

SKETCH OF THE PENOBSCOT SALMON-BREEDING ESTABLISHMENT.**By CHARLES G. ATKINS.**

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

The rivers of the United States tributary to the Atlantic, north of the Hudson, were, in their natural state, the resorts of the migratory salmon, *Salmo salar*, and most of them continued to support important fisheries for this species down to recent times. The occupation of the country by Europeans introduced a new set of antagonistic forces which began even in the seventeenth and eighteenth centuries to operate against the natural increase and maintenance of the salmon and other migratory fishes. In many localities the closing of smaller streams by dams, and the pursuit of the fish with nets and other implements, had already begun to tell on their number; but it was not until the present century that the industrial activities of the country began to seize upon the water power of the larger rivers and to interrupt in them by lofty dams the ascent of salmon to their principal spawning grounds. These forces were rapid in their operations, aided as they were by a greatly augmented demand for food from a rapidly increasing population. In 1865 the salmon fisheries were extinct in all but five or six of the thirty rivers known to have been originally inhabited by them. In many of these rivers the last salmon had been taken, and in others the occurrence of individual specimens was extremely rare. Among the exhausted rivers may be mentioned the Connecticut, 380 miles long; the Merrimack, 180 miles long; the Saco, 120 miles long; the Androscoggin, 220 miles long; and some twenty smaller rivers. There still survived salmon fisheries in the following rivers, namely, the Penobscot, the Kennebec, the Denny's, the East Machias, the Saint Croix, and the Aroostook, a tributary of the Saint John. The most productive of these was the Penobscot, yielding 5,000 to 10,000 salmon yearly. The Kennebec occasionally yielded 1,200 in a year, but generally much less. The other rivers were still less productive.

The movement for the re-establishment of these fisheries originated in action of the legislature of New Hampshire, seconded by that of the neighboring state of Massachusetts, having in view primarily the fisheries of the Merrimack and Connecticut Rivers. The course of the Merrimack lies wholly within the states of New Hampshire and Massachusetts; that of the Connecticut lies partly in the state of Connecticut, and many of its tributaries are in the state of Vermont. These two states were therefore early interested in the project, and their action soon led to similar exertions on the part of Rhode Island and Maine. Within the borders of the six states mentioned, collectively known as "New

England," are all of the rivers of the United States known to have been frequented by the sea-going *Salmo salar*, with the possible exception of certain rivers, tributary to the Saint Lawrence, in the northern part of New York.

The governments of these states having appointed boards of commissioners to whom was confided the task of restocking the exhausted rivers, other states, one after another, adopted like measures, and in 1872 the United States Government established a commission to inquire into the condition and needs of the fisheries in general, with authority to take steps for the propagation of food fishes.

The new England commissioners turned their attention at once to the two most important of their migratory fishes, the salmon and the shad. The utter extermination of salmon from most of their rivers compelled them to consider the best mode of introducing them from abroad.

Agents were sent to the rivers of Canada, where for several years they were permitted to take salmon from their spawning beds, and some hundreds of thousands of salmon eggs were thus obtained and hatched with a measure of success. After a few seasons permits for such operations were discontinued, and the only foreign source of supply thereafter remaining open to the states was found in the breeding establishments under control of the Canadian Government, and even these were practically closed by the high price at which the eggs were valued.

In 1870 it had become clear that to a continuation of efforts it was essential that a new supply of salmon ova should be discovered. Attention was now directed to the Penobscot River in the state of Maine, which, though very unproductive compared with Canadian rivers, might yet, perhaps, be made to yield the requisite quantity of spawn. A preliminary examination of the river brought out the following facts: The Penobscot is about 225 miles in length. The upper half of its course and nearly all of its principal tributaries lie in an uninhabited wilderness, and in this district are the breeding grounds of the salmon. The fisheries, however, are all on the lower part of the river and in the estuary into which it empties, Penobscot Bay. There was no means of knowing how great a proportion of the salmon entering this river succeeded in passing safely the traps and nets set to intercept them, but supposing half of them to escape capture there would still be but about 6,000 fish of both sexes scattered through the hundreds of miles of rivers and streams forming the headwaters of the Penobscot. It was very doubtful whether they would be congregated about any one spot in sufficient numbers to supply a breeding station, and it would be impracticable to occupy any widely extended part of the river, on account of the difficulties of communication. At the mouth of the river, on the other hand, the supply of adult salmon could be found with certainty, but they must be obtained from the ordinary salmon fisheries in June and held in durance until October or November, and the possibility of confining them without interfering seriously with the normal action of

their reproductive functions was not yet established. The latter plan was finally adopted, and in 1871 the first attempt at this method of breeding salmon was instituted by the commissioners of Maine, Massachusetts, and Connecticut. The site fixed upon for an inclosure was at Craig's Pond Brook in the town of Orland, and arrangements for a supply of fish were made with two fishermen of Verona at the very mouth of the river.

