountable dam, the most pernicious engine is that employed in some of the rivers in the South, consisting of a grating or net-work of wire, stretched from bank to bank, and forming an absolutely impassable barrier to the upward movement of the fish. They are, of course, arrested at this point, and while making fruitless efforts to ascend are captured by other nets set below.

Where the streams thus treated run partly in one State and partly in another, so that shad introduced by one State might be caught in another, the legislative interposition of the General Government would seem to be required.

Whether the causes herein suggested be actually those which have mainly affected the present reduction in numbers, there can be no question as to the fact of such decrease. During the spring of 1873, desirous of knowing exactly the basis upon which efforts might be made for the restoration of shad to the southern waters, and further transfer to western streams, I dispatched Dr. H. C. Yarrow on a tour of inquiry through the South, and his report is appended hereto, (page 396.)

The decrease proved indeed to be still greater than had been anticipated, and amounted to such a degree that on subsequently sending Mr. Seth Green and his parties to the Savannah River to prosecute their labors of shad-hatching, it was found impossible to procure enough spawning fish at Augusta, formerly the seat of a noted fishery, to carry on the work.

A similar state of things has existed, or at least until very recently, in the great majority of the rivers on our eastern coast, especially those north of the Potomac; and it is not to be wondered at, in view of the immense interests involved, that any suggestion of measures by which even a partial restoration of the abundance of shad may be accomplished, should be eagerly embraced.

The first efficient steps in reference to the artificial propagation of the shad appear to have been those of Seth Green, at Hadley Falls, in the Connecticut River, in 1867; but at a much earlier date a practical experiment was made looking toward the same general result. In the spring of 1848, Dr. William C. Daniel, of Savannah, now deceased, while at his plantation, ten miles from that city, was seized with the idea of attempting to introduce this fish into the Alabama River, and at once had a large number of shad-eggs squeezed out upon brown paper, and the milt of the male discharged over them. The eggs were dried, to what extent is not stated, and then sent by mail to Mr. Mark A. Cooper, at Etowah, in Cass County, who placed them in a small stream flowing into the Etowah River, a tributary of the Alabama, which, as is well known, discharges into the Gulf of Mexico. These eggs were carefully watched by Mr. Cooper, and after a time finally disappeared, allowing the inference that the young had passed away in the waters.

Up to that time, according to Dr. Daniel's testimony and that of others, shad were entirely unknown in the waters of the Gulf of Mexico; but in 1851 or 1852 some were taken in traps placed at the mouth of the Black Warrior River, near Tuscaloosa, Alabama, and also at the falls of the Alabama, near Wetumpka. In 1858, ten years after the transfer of the eggs, they were taken abundantly near Tuscaloosa, and since then have been regularly captured every year in greater or less numbers.

The ready inference from these statements is, of course, that the Alabama River shad referred to were the progeny of the spawn sent into its waters by Dr. Daniel. There is, however, considerable doubt whether shad-eggs, dried even to a slight degree and forwarded by mail, would retain sufficient vitality to mature. This, if true, might indeed furnish a practical suggestion for the more convenient introduction of the eggs into remote waters. The experiment might easily be made as to the vitality of the eggs under such treatment; and should this be established satisfactorily, we may unhesitatingly look upon Dr. Daniel as the originator of the experiments in regard to the transfer of this useful fish to new waters. In the appendix (page 387) will be found a series of letters from Dr. Daniel to myself, as long ago as 1860, having reference to this subject.

An additional fact in reference to the introduction of shad into tributaries of the Gulf of Mexico is furnished by Mr. William Gesner, of Birmingham, Ala., in a letter to the Atlanta Herald, in which he states that in the spring of 1858, in connection with Dr. E. R. Mordecai, of Mobile, and Mr. T. Hooker, of Montgomery, he placed 1,300 fish of

this species, and 7,000 eggs, taken from the Oconee at Milledgeville, and hatched out at Montgomery, in the Alabama River there; and that since that time they are caught in increasing numbers every year at Wetumpka, as also in Passalonga Creek, and at Eufala, on the Chattahoochee River.

As stated, it was in 1867 that the first precise efforts were made looking toward the increase of the supply of shad in any of our American rivers, this having been done in behalf of the fish commissioners of Massachusetts by Seth Green. He first treated the eggs as he would those of trout by placing them in hatching-boxes in a brook which emptied into the river. His experiment with several millions proved to be an entire failure; all the eggs spoiling before hatching. On examination he found that the temperature of the brook was thirteen degrees below that of the river, and he quite reasonably inferred that the water was not warm enough, and accordingly obtained some boxes, with wire gauze at the bottom, and allowed them to float on the surface of the river itself. To his great satisfaction, and that of his employers, the young were found to have hatched out at the end of three or four days, and swam about the boxes like the larvæ of mosquitoes.

This method answered a good purpose; but the percentage of loss was greater than Mr. Green considered satisfactory, mainly owing to the fact that the eggs were carried by the current to the lower end of the box and heaped up there, so that many were spoiled for the want of proper access to the water. By a happy inspiration he finally devised the hatching-box, to which reference has already been made, which is simply a wire-bottomed cubical box, with two slats nailed obliquely on each side, and floating on the water, so that the plane of the bottom shall be slightly inclined to the surface of the water, allowing the current to strike along underneath the entire length of the box, creating a slight eddy within, and causing a gentle agitation among the inclosed eggs.

Thus assured of success in the operation of hatching the eggs, the attention of many of the States was called to the advantages to be derived therefrom; and commissioners were appointed, charged with the duty, among others, of restoring the shad to the rivers. Massachusetts was followed in this effort by Rhode Island, Connecticut, and New York; in all of which very great success has followed their persistent labors in this direction. The most favorable situation for the purpose in question appears to be at South Hadley Falls in the Connecticut, where the impassable barrier of the Holyoke dam cuts off the upward movement of the fish, and permits them to be taken in great numbers. It is asserted by the Connecticut commissioners that in the spring of 1871 63,000,000 eggs were taken and fertilized; and in 1872 the enormous number of 93,000,000.

The data of the annual captures, here and elsewhere, will be found in an accompanying table, which contains an enumeration of the shad

hatched in the United States from the beginning of the enterprise to the end of the season of 1873.

The hatching of shad in the Connecticut River has been regularly prosecuted for several years past, although principally by the State of Connecticut. The only stream in which the work has been conducted continuously by Massachusetts is the Merrimack, in which several millions have been introduced each year since 1869, some of the fry taken here being transferred to adjacent waters.

In 1870 New York began her operations, and, as a first effort, introduced about 2,500,000 young fish into the Hudson, increasing the number every year since. It was found difficult to obtain a sufficient number of spawning fish as high up the river as Castleton, the station of the New York State shad-hatching camp; otherwise a greater approximation would have been made to the amount of work done on the Connecticut.

Nothing, I believe, has been done by New Hampshire in the way of increasing shad in her waters except by the transfer of several thousand eggs. But little has been accomplished by Maine.

In 1867 a fish-way was inserted in the Columbia dam on the Susquehanna, in Pennsylvania, to permit the upward passage of the fish, but no steps were actually taken to propagate shad until 1873, when the new commissioners established a camp at Newport, on the Juniata River, and succeeded in hatching out a considerable number.

As stated in the introductory portion of my report, the subject of national aid in increasing the abundance of shad and other useful food-fishes was first started in February, 1872, by a communication presented to the American Fish-Culturists' Association, at its meeting in Albany, by Mr. George Shepard Page.

The shad was, of course, a prime object in this application, and, Congress having responded to the appeal, the steps were taken which have already been detailed in a general way. As far as the shad were concerned, it was not considered necessary, or even proper, to make any effort in rivers belonging exclusively to one State, as it was considered the duty of such State to provide for its own food-resources. The prime object was to introduce the fish into the waters of the Mississippi Valley and into those of the Pacific coast, as also into the great lakes, since these waters are by their nature the common property of the Union, and, as already explained, where any effort on the part of a single State would, in all probability, inure to the benefit of those not resident within her borders; and it was not to be expected that any joint action would be brought about by which the result would be accomplished. Young fish introduced into the waters of the Upper Mississippi in Minnesota, or of the Ohio in Pennsylvania, would, in their return from the sea, traverse a large number of States, and, of course, be liable to be captured at any point before reaching their spawning-ground.

It was uncertain whether shad could be multiplied in the waters

west of the Alleghanies; but the cost of the experiment was so trifling compared with the benefits to result from a satisfactory solution of the question, that it was deemed best to make the trial.

I have already referred to the discovery of shad in the Alabama River, whether the result of Dr. Daniel's experiments already detailed or not; and I am assured by reliable testimony that they are found at the present time in other streams of Alabama. Of this I am well satisfied, having actually received a specimen from Mr. W. Penn Yonge, of Spring Villa, Ala., taken at Elba, Ala., and preserved in alcohol, and distinguishable in not the slightest particular from the shad of the eastern coast. I have also the assurance of Dr. Lawrence of their capture at the Hot Springs of the Ouachita; of Dr. Middleton Goldsmith, at the falls of the Ohio, near Louisville, and of Dr. Turner in the Wabash River of Indiana and Illinois, and in the Neosho River of Kansas. (See pages 391 *et seq.*)

I am not entirely satisfied that all these cases refer to the true shad, as there is a second species, found also on the eastern coast, known as the Tailor or Fall shad, which, while attaining nearly the same size as the true shad, is a totally distinct species, and very inferior in value. There seems, however, no reason why a young shad, hatched in the upper waters of the Mississippi Valley, may not make its way to sea and return again at the proper season. The distance to be traversed is probably a matter of very little consequence, as in former times shad penetrated to the very headwaters of the Atlantic streams, and exhibited no particular evidence of exhaustion. Starting at the mouth of the Mississippi, in the beginning of the year, and moving leisurely along, there would be nothing to prevent shad from reaching the upper waters of the rivers in the course of from two to four months' time. If they maintained enough vigor to deposit their eggs, the object would be accomplished, even though they were to die from exhaustion immediately after.

In illustration of what is here said in reference to the distance from the sea to which shad can penetrate, it may be remarked that among the most highly-prized fishes of China is a species of shad known among the European residents as the *Samlai*, which enters the Yang-tze-Kiang and the adjacent waters in May, and is in season for about sixteen weeks. By many persons it is considered to be even superior to the American shad, since, while of equally fine flavor, it is larger and more free from bones. According to the Chinese culinary authorities, shad should be neither boiled nor fried, its flavor and nutritious qualities being best preserved by being steamed, as is done by them with savory vegetables. By cutting the fish in transverse slices, the inconvenience of the bones is very greatly lessened. When first taken shad command fabulous prices, and, according to Dr. MacGowan, it is only the Emperor and the very highest officials who can procure them on their first arrival. They are then generally sold alive in tubs.

Besides the use made of the shad in China for food, it is highly

valued in the materia medica; the fish itself, and particularly its oil, being considered very efficacious in the treatment of consumption. Indeed, all the virtues which are usually ascribed to cod-liver oil are possessed, according to the Chinese, by shad-oil, and, in the opinion of Dr. MacGowan, there is a good deal of foundation for this impression.

The Yang-tze-Kiang, in which the shad is most abundant, is the largest river in China, having a length, as estimated, of 3,314 miles; and the shad are said to ascend almost to its source. This is a fact of very great importance in connection with the enterprise of stocking the Mississippi River and its tributaries with shad, since the distance from its mouth to the attainable waters of all the tributaries, excepting the Upper Missouri, is much less than that traversed by the shad of China. Indeed, a distance of about 1,500 miles from the mouth of the Mississippi would probably cover the extreme limit which the shad could profitably reach.

It is proper to state that while in the lower part of Yang-tze-Kiang the shad is highly valued as food, when it reaches the upper portions it is called "pestilence fish," from its alleged deleterious properties. This may be owing to the very extended journey which the fish makes in nearly the same latitude, (about 30° N.,) involving a great amount of exhaustion and consequent emaciation, while, of course, the temperature of the water becomes more and more elevated with the advance of the season. The case is quite different with the Mississippi River and most of the shad-producing rivers of the Atlantic coast, the direction of which is more nearly north and south, their sources being in a considerably higher latitude than their mouths, so that the fish entering them at a certain season, and passing slowly up, would about keep pace with the progress of the season, and not be subjected to extreme heat until after the actual spawning-period had passed, when, as is well known, all fishes are more or less unfit for food.*

According to Dr. Day, India possesses a migratory shad, which ascends the rivers for breeding purposes, like the American species in the United States. This is known as the *Alosa palasah*, and in Madras is called the sable-fish. These appear to ascend the rivers at a different season from our own fish, and generally to breed at the commencement of or during the monsoon. The main body of the shad begins to ascend the Kistna River about the middle of October, and disappears by April. In the Godaveri they ascend earlier, being most abundant from

* Although not bearing on this subject, it may be of interest to state that in the article from which we derive these facts, Dr. MacGowan informs us that the different species of sea-weeds, especially of a *Laminaria*, are considered to be efficacious in goitre, swellings of a scrofulous character, and cutaneous eruptions, those richest in iodine being valued most. There is a popular belief in regions where mineral coal is employed for fuel, that sea-weed is an indispensable corrective against the noxious fumes of the coal-fire. (Journal of the North China Branch of the Royal Asiatic Society, VII, 1873, 235.)

