XV.—REPORT ON THE CONDITION OF PISCICULTURE IN FOREIGN COUNTRIES FROM DOCUMENTS COLLECTED AT THE INTERNATIONAL FISHERY EXPOSITION AT BERLIN, 1880.

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THE UNITED STATES.

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

At present thirty-six States or Territories of the Union have each an official piscicultural organization, called a State Fish Commission, generally composed of three members, whose services are, in nearly all cases, given gratuitously,[1] and whose authority is generally limited to a period of three or four years. These Commissioners may, however, at the expiration of their term, be reappointed for another term; and their official position somewhat resembles that of the commissioned Inspectors of Fisheries of Great Britain. Their authority, however, is in no case very great. It is their duty to instruct fishermen, to stock the waters with young fish from the State piscicultural establishments,[2] to act as experts for the government, to point out desirable changes in legislation, to repress abuses, to adopt protective measures,[3] introduce

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[1] They are only reimbursed for their traveling expenses, and for expenses incurred during scientific researches or technical labors performed by them.

[2] The management of each establishment is generally confided to a superintendent, who draws a salary, and who is responsible for his administration.

[3] In the United States legislation affecting fishing differs in the different States. In the Northern States it generally resembles, more or less, the English legislation. Nearly

improvements, &c. Every year they submit to the legislature a statistical report, showing the work done during the year, the progress attained, and the observations made respecting pisciculture or fishing industries, the quantity of eggs or young fish distributed, &c.

Twenty-one States have State-hatcheries for the production of young fish, destined to restock the public waters. Some States, like Michigan, possess as many as three of these hatcheries. There are, therefore, in operation thirty-eight of these establishments, not counting those created for the piscicultural work undertaken by the Federal Government, besides that done by the States on their own account. In Connecticut the commission, which does not yet possess a hatchery, has made a contract with two private establishments for producing the young fish which it needs annually, and pays to the owners of these establishments a dollar for every thousand eggs which it hatches.

To the State of Massachusetts belongs the honor of having officially introduced pisciculture in the United States. This State was the first to intrust to a commission "the duty of studying facts relative to the artificial propagation of fish, and the ways and means of causing this industry to contribute, under the protection of the law, to the wealth of the State." Various experiments were made (in 1856) by this commission, which published a report on the condition of pisciculture in foreign countries, including a translation of the remarkable article published by M. Jules Haime in the *Revue des deux mondes* in 1854.

But the idea was not yet fully matured;[4] the public did not fathom the full importance of these experiments, which passed almost unobserved; and it was only in 1865 that Massachusetts definitely constituted her Fish Commission on the present basis.

Vermont and New Hampshire, and later, Connecticut and Pennsylvania followed the example set by Massachusetts, and created Fish Commissions whose duty it should be to restock the public waters. In 1864 Mr. Seth Green founded, near New York, the first American piscicultural establishment, on thorough business principles, and he soon found many imitators.

The results obtained by private enterprise proved the importance of similar establishments for rapidly restocking water-courses, and, in 1867, the State of Massachusetts established at South Hadley Falls, on the Connecticut River, a hatchery for the artificial propagation of shad.

In the same place and the same year Mr. Seth Green, who had also occupied himself with the propagation of shad, invented his hatching apparatus, consisting of inclined boxes floating in the water. These

everywhere, even in the largest rivers, such as the Mississippi, the right of fishing belongs to the inhabitants of the banks, but only to the point where the tide makes itself felt, and where the maritime domain commences. In the Southern States, on the contrary, the right of fishing in the great water-courses belongs to the State.

[4] It is only three years since Mr. Theodotus Garlich and Prof. H. B. Ackley of Cleveland, Ohio, the two pioneers of American pisciculture, made their first attempts at artificial fecundation.

boxes bear his name, and are as simple as they are ingenious, easy to manage, and inexpensive, and have in a very short time been adopted throughout the whole of the United States.[5]

A beginning had been made. The States of Maine (1867), New York (1868), California, New Jersey, and Rhode Island (1870), Alabama, (1871), Ohio and Wisconsin (1873), &c., soon possessed their official pisciscultural service.

