IX.—ON THE SALMON OF EASTERN NORTH AMERICA, AND ITS ARTIFICAL CULTURE.

By Charles G. Atkins.

A.—SALMON-CULTURE FROM IMPORTED SPAWN.

1.—THE APPOINTMENT OF COMMISSIONERS, AND THEIR PRELIMINARY WORK.

The extended efforts now making in the United States to restore and improve the river and inland fisheries had their origin in New Hampshire in 1864. The late Hon. Henry A. Bellows, of Concord, secured the adoption, by the legislature of that year, of resolutions providing for the appointment of commissioners to investigate the question of restoring the migratory fishes to the Merrimac and Connecticut Rivers, and requesting the States bordering on those rivers to pursue the same investigation. New Hampshire appointed H. A. Bellows and W. A. Sanborn. The other States responded favorably; Massachusetts appointing, in 1865, Theodore Lyman and Alfred A. Reed; Vermont, in the fall of the same year, appointing Albert D. Hager and Charles Barrett; Connecticut, in 1866, appointing F. W. Russell and Henry C. Robinson. The principal impediments in the way of the ascent of the rivers in question by fish lying in Massachusetts, the burden of the investigation naturally fell upon her commissioners, who thoroughly examined the subject in all its bearings, and in their report discussed in a lucid manner the habits and wants of the fish, the character of the impediments, and the means of overcoming them; and pronounced the project feasible. The commissioners of the other States made similar reports, and the several legislatures continued the commissions, giving them authority to institute measures for the realization of the project. A year later the State of Maine appointed commissioners for a similar purpose, and more recently the same action was taken in New York, Rhode Island, New Jersey, and Michigan. The powers and duties of the commissioners in the States that led the movement have been somewhat enlarged, but the main purpose of their first appointment, the restoration of migratory fishes, such as shad, salmon and alewives, to the rivers they formerly frequented has been steadily kept in view.

From the beginning the commissioners found serious difficulties in the way; not only were lofty dams to be furnished with ways whereby great shoals of fish could and would surmount them, but in many cases,

and as regards salmon in most cases, the fishes themselves were wanting, having been utterly exterminated, and not to be had again without bringing a new stock from abroad. Nor would it do to bring adult salmon and place them in the rivers to be restocked, for they could not be relied upon to remain and breed there. If, however, the salmon should be reared there from infancy they would return when grown to lay their eggs in the same streams. To get the young fish the most feasible mode was to bring the spawn and hatch them. One of the very first things the commissioners did, therefore, was to cast about them for a supply of spawn.

2.—OPERATIONS IN 1866.

In the fall of 1866 the commissioners of fisheries of the State of New Hampshire dispatched Dr. W. W. Fletcher, of Concord, to New Brunswick, to obtain salmon-spawn for use in stocking the Merrimac River. He obtained permission from the government of the province to take salmon for his purpose at the spawning season on the Miramichi River, and succeeded in taking with the spear salmon enough to yield about 70,000 eggs. Great uncertainty existing as to the best mode of packing eggs for transportation, Dr. Fletcher packed his in several modes. Some fifteen or twenty thousand were packed in moss in champagne-baskets, and these alone were transported to New Hampshire in safety. A small part of them, two or three hundred, were hatched in a spring near Concord, where their development could be observed, and 90 per cent. of them hatched. The remainder of the lot was planted at once in artificially-prepared beds in suitable gravelly rapids in the Pemigewassett River, a tributary of the Merrimac, where they were left to take their chances of hatching. The following autumn Dr. Fletcher discovered several young salmon (parrs) in that vicinity, a satisfactory proof that a certain degree of success attended the hatching of the eggs.

3.—OPERATIONS IN 1867.

This year Dr. Fletcher was again dispatched by the New Hampshire commissioners to the Miramichi River, and obtained again about 70,000 salmon-eggs, nearly all of which were transported in safety to New Hampshire. About half of these were placed in charge of Livingston Stone, of Charlestown, N. H., to be hatched out for the benefit of the Connecticut River; the other half were sent to Robinson and Hoyt, at Meredith, N. H., to be hatched out for the Merrimac. About 5,000 were hatched in each place,*† the remainder failing by reason of non-fecundation.* Of the fry hatched at Charlestown nearly all were lost during the hot days of July, 1868.* Of those hatched at Meredith but very few were lost, and the following spring they were turned into the Pemigewassett, a few miles above Livermore Falls.†

* Report of the [Massachusetts] Commissioners of Fisheries for the year ending January 1, 1869.

† Letter of Robinson & Hoyt.

4.—OPERATIONS IN 1868.

This year Mr. Livingston Stone, under the patronage of the States of Massachusetts and New Hampshire, established a salmon-breeding establishment on the northwest branch of the Miramichi River, eight miles above Newcastle, on the farm of Mr. Joseph Goodfellow. A hatching-house, 100 feet by 27, was built, and a pond with an area of about an acre. A large spring and a spring-brook supplied them with water. The Canadian department of marine and fisheries granted a permit to carry on the enterprise, including the privilege of taking the fish and spawn at the breeding season, under certain conditions, the main one being that half of the eggs obtained should be hatched out on the Miramichi and the young fish turned into its waters at the proper time. In September Mr. Stone, through his employés, began the work of catching the parent fish. A stake-net was set in the river, and the salmon caught in it each day were placed in the pond. Owing to a misunderstanding of some sort, this work was interrupted by the local fishery officers, who seized successively seven or eight nets. For this reason a sufficient number of salmon were not caught, although it appears that on two occasions, between September 27 and October 4, one hundred salmon were taken in the nets in a single night. The collection of salmon continued until October 15. At this date the taking of spawn from fish in the pond began. On the 15th, 16th, and 17th twenty-eight females were stripped, yielding 226,500 eggs. After this there were stripped, from among the salmon already impounded, eighteen females, and from the river two more were taken, ripe and full, after the 20th of October. Thus the whole number of females stripped was forty-eight, and the yield of eggs was 443,900.*

These were all deposited in the hatching-house, and there remained until the appearance of the eye-spots. The loss meanwhile, from all causes, amounted to 87,900. The remainder, 356,000 eggs, were divided into two equal portions; one was left in the troughs to hatch, and the other packed up and transported to New Hampshire. After Mr. Stone's departure with the transported eggs, the establishment was left in charge of Mr. Joseph R. Goodfellow, the owner of the farm on which it was situated. According to Mr. Stone's figures, there were 178,000 eggs left there. From the best information at my command it appears that they all came to naught. Late in July, 1869, the establishment was visited by Mr. Samuel Wilmot, the superintendent of the salmon-breeding establishment at Newcastle, Ontario, who found the young fry still in the troughs. He states that they did not exceed 10,000 in number, and that they were in a very unhealthy condition.† I infer that this was all that remained out of the whole lot of eggs. A few days later Mr. Goodfellow turned out all the young salmon remain-

* Domesticated Trout, by Livingston Stone, A. M., p. 300.

† Annual Report of the Department of Marine and Fisheries, [Canada,] for the year ending 30th June, 1869, p, 107.

ing into the tidal part of the Miramichi River, where it is possible that they all perished.*

Mr. Stone's share of the eggs was packed up in moss and successfully transported to his breeding-works at Charlestown, N. H. The Massachusetts and New Hampshire commissioners, jointly, purchased 100,000 of them, to be devoted to the restocking of the Merrimac River, and these were sent to the hatching-works of Robinson & Hoyt, of Meredith, N. H.; 7,600 were sent to the Massachusetts State hatching-house at East Wareham; small lots to Winchester and West Barnstable, Mass.; to the Poquonnoc Fish Company of Connecticut, and the South Side Club of New York.

The exact number delivered to Messrs. Robinson & Hoyt was, according to Mr. Stone's estimate, 99,400. From these were picked out 53,123 eggs that showed no sign of fecundation.† The rate of fecundation was therefore about 46 per cent. of those transported. Of the fecundated eggs only 329 died during incubation, leaving 45,948 that hatched. The first fish came out January 6; the hatching culminated on the 20th, and was concluded February 1. The incubation was conducted in a graveled trough with a gentle current of water an inch deep. After hatching, they were placed, at the suggestion of the commissioners owning them, in a wooden tank 60 feet long, 4 feet wide, and from 1 to 2 feet deep, and were fed by placing finely-chopped food in a stream of water which was led into a spout with a perforated bottom that ran the whole length of the tank, the food being thus very evenly distributed. The conditions, however, failed to meet the wants of the fish, and during the summer fully three-quarters of them died.† In October a freshet carried the greater portion of those alive into a trout-pond, from which, probably, few ever escaped. The remainder were kept until the following summer, when they were set at liberty in the Pemigewassett River, having meanwhile become reduced in number to about 1,000.‡

Among the eggs carried to Massachusetts there was about the same ratio of fecundation. Of the 7,600 sent to the State hatching-house 4,280 proved defective, the most of them being infecund; and the number hatched out was 3,320. During the season these got mixed with a lot of Schoodic salmon of the same age, and it was found impracticable to sort them out. They were left together until the close of the season. Until the 1st of September they were kept in a hatching-trough, where the water was only 4 inches deep. During this time, though perfectly healthy and feeding heartily, they grew very slowly, attaining a length of only an inch and a half. Most of them were then transferred to a long trench, with a foot of water and plenty of room,

* Annual Report of the [Canadian] Department of Marine and Fisheries for the year ending 30th June, 1869, p. 107.

† Letter of Robinson & Hoyt.

