ACCOUNT OF OPERATIONS AT THE NORTHVILLE FISH-HATCHING STATION OF THE UNITED STATES FISH COMMISSION, FROM 1874 TO 1882, INCLUSIVE.

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[Written by request of Prof. S. F. Baird, for the London Exhibition, 1883.]

It will be admitted without argument that nature, unaided by art, is wholly unable to furnish food for the sustenance of the human race. The necessities of existence have therefore always driven man to the culture and development of those kinds of animals and plants that are able to supply him with the means of subsistence. Science has pointed out the laws which govern the myriad orders of life, and by the aid of this knowledge we are able to multiply in vast ratios all the varieties of animal and vegetable nature necessary to meet our requirements. Until within comparatively few years the attention of mankind in this direction had been expended almost wholly upon the culture and propagation of land products. That portion of human food found in the paths of the sea and rivers of the earth had been left wholly to the care of nature, man not deeming it within his power to materially aid nature in this department of her supply. Somewhat recent investigations, however, have revealed the fact that some of the largest and most important fisheries of the world must soon cease to operate, for a time at least, unless some artificial means be devised for counterbalancing the vast drainage which is rapidly depopulating lakes, rivers, and seas of their inhabitants.

That such means have been discovered and successfully applied is abundantly demonstrated by the history and work of pisciculture. A single incident will well illustrate this statement, for it is only a sample of the success which, as a rule, has everywhere attended this science. I was myself personally cognizant of the facts in the case, and therefore can speak with definite knowledge. It is a well-known fact that forty or fifty years ago shad were so abundant upon our Atlantic coast that they were "caught by the million in many bays and mouths of rivers." As early as 1860 it became alarmingly evident that this great source of revenue to the country would soon be cut off, for the fish were not only no longer abundant, but it was becoming hard to obtain them even as a luxury. I was on the Connecticut River in 1873, and I could not obtain shad for less than one dollar apiece. In 1871, and again in 1872, several millions of young shad were liberated at the mouth of the Connecticut River. In 1874, three years' time, the most marvelous results were manifest. Those first set free began to return. It was reported by fishermen "that for twenty years such shoals of shad had not been seen approaching the land, and vessels which had come through the neighboring sound reported also great shoals which stood towards the mouth

of the river." Being on the ground at the time, I was offered all the fish I could buy for 10 cents apiece.

Approximately the same results are now being realized from the distribution of young whitefish in our great inland lakes. It is only within three or four years that the young fry have been liberated in sufficiently large numbers to increase the supply of the fisheries; and now from every point where such distributions have been made acknowledgments are numerous of the inestimable benefits already derived from this source. Similar results have been obtained elsewhere and with other kinds of fish; but these experiments have already entered into the history of the science, and have proven, beyond any question whatever, that pisciculture is the perfect solution of the problem of supplying the fisheries of the world with an inexhaustible revenue.

With this object in view, therefore, fish-breeding establishments have been erected at suitable localities in different parts of both the Old and New World. To begin with, these institutions were in many instances the result of private enterprise; but their work is now deemed of such great importance that states and governments have purchased the right of control over the best of these establishments.

The hatchery at Northville passed into the hands of the Government in the year 1880, and now to give a history of the inception and work of this institution is the remaining purpose of this article.

ORIGIN OF THE NORTHVILLE HATCHERY.

In the year 1868, Mr. N. W. Clark, of Clarkston, Mich., became interested in the subject of fish culture. His attention was first roused to the subject by the enormous waste of embryonic life observed among the fish, from which he concluded that not one egg out of thousands, left simply to a course of nature, could reach mature development. It is easily demonstrable that rivers, lakes, and oceans would literally overflow with their inhabitants if but a tenth or even a hundredth part of all fish-spawn should grow to adult size. Such an increase would not of course be possible, nor for many reasons desirable; but the question naturally occurred to Mr. Clark, as it had to others, Cannot some means be devised by which the prolific nature of the fish may be taken advantage of and the waste sufficiently prevented to annually restock all the important fisheries of the world with an abundant supply? This, as at once appears, was a most interesting and important question. He therefore determined to devote to experiments as much time as could be spared from his ordinary business pursuits, not so much as a means of personal profit as to appease his own love of research and experiment.

Having thoroughly informed himself of the nature and success of experiments made in this direction by other men, he at once began the erection of a building near Clarkston, and without and within he placed all the necessary appurtenances then known to the science. Here he

continued experimenting, with considerable success, until the summer of 1874, when, desiring to enlarge the scale of operations, he determined to seek for some locality possessing greater natural facilities. After carefully examining different places more or less favorable for the purpose, the present site of the Northville hatchery was selected, as affording not only the best advantages he was able to find, but as leaving little or nothing to be desired in the possession of all those natural surroundings necessary to the perfect development of piscicultural science. To this point he at once removed, and began the construction of a building and of ponds and raceways suitable for his purpose.