The year 1871 marks an important era in the history of pisciculture in the United States; from this year date two institutions, which have exercised a very beneficial influence on piscicultural industry throughout the entire territory of the Union, viz., *The American Fishculturists' Association*, and *The United States Fish Commission*.

William Clift, A. S. Collins, Fred. Mather, Dr. J. H. Slack, and Livingston Stone, all distinguished pisciculturists, well known by their writings and their practical labors, were the founders of the association, which has rendered such enormous service by influencing public opinion, and by giving a powerful impetus to piscicultural enterprise.

The useful character of the work accomplished in many States by the Fish Commission had not escaped the attention of the Federal Government, which, advised of the decrease of the results of both river and sea fisheries in all parts of the Union, did not hesitate to institute investigations as to the causes and remedies of this evil. A law passed by Congress on the 9th of February, 1871, authorized the appointment of a "United States Commissioner of Fish and Fisheries." The law empowered the President of the Republic to appoint said Commissioner with the sanction of the Senate, and stipulated that his services should be rendered gratuitously.

The President appointed to this important position Prof. Spencer F. Baird, then Assistant Secretary of the Smithsonian Institution, well known by his valuable works on zoology. No better selection could have been made; a vast knowledge, a prodigious capacity for work, great perseverance, enlightened zeal, indefatigable activity, a devotedness to his purpose bordering on self-denial, such are the eminent qualities which Professor Baird has brought to the exercise of those useful and absorbing duties which have been confided to him, and by the fulfillment of which he has justly become entitled to public gratitude, not only in the United States, but also in foreign countries benefited by the investigations and labors of the United States Commission of Fish and Fisheries.[6]

As soon as Professor Baird was appointed, he began work by conducting on the coast of New England for several months during the year

[5] A description of these boxes, and of other apparatus employed in America, will be found further on.

[6] We will here only recall the large number of embryonated eggs of various kinds of salmonoids (*Salmo quinnat, S. fontinalis, S. oebago, Coregonus albus, &c.*) which so frequently and liberally have been sent to France, Germany, England, Austria, the Netherlands, Russia, Canada, Australia, New Zealand, &c.

1871 exhaustive investigations relative to the condition of the fishing industries, and the causes which influence the development thereof.

In 1872, Congress added to the duties of the Commissioner of Fisheries that of restocking the waters, and his labor was henceforth divided into two distinct branches, viz:

(1.) Investigations relative to the fisheries: Statistics, zoological researches, dredging, sounding, &c.

(2.) Piscicultural operations. Artificial increase and propagation of the principal kinds of food fish[7] throughout the whole extent of the Union.

Each of these two branches of work has its special appropriation, the total amount of which, in 1872, amounted to $20,000, and has been gradually increased, so that at present the annual appropriation exceeds $80,000.[8]

The strictest economy is constantly practised in the expenditures. The Commissioner receives no salary whatever. Only a few assistants, charged with special duties (voyages of exploration, superintendents of the hatcheries, stocking operations, &c.), receive salaries. Specialists, who are occasionally employed, receive some remuneration, but only temporarily. Three or four clerks constitute the entire force of the Commission, which every day receives and dispatches a considerable amount of correspondence.

The establishments founded by the Commission are liberally supplied with all the necessary material, but no concessions are made to luxury and elegance.

Since 1872 eight zoological stations have been successively organized on the coast of the Atlantic for the purpose of carrying on researches in the interest of the fishing industries.[9] These investigations have been carried on in different localities each year, and the arrangements are

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[7] A report on the work accomplished and the results obtained is every year made to Congress by the Commissioner. This annual report is always accompanied by appendices (various treatises concerning the fisheries and pisciculture), which are generally documents of exceedingly great value both from a scientific and practical point of view. Six large octavo volumes of these reports have, so far, been published.