July to September, after which the fishermen believe that they migrate to the Kistna. In the Hoogli they continue ascending throughout the southwest monsoon, and some are found full of roe in September. They occur at Mandalay in Upper Burmah at the end of the year. In Siud they about February and descend about the end of September, after which none are met with. They are found in the rivers, usually during the periods of the flood, when their instincts or traditions inform them that the shallows are covered with water, so that they can proceed upward to their destination. In the Irawaddy they push on as far as Upper Burmah.*

Shad, in their ascent of the Mississippi, would have no falls and no current of inconvenient strength to overcome, and it would seem no more difficult for them to swim up the river than to sweep along in schools from one part of the coast to the other. Although they do not feed in fresh water, the privation of food for several months would be no serious inconvenience, as fish are frequently longer than that without sustenance. Starting, as they would, full of fat, the moderate expenditure required for this period of time would still leave enough to supply the substance for the ripening of the eggs and of the milt. For these reasons I am entirely satisfied, as are most persons who have given attention to the subject, that shad introduced into the upper waters of the Mississippi may be taken there again in the same vicinity as mature fish; provided, of course, that they are not destroyed, intercepted. And even should the entire range of the Mississippi and its main tributaries be too much for them, the uncertainty diminishes as we reduce the distance from the Gulf, and we may consider success assured in the shorter rivers, emptying directly into the Gulf and in the lower waters of the Mississippi and Missouri, at least from the mouth to the Ohio.

One great argument in favor of the attempt to introduce the shad as well as species of salmon into the Mississippi River and its main tributaries, is the general absence of dams as compared with the waters of the Atlantic coast. There is, even now, nothing to prevent fish from running up to a great distance, even to places where excellent opportunities for spawning can be had.

The question has been asked whether, admitting that the shad and salmon can live and propagate in the waters of the Mississippi Valley, they will not find the Gulf of Mexico too shallow and hot for them. To this we have the satisfactory reply that the recent researches of the Coast Survey show, directly outside of the mouth of the Mississippi, an immense area where the depths range from 1,200 to 6,000 feet. The temperature below 600 feet ranges from 35° to 29°, even in summer, due probably to the intrusion of the cold water from the Antarctic region in passing along the floor of the Atlantic Ocean.

The question of food, of course, does not come into account, as we have already explained that the shad does not feed in the fresh water;

* Fresh-Water Fisheries of India and Burmah, by Dr. Day, 22.

the examination of, we might almost say, millions of stomachs of fish, taken above the mouths of rivers, revealing nothing whatever in the way of food, or in a very few instances only. Four cases only have come to my knowledge where any food was detected, and that only within a short distance of salt-water. Once returned to the ocean, the shad feed voraciously; and although extremely thin and emaciated when emerging from the rivers, they soon fatten up.

It is not very often that shad are taken in the sea, but they are captured in large numbers in the Bay of Fundy in autumn, after returning from their spawning-operations in the Saint John and other streams. They are then taken in weirs, and are claimed to be of unsurpassed excellence o flesh.

Once in the sea, of course there is no limit to the amount of food they can obtain, this consisting of worms, small fishes, and most largely of minute crustaceans, especially of the genus *Mysis*.

The problem as to the possibility of naturalizing the shad in the great akes, so that they may subsist there the greater part of the year and find a supply of food, is more difficult of solution and one that can only be decided by experiment. We have, however, the interesting fact that the deep waters of the great lakes abound in certain species of minute crustaceans, precisely similar to those occurring on the Atlantic coast, and which, while consumed to a great extent by the white-fish, may be presumed to be in sufficient surplus to feed an indefinite number of shad. The experiment of stocking the lakes with shad has been already made by Seth Green, who planted 15,000 in the Genesee River, near Rochester, in 1871. A number of these were subsequently taken in nets, and it is thought probable that the spring of 1874 will witness the movement of mature fish up the Genesee River.

It is proposed also to try the experiment of introducing young shad into the Great Salt Lake of Utah by placing the young in the Jordan River; indeed, a beginning has already been made by the planting of 5,000. It is true that the water of the lake is excessively saline; but there is a large region adjacent to the mouths of the tributary streams, more or less diluted, and it may be that the fish on running down into the lake can gradually accustom themselves to its great density and concentration. They will, at any rate, not suffer from want of food, since the *Artemia* (a crustacean) and sundry dipterous larvæ are found in enormous numbers.

A similar reasoning applies to the question of introducing salmon, alewives, lobsters, oysters, &c., into the same waters.

The experiment of placing shad in the Sacramento River, already mentioned, initiated in 1871 as it was by the California State commissioners, with the help of Seth Green, and continued in 1873 by the United States Fish Commission, through Mr. Livingston Stone, may be considered as an actual success.

As already stated, the experiment of artificial propagation of shad

was not only made first in the Connecticut River, but also on a larger scale than elsewhere; and the results of the experiment of 1867 were seen as early as 1870. To the confusion of the incredulous, schools of shad in immense numbers were seen in the spring in Long Island Sound, all making their way to the Connecticut River, and on the 23d of May over 2,800 were taken from a pound near Saybrook. At another pound 3,560 were taken, and elsewhere they were caught in numbers varying with the locality. The largest haul previously on record was in 1811, when 2,280 were caught at one time, although a draught of 2,300 was reported at Haddam Pier in 1802.

The abundance of shad in the river in 1871 was still greater than in the previous year, so much so, indeed, that in the time of greatest plenty they could scarcely be disposed of at the rate of $3.50 per hundred. At the present period the increase has been such that numerous fishing-stations, for a long time abandoned, have resumed operations with very satisfactory results.

A great increase in the number of shad has also manifested itself in the Hudson and the Merrimac, and with a reasonable continuance of effort there is every reason to expect that the pristine abundance of fish will be restored, and possibly even increased, if young shad are hatched out in sufficient number.

2.—*The alewife or fresh-water herring.*

I am inclined to think, for various reasons, that too little has been done in our waters toward the restoration to their primitive abundance of the alewife (*Pomolobus mediocris*), the herring of our Southern and Middle States; not to be confounded with the sea-herring, (*Clupea elongata.*) It is better known as the alewife throughout New England, and is the gaspereau of the British provinces. Like the shad, it ascends from the ocean in early spring into the fresh or brackish waters, and has the advantage of breeding in quiet ponds, instead of requiring a river for its development. In former times, and before the introduction of dams across the streams, this fish was very abundant along the coast, and supplied an important article of food to the people, both fresh and salted.

The alewife in many respects is superior, in commercial and economical value, to the herring, being a much larger and sweeter fish, and more like the true shad in this respect. Of all American fish none are so easily propagated as the alewife; and waters from which it has been driven by the erection of impassable dams can be fully restocked, in the course of a few years, simply by transporting a sufficient number of the mature fish, taken at the mouth of the stream to a point above the dams, or placing them in ponds or lakes. Here they will spawn, and return to the sea after a short interval, making their way over dams which carry any flow. The young alewives after a season descend, and return, if no

prevented, at the end of their period of immaturity, to the place where they were spawned.

In addition to the value of the alewife as an article of food, it is of much service in ponds and rivers as nutriment for trout, salmon, and other valuable fishes. The young derive their sustenance from minute crustaceans and other objects too diminutive for the larger fish, and in their great abundance are greedily devoured by the other species around them. In waters inhabited by both pickerel and trout, these fish find in the young alewives sufficient food to prevent their preying upon each other. They are also, for the same reason, serviceable in ponds containing black-bass.

As a cheap and very abundant food for other fishes, the young alewives can be placed in waters that have no connection with the sea by merely transferring from any convenient locality a sufficient number of the living mature parents, taken at the approach of the spawning-season; they will remain for several months, and, indeed, can often be easily penned up by a suitable dam and kept throughout the year.

It is in another still more important connection that we should consider the alewife. It is well known that within the last thirty or forty years the fisheries of cod, haddock, and hake, along our coast, have measurably diminished, and in some places ceased entirely. Enough may be taken for local consumption, but localities which formerly furnished the material for an extensive commerce in dried fish have been entirely abandoned. Various causes have been assigned for this condition of things, and, among others, the alleged diminution of the sea-herring. After a careful consideration of the subject, however, I am strongly inclined to believe that it is due to the diminution, and in many instances to the extermination, of the alewives. As already remarked, before the construction of dams in the tidal rivers, the alewife was found in incredible numbers along our coast, probably remaining not far from shore, excepting when moving up into the fresh water, and, at any rate, spending a considerable interval off the mouths of the rivers either at the time of their journey upward or on their return. The young too, after returning from the ocean, usually swarmed in the same localities, and thus furnished for the larger species a bait, such as is not supplied at present by any other fish, the sea-herring not excepted. We know that the alewife is particularly attractive as a bait to other fishes, especially for cod and mackerel. Alewives enter the streams on the south coast of New England before the arrival of the blue-fish; but the latter devote themselves with great assiduity to the capture of the young as they come out from their breeding-ponds. The outlet of an alewife-pond is always a capital place for the blue-fish, and as they come very near the shore in such localities, they can be caught there with the line by what is called "heaving and hauling," or throwing a squid from the shore, and hauling it in with the utmost rapidity.

The coincidence, at least, in the erection of the dams, and the enor-

mous diminution in the number of the alewives, and the decadence of the in-shore cod-fishery, is certainly very remarkable. It is probable, also, that the mackerel-fisheries have suffered in the same way, as these fish find in the young menhaden and alewives an attractive bait.

The same remarks as to the agency of the alewife in attracting the deep-sea fishes to the shores, and especially near the mouths of rivers, apply in a proportional degree to the shad and salmon.

As indicated in a previous page, the usual method of multiplying the alewife consists in transferring the mature and spawning fish alive to the waters which are to be stocked. There they spawn in the spring, and with the young return in autumn to the sea. They will thrive in the brackish ponds along the coast, in rivers, and in small lakes; unlike the shad, preferring the quiet bodies of water rather than running streams. Little or nothing of any magnitude has been done in the way of artificial impregnation and hatching of their eggs, although a matter of no special difficulty.

There seems to be a difference of opinion as to the age at which alewives first return from the sea, some fixing it at two and others at three or more years. Capt. Treat, of Eastport, however, many years ago transported several hundred pairs of breeding-fish to a small sheet of water, known as Keene's Pond, situated some five or six miles from Robbinston, Me., and having its outlet into the Calais River just below Red Beach. The level of the lake is several hundred feet above that of the river, and the outlet is very precipitous, consisting of several falls entirely impassable to fish from below. No alewives had ever been known in this pond at the time of their introduction by Captain Treat. The young fish were seen in the pond in the course of the summer in myriads, all of them disappearing, however, after a heavy rain in the autumn, which swelled the waters to produce a sufficient discharge. Due examination was made for successive years, but not until the expiration of the fourth were they seen, when the outlet was observed to be almost choked up by a solid mass of alewives, struggling to make their way back again to the place of their birth.

3.—*The salmon of Europe and New England (Salmo salar).*

Among the fish, the multiplication or artificial increase of which has most occupied the attention of governments, the salmon (*Salmo salar*) is pre-eminent. The species is believed to be the same on the Atlantic shores of both America and Europe. It is true that the aggregate of effort in reference to the increase of trout, both in America and Europe, may be greater; but certainly the smaller species of the *Salmonidæ* are very much inferior in actual commercial value to the true salmon. An account of the measures taken to multiply this fish in America, including the various methods of hatching, &c., will be found summarized in Mr. Milner's article, and in those of Messrs. Stone and Atkins.

The interest in the preservation and increase of the salmon is due, in the first place, to its reputation as a game fish, and the sport experienced capture; but, perhaps, still more to its great size and economical value. No fish of its magnitude brings so large a price per pound, and is so universally regarded as a chief delicacy. It abounds in all the waters of the North Atlantic, both in Europe and America. Making its home in the sea, it passes into fresh water at periods varying with the locality, sometimes early in the winter, and again not until spring; and after remaining some months in the rivers, it seeks a suitable spawning-bed, where the eggs are deposited; after which the adults either return to the sea, or in some instances, as in Nova Scotia and New Brunswick, pass into the fresh-water lakes, and spend the winter and early part of the spring.

