# XIX.—REPORT ON THE PROPAGATION OF THE SHAD (ALOSA SAPIDISSIMA) AND ITS INTRODUCTION INTO NEW WATERS BY THE U. S. FISH COMMISSIONER IN 1873.

By James W. Milner.

## 1.—SHAD-HATCHING AN IMPORTANT DISCOVERY.

In the progress of fish-culture there has probably been no more difficult problem carried forward to a certain and successful conclusion in a short space of time than the propagation of shad, nor has the propagation of any species afforded more efficient results in the attempt to increase the numbers of the food-fishes.

## 2.—PLAN OF OPERATIONS.

The plan of the work of shad-hatching, under the appropriation for that purpose, as established by Professor Baird, was to begin as far south as the Savannah River, early in the season, and visit the rivers northward as the season advanced, it being a well known fact that the shad enter rivers in succession to the northward, at intervals of a few weeks, for the purpose of spawning. The Savannah River, of Georgia, and the Neuse and Roanoke Rivers, of North Carolina, on the representation of Dr. H. C. Yarrow, who investigated the southern streams, were selected, and the locations of the hatching-stations determined, with reference to the supply of fish obtained at the fisheries, and the facilities for transferring the young shad by rail to waters destitute of this species of fish. The intention of the work was not only to multiply numbers in the streams where the spawning fish were taken, but to stock other waters with this valuable fish where they had been exterminated or where they had never existed. The Potomac and Delaware Rivers, the Susquehanna and the Rappahannock Rivers, were kept in view as favorable streams for shad-hatching, with possibly one or two rivers still farther north late in the season, from which contributions could be made to the waters of the Mississippi Valley and the great lakes.

It was determined by the commissioner to obtain if possible the services of Seth Green, and arrangements were made with him for that purpose to afford to the commission his own aid and as many of his trained experts as could be spared for the season.

## 3.—OPERATIONS ON THE SAVANNAH, NEUSE, AND ROANOKE RIVERS.

On the 17th of April Seth Green, with a party of four, his son, Mr. Holton, Mr. Welsher, and Mr. Mason, all having had ample experience

in the work of shad-hatching, arrived in Washington, and Mr. Green, after learning the plans and intentions of the commission, left, accompanied by the whole party, for Augusta, Ga., where the first station was to be established.

The intense heat affecting Mr. Green unfavorably, he was obliged to return home, and the work fell to the hands of the rest of the party to perform.

Mr. Mason reports that a visit to the fish-markets on the 21st found only twenty shad offered for sale, and on visiting the fishing-grounds the fishermen asserted they did not think fifty shad would be taken in one day within ten miles of Augusta. Remaining at the fisheries until 11 p. m., only one shad was caught, though six drift-nets were in use on that portion of the river which he visited.

Until the 28th, the time was spent in visiting the different fisheries above and below Augusta, for a distance of twenty miles along the river, with no better results. From sixteen trap-nets in a rapid portion of the river he saw four shad taken, all dead from the rapid water crowding them against the lower side of the crib.

On the 28th, receiving advice from Mr. Welsher, who had gone north prospecting on the Neuse River, the camp on the Savannah was abandoned and the whole party proceeded north to New Berne, N. C., and on May 1st selected a location for a hatching-station fourteen miles up the river. At this place from eight to fourteen shad were taken nightly until the 0th, when the rains had raised the water in the rivers until the only fishing possible was with skim-nets. Two spawners were taken on the 5th with skim-nets, from which 45,000 eggs were taken and impregnated.

The river continued to rise until, on the 12th, the party were driven from their camping ground and returned to New Berne. The young shad were hatched with scarcely any loss of eggs, and were turned into the river, with the exception of about one hundred, carried to New Berne for exhibition.

On the 15th, orders having arrived from Washington, the party divided, Mr. Holton and Mr. Chester Green going to the Roanoke River and selecting a locality for a hatching-station near Weldon, N. C., and Messrs. Mason and Welsher came to Washington.

Messrs. Holton and Green at this point were so fortunate as to obtain and impregnate a quantity of spawn of the striped-bass or rock-fish, *Roccus lineatus*, which they placed in hatching-boxes and treated them in the same manner as shad ova and succeeded perfectly in bringing them to maturity in about the same period of time required for shad.

### 4.—OPERATIONS ON THE POTOMAC RIVER.

On the 16th the station on the Potomac River was established at the south end of Long Bridge, at Jackson Tavern, Virginia. Messrs. Knight and Gibson, owners of extensive fisheries in the vicinity of Washington, and owning the fishery at that point, afforded a supply of spawning shad

and extended many valuable favors through their foreman, Captain Evans, who was always ready to afford assistance.

On the night of the 17th twenty ripe spawners were taken and about 400,000 eggs impregnated and placed in the hatching-boxes. This large quantity afforded us anticipations of a more than ordinary success on the Potomac River, that were not destined to be fulfilled.

On the 18th about five hundred shad were taken at the fishery, and only two ripe spawners found among them, affording about 50,000 eggs. The temperature of the river on this day was 63° in the morning and 67° in the afternoon.

On the 19th about six hundred shad were hauled in the seines, among which ten ripe fish were found and about 250,000 ova impregnated. The temperature at 6 a. m. was 62°; at 6 p. m. it was 65°.

On the 20th, one hundred and twenty shad were taken, seven ripe fish found, and 120,000 ova obtained.

The 21st was cold and rainy. In the night-hauls six hundred shad were captured, seven ripe fish handled, and 150,000 spawn taken.

The night-catch of the 22d was one hundred and thirty shad, four ripe fish and 100,000 spawn.

The 23d saw the first young shad out of the egg, about one hundred and forty hours after the first eggs were impregnated, the water having varied in temperature between 62° and 67°, the time being just about double that occupied when the temperature ranges from 75° to 80°, in both instances the water remaining quiet. On this day four spawners were found and about 90,000 eggs obtained.

Arrangements were made with fishermen on the river, at Mr. Livingston Stone's request, for obtaining one thousand young cat-fish and five hundred yellow perch to be forwarded to the California aquarium car. The fisherman collected the perch, *Perca flavescens*, in a live box, and a number of cat-fish, *Amiurus albidus*, were also obtained.

On the 24th 50,000 eggs were put into the boxes.

On the 25th 400 shad were taken, three ripe fish, and about 60,000 eggs taken. Twelve boxes of the young fry were turned loose in the river, about 200,000 shad.

On the 26th, from a catch of about 200 shad, four ripe ones were obtained and about 75,000 eggs impregnated. There were also on this day about 220,000 young fish turned loose in the river.

On the 27th a heavy storm from the north broke the connecting links of the boom that had been arranged to protect the boxes, and sweeping it down upon some of them, released about 275,000 young shad into the river, with the eggs in the same boxes remaining unhatched, of which there was a small percentage just ready to hatch, and many of them, no doubt, emerged from the egg in good condition on the bottom of the river.

Out of 250 fish four ripe fish were taken and 80,000 spawn put into the boxes.

On the 28th about 155,000 young shad were put into the river, and 60,000 eggs impregnated from three spawners.

On the 29th the river was muddy and the water high from rains to the northward, and but few shad were taken in the nets, and no spawners found among them. The temperature of the river on the afternoon of the 28th reached 70°, and on the 29th varied from morning to evening from 70° to 75°.

On the 30th no ripe fishes were taken. The temperature of the river varied from 75° to as high as 80°. About 50,000 young shad were turned loose into the river.

On the 31st the temperature of the water had fallen as low as 62° in the morning, but rose again before night to 70°. Day-time fishing for spawners, though rarely successful, afforded this day three ripe fishes, and at night nine more were taken, and from all 250,000 ova were obtained.

June 1, no ova were obtained.

On June 2, 214 fishes were captured and five ripe fishes handled, producing 100,000 spawn, the temperature of the river varying between 68° and 72°.

On the 3d the fishermen made twelve hauls of the seine, capturing about 200 shad, among which were found four spawners, and 80,000 eggs taken from them.

On the 4th twelve hauls were made and but few shad taken. Eight ripe females were obtained in the evening, and 190,000 eggs impregnated.

The 5th saw but few shad taken at the hatching-station. More than 100,000 young fish were turned out of the boxes; four ripe females were obtained and about 70,000 eggs impregnated. The river for the first time during the season showed a temperature as high as 84°.

On the 6th the fishermen made twelve hauls, taking only ninety shad; eight of them were ripe females, but the eggs were all found to be dead, on extrusion, with a white speck in the normally uniform yellow tint of each egg, showing its addled condition. The temperature of the river in the morning and the evening was 78° and 84°. As dead eggs are seldom or never taken from the shad except in a time of high temperature of the river, this condition is without doubt to be attributed to this cause. There were about 75,000 young fish turned loose on this day.

On the 7th nine hauls were made, two ripe spawners obtained, and 15,000 eggs impregnated. There were about 125,000 young fish turned into the river. The highest record of the thermometer in the river on this day was 80°.

Knight & Gibson stopped fishing for the season on this ground, "cut out the nets," as it is termed on the river, their fisheries farther down the river having been stopped several days before, and it was with difficulty and additional expense the gang of men could be kept together

for the sake of procuring spawners, the proprietors of the fisheries being partially remunerated for their expenses during this additional time.

A new and less expensive seine was put in on the 8th, but no shad were taken in it, and but few other fishes, which was no doubt partly owing to the bad construction of the seine. About 20,000 shad were turned into the river.

On the 10th a new seine was set at work on the ground, and making eight hauls one shad was captured. The temperature of the water was 80° to 82°.

It was now decided to break up the station, and the boxes, chains, anchors, and boat were stored away until another year.

N. W. Clark, of Clarkston, a fish-culturist of Michigan, arrived in Washington on the 4th, sent out by the State commission for a supply of shad for waters in Michigan. A sufficient supply for this purpose was in readiness, and it was decided at the same time to move a shipment out to the head-waters of the Kanawha River, in West Virginia.