[8] For the period 1871 to 1880 the total expenditure of the Fish Commission has been $476,200.

[9] During the same period sounding and dredging operations have been carried on in more than 2,000 different localities by government vessels placed at the disposal of the Commission. These investigations have been productive of many good results. Besides a large number of very interesting observations respecting the temperature of the water, the currents, the nature of the bottom, &c., very important collections have been made and numerous species of crustaceans, mollusks, annelides, &c., have been studied and described. Two new kinds of food fish have been discovered in depths to which the fishermen had not yet extended their researches, viz, the *Lopholatilus chamæleonticeps* and the *Glyptocephalus cynoglossus*. The first mentioned is found in considerable quantity on a bank where its presence was not even suspected; the second, which belongs to the family of the *Pleuronectes*, had so far been entirely unknown, because the small size of its mouth did not permit of its being caught with lines, and because, owing to the great depth at which it lives, it can only be taken with very strong nets.

essentially of a temporary character. Some of the establishments are specially devoted to various experiments in pisciculture, such as the artificial propagation of the shad, of the codfish, the herring, and some other fish. But there are, besides, some permanent establishments, nearly all of which are each devoted to one special kind of fish, producing the embryonated eggs or the young fish needed for stocking the waters. Four of these establishments are of special importance; these are the one at Bucksport, Me., for common salmon; the one on the McCloud River, California, for California salmon; Grand Lake Stream, Maine, for lake salmon, called "land locked salmon"; and Northville, Mich., for fish of the Coregonus species.

The first of these establishments is in charge of Mr. Charles G. Atkins, formerly Commissioner of Fisheries of the State of Maine, who has made the raising of salmon the subject of special studies. We are indebted to him for treatises and observations of great practical utility, of which we shall have occasion to speak below. The establishment, located on the Penobscot River,[10] is entirely constructed of wood, with double walls, the space between being filled with sawdust, which shelters the interior equally well from the heat and cold. The large incubating room, 23 meters long and 9 meters broad, is occupied by 40 long wooden troughs, placed parallel with each other and lengthwise of the room, in groups of four, and furnished with wire frames for receiving the eggs to be hatched; 4,500 liters of water every 24 hours feed these troughs. This hatching establishment annually produces 6,000,000 to 7,000,000 of embryonated eggs, and hatches 4,000,000 to 5,000,000 young fish.

Two interesting facts must be mentioned respecting the Bucksport establishment, viz, (1) the application of the so-called "dry method," which its director, Mr. Atkins, has applied from the very beginning to artificial fecundation; (2) the system of "parking" salmon, also practiced by the director, so as to insure, at the proper time, a sufficient quantity of eggs and milt.

According to Mr. James W. Milner,[11] an assistant in the Fish Commission, a note on pisciculture in Russia, published in 1870 in the *Bulletin de la Société d'acclimatation*[12] had at the time drawn the attention of American pisciculturists to the happy results obtained by Mr. Vrassky with his method of fecundation, which consists in placing the eggs *dry* in a vessel, and moistening them with milt diluted in water. This is the so-called "Russian" method. Mr. Atkins conceived the idea of pushing the application of this system still further by moistening the dry eggs with undiluted milt, and adding the water afterwards. The

[10] This establishment is not maintained entirely at the expense of the Federal Government; several States generally subscribe a certain sum for the annual expenditure, and receive a number of embryonated eggs proportioned to the sum subscribed by them.