The salmon first brought were confined in a newly constructed artificial pond in the brook, which was of such remarkable purity that a small coin could be distinctly seen at the depth of 7 feet. All of these died except a few which after a short stay were removed to other quarters. The most prominent symptom was the appearance of a white fungoid growth in patches upon the exterior of the fish. In a lake (locally designated as Craig's Pond) of equal purity, but greater depth, several of these diseased fish recovered. Of the salmon later obtained some were placed in an inclosure of nets in the edge of a natural pond with but 7 feet of water, of average purity, some in a shallow inclosure in a brook, and some turned loose in a natural lake of some 60 acres area, with muddy bottom and peat-colored water. In each case the salmon passed the summer with few losses, arrived at the breeding season in perfect health, and yielded at the proper time their normal amount of healthy spawn and milt, though the great sacrifice of breeding fish by the early experiments of the season reduced the crop of eggs to the small number of 72,000.

The conditions of success were thus sufficiently indicated, and in 1872 the same parties, joined with the United States Commission of Fisheries, renewed operations on a larger scale, locating their headquarters at the village of Bucksport, confining the breeding salmon in Spofford's Pond (Salmon Pond on the general map of Penobscot station), and establishing their hatchery on the brook formed by its overflow. This is the lake of 60 acres in which, as mentioned above, a few salmon had been successfully confined the year before. Though not at all such water as would be chosen by a salmon at large, it nevertheless proved well adapted to the purpose of an inclosure for the breeding fish. It was shallow, its greatest depth, at the season of highest water, being but 16 feet; at its upper end it abuts against an extensive swamp, and almost its entire bottom, except close to the shore, is composed of a deposit of soft, brown, peaty mud of unknown depth. The water is strongly colored with peaty solutions, has a muddy flavor, and under the rays of a summer sun becomes warmed to 70° (Fahrenheit) at the very bottom.* Yet in such a forbidding place as this, salmon passed the summer in perfect health. There were some losses, but every reason to believe them all to have been caused by injuries received prior to their inclosure. Du-

*During the month of August, 1872, the bottom temperature at 1 p. m. was never below 70°, and on six days was found to be 71°.

ring and after the hottest term of each summer (the month of August) very few died.

The supply of salmon was obtained mainly, as in 1871, from the weirs in the southern part of Verona. They were placed in cars, specially fitted for the purpose, and towed to Bucksport on the flood tide. From the river to the inclosure they were hauled on drays in wooden tanks 3 feet long, 2 feet wide and 2 feet deep, half a dozen at once. From the weirs to the boats and from the boats to the tanks they were dipped in great canvas bags. From all this handling but few losses ensued.

In the establishment at Bucksport village the work was carried on for four years, from 1872 to 1876, with a fair degree of success. Then ensued a suspension till 1879, when the reappearance of salmon in the Merrimack, Connecticut, and some other rivers renewed the hopes of final success, and encouraged the commissioners to reopen the station. It had, however, been found that the old location had serious defects. The inclosure was costly to maintain, and the recapture of the fish involved a great deal of labor and trouble. The water supplied to the hatchery was liable in seasons of little rain to be totally unfit, causing a premature weakening of the shell and very serious losses in transportation. After a careful search through the neighboring country it was found that the most promising site for an inclosure was in Dead Brook, near the village of Orland (though within the limits of the town of Bucksport), and for a hatchery no location was equal to Craig's Pond Brook, the spot where the original experiments were tried in 1871. The only serious drawback was the separation of the two by a distance of some 2 miles, which could not offset the positive advantage of the hatchery site. Accordingly the necessary leases were negotiated, an inclosure made in Dead Brook, and a stock of breeding salmon placed therein in June, 1879. Since then the work has been continued without interruption.

It is still found most convenient to obtain the stock of breeding salmon, as in the early years of the enterprise, from about a dozen weirs in the Penobscot River along the shores of the island of Verona. The fishermen are provided with dip-nets or bags with which to capture the fish in their weirs, with tanks or cars in which to transport them to the collecting headquarters, whither they are brought immediately after capturing, about low water. The collection is in the hands of a fisherman of experience, who receives the salmon as they are brought in, counts and examines them, adjudges their weight, and dispatches them in cars to the inclosure at Dead Brook. The cars are made out of the common fishing boats of the district, called dories, by providing them with grated openings, to allow of a free circulation of water in transit, and covering them with netting above to prevent the fish from escaping over the sides. The car is ballasted so that it will be mostly submerged. Ten to fifteen salmon are placed in a single car, and from one to four cars are taken in tow by a boat with two to four oarsmen. From the

collecting headquarters to Orland village, a distance of about 5 miles, the route is in brackish water, and the tow is favored by the flood tide. At Orland is a dam which is surmounted by means of a lock, and thence, two miles further to Dead Brook, the route is through the tideless fresh water of Narramissic River. The sudden change from salt to fresh water does not appear to trouble the fish except when the weather is very hot and the fresh water is much the warmest. The cars are towed directly into the inclosure, where the fish are at once liberated.