‡ Fifth Annual Report of the [Massachusetts] Commissioners on Inland Fisheries, January, 1871, p. 11.

and here, by the end of October, a large part of them attained a length of 3 inches. They were now about nine months old, and only 8 per cent. of them had been lost since hatching. At West Barnstable Messrs. Dexter, Coolidge & Bacon hatched out, for the State, 1,700 salmon, and kept them through the season, losing, between the middle of May and the last of November, only 4 per cent. of this number. The largest of them were then 5 inches long, a remarkable growth, which is attributed in part to their having occupied during the summer and fall a pond 2 feet deep. About an equal number of salmon (1,700) was hatched by Mr. E. A. Brackett, of Winchester.* The final distribution of the several lots of young salmon hatched in Massachusetts from this stock of eggs is, as far as I have been able to trace it, as follows: 700, raised at Winchester, in the Mystic River; 1,500, raised at West Barnstable, in one of the streams of Cape Cod; the brood at East Wareham, "in suitable waters."†

Of the salmon hatched by Mr. Stone himself, 2,000 were sold in the spring of 1869 to the Poquonnoc Fish Company of Connecticut. A few of them were kept in the trout-ponds until the spring of 1870, and the rest were turned into Great Brook, a small stream tributary to Long Island Sound, about three miles east of New London.* Of those retained in the ponds a few became smolts in 1870, and all were turned into the same brook to take their chances. Ninety yearling salmon from the same stock of eggs were this year purchased of Mr. Stone and placed in the same waters.‡

Another lot of fry from Mr. Stone's hatching-works were sold to Vermont in 1869, and placed by her commissioners in small tributaries of the Winooski River, near Montpelier, and in West River, at Weston. Some observations made on the fortunes that attended these fish gave results that are worth recording as illustrating the dangers to which young fish are exposed. Care was taken to select streams in which there were no fish but very small ones; yet it was but a short time before quite a number of small dace were discovered in the midst of the young salmon; the former were very active, the latter sluggish and bewildered, and making no effort to escape. Within half an hour after placing some salmon in a stream near Montpelier, a dace only 2 or 3 inches long was caught, and found to have swallowed four young salmon. Some of this brood escaped destruction, however, and were seen late in the summer and fall of the same year.§

Of the disposition made of the remainder of Mr. Stone's stock of eggs, I have no definite information; but for the sake of an approximate estimate of the total number of young salmon turned into the rivers as

* Report of the [Massachusetts] Commissioners of Fisheries for the year ending January 1, 1870, pp. 31, 32.

† Fifth Annual Report of the [Massachusetts] Commissioners on Inland Fisheries, January, 1871, pp. 11, 15.

‡ W. Clift, MSS.

§ Letter of Prof. A. D. Hager.

the result of the expedition, I will assume that all of the 78,000 eggs remaining after the deposit of 100,000 at Meredith did as well as those sent to Massachusetts, of which not far from 40 per cent. reached the end of their artificial nurture and were set free. In this way we obtain 31,200 as the number of free young salmon. Adding to this the number that came from the Meredith lot of eggs, 1,000, we have a total of 32,200 young salmon as the net result of the expedition.

5.—OPERATIONS IN 1869.

Owing to causes that it is unnecessary for me to discuss, Mr. Stone was obliged to abandon his enterprise on the Miramichi. Mr. Joseph R. Goodfellow, however, collected in October, 1869, a lot of eggs, and sold them to the commissioners of Vermont. They were deposited in the hatching-troughs between the 20th and 24th of October, and remained there until the first week in December. They were then packed up in moss, in baskets, and sent to Vermont. After a series of mishaps, which prolonged the period occupied in transportation to three weeks and four days, they reached Chester, Vt., and were placed in Professor Hager's hatching-troughs. The whole number of eggs was 50,000, and the loss in transportation and incubation was estimated at 20 per cent., leaving 40,000 young fry, all of which hatched between the 1st and 15th of February. The water had a temperature of 45° F., and was so pure that no filtering was necessary. Not over 100 died during the absorption of the yolk-sack. From the 10th of May till the 1st of July they were fed regularly, and but few died. The whole lot was in July placed in Williams and West Rivers.* The number set at liberty is put down at 30,000.

6.—OPERATIONS IN 1870.

The spring of 1870 witnessed the first introduction of salmon from Lake Ontario. The establishment of Mr. Samuel Wilmot, at Newcastle, Ontario, started originally in 1866 as a private experiment, had attained such importance as to attract the attention of the Canadian government, and induce the department of marine and fisheries to assume the responsibility of carrying it on, for the general purpose of improving the fisheries of the Dominion.

The difficulties in the way of getting spawn from the maritime provinces induced the commissioner of fisheries of the State of Maine to apply to the superintendent of the Newcastle establishment for a small number of salmon-eggs. The application was referred to the department and was granted; and henceforth the sale of eggs became one of the objects of the establishment. The price of salmon-eggs was fixed at $40, in gold, per thousand. As compared with all previous rates, this was high. The price paid Mr. Stone by the States of New Hampshire

* Letter of Prof. A. D. Hager.

and Massachusetts in 1868 was $16 per thousand, and none of the parties offering New Brunswick eggs for sale had asked more than $20 per thousand.

Eight thousand were purchased by Maine, and as the ratio of unfertilized eggs appeared to be about 2½ per cent., 8,200 eggs were packed up. After a journey of three days they arrived at Alna, Me., and were unpacked April 3. The number dead was 870. By immersing them in a solution of common salt the opacity which is the regular attendant on death disappeared, and it was easy to distinguish the fecund eggs from the infecund; the latter counted 640, the former 230; which shows that the ratio of infecund eggs was about 8 per cent. The deficiency was made up, and, of the 8,000 good eggs, 7,400 were hatched. These were kept in an artificial pond one year, being reduced in number meanwhile, from unknown causes, to 1,500. These were set at liberty in May, 1871, in the Sheepscot River.

The introduction of these Ontario salmon is mentioned in connection with those from New Brunswick because the purpose of their introduction was the same, namely, the restocking of the rivers where they were placed with sea-going salmon. To the first purchasers of these eggs it did not occur that there was any doubt about the Ontario salmon taking readily to sea-water and the food to be found there; although it was the expressed opinion of Mr. Wilmot that, while the Ontario salmon were true *Salmo salar*, they nevertheless, in general, passed their whole lives in the fresh waters of the lake, finding there a congenial food. It appears probable that Mr. Wilmot is right in both particulars, but at the present time it must be regarded as an undecided point whether the Ontario salmon do migrate to and from the sea; and, if their residence in the lake becomes established, it will still be an open question whether they can, on being placed in our rivers, assume the migratory habits of the salmon of the coast.

A small lot of eggs from the Newcastle establishment found its way by another channel into the hands of W. S. Peavey, esq., of Whiting, Me. He had them hatched out, and the young fish, numbering 225, were placed in the Cobscook River in May, 1870.

Mr. Goodfellow again undertook the collection of salmon-spawn on the Miramichi in the fall of 1870. A considerable quantity was engaged, but only 8,000 eggs obtained. These were divided between the States of Maine and Connecticut, and the Poquonnoc Fish Company. The share of Maine amounted to only 800. They were hatched out near Augusta, and soon after the absorption of the sack disappeared; it is supposed that they escaped into a tributary of the Kennebec. Connecticut received 2,000 eggs, and had them hatched at Poquonnoc. They produced 1,876 young, and these, without accident or loss in transportation, were, in April, 1871, placed in the waters and tributaries of Broad Brook, a branch of the Quinnebaug River. *

* Fifth Report of the Commissioners of Fisheries of the State of Connecticut, 1871, p. 20.

7.—OPERATIONS IN 1871–'72.

In March, 1871, the Connecticut commissioners bought 10,000 eggs of Ontario salmon at Newcastle. They reached the hatching-house of the Poquonnoc Company March 11, and on opening them 7,000 were found to be spoiled through defective packing. Another lot was immediately sent to make up the deficiency, and from both shipments 6,000 fish were hatched, and placed in the Housatonic, Farmington, Shetucket, and Quinnebaug Rivers.

The first attempt to stock with salmon any of the rivers south of the Connecticut was made in 1871, by Mr. Thaddeus Norris and some other gentlemen, who purchased 11,000 eggs at Mr. Wilmot's establishment, and hatched them out for the Delaware. An accident reduced the number of fry to 2,000, and these were placed in the Bushkill, a tributary of the Delaware. In 1872 the same gentlemen got 12,000 eggs from Mr. Wilmot, and hatched 11,000 of them at a spring within a mile of the Bushkill.

The State of Rhode Island made its first attempt at the restoration of salmon in 1872, by the introduction of 9,000 eggs from Mr. Wilmot's establishment. They were placed in the hatching-troughs at Ponegansett February 11, and hatched in March. The young were placed in the Pawtuxet River.

B—SALMON-BREEDING ON THE PENOBSCOT.

1.—PRELIMINARY CONSIDERATIONS.

Though it was well known that the salmon-fishery of the Penobscot was better preserved than that of any other river on the Atlantic slope of the United States, and the project of obtaining thence a supply of eggs for the stocking of other rivers had occurred to me earlier, it was not until 1870 that the project received serious consideration. The earlier attempts at the collection of salmon-spawn for New England rivers had very naturally been made in the rivers of New Brunswick, where the abundance of salmon and the ease with which they were caught on their spawning-grounds seemed to promise sure and speedy success. Various causes, already sufficiently set forth in the detailed accounts given above of the several expeditions to the Miramichi, rendered the operations there less successful than had been anticipated. The purchase of salmon-eggs at the establishment of the Canadian government in Ontario required an expenditure greater than appeared to be warranted by the circumstances in which the fishery-commissioners found themselves placed, and, besides, there was some doubt whether the Ontario salmon would readily adapt themselves to our rivers and the sea into which they empty. The necessity of having a more abundant supply of eggs, at the cost of collection, was forcing itself upon the minds of the commissioners of all the States interested in the collection of salmon.

In 1870, being then commissioner of fisheries for the State of Maine, I determined to make an effort to find a supply of eggs in the Penobscot, and in October and November of that year I made two expeditions to those portions of the river where it appeared most probable that the breeding-grounds of salmon lay, exploring with canoe the river from Mattawamkeag up to Ambejegis Falls, on the west branch, and to the Seboois stream on the east branch, or Mattagamon. The result of these explorations was the discovery of many localities where salmon might be expected to spawn at the proper season; of others, visited at the right date for such a discovery, where their newly-made nests were actually found, and of some where facilities existed for the collection of spawn. That part of the Mattagamon near the Wassaticook and Seboois streams appeared best fitted for the natural breeding of the fish and for the collection of their spawn, and although the number of nests made before November 3 (some twenty-five or thirty being seen in a distance of three miles on the river) was not large, it appeared to warrant the expectation that a considerable number of eggs might be collected here at a moderate expense. But as the number of salmon to be caught in the vicinity at any season is very small in comparison with the number caught in the tidal parts of the river, it occurred to me that if salmon caught in these rivers could be kept alive and in good condition from June and July, when they pass up the river, till October or November, when they lay their eggs, operations might be carried on there on a much larger scale than here. Being in correspondence, about this time, with Rev. William Clift, of Connecticut, in relation to the breeding of salmon in some of our rivers, he also suggested the latter plan of operation as the one most likely to give satisfactory results. The co-operation of the commissioners of fisheries of Connecticut and Massachusetts was secured, and it was determined to try the experiment of collecting spawn near the mouth of the river.