[11] J. W. MILNER: *The progress of Fish-culture in the United States.*

[12] PAUL VŒLKEL: *L'établissement de Nikolsk pour l'éducation des poissons de luxe.* Bulletin 1870, p. 508.

result was excellent, as very few eggs failed to be fecundated. This mode of procedure, which constitutes the so-called "dry" method *par excellence*, is at the present day generally employed throughout the United States.[13] Its advantage over the "*moist*" method will easily be understood when one calls to mind the rapidity with which the spermatozoa of the milt lose their vitality when diluted with water.[14]

In operating on so large a scale Mr. Atkins occasionally found it difficult to procure the number of male and female fish, ready to spawn, which he needed for his artificial fecundation. He therefore took care to "park" in advance (according to the necessity of the case five or six months, and according to the number of fish caught in the Penobscot River) a large number of salmon.[15] These salmon are kept imprisoned till the moment they begin to spawn, when they are caught again for the purpose of gathering eggs and milt. At first they were placed free in a pond of an area of 24 hectares, but with this extent of water it became very difficult to catch them at the exact time when they were needed. It therefore became necessary to "park" them in a more limited space. A wire barrier extended across the pond only left them about 4 hectares; but as this barrier was not strong enough to offer resistance to powerful fish, which always found means of forcing a passage, it had to be replaced by a permanent barrier or wall of clay.

More recently, a small water course, a tributary of the Penobscot River, the Dead Brook, has been used for "parking" these reproducing fish. In this water-course an inclosure has been made by means of two barriers across the stream, formed of poles, placed in such a manner as to keep the salmon imprisoned whilst leaving a free passage for the water. In this inclosure are placed all the live salmon which can be procured during the season when fishing is permitted. These salmon are bought

[13] It is, as we have seen before, also very generally employed in Germany, and is the only method actually followed at Hüningen.

It should be mentioned that several practical pisciculturists have by their experiments been led to identical results. Mr. Seth Green one of the veterans of American pisciculture, has followed the "*dry*" method for a long time, the process of which he has for several years kept secret. The employment of this method gave him a decided advantage over other pisciculturists who followed the "*moist*" method, and invariably sustained losses by large numbers of their eggs not becoming fecundated.

[14] From experiments made by our eminent vice-president, M. *de Quatrefages*, it appears that the vitality of the spermatozoa only lasts—

In the milt of the barbel	2′ 10″
In the milt of the perch	2′ 40″
In the milt of the carp	3′
In the milt of the roach	3′ 10″
In the milt of the pike	8′ 10″

The above figures, however, must be considered as maxima, which are not always attained. (Memoir read at the Academy of Sciences May, 1853.)

[15] In Switzerland live salmon are sometimes brought in close proximity to the places where they were to spawn; or salmon ready to spawn have been kept "parked" for a few days so as to procure eggs or milt for artificial fecundation; but nowhere, as far as we know, have grown salmon been kept captive as long as at Bucksport for the purpose of procuring a sufficient number of reproducers.

from the owners of the weirs or permanent fisheries, and are taken to the inclosure in boats furnished with fish boxes. The depth of water in this "park" varies from 70 centimeters to 5 meters. An abundance of aquatic plants and shrubs on the banks, whose branches overhang the stream, furnish ample shelter and protection from the rays of the sun, for even in places where the water is deepest the temperature at the surface during the hot summer days only reaches 75 to 80 degrees Fahrenheit.

Throughout the whole extent of the inclosure the bottom is covered with a thick layer of mud, so as to prevent the salmon from spawning, which many of them would undoubtedly do if they found a sandy bottom.

The upper barrier is located in a place where the stream is shallow and only 4 meters broad. A small shed, close by, holds the necessary material for gathering the eggs and transporting them to the incubating establishment, which is located at a distance of about 5 kilometers.

When, in October, the days begin to grow cold, the instinct of reproduction makes itself felt in the salmon, which begin to seek favorable places for depositing their eggs. They leave the deep places where they have spent all summer and go up the stream until they reach the upper barrier, near the shed or pavilion above referred to. Twenty meters below this barrier a solid net stretched across the stream only leaves in the middle a narrow passage, on the principle of the fish-pot, permitting the salmon to enter without difficulty, but preventing their getting out again. They are thus kept prisoners within a very small space where they can be caught without the least trouble.