The eggs occupy from two to four months in their development, and the young are hatched in early spring and remain in the rivers for at least one year. There is evidence that a portion remain until the second year, this being especially the case with the female. Then, passing down to the sea as fish weighing a few ounces, they remain there several months, and return in autumn as grilse of several pounds. These are said to go back to the sea again before winter sets in, and to return the next season, as breeding-fish, weighing perhaps eight or ten pounds each. The growth of these fish is very rapid; and as this takes place in the sea, without the necessity of artificial feeding, it may be readily imagined how valuable a salmon fishery is likely to be, compared with one of trout, which, to be of any special economical importance, requires the constant feeding of the fish.

I do not at present propose to attempt a detailed biography of the salmon, as the facts at my command in reference to that fish, in America, at least, are not yet sufficient to warrant my doing so. The articles in the appendix, by Messrs. Stone, Atkins, and others, will, however, be found to contain much valuable information.

As to the important point of the period of their abode in the sea, authorities differ, but it is now the general impression, as already stated, that the male fish are mature frequently in three years, and that all are certainly so at the expiration of four years from birth.

The salmon is emphatically a fish of New England and the British provinces, and never belonged to any of the States south of that section of country. The Connecticut River is believed to have been its western limit on the Atlantic coast, as shown by the testimony of Douglass and others,* although some extend their range to the Housatonic. They were also abundant in Lake Ontario and Lake Champlain.†

*Douglass, William. A summary, historical and political, of the first planting, progressive improvement, and present state of the British settlements in North America. 2 vols., 8 vo. Boston, 1749–'51.

On p. 212, he says that salmon are a high-latitude fish, not to be found south of New England; the farther south, the later they set in, and continue a shorter time;

From a very early period, the preservation of the salmon-fisheries in Europe, or their restoration when exhausted, has occupied a great share of attention. The problem has perhaps been most carefully worked out in Great Britain, where in numerous localities, formerly exhausted, this fish has been restored, to the very great profit of those who control the streams. So far from being a luxury now, unattainable by any but the wealthy, salmon have become a staple fish of Great Britain, and are to be had in the season at prices very little more than are paid for ordinary kinds.

The history of the introduction of salmon into Tasmania exhibits an instance of enterprise highly to be commended, especially when we bear in mind the fact that it was necessary to transport the eggs over sixteen thousand miles of ocean, during a period of many months, involving an exposure to tropical heat; but which was actually accomplished with a percentage of loss scarcely greater than that at the celebrated establishment at Hüningen. The first experiment in this direction was made in 1862, and, according to Mr. H. R. Francis, failed from an insufficient supply of ice. The eggs were packed between layers of moss, in boxes, which were suspended, in order to break the motion of the ship. A small stream of ice-water was made to flow over them to keep them of a proper temperature. They were thus maintained in good condition for eighty days, during which time they passed through the tropics. But the supply of ice failing, the eggs all died.

Ultimate success was hoped for, however, from the result of an experiment made in an ice-house in London, where eggs, kept for periods from forty-five to one hundred and forty-four days, were afterward hatched out into vigorous fish.

In 1864 a more successful trial of sending eggs to Tasmania was made. The eggs were packed between layers of moss, as before, being stratified with successive layers of moss, ice, and charcoal, in boxes perforated

for instance, in Connecticut River they set in beginning of May, and continue only about three weeks; in Merrimac River they set in beginning in April to spawn, and lie in the cold, deep brooks until September and October, then silently, so as not to be observed, and with dispatch, they return to the sea. In Chebucto, Cape Breton, and Newfoundland they continue the greatest part of the year.

†Williams, in his History of Vermont, 1809, vol. 1, p. 147, remarks that "the salmon begins to pass up Connecticut River about the 25th of April, and proceeds to the highest branches; and that about the same time, or a little later, they are found in Lake Champlain and the large streams which fall into it. When going up in the spring they are round and fat, and of an excellent taste and flavor, and are taken in great numbers from the first week in May to the second week in June. When they arrive at the upper parts of the rivers, they deposit their spawn and remain there during the summer-season, but become very lean and flaccid. Toward the latter end of September they return to the sea, but so much emaciated that they are not taken or used for food. Some of these salmon in the spring will weigh thirty-five or forty pounds. They migrate only to cold waters. None of them are ever found to the south or west of Connecticut River. Those that go farther to the northward and pass up the river Saint Lawrence are generally more large and rich than those which come from the southward."

all over for the free admission of air. The eggs were thus kept from direct contact with the ice, but blocks of ice were placed over the boxes. The eggs were never actually frozen, although maintained at a temperature not far from 32°. An ice-house was built in the vessel, and the eggs were undisturbed from the beginning to the end of the journey. The transfer was made on the ship Norfolk, 50 tons of space being assigned for the purpose.

The eggs, to the number of about 100,000, were collected by Mr. Youl, and contributed voluntarily by various gentlemen in England. The vessel sailed on the 21st of January, and cast anchor in Hobson's Bay on the 15th of April. The ice-house was then opened for the first time since it had been closed on the Thames, and a large portion of the contents proved to be sound and in good condition. Strong wooden boxes were then prepared, in each of which about fifteen of the small original boxes of eggs, covered with a considerable thickness of ice, and wrapped in blankets, were securely packed. Eleven of these larger boxes, containing in all 170 of the English boxes, were then transported to Hobart Town, and eleven were retained by the Acclimatization Society of Victoria. On the 20th of April the Hobart Town eggs reached their destination, and were carried up the Derwent River to New Norfolk, and thence to the ponds prepared for them on the little river Plenty, about seven miles distant. The ova were immediately placed in the gravel of the hatching-boxes, and a stream of water directed over them, which for a time was cooled by the remainder of the ice; afterward, however, the water supplied was of the natural temperature. The number of healthy eggs placed in the pond was estimated at about 14,000, and the first embryo hatched out on the 4th of May.

In 1866 a second consignment of about 93,000 salmon-eggs was shipped to Tasmania, and, after a voyage of one hundred days, they reached their destination in Hobson's Bay on the 1st of May, and were forwarded to the hatching-house on the river Plenty, as before. About 30,000 eggs were found to be healthy, from which they succeeded in obtaining about 6,000 young fish.

The young fry hatched in May, 1864, were discharged from the pond as smolts toward the end of 1865, while the next lot, about 6,000 in number, was let out in September or October, 1867. Descending the Plenty into the Derwent River, they had a few miles of fresh water before reaching the estuary above New Norfolk. The experiment is believed to have been entirely successful, though it was not until 1874 that a specimen was taken of what is believed to have been a genuine salmon-grilse, actually born in Tasmania.

Corresponding experiments were carried on with reference to the English sea-trout, which proved entirely successful. This fish is now actually acclimated in Tasmania, and propagates naturally in the Derwent River, where specimens are constantly taken for the table, some of them weighing as much as seven pounds.

An interesting experiment was tried on this occasion as to the possibility of retaining the sea-trout in fresh water throughout the entire period of their existence, about fifty of them being used for the purpose. This has succeeded perfectly, the original stock having bred for five years in succession in fresh waters.

The history of the efforts in the United States, looking especially toward the restoration of salmon to American waters, may perhaps be considered as dating from a report upon the artificial propagation of fish made in October, 1857, to the general assembly of Vermont, by the Hon. George P. Marsh, now United States minister to Italy, almost simultaneously with one by Mr. A. H. Robinson, of New Hampshire. It was not until 1864 and 1865 that the fish commissioners of the New England States took measures to accomplish the desired object, and, according to Dr. Edmunds* and Mr. William Clift,† the first positive effort was made by Dr. Fletcher, of Concord, N. H., in 1866, who visited New Brunswick for the sake of transferring adult fish alive to the New Hampshire streams for the purpose of restocking them.

Dr. Edmunds, however, remarks that, according to Mr. Thaddeus Norris, James B. Johnson, of New York City, procured eggs of a salmon (*S. hucho?*) in 1864, and hatched them in New York City by Croton water; but that they all died when liberated.

According to Genio C. Scott, ‡ Seth Green, by his advice, made application to the French establishment at Hüningen, in 1865, for some salmon ova, and was presented with 20,000 in the spring of 1866, which were properly packed and shipped. They were, however, delayed in the New York custom-house until they died.

Dr. Fletcher went again to New Brunswick in September of 1866, and brought home 25,000 impregnated ova, of which a large number were placed in the Merrimac River after being artificially hatched, and, with the exception of a few, they were treated for this purpose in Concord. Whether the remainder hatched out or not it is impossible to say; but we may safely consider the date of March, 1867, as the first period when artificially-hatched American salmon were introduced into American waters; namely, in the Pemigewasset, at Compton, N. H., by Dr. Fletcher. In 1867 Dr. Fletcher again visited New Brunswick, and brought home, as he supposed, 100,000 eggs or more. Half of these were distributed to the New Hampshire commissioners, Robinson and Hoyt, at Meredith N. H., and the other half to Livingston Stone, at Charlestown. The entire yield of these eggs was about 5,000 of each lot, or 10,000 in all.

In 1868 Mr. Livingston Stone, in behalf of several parties, built a salmon-breeding establishment on the Miramichi River, New Brunswick,

*Introduction of Salmon to American Waters: Proceedings of American Fish-Culturists' Association, 1872, p. 32.
†Salmon and its Culture, 1872, p. 19.
‡Fishing in American Waters. New York, Harper and Brothers, 1869.

and brought home 182,000 eggs, which were hatched in various localities, principally at his establishment in Charlestown, N. H. Some were hatched by Mr. Brackett, one of the commissioners of Massachusetts, and turned into the Merrimac River in that State. Others were introduced near Cape Cod. Two thousand of the young fish, of the lot hatched by Mr. Stone, were introduced into West River and the Winooski, in Vermont; and a few of the lot were subsequently identified.

In 1869 Mr. Hagar, of Vermont, obtained 4,050 of the eggs from the Miramichi, 80 per cent. of which were hatched out at Chester, Vt., and introduced into tributaries of the Connecticut.

In 1870, according to Dr. Edmunds, 8,000 eggs were sent to him from the Miramichi River, which were distributed to the commissioners of Maine and Connecticut; Mr. Clift, of Mystic Bridge, also received a few.

In 1870 the fish commissioners of Maine and Connecticut purchased from Mr. Wilmot's establishment, at New Castle, Ontario, 18,000 eggs, which were hatched and distributed.

In 1871 Maine, Massachusetts, and Connecticut jointly built a salmon-breeding establishment on the Penobscot River, at Orland, placing it under the charge of Mr. Atkins; and from this a reasonable supply was received. The first operations for hatching fish on a large scale were those of Mr. Atkins, at Bucksport, in Maine, in 1872, when the aggregate subscriptions of the States were supplemented by an equal amount furnished by the United States Fish Commissioner, (page xviii.) It would therefore seem, as stated by Dr. Edmunds, that it is to Dr. William W. Fletcher, of Concord, that we owe the first practical success in introducing salmon into American waters, before destitute of them, by transferring the properly-impregnated ova from localities where they abound to salmon-breeding establishments, whence they were distributed to their destination. It is, however, to the method adopted by Mr. Atkins, (whether his own device, or that of some one else, I am unable to say,) in penning up the mature fish, on their entrance into the rivers, and keeping them until their eggs are ripe, that we owe the possibility of carrying on the work on a large scale.

A dependence upon the salmon-eggs to be furnished from British or Canadian waters would have been entirely futile, since the authorities as well as the people of the Dominion have always looked with great jealousy upon the efforts made by the United States to obtain eggs within their borders, this, in fact, having been prohibited by positive enactment. It was, therefore, only within the waters of the United States that such efforts could be carried on without interference, and the plan referred to, of penning up the fish and keeping them, has placed within our power the means of securing, with the least possible trouble and expense, as many eggs as can conveniently be manipulated.

To bring up the history of American salmon-culture to the date when

the isolated efforts of the States were supplemented by the more comprehensive co-operation of the General Government, Dr. Edmunds remarks that from the first salmon-fry introduced into the Merrimac River no returns have been realized. Some were seen and taken going to sea, but none have returned. Some ripe salmon were taken, however, at Holyoke, in the spring of 1872, and at Saybrook, at the mouth of the Connecticut; but, in his opinion, it is in vain to expect much in the way of actual results, in most of the streams, at least, until legislative enactments and the force of public opinion have caused the erection of suitable fish-ways in the dams.