The building is an ordinary one-story frame structure, 80 feet long by nearly 30 wide, and contains an office, sleeping apartment, and tank room, besides the main hatching room, which is furnished with such appliances as are best calculated to do the work. At first, and for several succeeding seasons, the style of incubator used was of Mr. Clark's own invention,* which had been thoroughly tested by him in the Clark-

*This invention consists in the construction of a suitable building, at one end of which, nearest the water supply, are tanks, containing many barrels of water conveyed through faucets from spring or lake, as the nature of the eggs to be hatched may require, which passes through flannel screens, and is thus filtered from all sediment before entering the troughs containing the hatching boxes. These troughs are about one foot (or more, as the case may be) in width and ten inches deep, each of them containing a series of water-tight compartments, which contain the same number of boxes of less dimensions, also water-tight, except the bottoms, which are covered with finely-perforated copper or brass wire cloth to prevent the eggs or fish from escaping when hatched out.

These last boxes are filled with several screens, each containing many thousand eggs, and may be of sufficient capacity to hatch an almost unlimited number of eggs.

Over these screens, and after the eggs are equally distributed over them, there is placed a finely-perforated metallic plate, B, and the whole is kept in place by a cross-bar, C, fastened to the sides of the main trough. These boxes are elevated upon feet to raise them from the floor of the trough, to allow a free passage of water under them and to raise them above any sediment that may pass through and settle on the said floor.

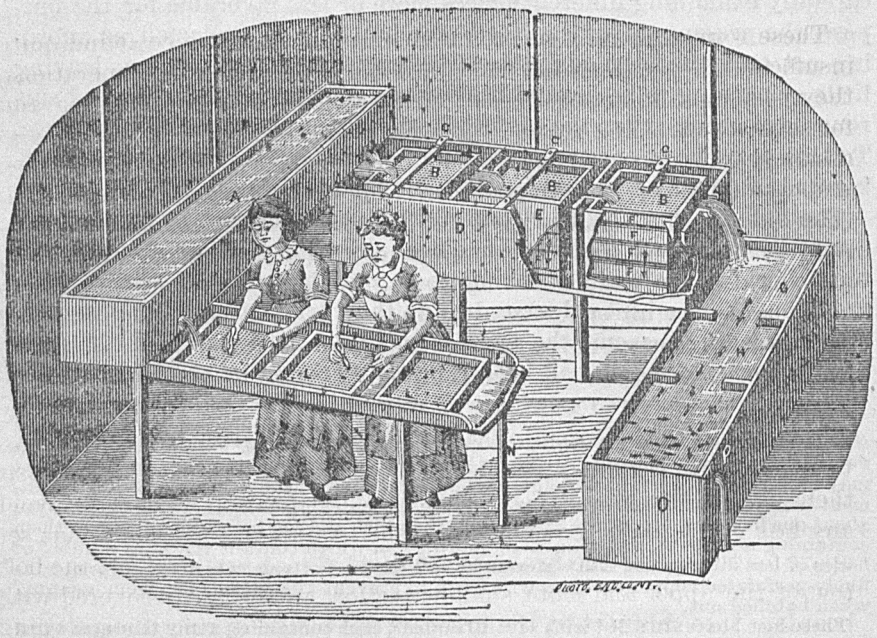
The first screen that lies over the copper cloth is also raised to gain free circulation to the water. The main trough must have a descent of three-sixteenths of an inch to the foot, to form sufficient fall of water into each separate box to produce a moderate current of water down through the eggs.

This arrangement completed, the water is let in at the upper end of the long troughs upon the perforated cover, which spreads it equally over the whole part of the eggs below, which, owing to the declivity of the main trough and the water-tight partitions in them, causes it to flow over said partition on to the next below, which produces an up and down movement to the current running throughout the whole series of hatching boxes, making changes around and through the whole number of eggs in each compartment constant while in process of hatching.

Many more fish are hatched by this process than can be stored and cleansed from their shells and other impurities consequent upon the last stages of hatching; hence, it becomes necessary to add store-room and an additional process for cleansing the fish when hatched out from the impurities above named.

To remedy this trouble a series of large tanks, G H K, are erected for the reception of the water as it leaves the hatching troughs. From ten to twenty days are required from the commencement of the hatching season to its close, consequently a proportionate number of fish are hatched daily. These are washed from the unhatched eggs into the first receiving-tank before mentioned, and allowed to stand quietly without much current to the water in which they are. The eggs thus cleansed are returned to the hatching boxes from which they came. As soon as the shells from the eggs are well settled to the bottom, a moderate current of water is allowed to flow through an opening to the next tank below, carrying the cleansed fish with it, depositing any impurities that may yet be left with the fish in said settler; and the fish are allowed to follow on with the current, passing still through another opening to the large recep-

ston experiments. The hatching room was at first equipped with 224 of these incubators, known as the Clark hatching box, together with their appropriate accessories. The hatching box itself was a great im-



provement over the system of gravel troughs formerly employed in fish hatching, and the method and character of its work are even now unsurpassed for incubating some of the larger eggs of the salmonoid species. The invention, however, involved the same principle of construction and operation that was embodied in two or three other similar inventions which appeared about the same time. In each the method of procedure consists in spreading the eggs in layers on wire trays, and causing the water to flow through them. In some incubators of this type the mechanical construction forces the water upward instead of downward, but whatever the direction of the water the results in all are substantially the same, since the eggs remain motionless.

From the site of the hatchery and its immediate vicinity innumerable springs send forth an inexhaustible supply of pure water. In the aggregate they furnish about 700 gallons per minute. From the head of this spring area to where the hatchery is situated occurs a natural slope

tion room, where they remain in perfect condition in pure running water until placed in the waters designed for them.