They are thereupon distributed, according to sex, in floating boxes, from which they are gradually taken by the operators whenever they are needed for artificial fecundation. These fish generally number five to six hundred and are capable of furnishing five to nine million eggs.

The fecundated eggs are immediately placed on wire frames and carried to the hatching establishment, where, without delay, they are immersed in the incubating troughs. At the end of sixty days they are embryonated and may be sent to any distance.[16]

[16] Eggs have thus been sent as far as Australia, where, at the present day, there are several water-courses which have salmon that originated in the Penobscot River.

When all the eggs have been gathered, the total number is ascertained, which is an easy matter, as every incubating frame having a single layer of eggs contains about 2,000; so you have only to count the frames. According to the total expenditure of the establishment during the current year the retail price per 10,000 eggs is fixed, and this price serves to determine the quantity of eggs to be given to each subscriber in proportion to the amount of his subscription. In 1881 the subscription and the proportionate quantities of eggs were as follows:

	Subscription.	Proportionate quantities of eggs.
Federal Government	$1,757	950,000
State of Maine	2,000	1,080,000
State of Massachusetts	500	270,000
State of Connecticut	300	162,000

At first, tin boxes of various sizes were employed for transportation, but the high price of these boxes caused them to be very soon replaced by boxes made of light wood, where the eggs are kept wrapped up in cloths and moist moss, according to the method generally adopted in Europe. For long distances a double box is used, with an intermediary and isolating layer of sawdust between the two walls which protects the fish both against heat and cold.

The results of the experiments in stocking water-courses with fish by means of eggs from the Bucksport establishment soon became evident. While the common salmon (*Salmo salar*) were formerly unknown in most of the streams of the United States (only being found in some rivers in Maine, the Penobscot, the Kennebec, &c.) they are, at the present day, found in many rivers and streams where they have been artificially introduced. In fact they are found in nearly every water-course from the river Denny in Eastern Maine to the Susquehanna in Maryland. The Merrimac, the Delaware, and the Pemigewasset are particularly rich in salmon. The same applies to the Connecticut River, where fish weighing 10 to 20 pounds are caught by hundreds and are sent to the New York markets. Such are the results which have been attained within the short space of six years.

The introduction of the common salmon, however, cannot be accomplished everywhere; for only in sufficiently fresh and clear water will there be any chance of success. The Fish Commission has, therefore, endeavored to find a species of fish which is less exacting as to the nature of the water; and its attention has been directed to a species of salmon (*Salmo quinnat*) found in a number of streams flowing into the Pacific Ocean,[17] and particularly abundant in California streams, notably the Sacramento and McCloud Rivers. This species of fish is robust and endowed with a remarkable power of resistance to heat, and seems specially designed for introduction into those water-courses where the *Salmo salar* could not live, either on account of the temperature of the water or on account of its being muddy.

We have in a former article[18] pointed out the great interest which attaches to the propagation of the California salmon, and given some information regarding the labors of the Fish Commission to spread this valuable kind of fish as much as possible. We think, however, that we must add some details calculated to give an idea of the gigantic scale on which the labors of the Fish Commission are carried on.

The first experiments were made in 1872, at the suggestion of Mr. Robert B. Roosevelt, Member of Congress. Mr. Livingston Stone, who

[17] The so-called "California salmon" is considered to be absolutely identical with the Sacramento salmon (*Salmo quinnat*, Richard), one of the largest members of the salmon family. The salmon caught in the Sacramento River generally weigh 20 pounds; but there are some weighing 100 pounds. The flesh of this fish is equal in quality to that of the *Salmo salar*.

[18] RAVERET-WATTEL: *Le saumon de Californie.* Bulletin de la Société d'acclimatation, January, 1878.

was placed in charge of these experiments, went to California during September of that year, thinking that he would arrive before the beginning of the spawning season, but he was too late, and it was only possible to gather a few thousand eggs, because the California salmon spawns much earlier than the common salmon, towards the end of August.