Six large milk-cans, with a capacity of fifty quarts each, had been provided for the purpose, but at the request of a prominent fish-culturist two large galvanized-iron cans, with a very convenient and ingenious device for aeration, were substituted for two of the milk-cans. About 50,000 young shad were put into the six cans. The water from the river at 5.45 p. m., the time when the fish were put into the cans, was 83.5° in temperature, and a quantity of ice was immediately procured for the purpose of reducing this high degree of heat, as it was much too high for the young fish to endure.

The ice placed around the cans while being transferred in a wagon from the hatching-station to the ferry-boat of the Orange, Alexandria and Manassas Railroad, reduced the heat somewhat, and while crossing the river on the steamer a small quantity of ice was put inside of the cans, so that at 8 p. m., when the train left Alexandria, two hours and fifteen minutes after the fish had been put into the cans, the temperature was reduced to 72°.

A reserve can of water, obtained at a hydrant in Alexandria, was taken on board the train and a quantity of ice put into it.

Fresh water was obtained at Warrenton Junction, at Staunton, and North Mountain Summit, always from the railroad-tanks, as no other water was to be obtained; the temperature of the water in the reserve can was reduced with ice to about 52° to 53° before it was put upon the fish, and the cans of fish held a very uniform temperature throughout the journey of from 68° to 73.5°.

In the night it was discovered that a large number of the fish in the galvanized-iron cans were dead, though those in the tin cans seemed to be all lively and in good condition, and in the morning very few living ones could be found in the galvanized-iron cans.

At 8.30 a. m. of the 6th, Ronceverte, West Virginia, the point on the

Greenbrier River selected for placing the fish, was reached. There had been fresh water afforded the cans five times, and the aerating apparatus applied seventeen times.

The temperature of the Greenbrier River was found to be 76°; the water in the cans from 72° to 74°, a difference too slight to injure the young shad. Procuring a boat, some time was expended in finding a spot free from minnows and small fishes; but they were finally turned into a quiet inlet to one side from the rapid current of the river.

The two cans of galvanized iron did not contain a single live fish, but the loss in the tin cans was very small. The process to which the sheet-iron is subjected while the zinc coating is applied had possibly left sufficient injurious matter on the metal, which had not been well cleaned and produced the fatal effect upon the fish; and, though large fish may not be materially affected by the use of this metal, it is not advisable to use it in the transportation of so delicate a creature as the young shad is.

Out of the *50,000 estimated to be the number that left Washington, about 30,000 were put into the river alive.

On the 9th 40,000 shad were put into the tin cans and sent to the New River, Virginia, headwaters of the Kanawha River, in the charge of Mr. Welsher.

The temperature of the water was reduced to about 70° before the cans were put into the wagon. Leaving the city at 7 p. m. they reached Central Station Virginia, at 10.30 a. m. of the 10th and were moved to the river in an ox-cart and turned out of the cans in good condition with an imperceptible loss.

The work of the season had resulted in the releasing of 1,370,000 young shad in the Potomac River, and about 90,000 contributed to the headwaters of the Kanawha River as a portion of the stocking of the waters of the Mississippi River tributaries, which was a part of Professor Baird's plan for the season's work.

The conservatism which Seth Green had taught his men, in estimating numbers of eggs, is to be taken into account, when comparing the success of the season with that of other localities; as the uncertain and unreliable method in estimating in different parts of the country have resulted in very different standards, by which the approximations to the true number have been attained.

In the future it will be advisable to begin operations earlier, as it is not probable, in ordinary seasons, that the temperature of the water will continue cold so late in the spring, and the last of April, or possibly the middle of the month, might find occasionally a fish spawning; and the true policy in effecting large results is not to allow a single spawning of eggs to escape the vigilance of the operators.

*The standard for estimation of numbers of the live fish adopted by Mr. Green's men, with commendable desire not to exaggerate, I suspected from the first to be too small, as it would not account for the estimated number of eggs in the boxes. A test was subsequently made as related on page 443, and any excess of numbers in this report over former published statements in the newspapers is to be attributed to this fact.

*Shad-hatching on the Potomac River, Jackson City, Va., opposite Washington, D. C., in the year* 1873.

| Date. | Number of shad taken. | Number of spawners stripped. | Number of ova. | Temperature of water. | Period of development. | Number of fish released in Potomac River. | Number of fish transferred to distant rivers. |
|---|---|---|---|---|---|---|---|
| | | | | 6 *a.m.* 6 *p.m.* | | | |
| May 17 | ..... ..... | 20 | 400, 000 | ..... 65° | About 7 days ... | ..... | |
| 18 | 500 | 2 | 50, 000 | 63° to 67° | ....do ..... | ..... | |
| 19 | 600 | 10 | 250, 000 | 62° 66° | ....do ..... | ..... | |
| 20 | Morning and evening. 270 | 7 | 120, 000 | 62° 64° | About 6 days ... | ..... | |
| 21 | Evening tide. 600 | 7 | 150, 000 | *d*62° 66° | ....do ..... | ..... | |
| 22 | Evening tide . 130 | 4 | 100, 000 | 62° 63° | About 5 days ... | ..... | |
| 23 | Few. | 4 | 90, 000 | 62° 65° | *f*About 4 days... | ..... | |
| 24 | Evening tide ..... | ..... | 50, 000 | 65° 68° | ....do ..... | ..... | |
| 25 | Morning and evening. 400 | *a*3 | 60, 000 | 66° 69° | ....do ..... | 200, 000<br>220, 000 | |
| 26 | 200 | 4 | 75, 000 | 66° 69° | About 3 days ... | | |
| 27 | 250 | 4 | 80, 000 | *c*63° 67° | ... do ..... | 275, 000 | |
| 28 | 150 | 3 | 60, 000 | 65° 70° | About 70 hours . | 155, 000 | |
| 29 | None. | ..... | ..... | 70° 75° | ..... | 100, 000 | |
| 30 | None. | ..... | ..... | 75° 80° | ..... | 50, 000 | |
| 31 | ..... ..... | *b*12 | 250, 000 | 70° 72° | ..... | 50, 000 | |
| June 1 | ..... ..... | ..... | ..... | ..... | ..... | ..... | |
| 2 | 214 | 5 | 100, 000 | 68° 72° | About 3 days ... | ..... | |
| 3 | 200 | 4 | 80, 000 | 68° 73° | ....do ..... | ..... | |
| 4 | Few. | 8 | 170, 000 | 70° 75° | About 70 hours . | ..... | |
| 5 | Few. | 4 | 70, 000 | 72° 84° | ....do ..... | 100, 000 | *g*50, 000 |
| 6 | 90 | *c*8 | ..... | 78° 84° | ..... | 75, 000 | |
| 7 | ..... ..... | 2 | 15, 000 | 77° 80° | About 70 hours . | 125, 000 | |
| 8 | None | ..... | ..... | 75° 78° | ..... | 20, 000 | |
| 9 | ..... ..... | ..... | ..... | ..... | ..... | ..... | *h*40, 000 |
| 10 | ..... ..... | ..... | ..... | 80° 82° | ..... | ..... | |
| | Total.... 3, 665 | 111 | 2, 170, 000 | 68°.2 71°. 9 | | 1, 370, 000 | 90, 000 |

Percentage of eggs hatched ..... .67‡

*a* One spawner in day time.
*b* Three spawners in day time.
*c* Eggs all dead.
*d* Cloudy and rainy.
*e* Heavy storm from north.
*f* First shad hatched on 23d, six days.
*g* Transferred to Greenbrier River, W. Va.
*h* Transferred to New River, Va.

## 5.—METHODS EMPLOYED IN SHAD HATCHING.

Up to 1867 the speckled trout, (*Salmo fontinalis*,) the salmon, (*Salmo salar*,) were the only fishes that had been hatched on any considerable scale in the United States. Experiments had been made with more or less success on the yellow perch, (*Perca flavescens*) and the wall-eyed pike, (*Stizostedium americanum*,) the common sucker (*Catostomus communis*,) the corporal,* (*Semotilus corporalis*,?) the salmon-trout, (*Salmo namaycush*,) and the white-fish, (*Coregonus albus*.)†

At the invitation of the States bordering on the Connecticut River, Seth Green visited the river and selected what afterward proved to be a most excellent locality for a shad-hatching station. He began his experiments in shad-hatching by using the usual methods for trout-hatching—the

* A Treatise on the Artificial Culture of certain kinds of Fish, &c., by Theodatus Garlick, M. D., Cleveland, Ohio, 1857, p. 137.

† Annual Report Department of Agriculture, 1859.

ordinary troughs, with a gravel covering on the bottom, and a stream running with a slight current over the gravel. Owing to the very light specific gravity of shad-eggs, it was soon found that there was no success whatever to be hoped for by these devices.

Several experiments of different devices were attempted before the mode now adopted was tried and proved successful. But a successful method was discovered and employed sufficiently long before the end of the season to hatch out a large quantity of shad, and the results were apparent to the fishermen of the river three years afterward.

The apparatus* devised by Mr. Green was merely a light pine box, 22 inches long, 15 inches wide, and 12 inches deep; the bottom was of wire-cloth—about twenty wires to the inch. It was used without a cover. On the ends of the box two pieces of two by four scantling were nailed diagonally to the lines of the box, so that floating in the water it was slightly tilted, the side of the box sunk to the least depth being up stream, so that the wire-screen bottom was presented to the current at a slight angle, sufficient to produce a circulation of the water inside of the box that kept the light shad-eggs in gentle motion. In a sluggish tide-current the floats are usually nailed on so that from the upper edge of the box to the top of the float in front there is a distance of 5 inches, and from the upper edge of the box to the top of the float behind there is 2½ inches. The angle of the floats is of course less for a more rapid current, the object being to produce a current that will move the eggs as gently as possible, a more rapid motion being regarded as injurious, especially in the later stages of development, when it materially hastens the rupture of the shell membrane and effects a too premature birth The wire-screen bottom is coated with coal-tar, or what is better, asphaltum varnish, both for the purpose of preserving the wire-cloth and for a supposed effect in retarding confervoid growth.