M is a shallow trough supplied with water drawn from the main tank, being the same temperature of that in which the eggs are hatched.

During the first few weeks of their incubation many imperfect and dead eggs are found, and for the purpose of removing them from the good ones the screens upon which they lie are removed from the hatching boxes to the shallow trough of running water and picked out in the usual way with forceps, as shown by the figures in the illustration.

that gives to the former an elevation of eight feet above the latter, thus giving to the hatchery an ample volume and fall of water for hatching purposes.

THE TROUT PONDS.

These were originally six in number, and, though since found quite insufficient to meet the requirements of the increased scale of operations, they performed their service well at the time of their construction and for several succeeding years. Since the supervision of the hatchery was assumed by the United States Fish Commission, in 1880, the ponds have undergone a thorough reconstruction. They have been greatly enlarged, their sides planked and secured beyond all possibility of muskrat depredations, their banks nicely ornamented with a coat of nature's green, and their capacity increased many fold. Entire new ponds have also been built, and all are suitably provided with discharging flues and gates for the control of the water. The bottom of each pond is made to gradually slope so that the depth of the water is eighteen inches at the head and four to five feet at the foot, this conformation being necessary to tempt the breeders up into the shallow, rapid current of the raceways to spawn. As is well known, however, the fish will sometimes deposit their eggs in the gravel beds of the ponds themselves, and, to avoid any loss which might be entailed by such an occurrence, the ponds set apart for the use of the breeders are divided into two sections, the bottom of the upper and more shallow section being tightly covered with boards. Into this section the breeders are placed during the spawning season, and are prevented from entering the lower part of the pond by a temporary partition, which is removed when the spawning season is over, the lower section being used simply as a receptacle for the fish as fast as they are manipulated and the eggs secured.

The uniformly cool temperature of spring water at all seasons of the year causes these ponds to be as healthful to the various kinds of trout as their ordinary haunts furnished by nature. Indeed, this fact, combined with the abundant supply of artificial food, produces an average maximum size that is not only unsurpassed, but absolutely unobtainable in many of the streams where the fish naturally flourish.

I find that among communities having no direct commercial intercourse with the large fisheries there prevails considerable skepticism concerning the real benefit to be derived from the artificial propagation of fish. The people who live near the great fisheries have been convinced of its value by the returns which they have actually realized from the work of the states and the general government in restocking the larger bodies of water with the best varieties of commercial fishes. Those in the interior have also been indirectly benefited, but this they are slow to realize. I therefore look with great hopefulness upon the present attempts now making everywhere to introduce the trout and other valuable species into such inland waters of the country as are suitable to their nature.

Although the natural habitat of the trout is confined almost wholly to the colder streams and waters of our country, the acclimatization of these species, and of their proper food, is no longer a matter of experiment; and if success in this direction can only be achieved sufficiently to bring this delicate luxury within reach of the people at large, they will need no other argument to convince them that trout-culture is not experimental, but is a work from which all may derive direct and substantial benefits.

But so far as our brook trout (*Salvelinus fontinalis*) are concerned, until they are more abundant in their native haunts than at present, it will be practically impossible to accomplish results at all appreciable or worthy of notice, except by the method employed here and in other hatcheries. This method proceeds upon the known adaptation of spring water to the artificial development and maintenance of the species. It insures a temperature corresponding with that of the waters of their natural habitat, and, by proper distributive arrangements, this temperature may be kept below 70° F. in the hottest summer weather. The method employed also takes into view the best means and facilities for obtaining a sufficient egg supply to meet the purpose in hand; and, with reference to this, experience has abundantly proven that there is but one reliable course to pursue, and that is to rear the breeders in sufficient numbers to obtain the desired number of eggs. To depend upon securing spawn by angling or seining these fish out of their natural streams would, at present, be almost wholly futile as well as expensive. Those ripe for spawning could not be caught in sufficient numbers by this means to pay the cost of labor expended. But where the fish are kept in ponds or preserves so constructed as to give us absolute control of every period of development from the embryo to the spawner, it is possible to secure very large returns from a comparatively small amount of stock. By this means not a single egg need be lost; every fish can be manipulated without receiving any harm, and the eggs removed and mixed with the proper amount of male secretion to fertilize at least 80 to 90 per cent. This is something, however, that art only can do. Nature alone would give fertilization to only a very small proportion of eggs spawned; but art, having the power thus to utilize all the resources which nature so lavishly furnishes, points out the way to obtain the largest results at comparatively little cost and trouble.

The ponds are fed directly from the lower spring area, which is underneath the hatchery, and indirectly by the water of the upper springs, which first makes the circuit of an artificial reservoir, from which it flows through the building, where its passage is utilized in hatching. Thence it enters the raceways at the rear of the hatchery. The amount of stock originally put into these ponds by Mr. Clark consisted of one hundred adult brook trout. This number has multiplied very many times since then. Other varieties of fish have also been introduced at various times, such as the California trout (*Salmo iridea*), California

salmon (*Oncorhynchus quinnat*), lake trout (*Cristivomer namaycush*), grayling (*Thymallus tricolor*), and land-locked salmon (*Salmo salar*, var. *sebago*).