2.—OPERATIONS IN 1871.

The place finally selected as the site of operations was Craig's Pond Brook, in the town of Orland. This stream has its rise in Craig's Pond, a small body of water of exceptional depth and transparency, tenanted by trout, smelts, and sticklebacks, and probably some other species of small fish, but entirely wanting in the pickerel, perch, sun-fish, and cyprinoids that inhabit nearly all of the ponds in the southern part of Maine. The stream runs alternately over coarse sand and ledge for half a mile, and empties into Allamoosook Pond, making in this short course a descent of probably 200 feet. A few rods above its mouth it receives the waters of several large springs of very pure water, having a temperature of 47° F. At this point there had formerly been a dam to supply power to a shingle-mill. This dam was rebuilt, and a pond formed about forty rods in area and 7 feet deep. So

clear was the water that objects could be seen on the bottom at the deepest point. In this pond it was proposed to keep the adult salmon.

A smaller pond was made at the very mouth of the brook for temporary uses. To this point the salmon could be brought direct by water from the weirs that are built about the mouth of the Penobscot. The nearest salmon-weirs were those near the lower end of Wetmore Island, (town of Verona,) and the salmon from these would have to be towed through five miles of salt and brackish water to Orland Village, then up Eastern River and across Allamoosook Pond, four miles more, to Craig's Pond Brook, passing, on the way up the river, three locks.

The salmon were obtained from several weirs in Verona. They were placed in a boat prepared for the purpose by piercing its bottom and sides with auger-holes to provide a free circulation of water, ballasted and buoyed to keep it at its proper level, covered with a net to prevent the fish jumping out, and towed after another boat propelled by oars. On the 7th day of June the first lot of salmon was brought to the works.

Twelve were placed in the boat at starting, but eight died on the way, and the remaining four were nearly dead. As there were only a dozen inch-holes in the bottom, it was thought that the poor success of the first experiment was owing to the lack of pure water. Another trial was made, with better provision for change of water. Seven salmon were put into the boat, and four of them came safely to the pond. But it was not until a hundred holes were made in the boat that the salmon were brought without serious loss. On neither occasion did there appear to be any difficulty during the passage through the comparatively cool waters of the river below Orland; but on coming into the warm fresh water at the lock at Orland Village the bad effect of the imperfect change of water became apparent. The improvement in the transporting boat enabled us to convey, in some cases, as many as ten fish at a time without losing any.

The work of transporting continued until June 20, when it became apparent that the arrangements for keeping the salmon were altogether unsuitable. After being placed in the pond prepared for them in the brook, the salmon never appeared to feel at home. They swam heedlessly about as if blind, often with parts of the fins out of water. In a few days white blotches appeared upon the surface of the head and back, and at last spread to the sides and lower parts. These blotches were found to be caused by a kind of fungus growing beneath the scales and pushing them from place, and before they had spread to all parts of the body the fish commonly died. Precisely what was the cause of the disease I cannot even yet say; but it must be sought among the peculiar conditions under which the fish were placed. The temperature of the pond ranged from 50° to 56°, while that of the rivers and streams that salmon naturally frequent is, at that season, probably from 65° to 70°. The extraordinary transparency of the water may have had some effect. Some of these fish, very badly afflicted, recovered when placed

in a pond where they had access to deep water. Finally the bottom of the pond was covered with vegetation that had become established there during several years when the dam was out of use, and in its decay it probably imparted some deleterious substances to the water. But, from whatever cause, the mortality was such as to threaten the speedy termination of the experiment by the total loss of the fish.

It was decided to abandon the brook and construct a pound of brush and netting in Allamoosook Pond, in which to keep the salmon that should survive. This pound was built at the mouth of Craig's Pond Brook, and inclosed an area of about twenty-five square rods, extending from the shore to a point where the water was 7½ feet deep. At this depth nothing could be seen from the surface, the water being of a brown color, like nearly all the pond and river water in Maine. The pound was completed on the 27th, and the nineteen salmon remaining on hand were placed therein. Such was their condition, however, as the result of their stay in the brook, that probably few, if any, lived through the summer.

Of the salmon received after this date, twenty-five in number, eighteen survived until the close of the season in good health. The last salmon were brought July 11, and after the 13th there was but one death.

During the summer the level of the pond fell, till the depth of water in the salmon pound was less than four feet. The average temperature of the surface was 64°.7 F. at the close of June, 73° during July and August, and as high as 62°.9 in September. The bottom temperature was not observed, but as the depth of the water constantly decreased until some time in September, when it was only 4 feet, it is probable that the temperature at the bottom was much higher in August than in July. In view of this probability, the fact of fewer salmon dying in August (only one) leads to the conclusion that the losses experienced in this pound were not the result of the heat, but of the injuries received in capture and transportation. In short, all the conditions attending their confinement appear to have been well suited to their wants. The narrow space which the receding water left them to swim in, being at the lowest ebb only 30 or 40 feet square, appeared to cause them some uneasiness, but the walls of the pound were secure and none escaped.

While the pound was building nine of the least healthy salmon in the brook were removed to Craig's Pond and turned loose. It is supposed most of them lived through the summer, for a careful watch for dead and floating salmon was kept up without discovering any. On several occasions salmon were seen swimming near the shore of the pound or leaping into the air. It is probable that the fish retired to deep water immediately on finding themselves at liberty, and that the protection there afforded against the glare of light, the character of the water, and other circumstances were favorable to a recovery from the malady that had attacked them and would have killed them if they had not been

removed from the brook. At the spawning season preparations were made to catch them in the brook should they chose to enter it in their search for a spawning-bed. About the 9th of November it was discovered that on a gravelly bottom under two feet of water, close by the shore, and within a dozen rods of the outlet of the pond, salmon had been spawning. A net was set here on the 10th, and on the morning of the 11th it caught two male salmon. Another was taken on the 12th, but, though the net was kept in place until the 23d, it took no more males and not a single female. The males taken were thinner than those from our pound in Allamoosook, had less red and more blue in their color, and bore large scars on their sides; otherwise they appeared to be in good health. This experiment at Craig's Pond showed that salmon cannot be relied upon to enter a small brook in search of a spawning ground when the water of the pond in which they are confined is pure and the bottom is gravelly and clean. In such cases they will lay their eggs in still water.

A third brood of salmon, eighteen in number, were placed in Dead Brook, a tributary of Eastern River, entering it several miles lower than Craig's Pond Brook, and accessible from the salmon weirs by passing through only one lock instead of three, as in the former case. Dead Brook is larger than Craig's Pond Brook—barely large enough to drive a saw-mill under a moderate head in spring and fall. In midsummer its head is very small, but it never completely dries up. Its water is less pure and more highly colored than that of Craig's Pond, but not darker than that of common brooks. Where the brook traverses a meadow two barriers were placed across it, making an inclosure about 200 feet long and 30 feet wide, with water 5 feet deep at the time the salmon were put in, (June 26 and 28,) but falling to less than 3 feet in September. Two of the fish died in June, but, so far as could be known, the remaining sixteen lived in good health until October. There were occasional freshets that brought down a great deal of mud, but this did no harm. On the 12th of October an extraordinary freshet carried away the barriers and let the salmon free. The most of them must have remained in the brook, for quite a number of spawning-nests were discovered after the water subsided in November, but only a single pair of salmon were seen; these were a mile further up the brook, above some difficult falls, lying side by side in the deepest part of a pool, while just below them, on a rapid, was a partially formed nest. The female fish was caught, killed, and carried several miles to the hatching-house, where her eggs were taken and milted. They were not so well fecundated as the other lots. I am uncertain what was the reason. The fish was afflicted with sores and very weak.

A fourth brood, numbering eleven salmon, were placed in Spofford's Pond, in Bucksport. These were caught in a weir near Bucksport village, and hauled in a tank of water on a dray one mile to the pond. There was no great expectation of catching many of them, but it was

desirable to test the effect of confinement in a pond of this character. It is a piece of water about sixty acres in area; is very deeply colored by the exudations of extensive meadows that drain into it, and its bottom, except a narrow belt along part of the shores, is composed of soft, peaty mud. The brook by which it discharges into the Penobscot is of sufficient volume to drive a grist-mill during the greater part of the year. Three of these fish were found in this brook at the breeding season, and, as several nests were seen, it was supposed that others had descended from the pond unobserved. But a single one was caught. This one was a male, in excellent condition, and in color much richer than any caught elsewhere. Thus the various mishaps of the season left us for a breeding stock only the eighteen fish in the pound at Craig's Pond Brook.

As the breeding season approached, preparations for the development of the eggs were made by fitting up a room in the basement of an old mill at the mouth of Craig's Pond Brook. Water taken from the open brook, which, though of small volume, is impetuous in character, dashing down over a ledgy bed, was led through several wooden troughs, each 18 feet long, 15 inches wide, and 8 inches deep. Grilles, made by setting narrow strips of window-glass on edge in wooden frames, were placed in these troughs, about an inch from the bottom. The eggs, when deposited on the grilles, arranged themselves in rows across the trough, each row lying on the edge of a glass rod, and between two other rods. The space underneath the grilles allowed the constant passage of a current of water, preventing stagnation, and a like current passed over the grilles. No attempt was made to filter the water, it being already uncommonly clean for brook water.

On the 2d of November the breeding fish were for the first time seined out from the pound and examined. There was no indication that any of them had begun to spawn, although if kept there many days longer it is not unlikely that they would have deposited a part of their eggs on the clean, sandy bottom. All of the males were found ripe; several of the females partially so, and 12,500 eggs were taken and fecundated. The fish were all returned to the pound to be seined out again another day. The work was continued daily until November 10, when all the ripe fish on hand had been deprived of their eggs, with a single exception. From one of the females we failed to obtain any eggs, and at last came to the conclusion that she was quite barren. She was, however, kept in the brook, and occasionally examined, until December 12, when she gave a few eggs that were apparently good, but could not be tested for want of milt. Dissection then showed that her ovaries contained a small number, probably a thousand, eggs, of nearly or quite full size and healthy appearance, and a much larger number that were not half grown. With this exception all the females yielded full litters of eggs, that came with ordinary ease, and were, as the result of incubation showed, in a state of complete development

and perfect health. The males yielded an abundance of healthy milt. After being stripped the salmon were placed in the small pond in the brook, near its mouth. While here the exhibitions of the sexual instinct were very marked. Lying in a current, the females would go through all the manœuvers of depositing the eggs, though they had already been deprived of all that we could press out. I have repeatedly observed the presence of eggs in the ovaries of fish of the salmon family months after the lapse of the ordinary spawning season. I should attribute the action of these spawned females to a reproductive impulse of a more general nature. The males were at this time very attentive to the other sex, and Mr. Dresser, our foreman, distinctly witnessed the emission of a cloud of milt by one of them while near a female.