The boxes are connected by bridles and lines in gangs of six, and to the first box an anchor-line with a large stone at the end holds the gang in its place in the river. The box next the anchor has the floats extending both ways beyond the box about 8 inches, but on the remaining ones they are sawed off flush with the box.

The method employed at the station at Washington is as follows: The fish are taken in a seine one thousand fathoms long. As soon as the bag of the seine comes near the shore the fishermen, gathering the lead-line and cork-line in their hands, gradually work it up to the top of the water, shaking the fish into the bunt of the bag. A boat is brought alongside and the fish thrown into it with a scoop-net, the shad being at once separated from the other species. The operators, provided with ordinary six-quart milk pans, containing about three-fourths of an inch of water in the bottoms, are in the boat and, taking up the shad one by one, detect at once, by a gentle pressure on the belly of the fish, if the spawn is ripe by its free emission from the

* See illustration at end of volume.

oviducts. In an unripe one the eggs will not flow at all, and if the eggs are only nearly ready, the extrusion is difficult and in masses and the fish is rejected. When a female is found from which the eggs flow in a liquid stream when a gentle pressure is applied, it is carefully taken in the hands of the operator, the left hand applied closely around the tail and the head of the fish crowded against his body, while with the right hand a slight pressure is applied with the thumb and finger to the abdomen of the fish, and a stripping movement executed which causes the eggs to flow rapidly into the pan. As soon as it is evident that the spawn is all obtained, the shad is thrown into the basket, it being impossible to preserve the lives of so delicate a fish even if the utmost care is taken in handling it. But though they are delicate in this particular, and have a very slight tenacity of life when taken from the water, they are a very muscular fish. Experts in fish-culture who have handled the white-fish and salmon-trout of the lakes, regard them much stronger than the same sized fishes of either of the latter species, and if the utmost pains is not taken to prevent their releasing themselves from the hold, they will flounder and splash in the pan of eggs and probably throw a large proportion out, and damage some of those that remain.

In stripping down the abdomen, a great many scales will be removed from the sides of the fish. These, if carelessly allowed to fall into the pan, will be an annoyance, as the eggs will adhere to them. They can be gathered and thrown away, by an adroit movement of the hand, with a little experience, without making any delay in the operation of stripping the fish.

Mr. Green estimates the number of ova taken from an average spawner at about 20,000 eggs, and rarely estimates above 28,000 for the most prolific shad. Mr C. C. Smith, operating for the Connecticut State commission, estimates an average good spawner at 50,000 ova. We have not made a test of these estimates, and are not prepared to offer an opinion with reference to the disagreement.

The salmon family contains the species that had, previous to 1867, been dealt with in fish-culture on any considerable scale in the United States, nor had any of the family of fishes that embrace the shad, the *Clupeidæ*, been experimented with in Europe.

The conditions that necessitated new methods in the shad-hatching from that of the trout and salmon were not only in the less specific gravity of the shad ova, but in the very much less period of time required for the development of the fish from the egg. With the trout, at the ordinary temperature of spring-water, about 47°, the trout-eggs remain in the hatching-troughs from seventy to one hundred days; with the salmon in some hatching establishments, where the water assumes a winter temperature of 35° or 36°, the fish are not hatched out under about five months from the time the eggs are impregnated. The shad, when the temperature of the water was as low as from 62° to 67°, only re-

quired about six days to emerge from the egg, while in a temperature between 75° and 80° only about seventy hours or three days from the time the eggs were impregnated, the fish were numerous in the boxes.

This fact was, of course, a great advantage over the trout, both in the very much less amount of labor in the care of the ova and in the fact that, being in the always precarious egg-stage for such an inconsiderable length of time, they suffered a proportionately less amount of exposure to the ills and damages the longer-developing *Salmonidæ* were subject to.

The eggs of the shad are somewhat smaller than those of the white-fish, (*Coregonus albus*, Les.,) which are smaller than in the trout, (*Salmo fontinalis*,) and much smaller than in the salmon, (*S. salar.*) The eggs, just after impregnation, of the white-fish are a little less than one-eighth of an inch in diameter, while those of the shad are but about one-tenth. The shell membrane is also thinner and the egg more delicate, and does not seem to endure the handling and ladling out into moss or cups for transportation, or even into the hatching-boxes. Experiments in the transportation of shad-eggs, even for short distances, have proved failures, while the white-fish eggs have been sent from Michigan to California, being on the road ten days, and have arrived in good condition, and trout-eggs and salmon-eggs have been shipped much farther, the latter from England to Australia and Tasmania.

A small percentage of loss occurs in the boxes of shads' eggs, and by careful fish-culturists the dead eggs, detected at once by their white hue, are removed; but by many are not interfered with, as they are usually too few to occasion very serious damage to the good ones.

The tool used for their removal is not the egg-tongs or forceps used in trout-culture, but a small net, of minute mesh, less than one-half inch extension measurement, mounted taut on a square frame of wire, about 3 inches square, and the bad eggs are floated up to the surface and thrown out with the *scaff-net*, the good ones passing through the meshes more readily than the bad ones, covered with the mossy parasitic growth that so soon develops upon dead eggs.

Unlike the fishes of the salmon family, the shad, instead of dropping the ripe eggs into the open cavity of the abdomen to pass backward and out through an ovipore, has a continuation of the oviduct to the outside, the two ovaries in their posterior prolongations uniting into an oviduct, in which, by dissection, the eggs can be seen to pass within the transparent membrane of its walls to its outlet.

## 6.—RELATION OF THE TEMPERATURE OF THE WATER TO THE PROPAGATION OF THE SHAD.

Temperature of the water of the sea, rivers, and lakes has a very important relation to the increase of the food-fishes, influencing the time of the spawning migration, the development of the eggs, and the wel-

fare of the young fishes. The eggs, not only after they are deposited and impregnated, but before they leave the body of the fish, are affected by the temperature of the water. The spawning season of the shad seems to be regulated by the increase of temperature as warm weather advances. Their migrations on the coast are in quite a regular succession of time with relation to latitude. From letters received, from published statements, tables of inspection, and personal observation, the periods of their migrations are nearly as given in the following: They make their first appearance in the Saint John's River, Florida, the 1st of December. The season of their greatest numbers is February, and they disappear in April. In the Savannah River, Georgia, it is much the same. On the coast of North Carolina* they make their first appearance in December, their greatest abundance is in March, and they disappear in May. In the Neuse River, North Carolina, the periods of these stages of their migration are a little later. In the Potomac River the advance individuals are found in February; they are found most numerous in April, and they disappear early in July. They are found in the Delaware River at first in March; in the Hudson River early in April. In the Connecticut River they are first found in the last of April, are the most abundant the last of May, and do not leave the river until late in July. In the Kennebec River, Maine, they are first taken in April, and have left by the middle of July; and the same dates apply to the Androscoggin River. In the Saint John River of New Brunswick† they appear about the middle of May, and in the Miramichi River of the Gulf of Saint Lawrence late in May.

But not only in the ordinary times of ascent is there evidence of their sensibility to the temperature of the water, but in late seasons, when the snow-water from the northern sources of the streams keeps the water cold for a longer period than usual, the shad are retarded in their ascent of the rivers, and are taken in quantities by the nets near the mouths of the rivers, while the fishermen above wait impatiently for the run up stream that they know to be prevented by the coldness of the water; even an entire failure in the shad-fisheries in Albert County, New Brunswick, was attributed by the fisheries overseer to the extreme lateness of the warm weather of spring.

Among the *Salmonidæ* of the great lakes the salmon-trout, (*Salmo namaycush*, Penn.,) the white-fish, (*Coregonus albus*, Les.,) and the black-fin, (*Coregonus nigripinnis*, Gill.,) avoiding high temperatures, remain in the deep waters during the warm weather, but in early winter are taken abundantly in the shoaler water near the shores. The antipathy to warm water varies to some extent, the white-fish showing the least, and the black-fin the most, sensitiveness to the warmth.

The transportation of young fishes in cans indicates this peculiarity also. The *Salmonidæ* will thrive in a temperature as low as 40°, and

* See Notes on the Shad, &c., by H. C. Yarrow, M. D., p. 452.
† Article on the Shad and Gaspereau, &c., by Charles Lanman, p. 460.

show no symptoms of lethargy in water kept at 45°, while the shad are most active between 68° and 72°, and become torpid and sluggish at a temperature below 65°.

In the case of the shad there are many indications that the development of the spawn within the ovaries is hastened by the heat and retarded by the cold. In a warm season ripe spawners are more numerous early in the season than in a cold one, and the period for obtaining them is apt to close earlier.

A temperature in the water of about 75° or 76° seems to be the most favorable for obtaining and hatching spawn. At 80° the eggs hatch very rapidly, but the young fish do not do so well, and a more serious difficulty is the fact that many spawners are taken with the eggs dead in the ovaries; that is, they have lost entirely the capacity for fecundation, and as there has been no instance of this kind reported when the water was below this temperature, it is probably correct to attribute the cause to the high temperature of the water.

The temperature of the water regulates the period of development of all fishes' eggs that have been experimented with. In the shad-eggs the period required for release of the fish from the eggs was, with an average temperature of 64°, though actually varying between 62° and 68°, about seven days. With an average temperature of about 65°, actually between 62° and 69°, the time was about six days. With an average temperature of nearly 66°, actually between 62° and 69°, the time for the most of the fish to be free was about five days. An average of 68°, between 66° and 75°, released them in about three days. An average of 72°, really between 65° and 80°, released the fish in about seventy hours, the shortest time observed for a large quantity of eggs, though usually some were hatched a few hours before the majority, and a few eggs lingered for several hours after the *eclosion* of the rest.