IMPROVED METHODS OF INCUBATING EGGS OF THE WHITEFISH (COREGONUS CLUPEIFORMIS).

Since the Northville hatchery was built, the method of incubating whitefish eggs has undergone a radical change. The hatching boxes are still used for the salmon and trout, but for whitefish they have been entirely supplanted by inventions which greatly reduce the expense and labor involved in hatching this species by artificial processes.

The principles upon which the construction and operation of these later inventions are based are substantially alike in all. Whitefish eggs are small and light, and hence are easily buoyed or influenced by currents of water; and the dead and confervaceous eggs are a trifle still more buoyant. These conditions are taken advantage of by having a proper head of water and releasing a graduated volume under a uniform pressure on a mass of eggs in a vessel of suitable size and conformation to secure the purposes in view. A fixed movement is thus given to all eggs of the same specific gravity, while the lighter eggs of confervaceous growth, contact with which imperils the safety of the living embryos, are driven from the presence of the latter by the outflowing current, which carries them out of the vessel or holds them at the surface, whence they can be removed *en masse* at leisure. In the use of the hatching boxes, where the eggs are not kept in motion but remain quiescent, it is necessary to be always on hand with a pair of tweezers to pick away the dead eggs one by one as fast as they become visible on the trays. Hence the hatching of large numbers by the box system involved a great deal of labor and expense, which is now largely dispensed with. Constant surveillance and manipulation to keep the dead and living ova separated is no longer necessary, and the actual work demanded to incubate any number of millions of whitefish embryos is now no greater than was formerly demanded for as many thousands.

The style of improved incubator first brought into use at the Northville hatchery is known as the Chase jar, and is the invention of Mr. O. M. Chase, of Detroit, Mich. The jar is a cylindrical glass vessel 19 inches high by 6 inches in diameter. The water is introduced through a glass tube resting in the center of the egg-chamber, and is released upon the eggs at the foot of the tube, which is slightly raised by three small feet. A tin rim provided with a gate and lip for discharging the water is fitted to the top of the jar, and the whole is placed directly underneath a spigot connecting with the top of the glass tube by a short piece of rubber hose.

These jars were used at Northville during the seasons of 1880–'81 and 1881–'82, sufficient tank room being provided to operate about 150.

Each jar will incubate 200,000 eggs of the whitefish. Tanks of uniform size are placed one above the other in three tiers, and the water enters the upper tank and feeds a row of jars on either side, whence it is discharged into the middle tank to supply another double row of jars, thence passing into the lower or waste tank. The jars rest in pairs on narrow shelves placed crosswise of the tanks.

During the season of 1881–'82 an improved whitefish incubator was devised by employés of the hatchery. The egg-chamber is substantially the same as that of the automatic jar; but the separation of the dead and living ova is more perfectly accomplished by improved distributive arrangements, which give to the currents of water absolute evenness and uniformity. A cone-shaped device is fitted to the bottom of the egg-chamber, and resting on this is the tube through which the water is introduced. The bottom of the tube assumes a conical form to correspond with the cone over which it is placed, being slightly raised or separated therefrom by narrow strips of tin soldered to the cone midway between its base and apex, to permit the water to escape. The column of water in its descent through the tube is pierced by the apex of the cone and radiated to the base of the tube, where it escapes into the egg-chamber. Side currents are thus formed which impart to the eggs the best possible motion; carrying them upward through the egg-chamber to descend again upon the base of the tube, which diverts them to its edge to be carried up again, as before, by the inflowing current. Fifty of these incubators are now employed at the Northville hatchery, and over two hundred at the Lake Huron hatchery, recently established at Alpena, Mich., by the United States Fish Commission.

As an experiment, Mr. S. Bower, of the Northville hatchery, constructed an incubator admitting of a larger scale of operations, at a greatly reduced cost for apparatus. It is made of wood and galvanized iron, in the form of a rectangular box, and is divided into upper and lower chambers; it is 11 inches wide by 13 inches deep and 30 inches long, although its length is not material, and may be extended indefinitely, increasing its capacity to correspond, without impairing or changing its operation. The movement of the eggs is obtained by introducing water into the lower chamber, whence it is admitted to the upper chamber through a sixteenth-inch crevice running lengthwise of the box. From each side the partition which divides the box into two chambers slants downward to the point where the water enters the egg-chamber. By this means the eggs carried to the surface by the inflowing current are constantly returned to the starting point, and thus a perpetual circuit is produced. The principle of operation thus reverses the motion employed in the jars, as the eggs ascend from the center and descend at the sides, instead of rising at the sides and returning through the center. Overflows are provided at intervals around the top of the box. The separation of the dead and living ova

is very well accomplished with this inexpensive apparatus; it requires, however, a greater head of water than the jar incubators, and for this reason the success of the experiment as tried was somewhat impaired.

PACKING FISH EGGS FOR SHIPMENT.