The mode of fecundation employed was an imitation of what is known as the Russian, or dry method, the distinctive feature of which is the exclusion of water from the eggs until the moment of the application of the milt. Vrasski, the originator of this method,* was accustomed to

* The experiments and observations of Vladimir Pavlovitche Vrasski were made at an establishment founded by him in 1860, in the government of Novgorod, district of Demiansk. In 1856 his observations led him to conclusions thus detailed in the bulletin of the Societé d'acclimation, Paris, August, 1871:

1°. Étant reçus dans de l'eau au moment où ils sortent du poisson les œufs la resorbent, et ne gardent le faculté d'être fécondé, que tant que cette résorption n'est pas finie, c'est-à-dire pendent une demi-heure au plus. Une fois remplis d'eau, les œufs ne recoivent plus les spermatozoides.

2°. Les spermatozoides de la laitance, en tombant dans l'eau, commencent immediatement à faire avec beaucoup de vigueur et de rapidité, des mouvements qui ne cependent qu'une minute et demi ou deux au plus; ce laps 'ecoulé, on ne voit plus que dans quelques rares spermatozoides des mouvements particuliers et convulsifs de l'agonie. Quand, au sortir du mâle, on reçoit la laitance dans un vase sec, elle ne change pas pendent plusieurs heures, et dans cet intervalle les spermatozoides ne perdent pas la faculté de se mettre à bouger des qu'ils se trouve en contact avec de l'eau. Enfermé dans un tube sec, et bien bouché, la laitance conserva sa vertue fécondante pendant six jours. Considérant ces observations ainsi bien que les œufs et la laitance sont obtenus avec lenteur, leur masse entière ne pouvant sortir à la fois, M. Vrasski arriva à la conclusion qu'en les recivant dans de l'eau, la plus grande partie des œufs se reussissent à se saturer d'eau, et que les spermatozoides cessent presque tous de bouger avant qu'il soit possible au pisciculteur de mélanger les œufs avec la laitance délayée. M. Vrasski adopta donc le système des vases secs, et versa sur les œufs la laitance ausitôt qu'il venait de l'étendre d'eau. Le succes fût complet; les œufs se fécondèrent tous sans en excepter un seul.

[*Translation.*]

1st. If the eggs are received in water as soon as they come from the fish, they absorb it, and preserve the capacity of fecundation only while this absorption is unfinished—that is to say, for half an hour at the longest. Once filled with water, the eggs no longer take in the spermatozoids.

2d. The spermatozoids of the milt, on falling into the water, immediately begin a series of rapid and vigorous movements that continue only for a minute and a half, or two at most; after that, nothing is to be seen except, in here and there a spermatozoid, disconnected, spasmodic movements. When the milt is taken from the male directly into a dry dish it does not change for several hours, and during this time the sperma-

take the eggs and milt in two separate dry dishes, then put water with the milt and turn the mixture immediately upon the eggs. I carried the dry feature a step further, taking the eggs and the milt into a dry pan and securing contact of the milt with every egg before allowing water to touch either of them. The contact was secured by moving the pan rapidly in a circle so as to send the eggs whirling together over its bottom. This being effected, water was added, and after standing fifteen or twenty minutes, or until the eggs ceased to adhere to the pan, they were carried to the hatching-house and placed upon the grilles. When sufficient time had elapsed, and the fecund eggs began to develop, it was found that they were 96 per cent. of the whole—a very gratifying result. The following table exhibits the number of eggs taken, the ratio of fecundation in each lot, and the number lost by the white diseases:

Lot.	When taken.	Estimated number of eggs.	Percentage fecundated.	Number of white eggs.	Number of eggs pack'd Dec. 18.
1	November 2..	12,500	100	93	12,500
2	November 3..	11,500	94	187	20,650
4, part 1	November 6..	9,500	92½	297	
4, part 2	November 6..	*3,000	85	510	.....
3, part 1	November 4..	300	(†)	4	.....
3, part 2	November 4..	2,500	95	17	1,700
3, part 3	November 4..	16,000	96	131	21,400
5	November 7..	5,000	100	144	
6	November 8..	4,500	100	10	
7	November 9..	7,000	97½	134	14,250
8	November 10.	85	100	.....	
9	November 10.	50	100	2	
10	November 10.	365	100	2	
		72,300	96	1,531	70,500

The temperature of the water was, at the beginning of incubation, 46° F., but from November 23 to December 18 the average was about 41°. The eggs came forward sufficiently to be transported on the 18th

tozoids retain the faculty of setting themselves in motion whenever they find themselves in contact with water. Inclosed in a dry tube, and well corked, the milt preserves its fertilizing properties for six days.

Taking into consideration these observations, and the fact that both eggs and milt are slowly obtained, their entire mass not coming at once, Vrasski reached the conclusion that, when in water, the greater part of the eggs filled themselves with water, and the spermatozoids ceased to move before it was possible for the pisciculturist to mingle the eggs with the diluted milt; he therefore adopted the system of dry dishes, and turned the milt upon the eggs as soon as he had diluted it. His success was complete; the eggs were fecundated without a single exception.

* These eggs came from the single fish caught in Dead Brook. The fish was killed when caught, carried about three miles, and, after it had been dead perhaps two hours, the eggs were taken and fecundated. On packing up they were found to be so defective that they were turned out into the brook.

† These were purposely left unfecundated.

of December, the circulation being at that time established in all the fecund eggs. They were packed for transportation in tin boxes in layers between wet moss. Each layer of eggs was placed between disks of mosquito-netting stretched on rings of brass wire to facilitate the work of packing and unpacking. The cans were inclosed in sawdust in the usual way. The eggs were divided as follows:

To Maine	21,750
To Massachusetts	21,750
To Connecticut	21,750
To William Clift	5,250
Total shipped	70,500

The portion belonging to the State of Maine was placed for hatching in the care of Crocket & Holmes, of Norway. They hatched out with a trifling loss, and in the spring were turned into a small brook tributary to the Little Androscoggin River, which enters the main Androscoggin just below Lewiston Falls. As the brook had been cleared of its trout to supply the breeding-works of Messrs. Crockett & Holmes, it is probable that an unusually large proportion of the young salmon survived the dangers that ordinarily attend them when turned out into open waters. The eggs belonging to Massachusetts were hatched at the State hatching-house in Winchester, and turned out remarkably well, as exhibited by the following statement:

Whole number sent		21,750
Died during transportation	289	
Died during incubation	141	
		430
Number hatched		21,320

Very few of these were lost, at least 21,000 good, healthy fish remaining on hand when ready to turn out into the stream. The number of deformed fish was small. Of the healthy fish 5,000 were put into a small river on Cape Cod, and the remainder into the Pemigewassett River, a tributary of the Merrimac.*

Of the eggs belonging to Connecticut, 4,579 were lost in transportation, hatching, and nurturing. The remainder, about 17,000, were distributed in various rivers, mostly tributaries of the Quinnebaug.†

Of the 5,000 belonging to Mr. Clift, nearly all were hatched, and in May were turned into Great Brook, the first large mill-stream tributary to Long Island Sound east of the Thames River.‡

* Letter of E. A. Brackett.

† Sixth Report of the Commissioners of Fisheries of the State of Connecticut, 1872, pp. 26, 27, 28.

‡ Letter of Rev. W. Clift.

Notwithstanding the great mortality among the parent fish, which seriously reduced the stock of eggs obtained, the experiment must be considered successful. There was no longer any doubt that salmon could be kept in confinement in a small inclosure, in fresh water, from June until November, without any injury to their health, or any interference with the development of their eggs and milt, and the conditions of success were now sufficiently plain. Spring brooks, newly-built ponds, and very clear lakes must be avoided, and dependence placed on ordinary pond or brook water with a muddy bottom.

The cost of collecting and developing these eggs, up to the shipping-point, was at the rate of $18.09 per thousand, and it was evident that, with the benefit of the first season's experience to guide in the care of the parent fish, this would become the most economical mode of collecting salmon-eggs available to the New England States.

3.—OPERATIONS IN 1872.

The parties interested in the experiment in 1871, together with the State of Rhode Island and the United States Commissioner of Fish and Fisheries, united in operations on a larger scale in 1872. The disadvantages connected with the site at Craig's Pond Brook, as detailed above, were such as to render a change very desirable, and a small pond in Bucksport, variously denominated "Great Pond," "Spofford's Pond," and "Salmon Pond," was selected as the new site of operations. This body of water, about sixty acres in area in the summer season, receives the drainage of a small tract in the interior of the town, through very small tributaries, that are completely dry in summers of ordinary dryness. There are a few springs near the shores, but the volume of water they discharge into the pond is very small, and in a very dry season the overflow nearly ceases, sometimes entirely. Around the pond are extensive meadows, that are overflowed the most of the time between October and June, and whose drainage imparts a dark, peaty color to the water, and deposits at the bottom a thick stratum of soft mud. The shores, except adjoining the meadows, are stony, and the adjacent bottom, down to a depth of from 3 to 6 feet below the surface, at summer level, is stony, gravelly, or sandy, for the most part hard, partially overlaid by a dark, peaty sediment. The bottom adjoining the meadow is peaty, and supports an abundant growth of aquatic vegetation, such as *Nuphar*, *Nymphaea*, *Brazenia*, *Potamogeton*, &c. The same vegetation grows to a less extent along nearly all the shores. The fishes inhabiting the pond are perch, (*Perca ;*) sun-fish, (*Pomotis ;*) pickerel, (*Esox ;*) hornpout, (*Pimelodus ;*) trout, (*Salmo fontinalis*,) very rare; eels, (*Anguilla ;*) suckers, (*Catostomus ;*) and a few other species of cyprinoids. The water is, in general, about 9 feet deep in mid-summer, and 13 or 14 in the fall and spring, when the pond is full. The outlet of the pond is commanded by a dam and gate, which regulate the flow of water for the use of the mills at the mouth of the brook. The brook is nearly a mile in length, for the greater part of its

course descending gently, but, as it approaches the Penobscot, rushing down over ledges at a grade that probably prevented any kind of migratory fish ascending, even before the erection of dams. Were it not for the natural impediments, the stream and pond would doubtless have been frequented by alewives. The volume of water is sufficient to drive a saw-mill nearly half of the year.