The inclosure is formed by placing two substantial barriers of wood-work across the stream 2,200 feet apart. The lower barrier is provided with gates which swing open to admit boats. Within the inclosure the water is from 3 to 8 feet deep, the current very gentle, the bottom partly muddy, partly gravelly, supporting a dense growth of aquatic vegetation. The brook has two clean lakes at its source, and its water is purer than that of ordinary brooks.

The collection of salmon usually continues from the first ten days of June until the beginning of July. During the early weeks of their imprisonment the salmon are extremely active, swimming about and leaping often into the air. After that they become very quiet, lying in the deepest holes and rarely showing themselves. Early in October they begin to renew their activity, evidently excited by the reproductive functions. Preparations are now made for catching them by constructing traps at the upper barrier. If the brook is in ordinary volume, these means suffice to take nearly all, but a few linger in the deeper pools and must be swept out with seines. About October 25 the taking of spawn begins. After that date the fish are almost always ripe when they first come to hand, and in three weeks the work of spawning is substantially finished.

Although the salmon are taken from the fisherman without any attempt to distinguish between males and females, it is always found at the spawning season that the females are in excess, the average of four seasons being about 34 males to 66 females. This is a favorable circumstance, since the milt of a single male is fully equal to the impregnation of the ova of many females.

The experiment has several times been tried of marking the salmon after spawning and watching for their return in after years. After some experiments, the mode finally fixed upon as best was to attach a light platinum tag to the rear margin of the dorsal fin by means of a fine platinum wire. The tags were rolled very thin, cut about half an inch long and stamped with a steel die. The fish marked were dismissed in the month of November. Every time it was tried a considerable number of them was caught the ensuing spring, but with no essential change in their condition, indicating that they had not meanwhile visited their spawning grounds. In no case was a specimen caught in improved condition during the first season succeeding the marking. But the following year, in May and June, a few of them were taken in

prime condition—none otherwise—and it several times occurred that female salmon were a second time committed to the inclosure and yielded a second litter of eggs. The growth of the salmon during their absence had been very considerable, there being always an increase in length and a gain of twenty-five to forty per cent. in weight. The conclusion seems unavoidable that the adult salmon do not enter the Penobscot for spawning oftener than once in two years.

The method of impregnation employed has always been an imitation of the Russian method introduced into America in 1871. The eggs are first expressed into tin pans, milt is pressed upon them, and after they are thoroughly mixed together, water is added. The result has been excellent, the percentage of impregnated eggs rarely falling so low as 95.

After impregnation the eggs are transferred to the hatchery at Craig's Pond Brook, where they are developed, resting upon wire-cloth trays in wooden troughs, placed in tiers ten trays deep, to economize space, and at the same time secure a free horizontal circulation of water.

The hatchery is fitted up in the basement of an old mill, of which entire control has been obtained. The brook is one of exceptional purity, and a steep descent within a few feet of the hatchery enables us to secure at pleasure a fall of 50 feet or less. The brook formerly received the overflow of some copious springs within a few hundred feet of the hatchery, which so affected the temperature of the water that the eggs were brought to the shipping point early in December, an inconvenient date. This has been remedied by building a cement aqueduct 1,600 feet long, to a point on the brook above all the springs, which brings in a supply of very cold water.

The shipment of eggs is made in January, February, and March, when they are sent by express, packed in bog-moss, all over the northern States, with entire safety, even in the coldest weather.

In the following statement is embraced a general summary of the results of each season's work:

Year.	Salmon bought.	Females spawned.	Eggs obtained.	Eggs distributed.
1871-'72	111	11	72,071	70,500
1872-'73	692	225	1,560,000	1,241,800
1873-'74	050	279	2,452,638	2,291,175
1874-'75	001	343	3,106,479	2,842,977
1875-'76	460	237	2,020,000	1,825,000
1876-'80	284	19	211,092	200,500
1880-'81	522	227	1,930,561	1,841,500
1881-'82	513	232	2,690,500	2,611,500
1882-'83	560	256	2,075,000	2,000,000
Total	4,873	1,829	16,148,941	14,024,952