### 7.—THE OVARIES AND OVA OF THE SHAD.

The ovaries of the shad are familiar to eaters of shad-roe, as they are usually cooked whole. They differ from those of the white-fish (*Coregonus albus*) in being shorter in proportion to their length, and the membrane of the ovaries is thicker and stronger, while the white-fish, unlike the shad, has the entire length of each divided transversely into folds, which, on removing the outer membrane, are found to hang suspended from the long thickened fold of the membrane on the dorsal side of the ovary, an arrangement that facilitates the passage of the eggs toward the walls of the ovaries, before they fall into the cavity of the abdomen.

The eggs remain in a compact solid mass until they ripen. At first minute, and the ovaries occupying but a small space in the abdomen, they gradually increase until the whole abdomen is distended with their bulk. On a close examination, as they approach the time of spawning, there will be found the maturing eggs, the larger, which are rather

uniform in size, and others of variable size. Whether the latter are the forming eggs for the next year, for two or three succeeding years, or for the lifetime of the fish, has not been determined. In a spent-fish, with the ovaries shrunken and small, they are still found full of these eggs of different sizes; and numerous specimens of this character were preserved in alcohol while at Topsham, Maine, at the close of the spawning-season.

Several weeks before the time of spawning the ovaries have grown so as to fill the cavity of the abdomen, though still increasing. A short time before spawning, transparent eggs of large size, contrasting strongly with the golden hue of less mature ones, will be found scattered through the still compact mass of ova. These become more and more numerous, and after a time the compact condition becomes less apparent and the eggs fall apart and separate, and the extrusion begins, a liquid stream of eggs and mucous flowing from the oviduct on the slightest pressure of the abdomen. After they lose their compact condition they are no longer preserved for cooking.

Unripe eggs, on extrusion, instead of flowing in a liquid stream, come away with difficulty in clotted masses, and generally with a little blood. The same thing will be observed on stripping a fish, with ripe eggs, too long, as the eggs of the season are not all ripe at once, as is frequently seen in dissecting the ovaries of spawning-fish.

The fish, after the spawn is taken away, has a soft and flaccid appearance about the abdomen, which, after natural spawning, becomes contracted and drawn up, tapering slenderly toward the tail, the familiar appearance that characterizes the despised "spent shad."

The eggs covering thickly the bottom of a pan containing water are not easily discernible, as they are so very transparent; and as they come from the fish are so soft and light that when the fingers are moved among them there is nothing other than the water apparent to the touch, and in the dark a person trying the experiment would be willing to admit that there was nothing in the pan but water.

### 8.—THE MALE FISH.

The male fish resembles the female so closely that there is very little certainty in attempting to distinguish between them by outward form, even when the comparison is to be made with a gravid female. The males are ordinarily rather smaller than a full-sized female, and the sex is quickly known, when ripe, by the flow of the milt from the spermaries. Of course dissection always reveals the sex, though the spermaries even in the height of the spawning-season are not nearly so large in proportion to the size of the fish as in most fishes handled by fish culturists.

In large lots of shad brought in by the fish-boats early in the season, ripe "milters" are often very numerous when as yet a ripe "spawner" is very rare, while later in the season the ripe males and females are not found in equal numbers, and it is not a seldom occurrence to have

a fine lot of spawn in the pans and not a single ripe male to be found to fertilize it with, and it has, to the great disappointment of the breeder, to be thrown away as worthless. This scarcity of ripe males, late in the season, may possibly be attributed to this fact, that many of them ripen so much earlier in the season than the females.

The amount of milt that can be expressed at one time is limited to a small quantity, but a very small quantity will impregnate a very large number of eggs, and it is asserted by some to be the more successful way, though usually the milt of a large number is made use of when available. Under the microscope the milt is seen to be thronged with myriads of spermatozoa. In impregnating by the dry method their strong impulse for movement is observed, by placing a small quantity of the milt on one side of a quantity of eggs covering the bottom of a pan, when, if left to itself but a short time, it will be found to have diffused itself between and among all the eggs. If but one of the spermatozoa is needed to fertilize each egg, but a very small quantity of the milt is required.

### 9.—THE IMPREGNATION OF SHAD EGGS.

The ova from the female being collected in the pan with a small quantity of water, a slight pressure on the ripe male near the anal opening will force out two or three jets of the milt, which, falling into the pan, is stirred by a gentle movement of the hand with the fingers spread, care being taken to keep the fingers from contact with the sides or bottom of the pan, as in that case some of the eggs would be crushed The milt being diffused throughout the water, the pan is left for a few moments to allow the spermatozoa to come in contact with the eggs. The pan should then be filled full of fresh water, and gently swayed until the water charged with milt is thoroughly mixed with the fresh water and the eggs slightly rinsed, when soon afterward the water may be poured nearly off and the pan refilled with fresh water, and after a slight and always gentle rinsing up of the eggs, the pan may be allowed to stand for several minutes.

The fact has been referred to that the eggs were not discernible to the touch when put into the pan, nor is there any change in this particular, if no milt is added; at any rate, for the length of time that the eggs have been observed in this condition, a half hour or more. For about twelve or thirteen minutes, when the temperature of the water was about 70°, after the milt was added, no change was observed, but about this time a careful movement of the fingers in the pan discerned their presence, and in a little more than twenty minutes from the time the milt was applied they were felt like shot against the fingers, and to an experienced eye were observed to have increased slightly in size.* This

* Dr. E. M. Schaeffer, of the United States Army Medical Museum, while making investigations with the microscope at the station, found that the increase in size was nearly nine-twentieths of their original diameter in one hour and fifteen minutes after contact with the milt.

stage of their condition is known to fish-breeders as the "spawn-rising," referring to the greater bulk in the pan from the increase in size of each egg. The increase in size and hardness continues for several minutes, during which the water is poured off and fresh water poured into the pan two or three times, and the eggs gently stirred with the fingers. In pouring in the water the edge of the dipper is placed against the sides of the pan and the stream directed between the eggs and the sides of the pan, as it is likely to damage the eggs if poured directly down upon them.

In the white-fish eggs it was observed that before impregnation an egg placed upon a hard substance was easily crushed by a slight pressure of the finger, but after impregnation the shell membrane became so tough and turgid that a very strong pressure with the finger failed to break it.

The assertion is made by nearly all experienced in shad-breeding, that there is a considerable fall in the temperature of the water in the pan containing eggs during impregnation; some of them judge from the sense of touch, and others have made the test with a thermometer, the amount of reduction claimed being from six to ten degrees. Having made this test with a thermometer on several occasions, I have to say that it never resulted for me, though on one occasion a very large number of eggs were in the pan. The temperature in the pan was 69° when the milt was applied, and the thermometer was put into the pan and the bulb immersed and allowed to remain, showing not the least change, though every phenomenon of impregnation occurred. When the changes of water were made the thermometer was each time inserted, but showed the same temperature as the river, the test being continued nearly one hour.

### 10.—THE SUSQUEHANNA, DELAWARE, AND HUDSON RIVERS.

On the Delaware River, hatching operations were begun by Dr. J. H. Slack, with Mr. Holton and Chester Green, at Lambertsville, N. J., on June 12, and continued until June 27, resulting in the placing of 433,000 young shad in the Delaware and 15,000 in the Monongahela, at Greensburgh, Pa.

The hatching-station at Washington was broken up on the 11th of June, and the same evening, accompanied by Mr. Welsher, on his way to Marietta, Pa., to work in connection with the Pennsylvania commissioners, and Mr. Mason, we went north to find a later migration of the shad.

At Newport, the Pennsylvania commissioners, operating with one of Mr. Green's men, had obtained up to date forty-three spawners, out of a little more than one thousand shad taken, and producing, according to Mr. Boehm's notes, 1,500,000 eggs. A greater success would have resulted if there had been a regular fishery established at this point.

We soon ascertained that there was not much prospect of procuring shad for transfer westward, and took the next train for Albany, N. Y.

We arrived at Castleton, N. Y., ten miles below Albany, on the afternoon of the 13th. The shad-hatching station of the New York commissioners is situated on the Hudson River nearly opposite this place, a few miles above Coeyman's Landing. Taking a boat, we crossed to Camp Green, and met a hearty reception from Mr. Monroe A. Green, to whose efficient management the responsibilities of this successful establishment are delegated by the superintendent, Seth Green.

The force to whom continual employment is afforded during the shad season is six or seven men at the fishery and five to seven men in the direct work of the hatching-station.

There were one hundred and twenty-two boxes, containing about two millions of eggs and young shad, anchored in a quiet channel of the river between an island and the west shore. Four boxes of young eels, (*Anguilla bostoniensis*,) of about 4 inches length, gathered from the river, were retained for transfer to distant waters, a large number having been provided the unfortunate California aquarium car.

They were at present obtaining from five to twenty spawners per day, and had taken the first spawner of the season the 25th of May, though they had been on the ground several days. The water on the 25th had a temperature of 56°; on to-day it was 78°.

Questioning Mr. Green for some exact data for results from his own personal knowledge in the improvement in the numbers of shad in the river, the following facts were developed: The first year spawners were scarce, and even fewer the succeeding years until the fourth year, when they began to feel the benefit of their own work in the marked increase of fish, and the spawners their special desideratum. Double the number of hatching-boxes were required for the accommodation of the increased quantity of ova. He remarked that, taking the standard now used in estimating the number of eggs, the correct estimate of the number hatched the first year would be about 7,000,000.

## 11.—JOURNAL OF A TRIP WITH SHAD AND EELS TO CALUMET RIVER, ILLINOIS.

At 6 p. m. the same evening the young fish were put into the cans; six fifty-quart cans, containing 70,000 shad, and one can containing 4,000 eels, with a reserve-can for fresh water, were put into a boat and carried across to Castleton, to be shipped upon a train passing at 9.12 p. m.