The plan of operations was essentially the same as the preceding year; the parent salmon were to be obtained alive in May, June, and July, and confined in fresh water until the spawning season. The place selected for confining them was the lower end of the pond, where an enclosure of some four acres was made by building a barrier of stakes and brush across from shore to shore, a distance of about 400 feet. Salmon placed herein would have access to the brook that forms the outlet of the pond, and would be kept by the barrier in such close proximity that when the breeding season arrived they would readily find the running water, and, passing down through the gate, would be in a narrow brook, where we could catch and manipulate them.

The salmon could be obtained only from the weirs, which are, in the vicinity of Bucksport, the only means employed in catching them. Arrangements were made with a number of fishermen to take salmon alive from the weirs and deliver them in good condition at Bucksport. They were provided with canvas bags with which to dip the salmon from the weirs to avoid the mutilation they receive from dip-nets, and with perforated boats in which to convey them to the place of delivery. These boats were the common "dories" in use by fishermen on the New England coast, and by cod fishermen on the banks. They were furnished with a smooth lining of boards inside, were perforated with large holes fore and aft, which could be closed when it was desirable to keep out the water, as when towing them empty back to the weirs, and covered with a strong net to prevent the fish from jumping out. When the boat was depressed with the holes open it was half filled with water, and when it was in motion a current ran freely through it, while iron gratings confined the salmon within a space 7 feet long in the middle of the boat, and prevented their escape through the holes. The weirs in use on the Penobscot, elsewhere described in detail, are so constructed that the salmon, together with other fish caught in them, are left by the receding tide on a board floor, where they soon die. In taking them for breeding purposes, the fisherman visits his weir a short time before low water, while there is still water enough above the boards for the fish to swim in. The salmon boat is brought alongside, and into it the salmon are carefully dipped. The same boat takes the salmon from several weirs, and as soon as they are all collected, or as soon thereafter as the flood-tide makes, the laden boat is taken in tow by a dory, which is propelled by wind when that is favorable, otherwise by oars, and brought to Bucksport. At first the salmon taken on the night tides were brought and

delivered immediately, but it was soon found that a considerable number of them could be kept in a boat over night when anchored in a current, and after that transportation by night was seldom attempted. The distance from the Bucksport landing to the nearest weir that furnished breeding salmon was less than half a mile, and to the farthest less than five miles. They were all in the towns of Verona and Stockton.

The collection of salmon might have begun as early as May 1, but the price was at that date high and only small numbers were caught. By the 1st day of June they were more plenty and the price had fallen to 30 cents per pound. The first salmon was received June 1, but they came in slowly during the first eight days, only twenty-five being received during that time. On the 10th, however, came twenty-three salmon, and on the 11th forty-eight, the largest number received on any one day of the season.

On the arrival of a salmon-boat, a dray carrying a large wooden box was backed down into the water, so that the boat could be drawn up to it, and the salmon dipped over into the box, which was partly filled with water. The box was three feet long, two wide, and two deep, containing, therefore, nearly ninety gallons of water when full. It was provided with a sliding cover, and a single hole in the center of this was found to admit an ample supply of air. A salmon of average size could lie at length in it easily, but one of the largest size could do so only when in a diagonal position. Six or eight salmon were commonly put into a box together, and this number sustained but little injury during the overland journey of one mile. As soon as a box had received its complement of fish it was filled brimful of water and drawn to the pond, where it arrived in about twenty minutes. The dray was backed into the pond until the box floated, or nearly so, and the salmon turned out gently. Some of them swam off at once into deep water, but often they were very sluggish, and lay for a long time in the edge of the water. A few died immediately, and others after a day or two. When the river-water with which the boxes were filled was cool and clear the salmon suffered much less than when it was warm and roily.

A part of the mortality was doubtless due to injuries received by the fish in dipping them from the weirs, or in transferring them to the boxes. Some were injured by rushing violently against the gratings in the boat, or against the sides of the boxes. This happened frequently during the last ten days of the collecting season, for the salmon had then become more restive than at first. The increased restlessness and activity of salmon at that time is recognized by fishermen, who call these salmon "jumpers," with reference to the habit of jumping into the air, which is observed oftenest at that date, (about the 1st of July,) and which is regarded as the characteristic of a particular school of salmon. This phenomenon, which appears to be pretty well established, might be supposed to be caused by the influence of an increase in the temperature of the water, but the observations made at Buckport, in the Penobscot,

from June 17 to July 15, 1872, do not show any marked increase in temperature during that time.*

The number of salmon bought in June, from the 1st to the 15th, was 231, and the average weight 12.2 pounds; from June 16, to 30, 309 salmon, averaging 12.5 pounds; from the 1st to the 8th of July, 152 salmon, averaging 12.2 pounds; which shows a remarkable uniformity in weight at different dates. Of the whole number bought, 692, there were only three that weighed less than eight pounds; one of these weighed seven, another six, and another two pounds. The largest weighed twenty-eight pounds.†

It was impracticable to distinguish between the sexes, and I bought indiscriminately. Toward the close of the season, however, distinctive marks were quite perceptible.‡

The dark color of the water and of the bottom in the salmon pond tended to a high summer temperature. From June 20 to the close of August four observations daily were made on the temperature of the water, both at the bottom and at the surface, and of the air; the hours being sunrise, 7 a. m., 1 p. m., and 9 p. m. The bottom temperature was observed at the depth of 10 feet in June, and 8 feet in August, by means of a milk-can sunk to the bottom and kept there all the time except when making the observation; it was then drawn up by a line that was constantly attached to it; the cover was removed, and the bulb of the thermometer being plunged into the water the mercury quickly settled at the proper point. I think this a very safe and accurate mode of observation, as it is certainly a very simple one. The mean temperature at the bottom on June 20 was 60° F. and at surface 71°.6, the mean temperature of the air being 64°. The highest bottom temperature observed was 62°, and the lowest 60°. The mean for the last eleven days of June was, air, 64°.38; bottom, 60°.53; surface, 72°.62; the water at the surface being thus about eight degrees warmer, and at the bottom about four degrees colder, than the air. In

*The mean of six observations of surface temperature in the channel between Bucksport and Verona on June 17 and 18 is 61°.8 F.; at bottom at same place in 30 feet of water the mean of five observations on same days is 46°.4 F. On 7th, 8th, and 9th July six observations at same point give a mean of 66°.3 F. at the surface, and 50°.3 F. at the bottom. Observations made at the south end of Verona fail to show any higher temperature between July 10 and 15 than between June 19 and 23. Observations in the main channel of the Penobscot opposite Bucksport might give a different result, but not, it is believed, to a great degree. (See table 4.)

†The weight was arrived at by estimate, at sight, no practicable mode of weighing the fish presenting itself. Persons accustomed to handling and weighing salmon soon learn to judge their weight by the eye so accurately that an error of a pound in the weight of a fish of average size will seldom occur. But there is, of course, a greater liability of error than there would be with the use of instruments, and this fact must be borne in mind in considering the statements of weight of salmon bought. (See table 8.)

‡As the proportion of the sexes was, however, quite satisfactory, as was found in the fall, the females caught from our pond outnumbering the males nearly two to one.

July the mean temperature of the water at the bottom was only a fraction of a degree lower than the air, the figures being, air, 66°.37; bottom, 65°.39; surface, 72°.45. In August the bottom temperature is higher than that of the air, the means being, air, 67°.01; bottom, 69°.48; surface, 73°.04. Owing to a misunderstanding the observations were omitted during the first half of September, and after that they were only made once a day on the water. The mean was now only 59° at the bottom, 62°.92 at the surface. The last of October the daily observation showed 45°.

On some days in August the bottom temperature was at midday as high as 74°. Yet the salmon did not appear to suffer in the least. During the hottest weather a dead one was rarely found, and their condition in the fall was unexpectedly fine.

Observations made on the temperature of several small rivers in the State in August and the early part of September exhibit averages quite as high as those in the pond,* and I think it altogether probable that in the pools where, in a state of nature, they lie during the summer, they are, in this State, often subjected to a temperature of above 70° F., and always without injury.

Of the salmon turned into the pond, none were found dead until the 12th of June. On the 15th fifteen salmon were found dead in a net that had been hung on the inside of the brush hedge to make it doubly secure. It was a common menhaden net, hung on loosely with the expectation that the salmon would see and avoid it. But the fish exhibited remarkable dimness of vision, and probably became entangled in the net before seeing it. It was therefore removed, and, the brush not proving an efficient barrier, the salmon passed out into the main pond in large numbers. The hedge being then useless, it was taken up. The deaths among the salmon continued, and during June counted, from all causes, fifty-six. Thirty-three died during July, all before the 23d day. In August there were only three deaths, and in September none. As the water was warmest in August, and lowest in September, I think the mortality among the salmon was not owing either to excessive heat or stagnation in the water, nor yet to any incapacity of the water to sustain the life of fish so lately from the sea, but wholly to the mechanical injuries received.

A good many of the salmon, after being placed in the pond, exhibited strong symptoms of uneasiness, swimming slowly to and fro along the shores, as if searching for a way of escape. Occasionally they swam about in compact schools, of perhaps ten to thirty each, near the surface, often with the tail or dorsal fin projecting. Others were continually leaping into the air, now to the height of a foot only, and again six feet high, or higher. While the hedge was standing a salmon was seen to jump clear over it at a point where it was five feet and a half above the water. This salmon jumped out of the enclosure, and it might be thought that the leap

* See tables 3, 4, 5, and 6.

was with the intention of escaping, but another salmon was shortly after seen to jump into the enclosure over the same hedge; and I presume both leaps were made at random.

At times during the summer the salmon would for a day or two almost entirely disappear. This happened on the 1st and 2d days of July, and an examination of a weather record shows that both days were warm, with very light and variable winds, and a clouded sky. But they re-appeared a few days later as active as ever.

This extraordinary activity soon diminished, and by the middle of August had decreased 80 per cent., but there was hardly a day during the whole season, up to the spawning time, when there were not some salmon leaping. Meanwhile they had ceased to frequent the shores, and had become so wary that it was no longer possible to approach within arm's-length of them, as might easily be done during the first days of their confinement.