In the earlier part of the present report (p. xviii) will be found an account of what has been done in the way of multiplying the Maine salmon, under direction of the General Government, beginning with 1872.

The most serious artificial obstruction in any of the American rivers to the upward movement of the salmon, as well as other fish, so far realized, has proved to be the Holyoke dam at South Hadley Falls; and a persistent effort has been made for many years, by the commissioners of Massachusetts, aided by those of other States, to cause the powerful corporation owning the dam to introduce a proper fish-way. An act of the Massachusetts legislature requiring this to be done was contested by the company, the suit being carried successively to the supreme court of the State, and then to that of the United States. Beaten at all points, the company has finally yielded gracefully to the necessity, and is now actually engaged in erecting a fish-way, devised by Mr. Brackett, one of the fish-commissioners of Massachusetts, in accordance with the unanimous recommendation of the commissioners of all the States through which the Connecticut River flows.

It will be sufficiently evident that the extent to which the restoration of salmon can be made to American waters will depend very largely upon the character of the obstructions, whether natural or artificial, which the fish must overcome; and, in order to have at hand all the data possible in this connection, I requested Dr. M. C. Edmunds, one of the fish-commissioners of Vermont, and the author of the valuable report from which I have just quoted, to make a special tour of Lake Champlain and the south side of Lake Ontario, with a view of ascertaining the best localities for the introduction of salmon and the character of the obstructions in the rivers. This he has performed faithfully, and has furnished a detailed report on the subject, with a map, which will be found appended.

About the same time Mr. Stilwell, one of the commissioners of Maine, prosecuted a similar inquiry as to the obstructions in the rivers of that State. His report and accompanying map are also given herewith. Corresponding information of the same character in regard to the James River in Virginia, as also for streams in Wisconsin and Michigan, tributary to Lake Michigan, has also been received; and, with what is being furnished from other localities, I hope to be able to present before

long a map of the United States showing the points where efforts must be directed toward opening the streams for the upward movement of fish.

Salmon were at one time very abundant in Lake Champlain and Lake Ontario, even within the memory of persons now living;* but their upward course in the great lakes was always barred by the Falls of Niagara. Now they are apparently unknown in either body of water, except on the Canadian side of Lake Ontario, where the judicious methods adopted by Mr. Wilmot, at Newcastle, have largely increased their numbers, and have enabled him, under direction of the government, to furnish a supply of eggs and young to adjacent waters in the provinces, and even to a limited extent to parties in the United States.

Much contrariety of opinion has been expressed as to whether the salmon of Lake Ontario really run to the sea, or whether the lake is to it an ocean in which it finds the necessary subsistence, except when moving up the streams to spawn. The size is rather less than that of the ocean salmon, but it is otherwise undistinguishable. Whether this be the case or not, there is not much question as to the possibility of keeping Lake Ontario supplied with salmon, provided obstructions to the passage of the fish to suitable spawning-grounds in inflowing streams be obviated by suitable fish-ways.

As far as the lakes above the falls are concerned, nothing can be determined without experiment; but it is extremely probable that enough of these fish might remain, without descending the falls, to establish a special stock. We know that the temperature of Lakes Michigan and Superior, of which we have the best information, amounts, at a depth of 145 fathoms, to 45 degrees in September, in the one, and to 39 degrees, in depths of over 40 fathoms, in the other. We also know that all the lakes abound to an enormous extent in minute crustacea, especially of the genus *Mysis*, which is undistinguishable from a species which in the North Atlantic is believed to furnish in large part subsistence to the salmon. It is upon this and two or three species of the *Gammarus* that the white-fish feeds, and it is not improbable that both salmon and shad

* Watson, in his history of Essex County, N. Y., speaking of the fish in Lake Champlain, says: "The early settlers of the valley of Lake Champlain found the streams upon both sides filled with salmon. They were very large, and among the most delicate and luscious of all fish. All that period they were abundant, and so fearless as to be taken with great ease and in immense quantities. A record exists of five hundred having been killed in the Boquet in one afternoon, and as late as 1813 about fifteen-hundred pounds of salmon were taken by a single haul of a seine, near Port Kendall. They have been occasionally found within the last twenty years, in some of the most rapid streams, but have now totally disappeared. The secluded haunts they loved have been invaded; dams have impeded their wonted routes; the filth of occupied streams has disturbed their cleanly habits, and the clangor of steamboats and machinery has excited their fears. Each of these causes is assigned as a circumstance that has deprived the country of an important article of food and a choice luxury. The subject is not unworthy the inquiry and investigation of the philosopher of nature."

may find them in so great abundance as to keep themselves in good condition, and obviate the necessity of going elsewhere in search of food.

In the eastern portion of North America, in addition to the true *Salmo salar*, some writers maintain the existence of a second species, which they call *Salmo hamatus*, or hook-billed salmon, and which they distinguish by the development of a hook in the lower jaw. Whether there be two species or not, there is no question that the true salmon has this development during the spawning-season to a very great degree, and therefore it cannot constitute a distinctive mark.

4.—The western salmon (Salmo quinnat?).

It is on the west coast of North America alone that salmon occur in anything like the numbers which formerly prevailed in the East, though the species are entirely distinct and peculiar to the Pacific. The waters of California, Oregon, and British Columbia boast of the possession of several kinds, how many has not yet been ascertained, as the different ages and sexes of one have in many instances been described as two or more totally distinct species. One of the objects of the Fish Commission is to solve the problem in question, by securing specimens of all ages and of both sexes from all North American localities, and, by a critical investigation and comparison, to determine precisely the limitations and relationships of each kind. Material for this will, with suitable illustrations, it is hoped, be ready before long, which will be presented to Congress for publication if it should be called for.

The term salmon properly implies a fish of the genus *Salmo*, which spends a certain portion of its time in the ocean, and then runs up into the fresh waters to spawn. We know of no species of the genus which remains in the salt water permanently throughout the year; but there are many that continually abide in the fresh water, and of these North America has her fair share.

An important memoir on the genus *Salmo*, by Dr. Suckley, was prepared for the report on the northwest boundary survey. This, by permission of the State Department and Mr. Archibald Campbell, has been in charge of the Smithsonian Institution for many years, and will be found in the appendix of this report, (page 91.) Although many of the conclusions of Dr. Suckley are doubtless erroneous, yet the amount of information and critical inquiry exhibited in the paper is very great, and it will serve as an excellent basis for more correct memoirs hereafter. The species given by Dr. Suckley, arranged in certain indicated groups, are mentioned on page 92.

In consequence of the fact that the waters of the Sacramento Valley are much warmer than the ordinary salmon-streams of the United States, the fish from that locality would seem to be especially adapted to the more southern waters of the United States. Its precise species has not been determined, but Dr. Suckley identifies it with the Columbia River "quinnat," (*Salmo quinnat*, Rich.)

The experience of salmon-culturists in Europe goes to show that the *Salmo salar* will not thrive where the water is of a higher temperature than 60°, or at most 65°, during the summer-season. There are few of the rivers of the United States that do not reach a higher temperature than that, especially those from Cape Cod southward. Indeed, experiments prosecuted during the period of shad-hatching in the Connecticut and the Hudson show that the waters there exhibit a temperature of 80° as early as the 1st of July.

For this reason, probably, as far as our reliable information goes, the salmon in olden times did not occur west of the Connecticut, or at least of the Housatonic River, the assumption of its existence in the Hudson resting upon the statement of Hendrick Hudson, to the effect that he had captured salmon in nets at the mouth of the river in August. There is, however, no question, as suggested by Mr. J. C. Brevoort, but that reference was had by him to the weak-fish, (*Cynoscion regalis*,) which has much of the appearance of the salmon, and with its allied species is frequently called salmon, salmon-trout, &c.; the known habits of the salmon entirely precluding the idea that it could have been seen by Hudson under the circumstances mentioned.

In the Sacramento fish, however, we probably have a species which will answer the purpose on our eastern coast, as far south as the James, and it is proposed to devote the greater part of the supply of eggs received from Mr. Stone toward stocking the waters of the Hudson, the Delaware, the Susquehanna, the Potomac, the James, and possibly the streams still farther south which head in the Alleghanies. The Hudson, the Delaware, and the Susquehanna appear pre-eminently adapted to these fish, as the first dams occur at a considerable distance from their mouths, respectively, and arrangements will doubtless be made for suitable fish-ways before there is any probability of the return of the young salmon from the sea.

It is also proposed to try the experiment of introducing the Sacramento salmon into the waters on the southern side of the great lakes, where the temperature is comparatively high, and the conditions otherwise favorable for the western salmon.

Whether this fish will thrive in the Mississippi River, it is, of course, impossible to tell, although it is proposed to make the experiment in this case also. Salmon penetrate the Columbia, Frazer, and Yukon Rivers to a very great distance from their mouths, and it is not at all impossible that in the Mississippi, with the absence of any obstructions for a long distance, or of any current materially greater than the tides of the sea, the fish would make their way without experiencing the exhaustion which they manifest in the western waters, where they are obliged to surmount so many barriers. Fish are necessarily continually in motion, and this, when not requiring violent efforts, as in ascending dams, is not more exhausting in a river than in the ocean.

As far as the sojourn of the California salmon in the Gulf of Mex-

ico is concerned, it is quite probable that whatever the degree of heat to which they are subjected in the summer-season, they probably require during their residence in the sea a temperature as low, at least, as about 40° Fahrenheit; this inference being based upon the fact of their restriction to more northern latitudes, in which this temperature is most likely to be found. In considering the question of introducing the California or other salmon into the tributaries of the Mississippi, the inquiry was naturally suggested as to the temperatures of the Gulf of Mexico, into which the salmon would pass in their outward journey, and where they would probably remain.

Application for information was accordingly made to Captain Patterson, Superintendent of the Coast Survey, who kindly furnished copies of records from the archives of the office, (for details of these, see appendix,) from which we learn that in certain portions of the Gulf, where the surface-temperature was 77°, it was 50° at a depth of 230 fathoms, and at 420 to 790 fathoms it was noted at 35° and 36° Fahrenheit, in the month of April. At another locality, with a surface-temperature of 77½°, that at the bottom was 38°. At a depth of 1,133 fathoms, in a line from the mouth of the Mississippi to the Tortugas, latitude 27° 16′ and longitude 86° 57′, the temperature at the bottom was found to be 29°. On another line of soundings, between the mouth of the Mississippi and the Tortugas, a temperature of 34° was found at a depth of 896 fathoms; while between Cuba and Florida 38° were noted at 600 fathoms; and on a line from Mobile to Key West the temperature at 190 fathoms was found to be 38°, that at the surface being 83°.

Although it is probable that these indications, some of which were perhaps made by the old-fashioned thermometers, may be somewhat erroneous, yet there can be no question as to the occurrence in the Gulf of Mexico of very deep water and of temperatures perfectly suited to the abode of salmon of any species. Neither can there be any doubt of the occurrence of suitable food in this same region. Therefore there seems to be no reason to question that all the conditions needed for the growth of this fish are to be met with in the Gulf of Mexico; and at any rate we are warranted in making the experiment for the purpose of determining the fact.

5.—*The land-locked salmon (Salmo sebago?).*

Certain bodies of water in Maine, especially the upper lakes of the Saint Croix, Reed's Pond, near Ellsworth, Sebec River and Pond, and the Sebago Pond, are inhabited by a variety of the salmon in general habits and appearance closely resembling the true sea-salmon but differing in size. Their average weight in most of the localities mentioned is from 2 to 4 or 5 pounds, sometimes, however, being taken weighing from 10 to 15 pounds. The Sebago fish is, however, much larger; the mature fish averaging perhaps 6 to 8 pounds. A similar fish occurs also in the lakes of New Brunswick and perhaps of Nova Scotia.

Much ingenuity has been expended in the discussion of the question whether these are or are not the true salmon. They appear to present trifling peculiarities; but so far no difference of any special value has been noted. They take the fly with the utmost eagerness, and there is no fish that affords better sport, especially in localities where they abound. To Dr. A. C. Hamlin, of Bangor, we owe a very interesting article upon this fish, published in Lippincott's Magazine for May, 1869, and reproduced on page 338. This gentleman is of the opinion, after a careful investigation, that the variety is really of modern origin, having been developed only since the erection of mill-dams on the streams mentioned. He thinks he has evidence that forty or fifty years ago, or possibly one hundred, no such kind of fish was known in these streams, and that it was only after the erection of the dams, making the passage of fish from below impossible, when the young fish were penned into the upper waters and rendered averse to the experiment of going down over them, that the so-called land-locked salmon was met with. This conclusion is, however, stoutly contested by other authors, as by Dr. A. Leith Adams. The land-locked salmon, however, whether a distinct species or a variety of the true salmon, is one of very great value for stocking our small lakes; and another season it is proposed, should Congress authorize it, to attempt operations on a large scale in securing these eggs and placing the young fish in the more western waters.