Mr. Stone, however, did not make his first journey entirely in vain, as he gathered much valuable information which enabled him to repeat the experiment during the following year under more favorable circumstances. The river McCloud was selected as the center of operations. This river, fed by the melting snow of Mount Shasta, has plenty of very cold water; which is not, like many other California rivers, made turbid by the washing of auriferous minerals. The hatching places are therefore always visited by numerous salmon.

On the banks of this river, and surrounded by Indian tribes, who, if not openly hostile, are at any rate not very kindly disposed towards the "pale faces," Mr. Livingston Stone pitched his tent, and laid the foundation of a fishing and piscicultural station,[19] whither he goes every year for four or five months, to gather salmon eggs, to fecundate them artificially, and to submit them to the beginning of the incubating process; because only when the eggs have become embryonated can they be sent to great distances without much difficulty.

On account of the large number of fish operated upon,[20] and the equally large number of eggs harvested (often nearly 10,000,000) these different operations represent a considerable amount of labor. A barrier stretched across the river stops the salmon in their ascent, and permits their being captured by means of immense seines. It is necessary that this barrier—a sort of palisade composed of poles placed close to each other—should be very solid, for the legions of salmon, often of enormous size, which throw themselves against it sometimes force a breach and succeed in making their escape. The labor of repairing such breaches, which of course ought to be done just as quickly as possible, is very difficult, obliging men to stand in the water, sometimes up to their neck; and this water, produced by the melting snow, is always very cold, even in summer resembling ice-water.

For the purpose of storing the captured fish, a "park" or corral has also been constructed here, by means of a row of palisades in the bed of the river. From this "corral", containing the direct products of the fisheries, the men in charge of the fecundation, draw the salmon which they need. But it is no easy matter to free these fish from their

[19] The encampment has been called *Baird*, in honor of the distinguished Commissioner of Fisheries.

[20] The eggs and milt which are harvested are all furnished by 5,000 or 6,000 salmon; but, in order to procure that number of fish ready to spawn immediately, forty or fifty times as many have to be caught. It is not a rare occurrence at Camp Baird, that from 7,000 to 9,000 salmon are caught a day; for a single haul of the seine often brings up 1,200 to 1,400; but it likewise often happens that, among several thousand, only a few hundred are able to furnish spawn immediately.

eggs or their milt; for they nearly all weigh from 15 to 20 pounds (often more) and are not easily managed. A veritable struggle with the fish has to be gone through; a struggle all the more fatiguing, as the back has to be bent in order to be able to gather the spawn.[21] Frequently the men have their hands lacerated by the rays of the fins or by the hard teeth of the male fish, which inflict painful and slow-healing wounds.

It should, moreover, be remembered that this operation has frequently to be carried on during the night, when the air is quite cool; for in this mountainous region the nights are, during the summer season, as cold as the days are hot. The station men who have often, during day time, to do hard work in a broiling sun, at a temperature of 54° C., are frequently at night while engaged in fishing or in artificial fecundation subjected to a cold air of +11° C., and, moreover, with their clothes constantly soaked in ice-water. Very few of them escape the consequences of such fatigues and exposure to a rapidly changing temperature; and this generally shows itself even during the first week by attacks of fever and rheumatic pains. Only men possessed of very strong constitutions can stand this work and carry it on without interruption.

In spite of all these difficulties the number of eggs gathered and fecundated every day generally exceeds 300,000, and often goes as high as 800,000 or 900,000. The gathering, that is the spawning, commences generally about the 20th of August, and comes to a close about the 15th or 18th of September.