Late in August, being now confident of the survival of a large part of the salmon, and of a correspondingly large yield of eggs, I began preparations for the spawning season. A site for a hatching-house had been selected on the brook, about 600 feet below the outlet of the pond, and a substantial dam had been built here by Mr. Swazey, the owner of the premises, from whom I had secured a lease. The only source from which to draw a water-supply was the brook itself, there being no spring of considerable size in the vicinity; and the house was accordingly so located as to take water conveniently from the dam. The main building was made 70 feet long and 28 feet wide, one story high,* and contained

*It was built entirely of wood, the walls being boarded on both sides of the studding, and the space between filled with sawdust, as a precaution against cold. With the same object in view, the exterior was covered with sheathing-paper and then shingled. Two stoves, one for wood and the other for coal, were provided, with the anticipation that it might prove a difficult task to keep the water in the hatching-troughs from freezing. Happily, the fact proved otherwise. Across the upper or north end of the building ran a feed-trough 11 inches deep and 12 inches wide, which received water from a conduit leading from the dam, and discharged it into fifteen hatching-troughs which ran lengthwise with the building. Thirteen of these troughs were each 60 feet long, 1 foot wide and 6 inches deep inside. The other two troughs were of the same width and depth, and 56 feet long. The trough-room, therefore, measured 892 square feet. A deduction of 18 inches per trough, as an allowance for waste room at each end, leaves 869.5 feet as the total available space for the deposit of eggs. Each trough was fed by a short spout an inch in diameter, and, when in actual operation, was found to use about 300 gallons of water per hour, making 4,500 gallons per hour as the total amount used in the building. The troughs were made of unseasoned spruce boards and put into use without paint or varnish of any kind, or even planing. They were set on the floor nearly level, and had no divisions to check or break the water.

The liability to an excess of sediment from the water of the brook was so great that it was not considered prudent to place the eggs on gravel, and a sufficient number of wire-cloth trays was provided to hold them. The trays were made of iron wire cloth, with wires an eighth of an inch apart, tacked to light wooden frames, two feet long, one foot wide, and seven-eighths of an inch deep; they were varnished with a so-called paraffine varnish to prevent rusting, and were furnished with legs five-eighths of an inch long

trough-room sufficient for the development of several millions of eggs. The building and all the fixtures were in order in season for the reception of the spawn, the first of which was taken October 28.

The preparations for taking spawn were the erection of a rough shed by the side of the brook, some 200 feet below the dam, and the construction of a number of pens in the brook at the same point. The pens had board bottoms and sides, and the ends were of wooden gratings, through which the water passed freely. They were to be used to confine the salmon in while waiting to be manipulated and marked. A gate opened from the upper pen into that portion of the brook lying between it and the dam, and other gates opened from pen to pen, so that the salmon could be driven from one to another. These were all of small dimensions of course, and a dip-net only was required in taking salmon out of them for manipulation. At the dam a small gate was made, nearly as high as the surface of the pond, and the water that came through it ran over a gently sloping floor about 12 feet long, with wide crevices in it, through which the water wasted, while a salmon coming into it would slide down until left without water enough to swim in, when it could not do otherwise than roll off the lower end of the floor into the brook. This arrangement would effectually prevent salmon returning to the pond after once coming into the brook; and being now enclosed above and below, they could be driven into the pens with a small sweep-net whenever wanted. After the first season a long, narrow sluice was built leading from the dam down to the spawning-shed, and in this form the premises are represented in the illustration.

The salmon having now the range of a pond of sixty acres, which would by the flowage of marshes be doubled in November, the task of catching them again for spawning purposes was by no means so easy as it would have been had they remained within the enclosure first made, which contained only about four acres of surface, and which would have kept them from straying more than forty rods from the brook, into which, it was hoped, they would voluntarily run. It was therefore thought necessary to take some new measures for catching them.

First. A hedge, obtusely funnel-formed, was placed across the narrow part of the pond a few rods above the dam, each arm of it resting on the shore, its apex pierced by an opening occupying the center and pointing down toward the dam. Salmon swimming down the pond, on either shore, would find one of the ends of the hedge crossing its path obliquely, would follow it out to the apex, pass through the opening, and then be within an inclosure out of which there would be but two ways of egress—

to keep them up from the bottom of the trough, so that there might be a current of water underneath, as well as above them. The troughs were not furnished with covers, reliance being placed on curtains at the windows for protection against an excess of light.

After the close of the season the position of the troughs was changed; they were cut into shorter pieces, placed across the building, and fed from a long trough that traversed the room lengthwise. This is the arrangement represented in the plan.

one being the way by which it entered, which it would not be likely to find; the other through the gate into the brook, to which it would have easy access. This structure was completed on the 9th of October, and the large number gathered within it before the close of the month attested its usefulness.

Second. A seine was prepared, 18 feet in depth and about 1,000 feet long, which was of sufficient size to span the pond at its widest part; and this was twice drawn the whole length of the pond toward the dam to drive the salmon inside the hedge. This appears to have done some service, although the character of the bottom, which was soft and studded with an abundance of snags, prevented its being as effective as it would have been on a smooth, hard bottom.

Third. On the two brooks that are tributary to the pond barriers were constructed to prevent the ascent of the salmon, and in the larger one at Redman's Bridge* a pound was made to entrap any that might try to pass that point. These barriers and pounds might have been successful had it not been for a heavy fall of rain, almost beyond precedent, that raised the water quite over their tops and let a large number of salmon pass up the larger brook.

Early in October the salmon showed an increased disposition to rove. There had been sufficient rains to flow the meadows adjoining the pond, and several salmon were observed there about the eighth day in very shoal water. Immediately after the hedge near the dam was completed, the fish began to gather in it, exhibiting great activity, running and leaping. Their manner of leaping, however, was different from that observed in summer. Then the leap was almost vertical in the air; now it was generally more oblique, describing the arc of a large circle. I have seen a salmon in October leap through the air a horizontal distance that I judge to be ten feet, without rising more than three feet from the surface of the water. Such movements suggested that they were either playing or fighting with each other, and that the leaps were accidentally made by salmon that were deluding the pursuit of others.

On the 24th day of October the grating, which up to this time had been kept before the gate, was removed, and a free but small passage was left open for the salmon. One very small male had already got through the grating into the brook, and his milt was found to be mature. Up to the evening of the 26th no more came down. That night it rained so heavily as to raise the pond. The next day, the 27th, a number of salmon were seen to pass through the gate into the brook. It was generally observed that they descended tail first. That was the case in every instance that I observed. The gateway was only eight inches wide, and some of the larger fish, turning partially on their sides as they dropped into it, could hardly get through. It was afterward enlarged.

On the 28th the taking of spawn began. The first eight females ex-

* See map of Spofford's Brook.

amined were found fully ripe. During the day twenty-four in all were examined, and only four of them appeared immature. All the others yielded full litters of eggs, amounting in the aggregate to 273,400 eggs, an average of 9,113 per fish. The small proportion of immature females was unexpected; but it was a welcome fact, since it saved a great deal of labor that would have resulted from the presence of a large proportion of immature fish. The males were all found ripe from the first. They were in smaller numbers than the females, the whole catch during October being fifty-six males and sixty-six females.

The mode of manipulation adopted, as, under all considerations, the best, was the following. The spawn-taker sits on a stool of convenient height, with a shallow ten-quart pan before him. He is so clad that he need not avoid close contact with the wet fish, and when a female salmon is brought him he seizes the tail with his right hand, puts her head under his left arm, and holds the vent over the pan. His left hand is free to press the abdomen and force out the spawn. In this way one man can do the whole work alone, and quite as rapidly as he could with two assistants to hold the fish. The eggs are accompanied by a sufficient quantity of transparent, viscous liquid to insure easy motion in the mass without friction, and to prevent rapid evaporation when they are exposed to the air. The time required to take all the eggs from a single fish varies from five to twenty minutes, depending in a great degree upon the size and disposition of the fish. Sometimes she is exceedingly restive, and in such cases it is found best to suspend pressure while she struggles. The eggs from a single fish form a mass of from three pints to four quarts. As soon as the female fish is relieved of all the eggs she will give, she is handed over to the weighers and markers. The spawn-taker seizes a male salmon, holds him over the pan in the same position as the other, and presses out his milt upon the eggs. The males are stronger, and struggle more than the females, but this part of the operation is soon concluded. When males are present in sufficient numbers, all the milt to be obtained from one is applied to the eggs of a single female; but when, as was oftener the case, the number of the males required economy in their use, each one of them are made to furnish milt for the eggs of two or more females. To distribute the milt thoroughly among the eggs, the pan is now moved rapidly around in a horizontal circle, which sends the eggs and milt whirling about over the bottom, and soon insures contact of the milt with every egg. Water is now turned into the pan, at first in small and then in larger quantites, and the eggs are then set away on shelves ranged around the walls of the shed, where they are allowed to stand until the absorption of water is complete. To facilitate this absorption, the eggs from a single fish are commonly divided among several pans, it being found that while the process may be completed in twenty minutes, with eggs lying in a single layer in clean water, it frequently takes an hour or more when the eggs are heaped on each other.

The presence of a great quantity of milt in the water also obstructs the process, and therefore the eggs are generally rinsed once or twice. As soon as the eggs are completely expanded, and have loosed their hold on the pan, they are poured into a pail and carried down to the hatching-house. In a full salmon the eggs are packed so far forward behind the gills that at the first pressure it is impossible to get them all at once. The fish were, therefore, after spawning, placed in one of the pens and left a day or two, or till a convenient time, when they were taken out and stripped again, this time yielding from two hundred to five hundred eggs each. With this second yield of eggs the success in fecundation was not so good as with the first taken, which I attribute to the presence of an excess of water in the abdomen.

The work proceeded rapidly until the 2d day of November, when nearly a million of eggs had been taken. The fish then came more slowly for a week. On the 7th and 8th of November fell 2.7 inches of rain. The pond rose rapidly, and poured into the brook a flood that overflowed our pens, letting out our salmon, and mingling them with a large number of new-comers. In the hatching-house it rose over the floor and over the troughs, where the eggs were deposited. To keep the floor in place, a few shores had been set against the beams above, but the buoyancy of the floor, or of the air confined under it, broke the shores, allowing parts of the floor to rise several inches, and some of the hatching-troughs swung out of place. In a day or two the water subsided, and was found to have done no harm in the house except that it left a heavy deposit of sediment in the hatching-troughs and on the eggs.

The new rise of the water had brought down a fine lot of salmon, a large part of them ripe and full. Most of those that had escaped from the pens were caught again and kept for marking.