The fish are taken readily with the fly throughout the greater part of the year, at least from early spring until late in the autumn, with the exception of a short interval in the hotter weather of midsummer.

Many persons maintain that the salmon of Lake Ontario is really land-locked; that is, it does not spend any portion of its life in the ocean. This, however, is a question which cannot be determined by our present data.

6.—*The sea-trout* (*Salmo immaculatus ?*).

Another fish which has been suggested for introduction into the waters of the United States is the sea-trout (*Salmo immaculatus ?*). This is very common in the waters of the Gulf of Saint Lawrence, and also in those of the Atlantic coast in Nova Scotia. It runs up in the spring into brackish waters in great numbers for the purpose of spawning. It is very abundant in Newfoundland and on the coast of Labrador, where immense numbers are caught and sent to the Boston market. As yet we know very little of its natural history; but there seems no reason to doubt that it would answer admirably for the streams on the coast of Maine. As a fresh fish it is of delicious flavor, although very inferior to the salmon when salted.

7.—*The lake-trout* (*Salmo namaycush ?*).

This fish, very characteristic of all the great lakes of the Northern States, and occurring in one variety or another in smaller bodies of water

all along our northern frontier, is variously called salmon-trout, lake-trout, togue, &c. The exact number of species, if actually more than one, yet remains to be determined. It is a valuable food-fish, and is especially prominent in this connection in Lakes Superior, Michigan, Erie and Ontario. As affording sport to the angler, it is far inferior to other members of the genus *Salmo*, but, from its size and ease of manipulation and transfer, has already attracted much consideration. It has for some years been the subject of attention on the part of the New York State commissioners and of their agent, Seth Green, who every autumn collects millions of eggs from the fisheries on the Canadian side of Lake Ontario to be hatched at Caledonia, N. Y., for distribution to the lakes in the interior of New York. The experiment has lately been made of planting the young fish in running water, as the Susquehanna, &c.; but it yet remains to be seen how they will thrive.

The lake-trout is eminently worthy the attention of States along the great lakes, since, with the white-fish, it constitutes by far the most important element in the great fisheries.

8.—*The hucho or Danube salmon, (Salmo hucho.)*

Another species which promises to be of value in the United States is *Salmo hucho*, or the salmon of the Danube. This fish has been warmly recommended as admirably suited for the Mississippi River, since, unlike the true salmon, it appears to spend most of its time in the river, seldom, if at all, making its way into the salt water. Opinions differ, however, in this respect, as to whether all the Danube fish spend a part of their life in the Black Sea, or whether it is those only which belong to its immediate vicinity that run into it. The hucho is of good quality for the table, and attains a weight of from forty to sixty pounds. It passes at the proper season into the smaller tributaries of the Danube, and is taken throughout its extent in immense numbers. It is a voracious fish, however, and feeds exclusively in the river, devouring other fishes with great avidity. In my judgment, it would be inexpedient to introduce this fish into waters where the true salmon live; the latter having the excellent quality of not disturbing the existing inhabitants of the rivers, but deriving the material of its growth, after the first few months of its existence, from the ocean. Unless the Sacramento salmon can be naturalized in the Mississippi, no other species but that of the Danube is likely to find suitable quarters there; and the question of its introduction will, therefore, be taken into consideration, after more full information in regard to the habits of the fish can be obtained. Further details respecting the hucho will be found in the article by Mr. R. Hessel on page 161.

9.—*Small American trout.*

I have already referred to the various questions connected with the propagation of the eastern brook-trout, (*Salmo fontinalis*,) and which, in view of the extent to which it is cared for by the States and by private

establishments, requires no attention on the part of the United States. A second eastern species, of great beauty, the blue-back, (*Salmo oquassa*, Girard,) is found in the lakes at the headwaters of the Androscoggin, Rangeley, Oquassoc, &c., where it inhabits their depths for the greater part of the year, only coming to notice for a few weeks in the autumn, when it enters the tributary streams or outlets to spawn. No proposition has yet been made to multiply this species artificially.

In this connection it may be remarked that, in the same lakes, the common brook-trout (*Salmo fontinalis*) occur of enormous size, even up to ten pounds, and that Mr. George Shepard Page, and his associates of the Oquassoc Angling Company, are about establishing a hatching-house for the purpose of securing eggs of this variety, known as the Rangeley.

There are many species of brook and pond trout in the Rocky Mountain and Pacific region of the United States, as well as in British North America; none of which, so far, have attracted the attention of fish-culturists on account of special merit.

10.—*The Sälbling*, (*Salmo salvelinus.*)

Another European fish that might be introduced to advantage is the char, or *Salmo salvelinus*. This is a species that lives, more or less, in the larger lakes, running up into tributary streams to spawn, and in this connection would serve an excellent purpose for stocking interior waters that have now no specially desirable inmates.

11.—*The grayling*, (*Thymallus tricolor.*)

A species of the salmon family found in restricted areas of the United States, has lately attracted much attention among fish-culturists and sportsmen. It seems to be prolific and numerous in favorable waters; is excellent as food, and what, to many, are more admirable qualities, will take the fly and make a spirited contest with the angler before he can land him on the shore or in his boat. It has also a most beautiful combination of colors on the body as well as on the very large dorsal fin that is a peculiar character in this genus.

The grayling has lately been brought extensively to notice as occurring in the waters of Michigan, and even in that State seems to be confined to certain spring-fed rivers in the lower peninsula. It is also found in the headwaters of the Missouri in the region adjacent to the valley of the Yellowstone. Whether it is different from the grayling found in certain rivers of Alaska, is a question not yet positively decided, but its separation as a species from the English and European *Thymallus vulgaris* Nilss. is marked and decided.

It has been successfully transported from Michigan to New York State by Fred. Mather and Seth Green, as also to Southern Michigan, for the purpose of introduction into trout-streams. Seth Green has succeeded in hatching the eggs, and has found them well adapted to the artificial processes.

12.—*The white-fish, Coregonus, etc.*

In the report by Mr. Milner, on page 1, will be found the result of his investigations, prosecuted through two seasons, with regard to this the most important fish of the great lakes; and in his general conclusions and recommendations, as to the future treatment of the subject, I entirely concur.

Few fishes of North America will better repay efforts for their multiplication than the white-fish. It is to this species especially that the States bordering on the great lakes have had their attention directed, and it is probable that the efforts of the United States will not be required to any great extent in aiding the multiplication of their numbers. It is understood that the newly-appointed commissioners of Michigan aim at introducing to the waters bordering on that State at least eight or ten millions of artificially-hatched eggs, and it is probable that Wisconsin, Ohio, and Minnesota will sooner or later follow suit. The introduction of this fish into the lakes of California and Utah will, however, continue to occupy my attention as far as the funds at my command will permit.

Otsego Lake in Central New York, the head of the Susquehanna River, is tenanted by a fish of the finest quality called the Otsego bass, (*Coregonus otsego*,) a true white-fish, and not yet satisfactorily distinguished from the *C. albus*, or the white-fish of the lakes. This is now the subject of experiment in the way of artificial multiplication for the benefit of Otsego Lake, and may hereafter furnish a valuable contribution to other lakes. Otsego Lake is, perhaps, the most southern station for the genus *Coregonus*, in the Eastern United States at least, and the fish from its waters are probably well adapted to other lakes of the same or even more southern latitudes. The experiment now making at Cooperstown, N. Y., under the direction of Capt. Elihu Phinney and Capt. P. P. Cooper, is, therefore, one in which the public have a great interest.

13.—*The nerfling, orfe, or golden tench.*—(*Idus melanotus.*)

A fish lately introduced into England from Germany is the "orfe" or "nerfling," *Idus melanotus*, a cyprinoid related to the European tench, and which is valuable for its beauty, color, and appearance, as well as for food.

It is said to surpass the gold-fish in the brilliant red color that covers the upper portion of the body. The belly portion is white. It is also said to be more active and lively in its movements, and attains a much larger size. It is very prolific, and sustains its numbers in larger bodies of water than the gold-fish does. Those who have seen this fish in its native waters state that there is no more brilliant sight imaginable than to witness the schools of "nerflings" rise in a body to the surface and flash along in the sunlight, as they delight to do.

The bright, red color of this beautiful fish is not found in the original wild species, but is a character developed in domestication, and perpetuated in the progeny by breeding in and in, or at any rate by selection of those individuals possessing the character in a superior degree. This process continued through many generations develops a tenacious tendency in all to reproduce the character, and a variety is established.

14.—*The carp.*

Sufficient attention has not been paid in the United States to the introduction of the European carp as a food-fish, and yet it is quite safe to say that there is no other species that promises so great a return in limited waters. It has the pre-eminent advantage over such fish as the black bass, trout, grayling, &c., that it is a vegetable feeder, and, although not disdaining animal matters, can thrive very well upon aquatic vegetation alone. On this account it can be kept in tanks, small ponds, &c., and a very much larger weight obtained, without expense, than in the case of the other kinds indicated.

It is on this account that its culture has been continued for centuries. It is also a mistake to compare the flesh with that of the ordinary *Cyprinidæ* of the United States, such as suckers, chubs, and the like, the flesh of the genuine carp (*Cyprinus carpio*) being firm, flaky, and in some varieties almost equal to the European trout.

Mr. Hessel informs me that there is the greatest imaginable difference in the taste of the so-called carp in the European ponds, and that a species very closely allied to the carp (*Cyprinus carassius*) differs from it in the greater abundance of bones and its muddy flavor. What he considers as a hybrid between the two described as *C. kollari*, is in very many parts of Europe the representative of the carp, being frequently found in Germany, Holland, and Belgium under this name.

Among the estimable varieties of the true carp, Mr. Hessel specifies as the best the king-carp, or *Cyprinus rex cyprinorum*. This has the peculiarity of being almost destitute of scales, only a few being attached here and there to the skin. There are also, according to this eminent pisciculturist, varieties of carp in which the generative apparatus seems to be atrophied so as to render them incapable of reproduction. These are found in various regions on the Upper Rhine, on the Danube, on the Rhine, and the Po, and are very much sought after, bringing three times the price of other fish; indeed, as already remarked, they are considered equal to the trout. Mr. Hessel professes to be acquainted with a method of producing this sterility on a large scale and with certainty. Another race equally eligible is the one entirely destitute of scale, (*Cyprinus nudus*, vel *alepidotus*,) in which the skin is soft as the finest velvet, requiring no scaling, and when cooked adding greatly to the savor of the fish. The constant form of this only occurs in certain lakes in eastern Europe. Neither of these varieties is known in England.

The best carp, Mr. Hessel thinks, are to be found in the region of the Danube, characterized by the elevated, fleshy, and compressed back, a rapid growth, and delicious flesh. For almost thousands of years they have been kept in ponds connected with various public and private estates.

15.—*The gourami.*—(*Osphromenus olfax.*)

A fish that has attracted the attention of all interested in the introduction of valuable animals to the country of their residence is the gourami.

It has had an existence, whether indigenous or not, for many centuries in the fresh waters of Cochin China, and is found also in portions of the mainland and islands of the China Sea and Indian Ocean. It has been successfully acclimated in certain islands to the eastward of Africa. Living specimens are now in the possession of the Museum of Natural History and of Mr. Carbonnier, of Paris. Attempts have been made, without satisfactory success, to introduce it into regions of South America, the West Indies, Southern Africa, Australia, Egypt, and France.

The qualities that are brought forward as causing so high an estimate of the value of the *gourami* are its superior excellence as food and the fact that it is adapted to waters under a hot sun, attaining the highest degrees of temperature. It is also largely a vegetable eater, feeding upon water-plants of genera that are found in widely separated regions of the globe. It may be fed, too, with numerous articles of ordinary food, and the refuse of the table, and kept in confined bodies of water, provided they contain suitable plants.

It attains, under favorable circumstances, the weight of twenty-five or thirty pounds, though from three to five is said to be the average. It is also said to thrive in brackish as well as fresh waters.

The numerous failures to transport it and keep it alive during long voyages would scarcely influence American fish-culturists against its attempted introduction, as it is well known that inexperienced persons lose those fish during transportation which have the greatest tenacity of life under proper treatment. The fish could be brought from the Mauritius, India, Java, China, or other accessible localities, and, by care in selecting the period and route of the transfer, the experiment would doubtless be successful. Recent experiments have shown that some varieties resist the influence of cold more than others; a temperature even of 47° F. having been endured with impunity in the case of a number lately transported to France. They might be readily introduced from the region of China into the high-temperature "tule" lakes of Southern California and Nevada, and from there distributed farther east.