On arriving at the east bank of the river the cans of fish remained at the water's edge until about half an hour before the train arrived, when one pailful, 12 quarts, of fresh water was afforded each can; the temperature of the river-water being 75°, and the air rather cooler.

The point determined upon for this first "planting" of shad in the Great Lakes was the Calumet River of Illinois, at South Chicago, on the Lake Shore and Michigan Southern Railway.

The cans were put into the baggage-car of the passenger-train, Mr. Mason remaining with them until their arrival in Albany, at 9.40 p. m.,

where they were put out and moved upon a truck to the penstock at the depot baggage-room, to await the 1.45 a. m. train, which afforded the best connections through to Chicago.

The temperature in the cans was 70°, and in the fresh water from the penstock 68°. Fresh water was supplied each can twice while waiting between the trains, about twelve quarts each time.

The cans were put into the baggage-car, Mr. Mason in charge of them, and fresh water was again afforded them from the reserve-can at about 4 a. m. At 5.15 a. m. the reserve-can was filled at Utica, and fresh water again supplied before reaching Syracuse, at 7 a. m. After leaving Syracuse, a partial change of water was afforded and fresh water again taken on board at Port Byron at 8.10 a. m.

The thermometer indicating 64° in cans, and the reserve-can showing a temperature of 60°, fresh water was again supplied, and at Palmyra, at 9.20 a. m., the reserve-can filled with water from the well at the depot, having a temperature of 50°. This, more than ten degrees of difference, necessitated the moderating of the cold in the well water, which was readily done by taking about four quarts of it in a pail and drawing off water from the can to be supplied until the pail was full, when it was emptied into the can. Seven or eight of the eels were found dead in the bottom of the can.

At Rochester met Seth Green at the depot and received profitable suggestions from him with reference to the transfer of young fish.

At Batavia, at 11.35 a. m., the reserve-can was filled from the faucet in the dining-room, the water of the reserve-can being as low as 54° and of the cans 64°. Water moderated before using it.

The water from the reserve-can being again exhausted, at 1 p. m. it was refilled from the penstock, at the east end of the depot, in Buffalo. The temperature of the water was 66°, and the fish-cans 64°. The cans were transferred to the baggage-car of the Lake Shore and Michigan Southern passenger-train.

After leaving Buffalo the fish-cans were again replenished, and at Dunkirk, at 2.10 p. m., nearly two hours after reaching Buffalo, the supply was replenished and a partial change afforded the cans.

At Erie, Pennsylvania, at 4.15 p. m., fresh water was again obtained and furnished the cans; the temperature remaining at 64°.

At Girard, Pa., 4.43 p. m., again filled the reserve-can. The bottoms of the cans were examined for dead shad, and a very few found. Before reaching Cleveland, Ohio, 4.43 p. m., fresh water was supplied, and at Cleveland a can of fresh water brought on board.

The water in the short interval of two hours had become sufficiently exhausted of the respiratory gases to dissatisfy the eels, and, very unfishlike, they were determined to get out of it and find something better. On taking off the cover they were found in large numbers adhering to the neck of the can, entirely above the water, and worming their way up its vertical surface, just as they are frequently seen, while small, at

a dam or waterfall that obstructs their passage up a stream. They persisted in clambering out of the can, and were with the greatest difficulty driven back by repeated washings down with dippersful of water, until it was freshened sufficiently to be agreeable to them, when they settled to the bottom and remained there. A few got out on to the floor of the car, and of course quickly perished. Water was also afforded to the young shad.

At Elyria, at 8.45 p. m., the reserve-can was supplied. The water from the well had a temperature of 54°.

At Sandusky, 10 p. m., changed the water partially, taking only a pailful from the well at the east end of the depot, as the train-men regarded it as poor water.

At Port Clinton, 10.28 p. m., examined fish and found them in lively condition.

At Toledo, at 11.45 p. m., we did not use the water from the artesian well, as it had a strong mineral flavor.

Mr. Mason took charge of fish the latter part of the night, obtaining water at Edgerton, Indiana, 2.04 a. m. He drew the water all away from the eels, finding about one hundred and fifty dead ones. Fresh water was supplied them again. It was evident they required more frequent changes than the shad, or a less number of eels to the quantity of water.

At Laporte, Ind., at 6.05 a. m., the can was refilled for the last time, fresh water having been supplied, about twelve quarts at a time, to each can sixteen times, the eels having had a larger supply at the time of refilling the can.

At 7.30 a. m. of the 15th we reached South Chicago, and Col. James H. Bowen, kindly responding to a telegram from Palmyra, was at the depot with a hand-car, and a boat on the river near by. The shad having been conveyed to this boat were moved up the river for some distance and consigned to the waters in the middle of the river, where no small fish were found to attack them. The young fish were found in vigorous condition, the number of dead ones being very small, and they swam around in the vicinity of the boat very actively and with no appearance of injury from their journey in the cans.

The eels seemed to evince a ludicrous state of elation at their escape from the cans, and showed similar indications of enjoyment of their freedom to what may be seen among a flock of lambs let loose into a pasture from confinement in a pen. They made sudden darts for short distances, and turned right and left, twisting and wriggling until everybody was laughing at their funny antics. A number of them persisted in following the boat as it moved slowly along while we were turning the young shad from the cans into the stream.

At Colonel Bowen's suggestion, one can of shad was retained to be moved up the river some seven miles, in his little steamer, in the afternoon, Mr. Mason remaining to take charge of it and see the fish safely

placed in the water, which was accomplished; Gov. J. L. Beveridge, of Illinois, being the guest of Colonel Bowen at the time, and witnessing the planting. A dozen or more of eels were carried to Chicago for exhibition, and some days later were placed by Dr. Walter L. Haines in one of the ponds at Lincoln Park.

The cans were returned by express to Castleton, and the same afternoon we were on our way back to the hatching-station on the Hudson for a new supply of fish, to be put into the waters of Wisconsin.

12.—SHIPMENT OF SHAD AND EELS TO THE FOX RIVER, WISCONSIN.

We arrived at Castleton on the 17th, and the same evening left again for the Fox River of Wisconsin with about 70,000 shad and 4,000 eels, and we again left by the 9.12 p. m. train.

At Batavia we were delayed a long time by the burning of a baggage-car; and again, on the Lake Shore and Michigan Southern Road, the train was obliged, because of a defective bridge, to take the longer route between Toledo and Chicago via Adrian, so that we reached the latter city one hour too late for the train of the Northwestern Road that should take us to our destination, Appleton, Wis.

The cans were moved to the Northwestern depot, and a convenient supply of excellent water from the hydrant afforded for use during the day; Mr. Mason, with his usual fidelity, caring for them.

A small can was procured at a tin-shop and about 200 eels put into it to be moved to Big Dead River, at Waukegan, Ill. This task was accomplished by the kindness of Mr. William H. Fay, of that city.

At 9 p. m. of the 19th the fish were again on the way to their destination, and at 10 a. m. of the 20th they were put into the Fox River, Mr. Reid, of the Appleton Post, accompanying us to the point on the river where they were put in. From the long delay there were a larger number found dead in the bottoms of the cans than at the former shipment, though not enough to make any apparent impression in their numbers when looking in at the mouths of the cans. There were probably less than 2,000 dead ones, or a little less than 3 per cent. of the whole number. The fish had been in the cans just sixty-five hours, standing still about eleven hours, and, though the amount of splashing that will benefit larger fish is an injury to shad, still it was made quite evident during our experience that even young shad do better while exposed to the motion of the cars, if managed so that it affect them slightly, than when standing perfectly still. It will be advisable, under similar circumstances, to have them put into a wagon and kept in motion during the delay.

13.—SHIPMENT OF SHAD TO ASHTABULA RIVER, OHIO.

The same evening we again took the return route to Castleton, arriving on the 23d. Your telegram calling me to New York City, Mr. Ma-

son was provided with about 50,000 shad for the Ashtabula River, Ohio, leaving on the same evening, while I took the train in the other direction.

Returning to Camp Green, Mr. Welsher had arrived, and was informed of the purposed shipment to California, which he was to accompany as far as Omaha, Neb.

Mr. Mason returned on the 25th, having put the fish, in good order, into the Ashtabula River on the 24th; Mr. Toombs, express-agent at that point, having afforded him assistance in moving the shad to the river.

In the evening Mr. Livingston Stone, with two assistants, arrived, and also Mr. George H. Jerome, commissioner of fisheries for the State of Michigan, desiring to take back a supply of young shad for his State. Mr. Stone was supplied with cans, tubes, siphons, and pails, and left the same evening for the Sacramento River with 40,000 shad, Mr. Welsher accompanying him as far as Omaha.

The supply of young fish at the hatching-station had begun to fall short, but few shad being taken at the fishery, and indications were numerous that the season was drawing to a close. Our claim for a supply of shad for another shipment was waived in favor of Mr. Jerome, who got away on the 26th with about seventy thousand shad for the waters of Michigan.

### 14.—SHIPMENT OF SHAD TO THE WABASH RIVER, INDIANA.

On the evening of the 28th Mr. Mason and I started for Logansport, Ind., with four cans of shad, about forty thousand. The weather was very warm, and we made use of a small quantity of ice in our reserve-cans whenever the temperature of the water was above 67°.

We arrived at Logansport at 8.50 a. m. of the 30th. Messrs. Bryer and Hunt of the Logansport Journal generously interested themselves in the work of moving the fish to the river, and Colonel Bringhurst, with a knowledge of the character of the waters in the vicinity, selected a locality in Eel River, a large tributary of the Wabash, into which the young shad were put, in fine condition, and with scarcely any dead ones.

We started for Castleton early in the evening, and arrived on July 2 to find the station abandoned and the boxes and apparatus stored away until another year. The season, as anticipated, had closed.