It was at this time that the salmon passed our barriers on the tributary brooks, traversed a mile of meadow beyond them, and gained a rapid, gravelly brook,* when they at once set about the work of spawning. Here they were found on the 10th in a little brook that a child could step across, above rapids where it seemed almost impossible that a salmon could ascend. Quite a number were found dead, and I doubt not that they killed themselves by striking against the rocks in the attempt to climb a difficult fall, which the most of them passed. About seventy fish were caught there, the majority of them females. Many had already spawned, and only about a hundred thousand eggs were obtained from them.

Scattering salmon continued to run into the brook until the 21st of November, when the last eggs were taken. Including those caught at Rich's Brook there were taken about 225 females and 130 males. A more exact statement cannot be made on account of the confusion occasioned by the freshet of November 9.

*Rich's Brook; see map of Spofford's Brook.

	Salmon.
There were placed in the pond in the summer	688
There had been found dead	92
	596
Caught in October and November	355
Leaving	241

Perhaps as many as 50 salmon came into the brook besides those caught; but that would still leave 191 not accounted for. It was supposed that they would make their appearance at the outlet of the pond in the winter or spring. A few came in February and a few in April, altogether perhaps 25; and there is still a remainder of 166 whose fate is unknown.

The fish caught at Rich's Brook were turned loose without marking. Those at the spawning-shed were all marked, and then set at liberty in the brook, whence they could at pleasure descend to the river. Over the most difficult fall in their way a sluice was built for them to run through, but it was found that instead of entering it they generally dropped over the edge of the dam and fell 16 or 18 feet upon a ledge without any apparent injury. They continued to descend all through the winter and spring.

The mode of marking adopted was by means of metallic tags. Aluminum was the metal chosen, being desirable on account of its lightness and anti-corrosive properties. It was rolled very thin and cut into tags about half an inch long and a quarter of an inch wide. A number was stamped on each tag with a steel die, and a small piece of gold, platinum, or silver wire attached to it. The tag was affixed to the fish in two different ways. The first mode was the attachment of the tag to a rubber band that was slipped on over the tail. The second was running the wire through the edge of the dorsal fin. Forty-two fish were marked in the latter way, one hundred and ninety in the former.

A record is kept of all fish marked, showing the sex, length, and weight of each one, and the date when marked and when set at liberty. The capture and identification of any of these fish hereafter may therefore contribute much toward a solution of the obscure points in the natural history of the species. At the beginning of the fishing season of 1873 I distributed circulars offering a reward of three dollars in addition to the market price for any of these tagged salmon that might be brought to me. But none were received, and I do not think any were caught. About the efficiency of the rubber band I have serious doubts. In many instances that came under my own observation the band had cut quite through the skin, and threatened to destroy the fish. Such, I think, will be the action of any band that is tight enough to stay on. Of the tags attached to the dorsal fin I expect more, and believe that to be the best mode yet suggested.

After the eggs were placed in the hatching-trays it was easy, by counting the number of eggs in a row across the tray, to compute the number in each. A tray of the size most used, two feet long and one foot wide, held about 4,000 of them when they were evenly spread in a single layer. The whole number was about 1,560,000. In taking them the eggs of each fish had, in the majority of cases, been kept by themselves as a distinct lot, the record showing when and how taken, and any noteworthy facts about the parent fish or the manner of treating the eggs.* In a number of cases, for the purpose of trying a series of experiments, the eggs of a single fish were divided into several lots. These were all kept separate in the hatching-troughs, and, although the fortunes of the season frustrated a portion of the experiments, others afforded interesting results.

The evidences of maturity of a spawning salmon commonly observed are, a soft condition of the abdomen and the flow of eggs under pressure. The latter is really less trustworthy than the former, for the fish appears to have the power of constricting the vent so that a man's strength is hardly sufficient to press the eggs out. When a gravid fish is held up by the tail, if the eggs are free from the ovary they run down toward the head, distending the anterior portion of the abdomen and leaving it flabby and loose near the vent. If the eggs are still adherent to the ovary they, of course, retain their position and the abdomen its external shape. The protrusion of the vent, which is one of the marks relied on by some breeders of trout, fails in the case of salmon. In many instances maturity of the eggs is accompanied by the temporary drawing in of the vent quite out of sight, and by its firm constriction. This is nearly always the case while the fish is struggling, whether during manipulation or before, and may, to a certain extent, be an incidental result of the efforts of the fish to get free; but it sometimes continues after muscular action has ceased in every other part.

I think it can be laid down as a general rule that at the time when a female salmon voluntarily begins to spawn, her eggs are all ready to be laid and capable of fecundation. To be sure, my observations have been made on salmon under a certain degree of restraint, which may have interfered to some extent with the normal development of the eggs and the normal exhibition of the reproductive instincts. But in the pond at Bucksport the range was so great that, as far as could be judged from the actions of the fish, they felt after the first few weeks quite at home; and I have seen nothing in their behavior which indicates that the degree of such interference is other than trifling. It is, therefore, presumed that the maturity of the eggs was nearly the same as it would have been in a state of nature.

In the case of the salmon manipulated, nearly every one yielded at once all of her eggs, except such as were packed in the anterior part of

* See table 9.

the abdominal cavity, so far forward that they could not be forced out by ordinary external pressure. The number of the eggs that we failed to get from this cause rarely exceeded five hundred, and averaged not more than three hundred. The rest, constituting 97 per cent. of the whole litter of eggs, came freely, with a uniform appearance of health and maturity, and, in a majority of cases, not one in a hundred failed of fecundation.* There were, however, during the early days of the spawning season, several females manipulated that appeared to be unripe, and such, after a trial which sometimes resulted in the flow of a few eggs and sometimes not, were placed in a pen to be tried again another day. In some of these cases the eggs may have been quite ripe, but voluntarily withheld by the fish; in the most of them, however, the evidence of immaturity was conclusive. From one of these was obtained at first trial three hundred eggs, of which 95 per cent. were fecundated; from another, one thousand eggs, and 22 per cent. fecundated. On being returned to the water these unripe fish made rapid progress in the development of the eggs, and very soon the whole litter was ready to be laid.

It would naturally be supposed that if all the eggs of each fish attain maturity nearly at the same time, the fish will, when left to follow her instincts, be but a short time in depositing them; and the phenomena thus far observed seem to support that view, although from the peculiar circumstances of the case they cannot be regarded as conclusive. The observations on this point were not many. The salmon that came into the brook, at the outlet, while waiting to be driven into the pens, found themselves in water running over a gravelly bottom, had the range of a portion of the brook about ten rods long, the current being moderately strong, and the bottom gravelly. Here they began promptly to lay their eggs, in spite of the crowded condition of the place, and when any of them were left there over night, as was sometimes necessary, both the condition of the females and that of the bed of the brook attested in the morning their industry at egg-laying. A few full females escaped from our pens and lurked in the artificial pond below, coming up in dull weather, and of nights, into the running water just below the pens, and laying their eggs on a fine gravelly bottom; when discovered here they were promptly pursued, so that they were not long left undisturbed; but they managed to make quite large nests, and did it in a very short space of time.

The tributaries of the pond, as has been previously explained, were guarded by hedges and traps, with the design of catching in the latter any salmon that should attempt the ascent of the brooks. With the exception of a single male caught near one of the hedges, about the 1st of November, no salmon tried to ascend the brooks until after the 7th of that month. On the 7th and 8th occurred a heavy fall of rain, so that on the latter day the water flowed quite over the tops of the hedges, let-

* See table 9.

ting a large number of salmon pass up the main brook. On the morning of the 10th I was apprised of their presence in a trout brook, to which they had ascended over rapids that would have been quite inaccessible had it not been for the freshet. Repairing immediately to the spot, with an assistant, I found the bottom of the brook, in every available spot, completely filled with their ridds, and salmon of both sexes, spent or full, occupying all the pools. We caught and examined nineteen female fish, of which six were wholly, and nine partly, spent. If these fish had begun to spawn in this spot, six of them had completed the whole process within forty-eight hours, or sixty at most. There is nothing conclusive about it, since it is by no means impossible that the females found spent on the 10th had begun their spawning before the storm of the 7th at some point on the shore of the pond, and feeling the sudden rise of water, had left the ground where they had already laid a portion of their eggs, and had traveled a mile or two up a small brook in search of a place to deposit the remainder.

The ratio of fecundation was ascertained in from twenty to thirty-five days after the eggs were taken. The germ begins, some days before that, to spread over the surface of the yolk, which it in the end completely envelops. During this process its advancing margin appears to carry along with it a row of colored oil globules, which form a distinct ring on the surface of the yolk. At first it enlarges as it advances, until it has passed half way round the yolk, when it is at its largest size; from that moment it grows smaller, until it finally closes up. In spring-water this phase of development begins at the tenth or twelfth day, and is completed in eight or ten days. During its progress the plainly marked ring of oil globules affords an easy means of distinguishing a fecund from an unfecund egg, since in the latter no such expansion of the germ occurs. A very strong light should be thrown through the eggs to see their condition clearly. This is best accomplished by placing them in a shallow metal box whose bottom is perforated with round holes almost, but not quite, as large as the eggs, placing the latter over the holes, and holding them so that the light shines through them from beneath. The box commonly used at Bucksport contains forty eggs, and if one of them proves infecund, it is held to indicate a rate of fecundation equal to 97½ per cent. If all of the forty are fecund, the rate is 100 per cent. A sample of forty from each lot is thus tested, and as there were in 1872 two hundred and fifty-seven lots, the average result is believed to be very accurate.

The eggs taken from full fish at the time of first handling them, and treated in the ordinary way, were, in the majority of cases, fully fecundated, and the average rate of fecundation obtained by the ordinary way was 98 per cent. There were, however, thirty-eight lots of this sort, in which the test applied gave a proportion of infecundated eggs. In the most of these cases the rate of fecundation indicated was 97½ per cent.; in only three of them did it fall below 90 per cent., being 87½ in two

cases and 67½ in another, the record affording no explanation of either of them. It is probable that few, even of the lots indicated by the trial to be fully fecundated, were quite so, since they had to be judged by samples, a method that does not admit of strict accuracy. In the thirty-eight lots alluded to, the presence of a small percentage of infecundated eggs is certain. The inquiry naturally arises, what was the cause of their failure? It cannot be traced to an insufficient supply of milt; for in two lots that were milted heavier than usual, only 97½ per cent. of the eggs were fecundated, while in another lot, taken on the same day and scantily milted, the percentage was 100.