There are a number of methods employed in preparing the eggs for shipping. The conditions most favorable to successful transportation are those which will best maintain a moderate degree of moisture of the eggs, and the lowest possible temperature that will not impair their vitality. Experiments have shown that 32° F. is the temperature best calculated to preserve the *statu quo* of the various species treated at this hatchery. Under the conditions named, development of the embryo proceeds very slowly, almost imperceptibly; the development of confervæ is likewise retarded. An ample period of time is therefore given them to make long journeys without losses, if the proper conditions are maintained. Various experiments have been made from time to time, by diversifying the details of preparation, but the method which has met with the greatest measure of success is substantially as follows: A sufficient number of canton-flannel trays are made to hold the eggs, and a case is constructed of such a size as to contain the trays when superimposed upon each other, and to allow 4 to 6 inches of space around the sides for packing material. The trays are placed in a tank of ice-water not less than an hour before eggs are transferred thereto. A quantity of eggs are transferred from the hatching vessels to wire-trays in the picking-trough, and feathered over to throw up dead or unimpregnated eggs, which are removed with nippers. The sound eggs are then collected by overturning and submerging the trays into a large tin vessel partly filled with water; thence they are skimmed up and measured in a graduate * and poured into the shipping trays, which are immediately taken to the packing room, where the temperature is between 30° and 40° F. The trays are then thoroughly drained of superfluous water, and the eggs are spread uniformly two layers in depth, with a half-inch margin of flannel between the eggs and wood frame of the tray. A single fold of dampened millinet is then thrown over the eggs, and over this a sufficient quantity of live moss, washed and wrung out to prevent drainage, to fill the tray when rather snugly pressed down. When admissible, the trays are allowed to stand in temperature a little below the freezing point until needles of ice have begun to form in the moss; they are then placed one above another and held to position by cleats nailed to top and bottom boards. The pack-

* The following is the standard of measurement used at the Northville hatchery: Whitefish, 1,250; brook trout, 450; lake trout, 200 to the fluid ounce. Eggs of whitefish and lake trout vary but little in size. Brook-trout eggs, however, depend in size a good deal on the age of the parent fish. Thus the product of the first egg-bearing period (fish twenty months old) will run about 500 to the ounce; from trout three and four years old, about 400 to 425 to the ounce, making 450 a fair average.

age is now transferred to the shipping case and surrounded with fine, dry, hardwood shavings, firmly champed in. The material which separates the eggs from the outside atmosphere is a poor conductor of heat, and the eggs are therefore carried through to destination in excellent condition, with very rare exceptions.

The following tables give a condensed summary of the work for the past seven years. They are somewhat incomplete, owing to the fact that the details of work were not formerly preserved with as much care as we are now accustomed to observe.

Season of 1874–'75.

Eggs placed in hatching boxes:

Whitefish	2,500,000
Lake trout	150,000
Brook trout	100,000
California salmon (in poor condition)	50,000
Wall-eyed pike (*Stizostedium americanum*)	25,000

Fish planted.

Whitefish, 2,000,000 for Michigan Commission; 100,000 for United States Fish Commission.

Lake trout, 125,000 for Michigan Commission.

Brook trout, 50,000 sold to private parties; 25,000 planted in adjoining States; 10,000 retained in ponds.

California salmon, 15,000 distributed in Ohio for United States Fish Commission; 10,000 retained in ponds.

Wall-eyed pike, 20,000 distributed in inland waters of Michigan.

During this season eggs of whitefish and lake trout were contracted for at the rate of $1 per thousand.

The requirements of the work necessitated the employment of extra help, as follows: Twenty-five girls for forty days, at 75 cents per day; three men for five months, at $50 per month.

The girls were employed to separate the dead and living ova. Seated before a long, shallow trough of running water, facing a row of windows and supplied with feathers and tweezers, the work proceeded by picking out the dead eggs one by one from the wire trays, which were transferred from the hatching boxes to the "picking trough."

Season of 1875–'76.

Eggs placed in hatching boxes:

Whitefish	3,300,000
Brook trout	50,000
California salmon	988,000

Distribution of the minnows.

Whitefish, 2,700,000, placed mostly in the Great Lakes, for United States Fish Commission.

Brook trout, 40,000 sold to private parties; 5,000 retained in ponds.

California salmon, 900,000 planted in the tributaries of the Mississippi and Ohio Rivers on account of United States Fish Commission.

During the season fifteen girls were employed for sixty days at 75 cents per day, and three men for six months at $50 per month. The whitefish eggs were supplied on contract at $1 per thousand. The California salmon were sent here from the McCloud River, California, in an advanced stage of development, to be hatched and retained in tanks until time for distribution, and for this work the charge was 50 cents per thousand.

In the spring of 1876 Mr. Fred. Mather turned over to the establishment about 2,000 eggs of grayling, taken from fish caught in the Au Sable River, Northern Michigan. Only a small percentage were hatched, and the minnows were retained in the ponds of the hatchery, together with about 150 yearlings brought from the same river.

Season of 1876–'77.

Eggs placed in hatching boxes:

Whitefish	1,250,000
Brook trout	50,000
California salmon	500,000

Disposal of eggs.

Whitefish, 500,000 shipped to California on account of United States Fish Commission; 50,000 shipped to Germany on account of United States Fish Commission; 500,000 sold to private parties.

California salmon, 450,000 hatched and planted in rivers in Ohio, Indiana, and Illinois, on account of United States Fish Commission.

The whitefish eggs were sold at 50 cents per thousand; California salmon were received from the McCloud River, California, as in the previous year, and a charge of 50 cents per thousand made for their subsequent treatment. The whitefish eggs shipped to California per express, a distance of 2,200 miles, arrived in good condition; those to Germany in rather poor condition.