Arranging unsettled matters, and providing for the storage of some surplus apparatus, we left the same evening for South Hadley Falls, Mass., Mr. Mason and Mr. Welsher joining me in Albany.

At South Hadley Falls found Mr. C. C. Smith superintending the hatching-station for the Connecticut fish-commission. He had some seventy boxes in operation, with eggs and shad in various stages of development, and was taking from twenty to ninety spawners nightly, affording large quantities of ova.

Mr. Welsher had been sick during the trip, and, feeling worse, returned home to Rochester, N. Y.

## 15.—SHIPMENT OF SHAD TO THE WATERS OF LAKE CHAMPLAIN, VERMONT.

On the evening of the 4th, with six cans, containing a much larger number of fish than in previous shipments, about one hundred thousand, we started for Burlington, Vt., intending to place the fish in the Winooski River. The weather being very warm we made free use of ice. We arrived in Burlington at 7 p. m. of the 5th, and, accompanied by Mr. H. S. White and a gentleman connected with the Burlington Free Press and Times, we drove to the river and put in the shad, in very fine condition, the loss being hardly apparent.

During 1872 a quantity of shad were planted at Whitehall, N. Y., the head of Lake Champlain, under the direction of Seth Green, and a quantity put in at the dock by Dr. M. C. Edmonds, commissioner for the State of Vermont. This season at the mouth of the Winooski, and at the shore of the lake at Burlington, a number of unmistakable shad five or six inches in length, had been taken; a son of Mr. H. S. White, in one instance, compelling their return to the waters.

We returned to South Hadley Falls, arriving on the 6th, (Sunday,) and remained at Holyoke, Mass., until the next day.

## 16.—SHIPMENT OF SHAD TO THE HOUSATONIC RIVER, CONNECTICUT.

In response to a telegram to Dr. W. M. Hudson, commissioner for the State of Connecticut, proposing to move fish to the waters of the State, the reply was received: "Take as many as convenient to New Milford, on the Housatonic."

On the 8th we started with 90,000 shad and arrived at New Milford in the afternoon, putting the fish in the Housatonic River with scarcely any loss. Although the people of the vicinity were wide awake to the fishing interests, and appreciated perfectly the value of stocking the waters with valuable fishes, their enthusiasm was very much checked by the condition of a fish-way in the dam at Birmingham, lower down the river, which was represented as in no particular constructed according to the models in use for this purpose, and was of no value whatever for the passage of fish.

We started back the same afternoon, arriving at the hatching-station the morning of the 9th. In the afternoon we witnessed the sport of taking shad with a fly-hook*. A citizen of Holyoke, Mr. Thomas Chalmers, has made this line of hook-fishing quite popular on the Connecticut by his successes; on this evening we saw him take eleven full-grown shad. The tackle used is a trout or salmon rod, with a reel containing one hundred or more feet of line, and a small hook (about No. 6) with a brown fly. A peacock body, long, turkey-feather wings, and light-brown hackel is the fly in common use. Two persons in a boat select a spot where the current is quite rapid, and anchor the boat and let their

* A prevalent impression that this is a new sport will be corrected by referring to page 181 of Frank Forrester's Fish and Fishing, &c., by Wm. Henry Herbert, 1850.

flies trail down stream, with about 60 feet of line out, the whirl of the current keeping the fly in play at the surface. The first pull of the shad will bend the pole into a circle, and its weak mouth necessitates the most skillful play and management to get it near the boat, where it is usually taken in with a dip-net.

A singular point to fish from was the high bridge, some 40 feet above the water. A number of men and boys were always to be found in the evening with long hand-lines trailing down stream over the bridge-railing. When a shad took the hook he was carefully drawn in until he was landed on one of the small islands beneath the bridge, and allowed to remain there until life was nearly extinct, when he was drawn up on the bridge. Of course many more were lost this way than when fishing from the boat.

### 17.—SHIPMENT OF SHAD TO THE PENOBSCOT RIVER, MAINE.

On the 10th we started for the Penobscot River, Maine, with 100,000 young shad. While waiting at Portland some four hours between trains, Mr. Mason went over to the bay and brought a pail of sea-water. About two dozen of the shad were taken from a can and put directly into the salt-water and were allowed to remain in it over two hours, at the end of that time they were all apparently in as healthy and lively condition as when taken from the fresh water, neither the salt nor the difference in specific gravity affecting them in the least. If this experiment should prove successful for a longer period of time, it would make the transportation of shad across the ocean a comparatively easy task. And it would be well worth while for some fish-culturist situated conveniently to the sea-coast to experiment on other species of young fishes, as, if successful, it would simplify the carriage of fish on long voyages very much.

From Bangor, Mr. E. M. Stilwell, commissioner for the State of Maine, accompanied us to Mattawamkeag, fifty-eight miles above Bangor, on the Penobscot River, at the junction of the Mattawamkeag River, where the young fish were consigned to the waters, in good condition, at 1 a. m. of the 11th.

### 18.—ESTABLISHMENT OF STATION ON THE ANDROSCOGGIN RIVER, MAINE.

On the 14th we arrived in Topsham, Me., with the purpose in view of establishing a hatching-station on the Androscoggin River, and the same evening employed a party of men to haul the seine about two miles below the dam.

A hatching-box was hurriedly made up from a soap-box and a piece of millinet, but the result of the fishing disappointed us, as only eight spent shad were obtained, all of them with the abdomen shrunken and slender, indicating that the spawning season was over with them.

The next night, the 15th, four hauls were made, resulting in eight

spent shad, males and females, and it was decided to abandon the attempt for the season.

### 19.—SECOND SHIPMENT OF SHAD TO THE WATERS OF LAKE CHAMPLAIN, VERMONT.

On the 18th, receiving a favorable answer from South Hadley Falls in reply to the inquiry whether young shad were still to be had, we returned to that point on the 19th, and the same evening started for Vergennes, Vt., with 100,000 shad, to be put into Otter Creek, a river emptying into Lake Champlain, seven miles below the town. Dr. Hopkins, a resident, afforded us assistance in conveying the cans to the river and in finding a proper place for turning them free in the waters, which was done early on the morning of the 20th, there being scarcely any loss in the cans.

Remaining in Vergennes during Sunday, we returned to the hatching-station on the 21st, and found that we should have to wait until the next evening to obtain a supply of fish, which we intended to take through to Michigan.

### 20.—SHIPMENT OF SHAD TO THE DETROIT AND GRAND RIVERS, MICHIGAN.

On the afternoon of the 22d, with 100,000 shad in the cans, we started for Detroit. At Toledo, Ohio, we were obliged to wait over about nine hours, and arrived in Detroit on the 24th. Mr. George Clark, of Ecorse, one of the State fish-commissioners, joined us before reaching Detroit, and with his advice about 20,000 shad were put into the Detroit River, near the Detroit and Milwaukee Railway depot, and the remaining 80,000 carried to Ionia, Mich., where they were put into the Grand River about midnight of the 24th, being in vigorous condition, and with but a small percentage of loss.

Mr. J. Mason returned home from Detroit, as this was the last shipment of shad for the season. I desire to refer to him as a man of marked fidelity and conscientious faithfulness to the work allotted him. To his continued attention and skillful judgment in the care of the young fish is due the success of the transfers just recorded, and though the lack of the least failure in the different shipments referred to might lead the inexperienced to think it an easy task, there are many who have attempted the work this season who would acknowledge that it was anxious, toilsome, wearying work, resulting in failure and loss after every effort possible was made to prevent it.

*Table of distribution of shad and eels.*

| Shad-hatching stations. | Rivers planted. | Eels. | Shad. |
|---|---|---|---|
| UNITED STATES COMMISSION. | | | |
| Potomac River, Washington, D. C..... | Greenbrier River, Ronceverte, W. Va... | ..... | 50,000 |
| | New River, Central Station, Va ..... | ..... | 40,000 |
| Delaware River, Lambertsville, N. J .. | Monongahela River, Greensburgh, Pa ... | ..... | 15,000 |
| NEW YORK STATE COMMISSION. | | | |
| Hudson River, Coeymans, N. Y..... | Calumet River, South Chicago, Ill ..... | 4,000 | 70,000 |
| | Fox River, Appleton, Wis..... | 3,800 | 70,000 |
| | Big Dead River, Waukegan, Ill ..... | 200 | ..... |
| | Ashtabula River, Ashtabula, Ohio ..... | ..... | 50,000 |
| | Wabash River, Logansport, Ind..... | ..... | 40,000 |
| | Jordan River, Jordan, Utah Ter..... | ..... | 5,000 |
| | Sacramento River, Tehama, Cal..... | ..... | 35,000 |
| CONNECTICUT STATE COMMISSION. | | | |
| Connecticut River, South Hadley Falls, Mass. | Winooski River, Burlington, Vt ..... | ..... | 100,000 |
| | Housatonic River, New Milford, Conn ... | ..... | 90,000 |
| | Penobscot River, Mattawamkeag, Me ... | ..... | 100,000 |
| | Otter Creek, Vergennes, Vt..... | ..... | 100,000 |
| | Detroit River, Detroit, Mich..... | ..... | 20,000 |
| | Grand River, Ionia, Mich ..... | ..... | 80,000 |
| | Total..... ..... | 8,000 | 865,000 |

## 21.—MODE OF ESTIMATING NUMBERS OF EGGS AND FISH.

The estimation of the numbers of shad-eggs and of the young fry is a rather difficult matter to accomplish satisfactorily or with even approximate definiteness. The standard made use of on the Connecticut River is, without doubt, very much too high. Mr. C. C. Smith, who is a most faithful and successful breeder, has adopted the exaggerated estimates of his predecessors, and in the earlier years of his work, when the restoration of the shad by artificial propagation was an experiment, the contraction of the round numbers that had appeared in the reports of previous years might have discouraged the people and the legislators, and the support that was so necessary to this initiation of the work might have been withdrawn. But now that the experiment has proven itself so thoroughly and evidently a success, and the river is again teeming with shad, it makes very little difference to the citizens of the State whether it has been accomplished by placing 10,000,000 or 90,000,000 of young shad in the waters, and a system of measurements and counts should be carried out so that some more definite knowledge of the number of eggs handled may be attained. One of the commissioners of the State, in 1870, feeling dissatisfied with the estimates afforded, attempted to induce more careful modes of numbering the eggs and fish, and in the following year succeeded in having them modified to a certain extent. The numbers of fish we carried in the six cans were, by these standards, millions, while the most careful means of numbering we could employ did not place them over from twelve to twenty thousand to the can.