The incubating process takes place in wooden troughs arranged parallel to each other on a scaffolding about breast high, and sheltered by a vast tent 20 meters long and 10 meters broad. These troughs, to the number of ten, are grouped two by two, leaving sufficient space between them to allow the watchful care and the manipulations which the eggs require. Each large trough is formed of three smaller ones, five meters long, placed end to end, with a difference of level of a few centimeters, to give fall to the water which is necessary to keep it fresh. In spite of the rapidity of the current and a sufficient quantity of water, the eggs at the end of the troughs are sometimes exposed to a lack of oxygen, the water having yielded to the eggs higher up the greater portion of the air which it contained.[22]

[21] But as the object is not to keep the fish, and as it consequently does not matter even if the fish are a little hurt, skillful operators often manipulate only small salmon. They hold the head of the fish tightly between their knees, hold the tail in the left hand, and with the right extract the eggs or the milt. Large fish often require two or three men to manage them. The salmon which have thus been operated upon are abandoned to the Indians of the neighborhood, whose friendship and even aid in this difficult work is thus gained, at least to a certain point.

[22] Mr. Livingston Stone states that, especially towards the last period of the embryonic evolution, the eggs need plenty of oxygen in the water. At the beginning of the hatching process, the eggs may, without any detriment, be heaped up in the apparatus and exposed to a feeble current; but from the time the embryo becomes distinctly visible, great care should be taken to spread the eggs on the frames, and to make the current as rapid as possible.

In each trough the eggs are arranged on wire frames fixed in an ingenious manner (the Williamson apparatus) which we shall describe below. This method economizes much space (which is particularly useful when large quantities of eggs are to be operated on), and thoroughly aërates the water by keeping it constantly in motion.

Long boards, forming covers, should be placed over the troughs; for the light which, by daytime, penetrates the canvas of the tent would be sufficient to destroy the eggs.

The water which feeds these hatching troughs comes from the river. It is raised to a height of 3 meters and led into the apparatus by means of a hydraulic wheel, supported by two boats in the middle of the river, and furnished at its circumference with large buckets which at each revolution pour their contents into a wooden aqueduct raised on poles. This wheel, placed in the midst of the rapids, is thus driven by a very strong current, and is sufficient to raise and supply the apparatus with about 300,000 liters of water per hour.

The water of the river McCloud, which is almost always limpid during the fine season of the year, becomes generally turbid during the spawning season of the salmon, as these fish root in the sand to make their nests. In order to serve for the incubating process, this water must be considerably filtered. The filter used consists of three wooden boxes, the one of which, larger than the others, forms a first receptacle. The water flows through it, first through a vertical wall of coarse cloth or canvas, doubled, and firmly extended on a frame, and afterwards through four similar walls of flannel or some woolen fabric; each wall presenting a filtering surface of 1 square meter. In the two other boxes it flows through a triple canvas and seven flannel filters.

As the temperature of the water in the hatching troughs averages 12 to 14 degrees C., the eggs are generally embryonated at the end of sixteen days; when they have reached that degree of development desired for their transportation, they are packed in damp moss and placed in boxes measuring 60 by 15 centimeters. This packing in itself involves considerable work, considering that 10,000,000 eggs represent a volume of about a hundred decaliters. More than 200 decaliters of moss are required for packing these eggs in an almost equal number of boxes, which are packed two by two in hay in open cases, having an upper compartment destined for the ice which is supplied during the journey. The whole thus packed makes a hundred packages, weighing in all more than 20 tons. On account of the heat the packing must be done very rapidly, and requires a great degree of activity.