Season of 1877–'78.

Eggs placed in hatching boxes:

Whitefish	1,500,000
Brook trout	50,000
Land-locked salmon from Maine	10,000

Disposal of eggs.

Whitefish, 500,000 shipped to New Zealand; 500,000 shipped to California; 250,000 shipped to Nevada; 50,000 shipped to New Jersey.

Brook trout all sold to private parties.

The land-locked salmon eggs arrived in such poor condition that but few were hatched.

The whitefish eggs sent to New Zealand were about fifty days *en route*, and arrived in very fair condition. The California and New Jersey shipments were also successful.

Season of 1878–'79.

Eggs placed in hatching-boxes:

Whitefish	2,500,000
Brook trout	75,000
California salmon	250,000
Land-locked salmon	15,000

Shipments of eggs.

Whitefish, 500,000 to California, on account of United States Fish Commission; 250,000 to Nevada, on account of United States Fish Commission; 100,000 to Iowa; 500,000 to New Jersey; 1,000,000 to New Zealand.

Disposal of fry.

Whitefish, 40,000 sold to private parties.

Brook trout, 60,000 sold to private parties; 5,000 retained in ponds; 5,000 planted in adjacent streams.

California salmon, 225,000 shipped to and planted in rivers of Texas, Louisiana, Mississippi, Arkansas, Missouri, and Illinois.

Land-locked salmon, 10,000 distributed in Ohio; 1,000 retained at hatchery, but did not do well.

Season of 1879–'80.

Eggs placed in hatching-boxes:

Whitefish	3,250,000
Brook trout	50,000
Land-locked salmon	50,000

Shipments of eggs.

Whitefish, 2,000,000 to New Zealand; 500,000 to California; 250,000 to Maine.

Brook trout, 30,000 to private parties.

Disposal of fry.

Brook trout, 10,000 sold to private parties; 5,000 retained in ponds.

The land-locked salmon eggs were forwarded from Maine to this hatchery for reshipment to California, but on opening the crates the eggs were found too far advanced for further shipment; they were, therefore, hatched and distributed to Iowa and Minnesota waters.

Season of 1880–'81.

Eggs of whitefish placed in hatching-jars, 13,780,000.

Shipments of eggs were made as follows: To Germany, 250,000; Maine, 1,000,000; Iowa, 500,000; Minnesota, 250,000; Kentucky, 500,000; California, 500,000; Nevada, 100,000; and Pennsylvania, 100,000; total, 3,200,000. With one exception, these shipments were made with perfect success. Something over nine million minnows were also hatched, and released in the waters of the Great Lakes.

Number of eggs of brook trout placed in hatching-boxes, 75,000, disposed of as follows: 50,000 sold to private parties; loss on eggs, 12,000; fish hatched, 13,000, of which 3,000 were retained in artificial ponds and the remainder planted in adjacent streams.

A few hundred eggs of California trout were also obtained from a few adult fish of this species held in the ponds of the station. These were hatched, and the fry retained at the hatchery.

Season of 1881–'82.

The work was quite largely increased this season. The number of whitefish embryos placed in the hatching-jars from fisheries of Lake Erie and Lake Huron was something over 22,000,000. From these nearly 2,000,000 were shipped, and over 17,000,000 fish hatched and planted. The minnows were distributed by the United States Fish Commission car to various points on the Great Lakes, and eggs were shipped as follows: To Germany, 300,000; France, 250,000; Iowa, 500,000; Connecticut, 10,000; California, 750,000, and New Jersey, 100,000.

About 60,000 eggs of lake trout were obtained from Lake Huron fisheries and brought to this hatchery for incubation and shipping. Of these, 20,000 were shipped to F. Mather, Newark, N. J., for transmission to Germany, and 30,000 were sent to the State of Iowa.

From the California trout mentioned above, some 4,000 or 5,000 eggs were obtained; they were hatched and the fry retained at the hatchery.

Upwards of 150,000 eggs of brook trout were laid in from the breeding-fish reared in the artificial ponds adjoining the hatchery; 30,000 of these were shipped to the Druid Hill hatchery, Baltimore, Md., and 20,000 to F. Mather, Newark, N. J., for reshipment to France. About 75 per cent. of the remainder were hatched; 30,000 of these were taken to West Virginia by United States Fish Commission car No. 1; 10,000

were retained at this hatchery; and the remaining 35,000 were planted in brooks in Oakland and Wayne Counties, Michigan.

Seventy-five thousand eggs of California trout were received from Baird Station, California, and hatched and transferred to Michigan, Illinois, and Missouri waters, except a few thousand retained at the hatchery to rear for breeders.

About 50,000 eggs of Schoodic salmon were also forwarded to this station from Grand Lake Stream, Maine. These were hatched and liberated in Michigan, Ohio, and Indiana waters, except a few hundred retained at hatchery for experiments in growing them in confinement, on artificial food.

One thousand five hundred German carp were sent to this station from Washington, D. C., and from this point dispatched in lots of 20 to various parties throughout the Northwestern States.

Season of 1882–'83.

The present season has witnessed the building of an auxiliary hatchery at Alpena, Mich., on the coast of Lake Huron. The work was begun about the first of October, and pushed rapidly forward to completion. The building was up and the equipments in by the 12th of November, when eggs began to arrive from the adjacent fisheries.