In estimating the numbers of fish in the cans, we had, as our sole reliance for accuracy, only their apparent thickness in the water, which, after considerable experience, afforded an approximate estimate within a margin of a few thousands of the real number.

Seth Green's instructions to his men were, to fall within the whole number of fish rather than to exaggerate the quantities. The numbers they were in the habit of estimating in the cans, taken from the boxes, would not account for the number of eggs impregnated and placed in the boxes, and for which much more accurate means of numbering were available than for the young fishes.

It was determined, while at the hatching-establishment on the Connecticut River, to attempt to obtain a more definite knowledge of the numbers of fish we were planting in different rivers.

To do this, dippers full of fish were taken, having the shad about as thick in the water as we had been accustomed to carry them in the cans. These were carefully counted, and, knowing the number of dippers full that were put into a can, we found we had been calculating about 35 per cent. (probably rather more than this) short of the actual number carried.

As it is scarcely practicable to ladle out the shad-eggs into the hatching-boxes, a very good mode would be to have lines either graved or painted around the insides of the impregnating pans, and their distance from the bottom would show approximately the number of eggs, if this should be determined in the first place by weighing the quantities that would fill the pan to the lines, and counting a definite fraction of the weight.

An overestimate in any locality, of course, places more accurate estimates in other regions in unfair comparison, and, too, the more exactly and correctly we understand the extent of the means necessary to produce the results required, the more definite our knowledge and the greater precision in the direction of the efforts to be used.

Judging from the reports of State commissioners and the general literature of pisciculture, there is a well-understood need for some definiteness and uniformity of standard in estimating eggs and young fishes among practical workers; and it would employ the time of some one interested to good advantage if he would devise methods for this purpose sufficiently practicable to receive the approval of others of the profession. The occasional discrepancies that are discovered in published statements, between the sums of the number of eggs received and the number of young fishes produced from them, indicates the great need there is in this direction.

## 22.—THE CARE OF YOUNG SHAD DURING TRANSPORTATION.

(22*a*.) *The apparatus.*—The apparatus used in the transfer of the fish we had obtained in Washington, modeled after that seen in Seth Green's establishment near Rochester, N. Y. It consisted of the articles described as follows:

The cans were large fifty-quart milk-cans, made in the best manner, from the strongest material used by the manufacturers; the principal

necessity in their model is the shoulder arched in toward the neck of the can; this, when the water fills the can quite up to the neck, has the tendency to confine, or, as I have heard it termed, "to bind" the water and prevent the violent splashing that a large area of surface would be subject to, and that would be of great injury to the delicate young fish.

A piece of rubber-hose about twice the length of the can to be used as a siphon when drawing down the water in the cans of fish preparatory to replenishing them with fresh water.

A tin tube the length of a can and about two inches in diameter, one foot of the lower portion being made of perforated tin, is to be used with the siphon, the tube hanging from a hook, soldered to its upper end, to the mouth of the can and the rubber-siphon being put down inside of the tube draws the water from within it, the perforated tin preventing the young shad from being drawn through, though the water has easy access.

The rubber-tube should not be more than three-fourths of an inch in diameter, as a larger siphon would create too strong a current through the perforations, and lodge and injure the young fish against the sides of the tube. For the same reason it will be seen that an attachment of perforated tin tube to the bottom of the rubber-pipe, though a simpler instrument for the purpose would be injurious, as a much less current is created through the orifices in the large area of a tube of wide diameter than one having a small one.

A couple of tin pails for carrying away the stale water and obtaining fresh water from pumps and hydrants, a thermometer to observe temperatures of the water on the fish, and a tin dipper, completes the simple apparatus required for the successful transfer of young shad.

(22*b*.) *The care of the fish.*—The care of fish while transporting them is an essential part of the art of fish-culture, and often requires more skill and judgment than the propagation of young fish.

The shad are perhaps the most delicate and most liable to loss of any fish handled in this country. Many who have been successful with salmon and trout have failed entirely when attempting to transfer shad even for short distances. Still, their proper care and treatment is a very simple matter. The first essential is continual attention. For any long distance there should be two persons in attendance, relieving each other at intervals of several hours; and on no account, no matter how flattering the conditions of the young fish may be, should they both lie down to sleep at the same time.

From 12,000 to 24,000 are safe numbers for a fifty-quart can when carried from ten hours to three days, if good water can be afforded as often as once in two hours. For a trip to California, occupying from six to eight days and with several days without a supply of fresh water, 5,000 to the can would probably be as many as it would be advisable to carry.

Experience only will enable one to judge from their appearance in the water as to the numbers that have been put into a can.

The principal means for sustaining life and vigor in the fish is affording them supplies of fresh water. Minute as they are their gills are developed and their breathing exhausts the respiratory gases from the water more or less rapidly according to the numbers in the can. Even the ova, it has been proven by experiment, utilizes a small portion of oxygen from the air.

A reserve-can is required for every five or six cans of fish, which should be filled with water at the stations, generally where the locomotive takes wood or water or where meals are afforded, the attendants remembering to fill the can first and eat the meal afterward. A pailful or two may often be obtained at minor stations.

The tube is put into the can, hanging by the hook from the top so as not to roll about and bruise the young fishes, and one end of the rubber-pipe inserted in the tube. Apply the mouth to the other end of the hose and suck until it has filled with water; the end is to be at once lowered into a pail, when the water will run freely until the pail is full. This water is to be thrown out at the door of the car and the same quantity of fresh water replaced from the reserve-can, filling a dipper and lowering it to the surface of the water in the fish-can before it is emptied, until sufficient has been afforded.

An examination of the bottom of the cans for dead fish can be made by tying the rubber-hose to the end of a piece of lath, and then, while guiding the end of the hose by means of the lath around the bottom of the can, start the water running, and dead fish and settlings at the bottom of the can can be drawn off into a pail. On a long journey, of five days or more, the shad may be transferred from one of the fish-cans by means of the siphon to the extra one, and the can be scoured clean from slime and sediment, and the fish from another can being emptied into it by the same means this can in turn be cleansed, and so on throughout them all.

In moving the cans from car to car or into a wagon, care must be taken that they are carried upright, as the least spilling of the water through the crevice around the cover, if examined, will be found to contain young shad. A spring-wagon should be used, if possible, in moving them by this kind of conveyance, as the jolting of a common wagon will be found to splash the water much more than a railroad-car, unless driven very slowly.

(22*c*.) *Water adapted to young fish.*—Tests made in keeping young fish in different waters prove that but little danger is incurred in using it from any source where it is clean, of not too high or low a temperature, and free from decayed matter. The clear water from springs and wells, though nearly destitute of living forms, answers the very best purpose in carrying shad. Clear river-water full of minute forms of life is perhaps preferable for fish after the yolk-sacks disappear. Seth Green,

when carrying through the first shipment of shad to California, found them on the sixth and seventh days out looking for food, and felt satisfied from their actions that they found it in the water supplied them from the rivers after passing the region of impure waters.

Mineral waters may inspire fear, and it is perhaps premature to advise their use, but that they are not all injurious has been proven by several tests made this season. While at Toledo, Ohio, the water of the artesian well at the depot, clear and cold, but having a strong mineral flavor, thought to be sulphur, was avoided for use in the cans, but a couple of quarts were put into a vessel and about two dozen shad put into it about midnight, and remained in most perfect condition up to 8 o'clock in the morning, when they were put into the Maumee River.

At Castalia, Ohio, at the paper-mill of Mr. John Hoyt, speckled trout are hatched and raised successfully in water from a spring so heavily charged with calcareous matter that the tufa incrusts everything falling into its waters. Prof. J. Lang Cassels, of Cleveland, found that out of ninety-two grains of solid matter to the gallon there was of carbonate of lime 58.86 grains, and of carbonate of magnesia 10.632 grains.

Seth Green, in his trip with shad in 1871, found water from Omaha westward for four hundred miles unfavorable to the shad, and in some of it the young fish died within five minutes from the time they were put into the vessel containing it.

All mineral-waters should be used cautiously and tests made with small quantities of water before they are used on the fish in the cans.

While at Portland, Me., this season, two dozen shad were removed directly from fresh water and were kept in a few quarts of sea-water for two hours without the least apparent injury from the salt or the greater specific gravity.

There are some who assert that roily water has no objections for use with young shad. If there were no other objection the anxiety as to the condition of the fish, which it is almost impossible to ascertain in muddy water, is a sufficient one. Besides, the silt or sand is liable to trouble the movement of the gills, and the attrition upon the delicate membranes of the embryo fish, while the water is agitated in the railroad-car, must do some injury to them. And the experience of this season's work has been that the large percentages of losses in the cans have been when roily water had been used at some locality while *en route*, and of course indicating that a longer use of it would have resulted disastrously. When it is necessary to use muddy water, as soon afterward as clear water can be procured, the largest change practicable had better be afforded the cans.

The water from railroad-tanks, though avoided during this season's shipments, was, perhaps, rejected through a somewhat unfounded prejudice. Where few locomotives are supplied, the water may become warm, stagnant, and tainted from decaying wood, but when the tank is frequently replenished with fresh water no such objection can arise,

and the water is, without doubt, nearly as good as if taken directly from its source.