They guard their eggs and young with the utmost vigilance and courage, and their propagation and multiplication can be left to nature if the proper conditions in water and food are afforded them.

16.—*The sterlet.*

The sterlet, (*Acipenser ruthenus*,) a small species of sturgeon, found in Russia, has a superior reputation as a table-fish. The Russian minister of Crown lands has caused it to be introduced from its original home in the Volga to the vicinity of St. Petersburg.

As the embryo has so short a period in the egg stage, the transportation of the latter for long distances is attended with many difficulties. By means of a carefully-constructed apparatus, and provision for the anticipated hatching of the eggs *en route*, in 1870, a considerable number of the young fry were transported from Russia and introduced into the waters of Sutherlandshire, Scotland, in apparently good condition.

It has been, on several occasions, suggested that it would be a valuable acquisition to the United States for such waters as the Ohio and Mississippi Rivers, which are said to be very similar in their character and in their related climate to the Volga, of Russia, in which the species is native.

Quite recently a number of sterlet were brought from St. Petersburg to the Brighton aquarium, where they form a conspicuous feature. They were obtained in the Volga, and transported 1,400 miles in the well of a fishing-boat to St. Petersburg, and thence by steamer to London.

It is from the roe of the sterlet that caviare of the finest quality is made, which constitutes an article of commerce and trade in Russia; and of which, in late years, a limited quantity has been made in the United States from the lake and Atlantic coast sturgeons.

17.—*Hybrid fish.*

In certain establishments in Europe much attention is paid to the artificial production of crosses between certain closely-allied species of the Salmonid family, as the Salmon, the Brook-Trout, the Lake-Trout, the Säbbling, &c. The fish thus produced, though for the most part barren, and requiring a continuation of the operation in successive years, are of very superior quality, of tender flesh, and grow with great rapidity, as is usually the case with animals with deficient organs of generation. They, indeed, bear the same relations to other fishes of their kind, as do domestic cattle, hogs, chickens, &c., when altered to the perfect animal. Salmon thus hybridized lose the instinct of migration to the ocean. There is no reason why the same method may not be applied to other fresh-water species, and to certain sea-fish, with corresponding results.

CONCLUDING REMARKS.

It is perhaps hardly necessary to summarize here the steps taken to increase the supply of shad in the United States, as the subject has already been fully treated of.

As shown in the earlier part of the present report, my efforts, in 1872,

as United States Commissioner of Fish and Fisheries, so far as salmon were concerned, were directed to securing a large supply, first of *Salmo salar*, or the Atlantic salmon, from the establishment of Mr. Atkins, at Bucksport, and from the river Rhine, in Germany; and, second, of the California salmon (*Salmo quinnat?*) from the Sacramento River, through Mr. Livingston Stone, the details of which efforts it is unnecessary to repeat here.

In the accompanying report by Mr. Atkins (page 226) will be found the history of his experiments, with much practical information in regard to the habits and peculiarities of the fish. A similar article in reference to the California salmon, by Mr. Stone, is given on page 168.

The labors of 1873 will, it is hoped, be conducted on a much larger scale, and I trust that enough eggs of the Sacramento salmon may be procured to make a satisfactory beginning of the experiment. I am quite well satisfied that it is to this species that we are to look for a supply for such rivers as the Hudson, Delaware, Susquehanna, Potomac, James, and perhaps others still farther south, as well as for the waters of the Mississippi Valley. Eastern salmon, on the other hand, will perhaps be best adapted to the rivers of New England and to the great lakes; although it is proposed to introduce both kinds into such localities as the means at my command will permit. There is nothing to prevent the two species living together in the same stream, especially in view of the fact that it is only the young fry, for the first year or two, which require food in the fresh water, the great mass of the material of growth being derived from the sea. Their periods of migration, too, are entirely distinct; the western species entering the rivers early in winter, and spawning at the headwaters as early as August; while the eastern salmon, coming in several months later, does not spawn until October or the beginning of November. Should no change take place in the habits of either kind, the salmon season would be very much longer than otherwise, and salmon could be had, perhaps, over a period of from eight to eleven months, instead of three or four, as at present.

The great advantage of the Sacramento fish is to be found in its ability to sustain itself in a much higher temperature than that endurable by the Atlantic-coast salmon. Thus, while the eastern is said to be driven back to sea, in Germany at least, by a temperature of 65°, (60° being the maximum of preference,) the Sacramento fish occupies a river flowing through one of the hottest regions of North America, where in the season of 1872 Mr. Stone found the prevailing temperature during the whole season of the salmon-spawning to be from 100° to 115° in the shade, and almost unendurable. It is true that the river-water at the United States hatching establishment is cooled by the melting ice and snow from Mount Shasta, but lower down the Sacramento, where the salmon formerly spawned in great numbers, and do still to some extent, the temperature in the river reached 75° F., and even more during the summer.

Another fact of importance connected with the Sacramento fish is the great rapidity of its growth, those of corresponding age being almost twice as heavy as their eastern relatives. According to Mr. Reeder, fish commissioner of Pennsylvania, the Sacramento salmon, which were introduced into the Susquehanna River in February, 1873, were found in good health and condition in the following September, measuring seven or eight inches in length, while the Penobscot salmon, about ten months old, were not half the size. This difference is appreciable in all stages of growth, the eggs and young fish being twice as large as those of the eastern species.

The Sacramento salmon is said to lack the very delicate flavor of the eastern fish. This, however, is stoutly denied, especially by Mr. Throckmorton, whose letter on the subject will be found on page 373.

In any event, the difference must be trifling when the fish is procurable fresh; and if the two species could be tasted side by side, under the same conditions, it is probable that the difference would prove to be of very little moment.

The supposed disinclination of the Sacramento fish to take the hook has been presented as a great objection to it. This, if well founded, would be of very little consequence, since salmon, for economical purposes, are more generally taken in nets than with the hook. But, according to Seth Green, they can be taken with the fly; and Mr. Livingston Stone maintains, as shown in his report, that they will bite voraciously at the roe of their own species, and can be taken in any number. The young fish in the hatching-ponds rise with the greatest readiness To Mr. Stone's report on this species I refer for further details.

As already remarked, experiments are contemplated in reference to the multiplication of the land-locked salmon and of the lake-trout. Whether the sea-trout, or white trout of the eastern coast, will be worth any special effort for its increase, is very doubtful. It is proposed, however, as soon as it can be accomplished, to secure some of the impregnated eggs of the Danube salmon, (*Salmo hucho*,) which appears especially fitted to the Mississippi River. The objection to this species, which attains the weight of fifty pounds and multiplies very rapidly, is mainly drawn from its alleged voracity, and from the fact that it is almost exclusively a river-fish, feeding therein all the year, and, of course, devouring other kinds in keeping up its own growth. At present, however, there are very few fish of any special value as food in the great system of waters of the Mississippi Valley; the black bass, the salmon-perch, or-wall-eyed pike, (*Lucioperca*,) and, perhaps, one or two species of pickerel, being most important. Of the great variety of suckers, chubs, sun-fish, &c., but little commendatory can be said. The great bulk of these fish, however, and of nearly all the *Cyprinidæ*, are proverbial for their insipidity, and they are generally esteemed worthless as food. The effect of introducing the Danube salmon would be simply to substitute for a superfluity of fish of very inferior value, a kind having all

the gamesomeness and excellence of flesh of the salmon, and I think it would be perfectly safe to make the experiment. Under any circumstances, the Danube salmon is a less voracious fish than the pickerel, and might probably require much less weight of food to acquire a given amount of growth.

Some of the other species referred to above will probably be taken up for consideration at an early day.

The restoration of food-fishes to localities originally tenanted by them, or their transfer to new waters, is, however, a question of time; and in the immense extent of our river and lake systems, many years must necessarily elapse before the work can be accomplished. It is also inexpedient to attempt to cover too much ground at once, as in the necessary limitations furnished by the amount of the appropriations, and the difficulty of finding skilled assistants, it is considered the better policy to render fish very abundant in a few centers by concentrating effort upon them, and then from these centers to carry on the work elsewhere. It is not a percentage so much as an absolute number of young fry that must be sacrificed to the rapacity of the pre-existing inhabitants of the stream into which they are introduced; and it is evident that, supposing that the average probability of destruction amounts to 10,000 fish in a given period, if we introduce only that number there will be no surplus; whereas with 50,000 the excess will be enough to allow the maturing of adults sufficient to stock the waters.

It must, however, be borne in mind that it is not sufficient to take measures for introducing the fish, whether young or adult, into new waters, but that much then remains in the way of protecting them when once established, and in securing their passage to and from the sea. State legislation will be required to bring about the removal of obstructions; introduction of suitable fish-ways; prevention of the pollution of the waters, and the capture of the fish at improper times, by improper modes, &c.

When we consider that the prime cause of the decrease in our salmon and shad fisheries is believed to be in the erection of impassable dams, thus preventing their access to the spawning-grounds, it will be readily understood that, unless some provision be made for surmounting these obstructions, the fisheries cannot be self-sustaining. Fortunately, however, in the fish-ways, of which a great variety has lately been devised, we have in most cases a practical remedy; experience having shown that where these are inserted in dams, with the lower end perfectly accessible to the fish and a sufficient volume of water issuing from it, fish will ascend with great facility. This is especially the case with the salmon and alewife, but it is also probably true of the shad. The general theory of fish-ways, and the various forms suggested, or in use, will be found given in detail in an admirable essay on the subject in the present report as prepared by Mr. Atkins.

Care must also be taken, in planting the fish, to introduce them as far

up the stream as practicable, since it is an established fact that adult fish will always return to the place where they first made acquaintance with the water, passing directly by the mouths of streams or tributaries better adapted to their purposes, to gain their orignal home. For this reason, it is well to carry the young fish to the highest point in a stream that can be reached, even though numerous fish-ways may be required to permit the return of the adult fish. It may safely be assumed that fish born below an impassable dam will not ascend far above it, even with a suitable fish-way; although it is quite possible that when they feel themselves in a powerful current of the fish-way, they may enter it and reach the uppper part of the dam. Here, the water being quiet, they will probably remain without proceeding to any considerable distance. Mr. Seth Green informs me that the fish hatched at Castleton, below Albany, when ascending the river as adult fish, very rarely go beyond their original starting-point, so that, while there is a great supply at that locality, there has been little or no increase in the numbers higher up the river.

In addition to the construction of fish-ways, steps must be taken to prevent the capture of the breeding-fish in improper numbers. This can only be done satisfactorily by providing for a close time during the fishing-season of two or three days in each week, during which no fish are to be taken, and by stopping the fishery entirely after a certain date. This period will vary with the season; the time of cessation, as far as shad are concerned, coming earlier in the South than in the North—perhaps about the middle of May for the Potomac River, the first of June for the Delaware and Susquehanna, the middle of June for the Hudson, and the twenty-fifth of June for the Connecticut. A proper close time for the eastern salmon would fall some time in August or the beginning of September.

The use of nets and other engines for the capture of adult fish can only be considered improper when carried to an excess, and covering too great a period of time. Anything, however, that affects the young and destroys them before attaining their full growth should be prohibited. Among the most injurious agencies in this direction are the fish-dams, so abundant in certain streams in the autumn, consisting of two walls of stone in the shape of the letter V, the angle pointing down the current, and opening into what is called a fish-basket. The object of this is to guide the descending fish, in the entire breadth of the river, into this basket, into which they fall, and from which they are sometimes removed by the wagon-load. The special object of this kind of fishery is the capture of eels, which, as is well known, run down, when mature, in the autumn to the sea for the purpose of spawning; but the baskets take millions of other fish, and are especially injurious to the young shad. Pennsylvania and Delaware have, we believe, prohibited the use of these dams in shad-streams, and with very great propriety.

Other points to be regulated, and requiring more or less of legislative

interference, are the introduction of injurious chemicals, refuse of gas-works, sewage, and other substances, into the rivers, by means of which the fish, both adult and young, are poisoned, or else their passage through to their proper spawning-grounds prevented, to say nothing of the unpleasant taste imparted to the fish themselves when exposed to these influences. These and other improper interferences with the fish and the rights of the people at large, which will readily suggest themselves, should, as already stated, invoke the legislation of the States; and, unless these can be guaranteed, it is hardly worth while to attempt the planting and propagation of fish in American rivers.