This hatchery is equipped exclusively for whitefish propagation, and will admit the easy manipulation of 100,000,000 eggs of that species. Owing to the tardy commencement of this work, however, provision was made for hatching only a little more than 40,000,000 this season. This number of eggs was safely secured from the 10th to the 30th of November. Next season and thereafter we hope to operate the hatchery to its full capacity. The location of this hatchery is all that could be desired to suit the purpose in hand, as spawning fish are caught in great numbers in the immediate vicinity, and the situation furnishes a good distributing point for a large section of the northern part of the "Great Lake Chain."

A large supply of eggs has also been placed in the Northville hatchery this season. This includes 300,000 eggs of lake trout from Lake Huron, over 400,000 eggs of brook trout from the ponds of the Northville hatchery, and nearly 30,000,000 eggs of whitefish from Lake Erie. Our brook-trout supply this year was augmented by 20,000 to 25,000 eggs obtained wholly from wild trout inhabiting the neighboring stream, out of which they had run into the waste-channel of the ponds.

The eggs in stock are in excellent condition, and the aggregate results in embryos and minnows from these alone will far surpass anything heretofore accomplished in the work of the hatchery, to say nothing of operations at the auxiliary station at Alpena. It is expected also, before the close of the current season, to lay in several million eggs of wall-eyed pike, from Lake Huron fisheries; and at least 200,000 eggs of California or rainbow trout from the parent fish now held in

our trout ponds. Both of these species spawn in this latitude during the spring months.

An important departure in the method of obtaining whitefish eggs, and one which from the very outset has been signally successful in a number of instances, is a system of operations by which the fish nearly ready to spawn are confined within certain prescribed limits until their eggs have been secured. The whitefish is not adapted to continuous confinement in artificial ponds, like the trout; and as they are usually caught in very large numbers from their natural habitat during the spawning season, it has been the custom heretofore to depend for our supply of eggs of this species upon the "ripe" fish found in the nets when lifted by the fishermen; no opportunity was given to handle the "lifts" a second time; and as a great majority are either "spent" or "unripe," but a comparatively few individuals are found in which the spawn is in proper condition for fertilization, and hence but a small proportion of the spawning fish actually captured were manipulated. However, almost fabulous numbers of eggs can be secured even from this source, with fair weather prevailing during the brief period that whitefish naturally spawn; but this period is usually cotemporaneous with a series of violent storms for which our Great Lakes are noted, and which compel a discontinuance of fishing operations; so that more or less uncertainty must attend all efforts in this direction, and much labor and expense may produce only the most meager results.

The improved method referred to holds a large number of the adult fish in confinement only during the spawning season. Pens of the requisite size are constructed in those parts of the lake where the fish are caught in great numbers and where there is protection from heavy wind and sea. Being thus imprisoned they can be handled and rehandled at pleasure, regardless of wind and weather, until every egg is secured.

Thus far this season eggs have been shipped from Northville as follows: Whitefish: To Washington, D. C., 1,000,000; Maryland, 150,000; Germany, 500,000; France, 200,000; Minnesota, 5,000,000; California, 500,000; New Hampshire, 200,000; North Carolina, 250,000; Pennsylvania, 2,000,000, and Cold Spring hatchery, New York, 1,000,000; total, 10,800,000. Brook trout: To Washington, D. C., 150,000; Germany, 45,000; Bogota, South America, 10,000; France, 20,000; England, 10,000; Ohio, 15,000, and Cold Spring Hatchery, New York, 150,000; total, 400,000. Lake trout: To Washington, D. C., 50,000; Germany, 100,000, and France, 50,000; total, 200,000.

So far as reports have been received the above shipments have reached their destinations in excellent condition.

FUTURE PROSPECTS OF THE NORTHVILLE HATCHERY.

From very moderate beginnings the work here has assumed very fair proportions, and has, in some respects, surpassed the hopes at first entertained. Six seasons of work under private auspices placed the in-

stitution on a thoroughly practical basis, and since its control has passed into the hands of the United States Fish Commission new and more extended undertakings have been successfully inaugurated. There are natural facilities here, however, that have not yet been fully utilized. The trout work, to which this station is peculiarly adapted, may readily be enlarged to such an extent that our present operations may be multiplied eightfold, while the cost will not be more than three times what it now is.

The water supply now controlled by the hatchery is wholly of spring origin, the character and volume of which have been heretofore alluded to; and, while it is sufficiently ample to sustain a considerable pond area and do a creditable work, as the figures given indicate, the additional water-power adjacent and available for the purpose in question will make it possible to increase the volume of work with increased outlay in the ratios given above. The power referred to is embodied in a stream flowing near the hatchery, and which has its origin in numberless little springs one mile away, its quality being sustained and volume increased by numerous contributions of like character all along its devious channel, which finally passes within a few feet of the trout ponds in connection with the hatchery. As the degree of success already established will doubtless justify the acquisition, either by lease or purchase, of sufficient land through which the stream flows on which to create ponds and to control three-quarters of a mile of the stream itself, a prospective glance at the magnitude the work may attain is worthy of notice and will be a fitting conclusion to the history of a work just fairly begun.