At last everything is ready, and nothing remains to be done but to forward the packages to their destination. They are (care being taken to shake them as little as possible) by a rather rough road of 35 kilometers, taken to Redding, Cal., the nearest station on one of the branch lines of that gigantic railroad (the Central Pacific Railroad) which unites the coasts of the Pacific and Atlantic, climbing the solitary heights of the Rocky Mountains and crossing the immense prairies of the "Far

West." After a journey of almost 4,500 miles the eggs arrive in the Eastern States, where they are distributed in accordance with the demands made by the various State commissions. Those destined for Europe are sent to New York, where, under the care of Mr. Fred. Mather, assistant of the U. S. Fish Commission, they receive, before being shipped, a new, special packing according to the method invented by that skillful pisciculturist. They are placed in thin layers on a sort of rectangular tray formed of light wooden frames, over which a kind of cotton fabric is extended. These frames are thick enough to allow of a number of them being placed one above the other without crushing or pressing the eggs. A solid box incloses the whole, leaving at the top, and sometimes also at the sides, an empty space sufficiently large to hold the ice needed for keeping the temperature low and retarding the embryonic evolution. Thanks to this ingenious arrangement, and by taking the precaution to have the ice renewed as soon as it is melted, eggs could safely be sent longer distances than across the Atlantic.

In spite of the very large and constantly increasing number of eggs annually distributed, this number is still insufficient to supply the steadily increasing demand for them, which is caused by a growing recognition of the merits of the California salmon.[23]

Of all the salmonoids this one is certainly best adapted to artificial propagation. When properly packed and kept at a sufficiently low temperature, eggs may be transported with hardly any loss. The loss in the hatching apparatus during the period of incubation is generally very small. As regards the young fish they are exceedingly vigorous and grow rapidly, and the mortality which takes off so many young fish of other kinds is hardly noticed among them. Every one who has raised them has been struck with the robustness and vigor of these young fish, and particularly with their excellent appetite, all of which are very favorable symptoms in young fish. When grown these fish easily adapt themselves to the most varied conditions of life. They ascend the Sacramento when the waters of this river have become muddy from frequent rains and the washing of minerals. In July and August they enter the San Joaquin River in large numbers, and ascend that stream a distance of 150 kilometers, thus traversing the hottest valley in California, where the temperature of the air, rarely lower than 26° C. at noon, often rises to 40° C. The temperature of the water of the river varies from 28° C. at the surface to 27° C. at the bottom. Leaving the hot and turbid waters of the San Joaquin, these fish full of vigor will enter, for the purpose of spawning, the tributaries of that river, the Merced, the Stanislaus, &c., which are principally fed by the melting snow among the mountains.

[23] The total number of eggs gathered and distributed up to date is about 80,000,000. In order not to exhaust the McCloud River by thus constantly drawing upon the products of its spawning places, the establishment annually hatches from 1,000,000 to 1,500,000 eggs to supply the river with young fish, which is therefore always full of salmon, though possibly not to the same degree as in former times.

To judge from the nature of the waters which are continually inhabited by the California salmon, it seems certain that these fish could be successfully introduced in a large number of water-courses. In the United States these salmon seem to spread very successfully in the Eastern States, where few rivers have as turbid waters as the Sacramento, or as hot water as the San Joaquin. Furthermore, the long journeys annually undertaken by the California salmon, the strength and energy exhibited by these fish during their migrations in the waters of the Sacramento and McCloud Rivers, all prove that no other kind of fish equals them in the capacity of ascending the rivers for a considerable distance from the sea for the purpose of spawning.

The Shoshone Falls on the Snake River, one of the tributaries of the Columbia River, is the point where the salmon stop and where large numbers of them spawn; and these falls are more than 700 miles from the sea. It does not seem impossible, therefore, that the California salmon might live and flourish in the Mississippi, the tributaries of which river would afford spawning-places at a shorter distance from the ocean. As for waters of the Gulf of Mexico, where its annual migrations would take this fish, they are not any hotter at a certain distance from the mouth of the Mississippi than the waters of the sea along the coasts of New England. These considerations have induced the Fish Commission to make vigorous efforts to propagate the California salmon in the Southern States, where a special establishment will soon be created for the artificial propagation of these fish.

So far this salmon has been introduced into a large number of water-courses; and also into several lakes having no communication with the sea, where they have nevertheless begun to increase. It will hardly be necessary to point out the great importance of acquiring for our own waters a species of fish so remarkable and valuable in every respect.

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