It is true that by continuing indefinitely the practice of artificial impregnation of the eggs and introduction of the young into the water, the supply of fish can be maintained; and should they, in ascending the streams, find an impassable barrier, the only effect would be to furnish a great abundance to the fishermen below the obstruction, while those above it would be entirely cut off. It is not to be expected, however, that either State governments or Congress will continue to make such appropriations indefinitely, and it is quite time that a general system of legislation should be devised and carried into effect by the various States.

In concluding the present report, I have much pleasure in returning my special acknowledgments to the commissioners of Maine, Massachusetts, Connecticut, and New York for their hearty co-operation in the steps taken to carry out the law of Congress in reference to the multiplication of the food-fishes.

Salmon-hatching operations in the

Under whose auspices.	Place where spawn was collected.	Place where eggs were hatched.	In charge of hatching.	Waters stocked.
Maine	Newcastle, Ont	Whiting, Me	W. S. Peavey	Cobscook River
	do	Alna, Me	David C. Pottle	Sheepscot River
	Miramichi River, N. B.	Augusta, Me		Kennebec River
	Penobscot River, Orland, Me.	Norway, Me	Crockett & Holmes	Androscoggin Riv.
	Penobscot River, Bucksport, Me.	Bucksport, Me	Charles G. Atkins.	Penobscot River
				Saint Croix River
				Androscoggin Riv.
New Hampshire	Miramichi River, N. B.	Woodstock, N. H	W. W. Fletcher	Merrimac River
	do	Concord, N. H	do	do
	do	Meredith, N. H	Robinson & Hoyt	do
	do	do	do	do
	Penobscot River, Bucksport, Me.			do
	do			do
	do		W. W. Fletcher	do
Vermont	Miramichi River, N. B.	Charlestown, N. H.	Livingston Stone	Lake Champlain
	do	do	do	Connecticut River.
	do	Chester, Vt	A. D. Hager	do
	do	do	do	do
	Penobscot River, Bucksport, Me.	Rochester, N. Y	Seth Green	Lake Champlain
Massachusetts	Miramichi River, N. B.	East Wareham, Mass.	S. T. Tisdale	
	do	West Barnstable, Mass.	Dexter, Coolidge, & Bacon.	Stream on Cape Cod.
	do	Winchester, Mass	E. A. Brackett	Mystic River
	Penobscot River, Orland, Me.	do	do	Stream on Cape Cod.
	do	do	do	Merrimac River
	Penobscot River, Bucksport, Me.	do	do	do
	do	do	do	Mystic River
	do	do	do	Red Brook
Rhode Island	Newcastle, Ont	Poneganset, R. I		Pawtuxet River
	Penobscot River, Bucksport, Me.	do	J. H. Barden	Blackstone River
			do	Pawtucket River
			do	Pawcatuck River
Connecticut	Miramichi River, N. B.	Charlestown, N. H	Livingston Stone	Great Brook
	do	do	do	do
	do	Poquonnock, Conn	Poquonnock Company.	Quinnebaug River.
	Newcastle, Ont	do	do	Housatonic River.
	do	do	do	Farmington River.
	do	do	do	Quinnebaug River.
	do	do	do	Saugatuck River
	do	North Branford, Conn.	Waltonian Hatching Society.	Farm River
	do	Middletown, Conn.	Robert G. Pike	Connecticut River.
	Penobscot River, Orland, Me.	Poquonnock, Conn	Poquonnock Company.	Quinnebaug River.
	do	do	William Clift *b*	Great Brook
	Penobscot River, Bucksport, Me.	do	do	Saugatuck River
		North Branford, Conn.	Waltonian Hatching Society.	Southport River
	do	Westport, Conn		Connecticut River.
	do	do	do	Mystic River
	do	do	do	Thames River
	do	do	do	Housatonic River
	do	do	do	Stream at North Branford.
	Penobscot River, Bucksport, Me.	Poquonnock, Conn	William Clift *b*	Great Brook

a Doubtful. The distribution was proposed in 1872, and no subsequent references made.

United States between 1866 *and* 1872.

Tributaries in which fish were placed.	Name of nearest city or village.	Number furnished by United States Commission of Fish and Fisheries.	Date of planting.	Total number of fishes.	References.
.....	.....	.....	1870	225	Atkins's Report, p. 232.
.....	.....	.....	1871	1,500	Fourth Report Commission of Fisheries, Maine, 1870, p. 28.
.....	.....	.....	1871	800	Sixth Report Commission of Fisheries, Maine, 1872, p. 15.
Little Androscoggin River.	.....	.....	1872	21,000	Do.
Tributaries	.....	50,585	1873	67,000	Atkins's Report, Table XI, p. 288.
.....	.....	77,550	1873	10,000	Do.
Tributaries	.....	98,150	1873	130,000	Do.
Pemigewasset River	Woodstock, N. H.	.....	1866	15,000	Report Commission of Fisheries, New Hampshire, 1869, p. 6.
.....	.....	.....	1867	250	Do.
Pemigewasset River	Livermore Falls, N. H.	.....	1869	5,000	
.....do	.....	.....	1870	1,000	Report Commission of Fisheries, New Hampshire, 1871, p. 6.
.....	Woodstock, Thornton, N. H.	.....	1872	16,000	Report Commission of Fisheries, New Hampshire, 1873, p. 4.
.....	.....do	.....	1873	160,000	Do.
Tributaries	.....	14,000	1873	14,000	Atkins's Report, Table XI, p. 288.
Winooski River	Montpelier, Vt.	.....	1869	2,500	Report Fish Commission of Vermont, 1869, p. 11.
West River	Weston, Vt.	.....			
.....do	.....	.....	1870	30,000	Report Fish Commission of Vermont, 1871–'72, p. 5.
Williams River	Bellows Falls, Vt.	.....			
Winooski and Lamoille Rivers.	.....	7,000	1873	7,000	Atkins's Report, Table XI, p. 288.
Agawam River (?)	.....	.....	1870	3,000	Massachusetts Report, 1871, pp. 11, 12.
.....	.....	.....	1870	1,500	Do.
.....	.....	.....	1870	700	Do.
.....	.....	.....	1872	5,000	Massachusetts Report, 1873, p. 16.
Pemigewasset River	Plymouth, N. H.	.....	1872	16,000	Do.
.....	.....	21,450	1873	165,000	Atkins's Report, Table XI, p. 288.
.....	.....	1,430	1873	11,000	Do.
.....	.....	1,430	1873	11,000	Do.
.....	.....	.....	1872	9,000	Third Annual Report Rhode Island, p. 4.
.....	.....	6,400	1873	64,000	Atkins's Report, Table XI, p. 288.
Tributary to Long Island Sound.	New London, Conn	.....	1870	2,000	Atkins's Report, p. 230.
.....do	.....do	.....	1871	90	Do.
Broad Brook	.....	.....	1871	1,876	Connecticut Report, 1871, p. 20.
Tributaries	.....	.....	1871	8,000	Connecticut Report, 1872, p. 28.
.....do	Westport, Conn.	.....	1872	*a*7,377	Connecticut Report, 1872, pp. 27, 28.
.....	North Branford, Conn.	.....	1872	*a*900	
Little River	Middletown, Conn.	.....	1872	*a*600	
Tributaries	.....	.....	1872	17,000	Connecticut Report, 1872, p. 28.
.....	.....	.....	1872	5,000	Atkins's Report, p. 241.
.....	.....	1,365	1873	4,500	Atkins's Report, Table XI, p. 288.
.....	.....	1,365	1873	4,500	Do.
Tributaries	.....	34,880	1873	115,000	Do.
.....	.....	1,500	1873	5,000	Do.
Tributaries	.....	3,000	1873	10,000	Do.
.....	.....	21,200	1873	70,000	Do.
.....	North Branford, Conn.	10,100	1873	35,000	Do.
.....	.....	.....	1873	43,000	Do.

b Private enterprise.

Salmon-hatching operations in the United

Under whose auspices.	Place where spawn was collected.	Place where eggs were hatched.	In charge of hatching.	Waters stocked.
New York	Penobscot River, Bucksport, Me.	Caledonia Springs, N. Y.	Seth Green	Hudson River
	do	do	do	Lake Ontario
	do	do	do	do
New Jersey	do	Bloomsbury, N. J.	J. H. Slack, M. D.	Long Island Sound
	do	do	do	Raritan River
	do	do	do	Delaware River
Pennsylvania	Newcastle, Ont	Dutchess Co., N. Y.		do
	do	Easton, Pa.	Thaddeus Norris	do
	Penobscot River, Bucksport, Me.	do	do	do
Ohio	do	Castalia, Ohio	John Hoyt	Lake Erie
Michigan	do	Clarkston, Mich.	Nelson W. Clark	Lake Saint Clair
	do	do	do	Lake Erie
	do	do	do	do
	do	do	do	do
	do	do	do	do
	do	do	do	
	do	do	do	
	do	do	do	
	do	do	do	
	do	do	do	Lake Michigan
	do	do	do	do
	do	do	do	do
	do	do	do	do
	do	do	do	do
	do	do	do	do
	do	do	do	do
	do	do	do	do
	do	do	do	Lake Huron
Wisconsin	do	Waterville, Wis.	H. F. Dousman	Lake Michigan
	do	do	do	do
	do	do	do	do
Total				

States between 1866 *and* 1872—Continued.

Tributaries in which fish were placed.	Name of nearest city or village.	Number furnished by United States Commis'n of Fish and Fisheries.	Date of planting.	Total number of fishes.	References.
Peating and Ingleby Creeks.	.....	30,000	1873	30,000	Letter from Seth Green.
Salmon River	.....	15,000	1873	15,000	Do.
Oswego River	.....	15,000	1873	15,000	Do.
Small tributaries	.....	2,500	1873	2,500	Do.
Headwaters	.....	15,000	1873	15,000	Do.
Musconetcong Creek	.....	18,000	1873	18,000	Do.
Bushkill River	.....	.....	1871	2,500	Pennsylvania Report, 1873, p. 15.
.....do	.....	.....	1872	11,000	Pennsylvania Report, 1873, p. 16.
Heitzman Spring Brook.	.....	25,000	1873	25,000	
Castalia Spr'g stream	.....	2,500	1873	2,500	Atkins's Report, p. 288.
Lord's Lake	Pontiac, Mich	.....	1873	400	Information from N. W. Clark.
Orchard Lake	Oakland Co., Mich.	.....	1873	500	Do.
Walled Lake	....do	.....	1873	500	Do.
Whitmore Lake	Washtenaw Co., Mich.	.....	1873	500	Do.
Gun Lake	Hillsdale Co., Mich	.....	1873	500	Do.
Barrier Lake	....do	.....	1873	500	Do.
Diamond Lake	.....	.....	1873	1,000	Do.
Barren Lake	.....	.....	1873	500	Do.
Lake near Marshall	Calhoun Co., Mich.	.....	1873	500	Do.
Headwaters St. Joseph River.	Hillsdale Co., Mich	.....	1873	500	Do.
North Branch St. Joseph River.	.....	.....	1873	1,000	Do.
.....do	.....	.....	1873	1,000	Do.
Stream tributary to St. Joseph River.	St. Joseph, Mich.	.....	1873	1,500	Do.
Headwaters Kalamazoo River.	Jackson Co., Mich.	.....	1873	500	Do.
Grand River	....do	.....	1873	500	Do.
Muskegon River	.....	.....	1873	1,500	Do.
Manistee River	.....	.....	1873	1,500	Do.
Ausable River	Roscommon Co., Mich.	.....	1873	2,000	Do.
Menomonee River	.....	.....	1873	7,000	Letter of H. F. Dousman.
Oconomowoc Lake	Oconomowoc, Wis	.....	1873	1,000	Do.
Milwaukee River	Wauwatosa, Wis.	33,900	1873	11,000	Do.
.....	.....	517,805	.....	1,258,841	

Table of the distribution of young shad

By whom conducted.	Shad-hatching stations where young shad were procured.	Waters stocked with shad.
United States Commission of Fish and Fisheries.	Coeymans, N. Y., Hudson River	Alleghany River
Do	do	Mississippi River
Do	South Hadley Falls, Mass., Connecticut River.	Alleghany River
Do	do	Cuyahoga River
Do	do	White River
Do	do	Missouri River
Do	do	Platte River
Do	Washington, D. C., Potomac River	Greenbrier River
Do	do	New River
Do	Coeymans, N. Y., Hudson River	Calumet River
Do	do	Fox River
Do	do	Ashtabula River
Do	Lambertsville, N. J., Delaware River	Monongahela River
Do	Coeymans, N. Y., Hudson River	Wabash River
Do	do	Jordan River
Do	do	Sacramento River
Do	South Hadley Falls, Mass., Connecticut River.	Winooski River
Do	do	Housatonic River
Do	do	Penobscot River
Do	do	Otter Creek
Do	do	Detroit River
Do	do	Grand River
New Hampshire Commission of Fisheries.	North Andover, Mass., Merrimac River	Lake Winnepiscogee
Do	do	do
Do	do	do
Do	do	do
Vermont Commission of Fisheries.	South Hadley Falls, Mass., Connecticut River.	(Not recorded)
Do	do	Merrimac River
Do	Coeymans, N. Y., Hudson River	Lake Champlain
Massachusetts Commission of Fisheries.	South Hadley Falls, Mass., Connecticut River.	Whitney's Pond
Do	North Andover, Mass., Merrimac River	Mystic River
Do	do	Ipswich River
Do	do	Concord River
Do	do	Weweantit River
Do	do	Eel River
Do	do	Newmasket River
Do	do	Mystic River
Do	do	do
Do	South Hadley Falls, Mass., Connecticut River.	do
Rhode Island Commission of Fisheries.	do	Blackstone River
Do	do	Pawtuxet River
Do	do	Pawcatuck River
Connecticut Fish Commission	do	Poquonnock River
Do	do	Saugatuck River
Do	do	do
New York Commission of Fisheries.	Coeymans, N. Y., Hudson River	Genesee River
Do	do	do
Do	do	Lake Champlain
Do	do	Mohawk River
Do	do	Genesee River
Do	do	Lake Onondaga
Do	do	Canandaigua Lake
Do	do	Cayuga Lake
Do	do	Genesee River

(*a*) A few fry.

to the waters of the United States.