The plan of utilizing this stream contemplates the creation of large ponds or reservoirs of irregular coast lines along the border of the stream, into which a sufficient quantity of water will be diverted to sustain a large stock of breeding fish. The outlet of the ponds will be so constructed as to carry the water back again into the main channel. As the capacity of this stream is fully 3,000 gallons per minute, an immense pond area can be sustained, while the stream itself will make a home for thousands of growing fish. The water is well adapted to the purpose in hand, as is attested by the fact that the stream is now inhabited by hundreds of brook trout of various sizes which are the result of plants at the beginning of the work at Northville. Schools of 10 to 25 trout can frequently be seen around favorite gravelly pools where they are wont to congregate. By actual count 350 of these wild trout were taken during the past fall from the little rivulet created by our springs and flowing into the main channel, whence they had run for spawning purposes. About 25,000 eggs were taken in this way, as before mentioned, which was clear profit, besides increasing our stock of breeders by the 350 fish that were transferred to the ponds.

The use of this stream will also make a very material proportionate reduction in cost of food, as it is stocked with shrimp (*Gammarus*), the

natural food of the trout, in sufficient numbers to sustain a great many fish without the aid of artificial food.

A comparative statement in figures will better illustrate the future possible trout work of this station. The extension of facilities to the limit of the *present* water-power of the station will show an aggregate pond area of 16,463 square feet, which will contain a sufficient stock of parent fish (together with the requisite number of growing fish to keep the stock good) to yield an annual income of 1,500,000 eggs of either the *Salvelinus fontinalis* or *Salmo iridea*. The acquisition of sufficient basin of the adjacent stream for pond-room and for control of three-quarters of a mile of the channel bed will swell the aggregate pond area to about 140,000 square feet. This, with the stream itself, will carry a maximum of stock, at the minimum of cost, sufficient to yield annually 12,000,000 eggs. These figures may be regarded as an under rather than an over estimate, since they are made up from the standpoint of our present methods of rearing and handling fish, which experience and experiment are constantly improving.

We now have on hand in the ponds of the hatchery—

Brook trout:	
Fry	8,000
One year old	1,200
Two years old	850
Three and four years old	400
California trout:	
Fry	10,000
One year old	200
Two years old	700
Three and four years old	20
Land-locked salmon of last spring's hatching	500
Lake trout of last spring's hatching	300

Below is a statement of the whole number of fertilized eggs placed in the Northville and Alpena hatcheries to date, including the prospective supply of eggs of California trout for the current season:

Whitefish (*Coregonus clupeiformis*)	120,580,000
Lake trout (*Cristivomer namaycush*)	510,000
Brook trout (*Salvelinus fontinalis*)	1,050,000
California salmon (*Oncorhynchus quinnat*)	1,788,000
California trout (*Salmo iridea*)	283,000
Land-locked salmon (*Salmo salar;* var. *sebago*)	125,000
Wall-eyed pike (*Stizostedium americanum*)	25,000
Grayling (*Thymallus tricolor*)	2,000

Season.	Grayling.			Wall-eyed pike.			California trout.		
	Eggs received.	Eggs shipped.	Fish hatched.	Eggs received.	Eggs shipped.	Fish hatched.	Eggs received.	Eggs shipped.	Fish hatched.
1874–'75				25,000		20,000			
1875–'76	2,000		500						
1876–'77									
1877–'78									
1878–'79									
1879–'80									
1880–'81							3,000		2,500
1881–'82							80,000		70,000
1882–'83							200,000		175,000
Total	2,000		500	25,000		20,000	283,000		247,500

Season.	Lake trout.			Brook trout.			Land-locked salmon.		
	Eggs received.	Eggs shipped.	Fish hatched.	Eggs received.	Eggs shipped.	Fish hatched.	Eggs received.	Eggs shipped.	Fish hatched.
1874–'75	150,000		125,000	100,000		85,000			
1875–'76				50,000		45,000			
1876–'77				50,000		42,000			
1877–'78				50,000	43,000		10,000		2,000
1878–'79				75,000	60,000	10,000	15,000		11,000
1879–'80				50,000	30,000	15,000	50,000		46,000
1880–'81				75,000	50,000	13,000			
1881–'82	60,000	50,000	2,000	150,000	50,000	75,000	50,000		45,000
1882–'83	*300,000*	*200,000*		*450,000*	*400,000*	*25,000*			
Total	510,000	250,000	127,000	1,050,000	633,000	310,000	125,000		104,000

Season.	California salmon.			Whitefish.		
	Eggs received.	Eggs shipped.	Fish hatched.	Eggs received.	Eggs shipped.	Fish hatched.
1874–'75	50,000		25,000	2,500,000		2,100,000
1875–'76	*988,000*		*900,000*	*3,300,000*		*2,700,000*
1876–'77	500,000		450,000	1,250,000	1,050,000	
1877–'78				1,500,000	1,300,000	
1878–'79	250,000		225,000	2,500,000	1,900,000	400,000
1879–'80				3,250,000	2,750,000	
1880–'81				13,780,000	3,200,000	9,000,000
1881–'82				22,500,000	1,910,000	17,500,000
1882–'83				70,000,000	10,800,000	50,000,000
Total	1,788,000		1,600,000	120,580,000	22,910,000	81,700,000