On the few occasions when we have been obliged to obtain the water from the tank in the tender, it was found clear and pure, and with no indications of oil or grease, and it is probable it would always be found so.

(22*d*.) *Temperature of the water in the cans.*—The temperature of the water which the fish are in is also an essential point in their welfare.

A too low temperature produces lethargy and torpidity in the young shad, which, if suffered too long, occasions death.

The young shad suffer in low temperatures in which the *Salmonidæ* thrive well. By experiment it has been proven that between 65° and 72° the shad are found to be in the best condition. The springs of the lake region have from 46° to 50° of temperature, the deeper wells from 54° to 60°, and the streams from near the freezing-point, in winter, to 85°, perhaps more, in hot summer-weather.

Where there is six or more degrees difference in the water of the reserve-can and of that on the fishes, the temperature of the fresh water should be moderated before using it. This is readily done by preserving a portion of the stale water drawn from the fish, which can be aerated by repeated pouring from the dipper, the pail is then filled up from the fresh water, and according to the proportions used the temperature can be raised before supplying the can containing fish.

A temperature higher than 80° is dangerous, as the fish become weak, the supply of respiratory gases in the water is much less, and the fish very soon die. In hot weather the use of ice is necessary where water from wells or springs cannot be obtained. The ice should be applied in the reserve-can, and not in the cans with the fishes, as in knocking about on the surface it kills many of them, and if in the splashings of the water any are lodged on top of the ice they soon die. Caution must be taken in using ice in the fresh water, not to put in sufficient to reduce the temperature below the proper standard.

(22*e*.) *Transferring the shad from the cans to the river.*—On arriving at the river the first necessity is to determine that the temperatures of the cans and the stream are so nearly equal as not to endanger the fish when consigned to their new home. If there is five or more degrees difference, it can be readily equalized by drawing a quantity of water from the cans and filling them up again with the river-water.

The locality for planting should be chosen so that the fish will not be too soon carried into the whirl of a rapid current, but may recruit for a time from their fatigue, and, possibly, their hunger, before being obliged to struggle with swift running water.

Another very important matter is to avoid schools of minnows or other small fishes, who will congregate at the spot in large numbers and devour a large proportion of the fish that have cost a large amount

of pains and labor to be conveyed to the spot. The middle portion of the stream or inlet is generally the freest from the smaller fry.

When the locality is selected, the temperature equalized, and a boat provided, there is nothing more to do than to lift a can over the side of the boat, dropping it upon its side into the water, and while the boat is leisurely pulled up stream the young fish are allowed to slowly escape from the can. Scattering them along a considerable distance is thought to be the best for them, as they make less attraction for predatory fishes when widely distributed than when concentrated in a large school, and, as they are probably not gregarious while so young, they are not likely to collect together immediately.

(22*f*.) *Facilities required from the railroads.*—The necessities and conveniences required in the transporting of young shad are peculiar, and different from all other freightage. Fish-eggs, when properly packed, are shipped with safety without an attendant, requiring only that the express messenger follow the few instructions lettered on the outside of the can or box. Young trout and salmon are occasionally shipped short distances in the same way, the water having been reduced to a low temperature, so that the respiratory action is lessened and frequent changes of water are not required.

The shad are found to withstand confinement in a small quantity of water with much less endurance than other species that have been experimented with. There is very little tenacity of life in the mature fish when removed from the water, and attempts to preserve male fishes for "milters" from one seine-haul to another, have been failures, even where they were confined in an inclosure through which the water of the river circulated. A temperature sufficiently low to retard respiration does not work to advantage with the shad, and experimenting with reference to favorable temperatures has proven that a range between about 62° and 78° is the only one suited to their welfare, while 65° and 72° are better limits. Frequent changes of water are required, necessitating hurried visits to pumps and hydrants when the train stops, and it is sometimes necessary to procure and use ice; so that it will be seen that experienced attention is required and too much time occupied in the care of the fish to permit the work to be given into the hands of messengers usually having sufficient to occupy their time in their regular duties.

The amount of room afforded, the facility for getting out and in, and the less rigid enforcement of regulations as to access to the car, to say nothing of the liberality frequently extended in passing the freight without charge, makes the baggage-car the only suitable place for the transportation of shad, or for any species of fishes for long distances.

The inconvenience of carrying large cans of water in the car because of the slopping, will probably suggest itself to some, but experience has proven that with a little care there is no necessity whatever of wetting the bottom of the car, even around the spot where the cans are placed.

The necessities in the work depending on the accommodations afforded from the railroads, are access to the baggage-car and opportunities to obtain water from wells, hydrants, tanks, and the tender. In all these particulars the most generous spirit has been manifested by both managers and employés.

### 23.—POSSIBILITY OF STOCKING THE GREAT LAKES WITH SHAD.

The stocking of fresh waters with fish from the sea, or of those who spend a portion of their lives in the sea, will perhaps be questioned by many as an uncertain experiment and likely to end in failure.

The conditions found in their natural homes of which the shad may avail themselves may be enumerated as follows: Streams of the right volume of fresh water and the right temperature, to ascend in the spring season to deposit their spawn, and in which the young shad will find a favorable home until they are the proper age to descend to the sea; a great body of water of unlimited volume on the bottom of which the small forms of *Crustacea*, the *Gammaridæ*, and *Mysidæ*, small shrimp-like animals, are found abundantly, affording an ample supply of food during the greater part of the year, as but very little is ever found in their stomachs when they are up the streams in the spawning season. Another condition of this great body of water is that it is salt.

In all these particulars but the latter the lakes answer every demand. There are streams suitable for spawning localities; there is an unlimited range of clear, cool waters; the dredgings on the bottom at all depths have proven these same crustaceans of the *Gammaridæ* and *Mysidæ* to be abundant, and except in the one particular of the saltness of the sea every requisite condition of their natural home is afforded them. The only point to be tested in the experiment is whether this is an essential requirement in their existence.

Several species of white-fish found in the Arctic Seas live indifferently in salt and fresh waters, and the *Coregonus omul*, as related by Pallas, sends off large detachments from its schools in the spawning season from the sea up the long series of streams and lakes that find their head in the great Lake Baikal, where the schools find a permanent home, never returning to the sea.

The eel, brook-trout, striped-bass, and several other species on the eastern coasts, live indifferently in the sea and fresh waters.*

It is not probable that all fishes which spend their entire lives in the sea could become accustomed or acclimated to fresh waters. Still, among these it would not be unlikely to find a few having strong tenacity of

*Günther says, in referring to *Gobiidæ*, that "This family offers numerous instances of the fact that a part of the individuals of one and the same species are entirely confined to fresh waters, whilst others live in the sea."—*Cat. Acanth. Fishes, &c., vol. 3, p. 1, by Dr. Albert Günther.*

life that would endure the change of condition without detriment to their health and vigor, provided their proper food was supplied them.

But it is the habit of those most desirable to transfer, to spend a portion of each year in fresh water, and it is difficult to find the reason why if the salt-water is not essential to them part of the year it should be during the remainder. The absence of their proper food in the streams they ascend would seem to be the principal necessity for their return to the sea.

Experiments in planting salt-water fishes in fresh waters have been made heretofore with success. The striped-bass of the Atlantic waters has been kept for a number of years in inland ponds. Rudolf Hessel, a fish-culturist of Europe, informed me that he had put a number of flounders in Lake Constance, of Switzerland, several years ago, and that fishermen occasionally found them in their nets at the present day.

The transfer of shad to the lakes was not, however, an entirely new experiment. Seth Green, when moving shad to the Pacific coast in 1871, made small plants at Cleveland, Toledo, and Chicago, and the same year put 5,000 shad into the Genesee River, of New York State.

At Toledo, Ohio, last fall, the firms of Bowes & Howell and Davis, Brother & Beatty reported having had unmistakable shad in their ware houses during the season. These were undoubtedly from Mr. Green's planting. At the Genesee River many shad were taken in the nets of the fishermen developed from the young of the planting of 1871. In the latter case they might possibly descend to the brackish waters of the Saint Lawrence, but in the former they must necessarily have spent the whole of the intervening year and a half in fresh water.

The finding of the yearling shad in Lake Champlain has been referred to on another page. Two plantings were made in 1872 at Salamanca, N. Y., in the Alleghany River, and one at Indianapolis, Ind., in the White River. At Terre Haute, Ind., this season, young shad were taken from the Wabash River that had strayed thus far from the place where they had been consigned to the waters of the Ohio Valley.

All these facts afforded sufficient hope of success to warrant a large planting of shad as an experiment in the lakes.

### 24.—POPULARITY OF THE WORK OF THE COMMISSION.

In continual conversation with those I have met a uniform approbation and satisfaction has been expressed that an effort was being made to restore the stock of food-fishes in the waters of the country, and from citizens of those States we have not been able to benefit this season, the desire was expressed that their claims should be regarded as early in the future as possible. The general awakening all over the country to the interest of food-fisheries is indicated by the numerous bills passed in the legislatures in late years.

Of the States bordering on the lakes, Vermont, New York, Penn-

sylvania, Ohio, Michigan, Wisconsin, and Minnesota have appointed commissioners and made appropriations for propagation, while Indiana and Illinois have passed protective laws as to the obstruction of the passage of fish in the rivers.

The State of Michigan has erected a large hatching-house, and will propagate the white-fish of the lakes on a large scale. The judicious management of the New York State commissioners has made their work very efficient, and people from all quarters of the State have visited the hatching-house and carried back thousands of young fish, without charge, to stock the waters in the vicinity of their homes, some half-dozen species of food-fishes being afforded in quantities to all who applied.

A very general and strong interest was exhibited on the southern rivers at the attempt to hatch shad, which made very little success, because of the great reduction of numbers in these waters and the consequent lack of spawners. The promises to endeavor to supply their rivers with a new seed-stock from more northern rivers was met with earnest interest and satisfaction.