Name of city or village.	Date of planting.	Number of shad when starting.	Number of shad at destination.	Time young shad remained in the cans.	In charge of transfer.
Salamanca, N. Y	June 30, 1872	25,000	25,000	Ab't 7 h. 30 m.	Jonathan Mason.
Saint Paul, Minn	July 5, 1872	25,000	25,000	Ab't 60 h.	J. Mason & Chester Green.
Salamanca, N. Y	July 3, 1872	2,000,000	400,000	24 h. 30 m.	Rev. William Clift.
Kent, Ohio	July 3, 1872	.....	(*a*)	35 h. 15 m.	Do.
Indianapolis, Ind	July 4, 1872	.....	400,000	48 h.	Do.
Washington and Herman, Mo.	July 5, 1872	.....	(*a*)	78 h. 25 m.	Do.
Denver, Colo	July 7, 1872	.....	2,000	124 h. 30 m.	Do.
Ronceverte, W. Va	June 6, 1873	50,000	30,000	15 h. 15 m.	James W. Milner.
Central Station, Va	June 10, 1873	40,000	40,000	25 h. 30 m.	H. W. Welsher.
South Chicago, Ill	June 16, 1873	70,000	70,000	38 h.	James W. Milner and J. Mason.
Appleton, Wis	June 20, 1873	70,000	70,000	62 h.	Do.
Ashtabula, Ohio	June 24, 1873	50,000	50,000	25 h.	Jonathan Mason.
Greensburgh, Pa	June 25, 1873	15,000	15,000	15 h.	J. H. Slack, M. D.
Logansport, Ind	June 30, 1873	40,000	40,000	40 h.	James W. Milner and J. Mason.
Jordan, Utah	June 30, 1873	40,000	5,000	Ab't 121 h.	Livingston Stone and H. W. Welsher.
Tehama, Cal	July 2, 1873	.....	35,000	170 h. 30 m.	Do.
Burlington, Vt	July 5, 1873	100,000	100,000	15 h.	James W. Milner and J. Mason.
New Milford, Conn	July 8, 1873	90,000	90,000	5 h.	Do.
Mattawaumkeag, Me	July 12, 1873	100,000	100,000	28 h.	Do.
Vergennes, Vt	July 20, 1873	100,000	100,000	12 h.	Do.
Detroit, Mich	July 24, 1873	100,000	20,000	44 h.	Do.
Ionia, Mich	July 24, 1873	.....	80,000	53 h. 30 m.	Do.
.....	1868	.....	(*b*)	.....	
.....	1869	.....	400,000	.....	William W. Fletcher, M. D., and W. A. Sanborn.
.....	1870	.....	(*c*)	.....	
.....	1872	.....	(*d*)	.....	
.....	1867	.....	(*e*)	.....	Albert D. Hager and Chas. Barrett.
Concord, Vt	1867	.....	(*f*)	.....	Wm. W. Fletcher, M. D.
Burlington, Vt	1872	.....	50,000	.....	
——, Mass	1867	.....	5,000	.....	
Winchester, Mass	1868	.....	(*b*)	.....	
.....	1869	.....	100,000	.....	
.....	.....	.....	180,000	.....	
.....	.....	.....	100,000	.....	
.....	.....	.....	100,000	.....	
.....	.....	.....	100,000	.....	
Winchester, Mass	.....	.....	1,125,000	.....	
.....	1870	.....	(*c*)	.....	
——, Mass	1872	.....	(*g*)	.....	
.....	1872	.....	750,000	.....	Robert Holmes.
Mystic, Conn	1871	.....	1,500,000	.....	Rev. William Clift.
Westport, Conn	1871	5,000,000	(*h*)	.....	E. M. Lees.
....do	1872	(*g*)	.....	.....	Do.
Rochester, N. Y	June 30, 1870	.....	(*i*)	Ab't 10 h.	
....do	June 8, 1871	.....	15,000	Ab't 10 h.	
Whitehall, N. Y	June —, 1871	.....	50,000	Ab't 4 h. 30 m.	
——, N. Y	June 18, 1872	.....	150,000	.....	
Rochester, N. Y	June 21, 1872	.....	60,000	Ab't 10 h.	
Syracuse, N. Y	June 25, 1872	.....	30,000	Ab't 6 h.	
Canandaigua, N. Y	June 12, 1873	.....	54,000	Ab't 10 h.	Oren Chase.
.....	June 16, 1873	.....	54,000	Ab't 9 h.	Do.
Rochester, N. Y	June 19, 1873	.....	70,000	Ab't 10 h.	Monroe A. Green.

(*b*) A certain amount of spawn.
(*c*) Some spawn.
(*d*) Several thousands of eggs.
(*e*) A few in a bottle.
(*f*) Several millions.
(*g*) A few thousands.
(*h*) Not on record.
(*i*) A few shad.

Table of the distribution of young shad

By whom conducted.	Shad-hatching stations where young shad were procured.	Waters stocked with shad.
Michigan Commission of Fisheries.	Washington, D. C., Potomac River	Potomac River (*a*)
Do	Coeymans, N. Y., Hudson River	Grand River
Do	do	Raisin River
Do	do	Grand River
California Commission of Fisheries.	do	Lake Erie
Do	do	do
Do	do	Lake Michigan
Do	do	Bear River
Do	do	Sacramento River

(*a*) Destined for Grand River, Michigan. Finding that they were dying rapidly, the remaining living ones were put into the Potomac River. A trip of forty hours is too long for one man to attempt to carry shad successfully.

to the waters of the United States—Continued.

Name of city or village.	Date of planting.	Number of shad when starting.	Number of shad at destination.	Time young shad remained in the cans.	In charge of transfer.
Cumberland, Md	June 5, 1873	50,000	10,000	Ab't 9 h.	N. W. Clark.
Lansing, Mich	June 17, 1873	80,000	80,000	Ab't 45 h.	N. W. Clark and George Clark.
Monroe, Mich	June 28, 1873	.....	50,000	Ab't 44 h.	George H. Jerome and Oren Chase.
Lansing, Mich	June 28, 1873	.....			
Cleveland, Ohio	June 20, 1871	12,000	200	25 h. 45 m.	Seth Green.
Toledo, Ohio	June 20, 1871		(b)	.....	
Chicago, Ill	June 21, 1871		200	51 h.	
Ogden, Utah	June 23, 1871		200	104 h.	
Tehama, Cal	June 26, 1871		10,000	184 h.	

(b) Not stated.

Table of shad-hatching operations in the United States.

By whom conducted.	Year.	Place of operation.	River.	Superintendent.	Beginning.	Ending.	Average temperature of water.		Shad taken.	Males.	Females.	Ripe females.	Number of eggs.	Young shad released.	Young shad sent to distant waters.
							Morning.	Evening.							
United States Commission of Fish and Fisheries.	1873	Augusta, Ga	Savannah	Seth Green	Apr. 21	Apr. 28	.....	.....	13	.....	.....	(*)	.....	.....	.....
		New Berne, N. C	Neuse	do	May 1	May 14	64.6	65.6	57	.....	.....	2	50,000	43,000	.....
		Weldon, N. C	Roanoke	do	May 15	May 29	.....	.....	.....	.....	.....	(*)	.....	.....	.....
		Washington, D. C	Potomac	James W. Milner	May 17	June 10	68.2	71.9	3,605	.....	.....	111	2,170,000	1,370,000	140,000
		Lambertsville, N. J	Delaware	J. H. Slack	June 10	June 30	73.2	78	169	.....	.....	29	495,000	433,000	15,000
		Topsham, Me	Androscog'in	James W. Milner	July 14	July 16	.....	.....	16	.....	.....	(*)	.....	.....	.....
Maine Commission of Fisheries.	1868	Augusta, Me	Kennebec	N. W. Foster and Chas. G. Atkins.	June 28	July 4	70	75	.....	.....	.....	.....	100,000	50,000	.....
	1873	Bowdoinham, Me	.....	Henry O. Stanley	June 15	.....	.....	.....	.....	.....	.....	.....	.....	100,000	.....
Massachusetts Commission of Fisheries.	1867	South Hadley Falls, Mass.	Connecticut	Seth Green	July 1	July 21	.....	.....	.....	.....	.....	.....	.....	40,000,000	5,000, and "several millions."
	1868	do	do	do	June 20	July 16	.....	.....	.....	.....	.....	.....	.....	60,000,000	.....
	1869	North Andover, Mass.	Merrimac	A. C. Hardy	June 24	July 15	.....	.....	.....	.....	.....	.....	.....	Not rec'd	"A certain amount of spawn."
		Winchester, Mass	Mystic	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	"A large No."	.....
	1869	North Andover, Mass.	Merrimac	J. M. Gage	June 1	July 11	65.8	68.2	1,442	.....	.....	.....	2,370,000	"A large No."	.....
		do	do	A. C. Hardy	June 10	July 27	(†)	.....	1,500	1,105	367	....	2,160,000	.....	2,105,000
	1870	do	do	do	June 1	July 19	69.8	74.4	934	401	533	....	1,861,000	.....	"Some spawn."
	1871	do	do	do	May 20	July 22	.....	68	4,389	3,053	1,336	....	4,530,000	.....	.....
	1872	do	do	do	June 2	June 24	.....	70	2,447	1,479	968	....	5,895,000	.....	"Several thousand eggs."
Connecticut Commission of Fisheries.	1870	South Hadley Falls, Mass.	Connecticut	James Rankin	June 16	July 7	66.7	75.3	.....	.....	.....	....	54,620,000	.....	.....
	1871	do	do	Charles C. Smith	June 15	July 14	70.5	73	4,783	2,421	2,362	....	63,177,000	.....	6,500,000
	1872	do	do	do	June 24	July 22	77.6	79.2	3,398	946	2,452	....	92,065,000	.....	2,750,000, ("and a few thousand.")
	1873	do	do	do	June 23	July 23	.....	.....	3,013	1,051	1,962	....	44,556,000	.....	.....
New York Commission of Fisheries.	1868	Coeymans, N. Y	Hudson	Seth Green	June 18	.....	.....	77	.....	.....	.....	.....	.....	"Sev'l mil'ns"	.....
	1869	do	do	do	June 1	July 13	.....	.....	.....	.....	.....	.....	.....	15,000,000	.....
	1870	do	do	do	May 25	July 7	.....	76.5	1,334	.....	.....	110	2,604,000	.....	"A few shad."
	1871	do	do	do	May 18	July 5	72.9	75.3	3,758	.....	.....	480	8,620,000	8,050,600	127,000
	1872	do	do	do	May 17	July 2	66.4	69.5	4,527	.....	.....	439	8,750,000	6,177,000	290,000
	1873	do	do	do	May 20	June 30	67.3	70.6	1,643	.....	.....	293	5,740,000	4,503,000	658,000
Pennsylvania Commission of Fisheries.	1873	Newport, Pa	Juniata	Edward Boehme	May 10	June 15	.....	.....	(‡)	.....	.....	43	1,500,000	.....	20,000
		Marietta, Pa	.....	H. W. Welsher	.....	.....	.....	.....	.....	.....	.....	.....	.....	500,000	.....

* None. † Water at noon, 67°.2. ‡ Over 1,000.