After being once manipulated, the females were placed in the water to recover from their exhaustion, and await a second manipulation a few days later, when they would yield about three hundred eggs each. The rate of fecundation in these eggs was unequal. On the 1st day of November all the females used before, sixty in number, yielded at a second trial 16,300 eggs, and only 77½ per cent. were fecundated, while in some of the subsequent lots of this kind the fecundation was complete.

The eggs taken from those spent fish that had spawned naturally exhibited the same inequality in their susceptibility to fecundation. I think it is to be explained, not by an original defect in the egg, but by the action of the water that frequently obtains access to the abdominal cavity after it has been emptied of most of the eggs, and when present in great quantities might be expected to exert an influence similar to that which it would exert on the eggs after they had left the fish. It would incite them to expansion, and they would then lose their susceptibility to fecundation. A small quantity of water might remain near the vent or be insufficient to overcome the viscid fluid in which the eggs swim, and which, while it surrounds them, prevents their absorbing water.

From all this it would appear, first, that there are, as a general rule, no defective eggs in the ovaries of a salmon; and, second, that when she first begins to spawn, the eggs are all ripe and ready to be laid and fecundated.

There are exceptions to the first proposition. One of the salmon manipulated at Orland in 1871 yielded no eggs until December, when it was found by dissection that, though her ovaries contained some full-sized eggs, the majority of them were only partially grown, being of a great variety of sizes, from nearly a quarter of an inch down to the fiftieth of an inch in diameter. These were all adherent to the ovary. Unfortunately the lack of milt prevented the testing of the susceptibility of the full-grown eggs to fecundation. There are occasionally found in a lot of healthy eggs a few that are white and opaque on issuing from the fish; and I have found them in the abdominal cavity. I can assign no cause. I have also seen eggs that at the moment of leaving the fish bore to the eye distinct evidence of being in an abnormal state, apparently a stage in the process of disorganization. In some cases, although the egg was of full size, the yolk and the oil-globules only appeared as

a small body of colored matter floating in the transparent fluid that filled the outer shell. This was the case with eggs found in salmon late in the winter and in the spring, and I thought it proceeded from a rupture or shrinking of the yolk membrane of an egg originally healthy. Some eggs of this character were taken with healthy ones from a living fish at the spawning season, and I have found them to abound in fish that had been a short time dead. This, in fact, appears to be the ordinary course of an egg that remains too long in the fish. It is not unlikely that there are imperfections of other kinds than those mentioned, that render the affected eggs incapable of fecundation under the most favorable circumstances. On the other hand, eggs that are in perfect condition on issuing from the fish may fail from a variety of causes. Water may reach them and lie in contact with them too long before the milt is applied; the milt itself may have lost its power through the influence of water or air. Further, it is possible that in some cases the milt is originally inert, or becomes so while yet in the spermaries of the salmon. The latter might easily occur through the influence of water entering by the vent. In manipulating males that have been used once or oftener before, a good deal of water is sometimes pressed out first, but the milt that follows it appears to be efficient. Without continuing these speculations further, I will state the result of several experiments on the fecundation of the eggs.

4.—THE FECUNDATION OF EGGS IN LARGE OR SMALL MASSES, AND WITH OR WITHOUT STIRRING.

Experiment 1.—Lot 25, containing 3,800 eggs, was milted as usual, was then watered and allowed to stand during absorption in one pan without any stirring; (the pans used in all cases were circular in shape, and 11¼ inches in diameter; these eggs, therefore, lay about two deep on the bottom of the pan;) fecundation 40 per cent. Lot 26, containing 7,600 eggs, was stirred five minutes and underwent absorption in three pans; (being 2,533 per pan;) fecundation 100 per cent. Lot 30, containing 7,000 eggs, stirred and set in one pan; fecundation 97½ per cent. Lot 31, 13,000 eggs, milt scanty, stirred two minutes and a half, then watered heavily and set in three pans; fecundation 100 per cent. Lot 33, containing 7,000 eggs, set in one pan; fecundation 100 per cent. The conclusion drawn from these results is that it makes little or no difference whether the eggs are treated in large or small masses, but that it is important that they should be stirred. I suppose that when the eggs lie quietly in a mass just as they were taken from the fish, even though they be covered with water, the viscid fluid that envelops them wards off, not only the water, but also the spermatozoids of the milt, until the latter have become inert. I have observed with certainty that the fluid referred to seriously hinders the absorption of water, and prolongs the process for sometimes an hour beyond the usual time, which is twenty minutes. Stirring assists both the water and milt to penetrate to the egg.

5.—THE SUSCEPTIBILITY OF THE EGGS TO FECUNDATION IN WATER.

Experiment 2, *October* 29.—Lot 34 treated in the usual way; fecundation 100 per cent. Lot 36, from same female, allowed to stand in water two minutes, before the milt was applied, which was done without pouring off the water; fecundation 20 per cent. Water, 44° F.

Experiment 3, *October* 31.—Lot 49 treated with water four minutes before the application of milt; fecundation 7½ per cent. Water, 43° F.

Experiment 4, *November* 4.—Temperature of the water 40° F. Lot 119, treated as usual, was completely fecundated. Lot 120, from the same fish, stood in water several minutes before the milt was applied; fecundation, none.

Experiment 5, *November* 5.—Temperature of the water 40° F. Lots 136, 137, 138, 139 and 140. The milt for these eggs was taken first in a dish, dry; then the eggs were taken, divided and watered; then, after the lapse of one, two, three, and six minutes, respectively, the milt was applied and the eggs stirred; all then stand until free. Results: after one, two, and three minutes, fecundation 100 per cent; after four minutes, 92½ per cent; after six minutes, 65 per cent.

Experiment 6, *November* 11.—Temperature of the water 40° F. Lots 180 to 189, inclusive, were milted successively; the first immediately, and the rest at intervals of from half a minute to ten minutes after they were placed in water. The result was as follows, viz, in the lot milted immediately, 97½ per cent. fecundated; at the end of half a minute after application of water 92½ per cent. fecundated; at the end of one minute 95 per cent.; at the end of two minutes, 77½ per cent.; at the end of three minutes, 80 per cent.; at the end of four minutes, 85 per cent.; at the end of five minutes, 87½ per cent.; at the end of six minutes, 85 per cent.; at the end of eight minutes none fecundated; at the end of ten minutes 2½ per cent. fecundated.

The inequality of these results may be attributed to minor differences in the mode of manipulation; for instance, the difference in the shape of the dishes used, in the quantity of water applied, and in the amount of agitation given to the eggs. In experiments 2, 3, and 4, the dishes were broad and shallow, and the quantity of water liberal. In experiment 6 the dishes were small mugs, and the quantity of water proportionably small. In the case of lot 189, perhaps the stirring given before the milt was applied was insufficient to give the water access to those eggs which lay in the bottom of the mug, and that they, therefore, retained the susceptibility of fecundation for some minutes longer than they would have done if pure water had had free access to them.

6.—THE SUSCEPTIBILITY OF EGGS TO FECUNDATION OUT OF WATER.

Experiment 7.—Lot 67 stood long before milting or watering; rate of fecundation, 100 per cent.

Experiment 8.—Lot 92 stood without milt, while lot 93 was taken and milted; rate of fecundation, 100 per cent.

Experiment 9.—Lots 133 and 134 were kept in a pan half an hour before milt was applied, and the rates of fecundation were 90 and 80 per cent. respectively. In the former case water was applied as soon as usual; in the latter case the eggs, with the milt, were carried without water to the hatching-house, and turned directly into the troughs. This circumstance is not, however, believed to have been influential, for in other cases it was found to make no difference. (See lots 129 to 132, in table 9.) That the eggs themselves were healthy is proved by the successful fecundation of the remainder of the eggs from the same fish, by the ordinary method, the rate in all being 100 per cent.

Experiment 10.—The eggs were taken from a healthy fish, and part of them (lot 210, containing 4,400 eggs) milted at once with complete success. The remainder were kept in the hatching-house in a pan covered over, but not secluded from the air. At the end of twelve hours, thirty hours, two days, and four days, successive lots (225, 229, 234, 250) were taken from this pan, and milted with fresh milt. The rate of fecundation was as follows: at the end of twelve hours, 90 per cent.; thirty hours, 87½ per cent.; two days, 75 per cent.; four days, 12½ per cent.

The results above stated show that the egg retains the susceptibility to fecundation for several days, under favorable circumstances, but that in some cases a considerable percentage loses it in half an hour.

7.—DURATION, IN AIR, OF THE FECUNDATING POWER OF THE MILT.

Experiment 11.—Lot 76: milt taken ten minutes before its application to the eggs; fecundation, 92½ per cent.

Experiment 12.—Lot 85: milt taken from the fish several hours in advance, and kept in an open dish; fecundation, 100 per cent.

Experiment 13.—Lot 249: milt kept four days before application; fecundation, none. This total failure is supposed to have been the fault of the milt, since some of the same eggs treated with freshly-taken milt were fecundated. (See lot 250.)

8.—DURATION, IN WATER, OF THE FECUNDATING POWER OF THE MILT.

Several extensive experiments were undertaken for the purpose of determining this point, but accident frustrated them, and they are not reported. But it may be stated, in general, that milt was found to preserve its efficiency for several minutes after being placed in water.

Doubtless it makes a great difference whether the milt is mixed thoroughly with the water, or is permitted to settle in a body to the bottom, as it will when dropped gently into water. In the latter case the water may not gain access to the main mass of the milt for some time.

9.—DURATION OF CONTACT NECESSARY TO INSURE FECUNDATION.

In the ordinary course of procedure the milt was in contact with the eggs not far from a minute before the application of water, and from twenty minutes to an hour, or even longer, thereafter. In two instances, immediately after the application of the milt and the stirring of the eggs enough to diffuse it among them, it was washed off by rinsing the eggs several times with clean water, the whole being done with the utmost possible dispatch.

Experiment 14.—Lot 125, containing 3,300 eggs; the eggs were rinsed with clean water immediately after milting; fecundation, 100 per cent.

Experiment 15.—Lot 127, containing 2,700 eggs; rinsed immediately after milting; fecundation, 100 per cent.

From this it appears that fecundation is effected so quickly that, for practical purposes, it may be considered instantaneous.

10.—TEMPERATURE OF WATER AND DEVELOPMENT OF EGGS.

The temperature of the water in the hatching-house when the first eggs were deposited, was 44° F., and they developed rapidly. On the 3d day of November it had fallen to 42°, and from that time till the 16th it vibrated between 42½° and 39°. On the 20th it sunk to 37°, and on the 21st to 35°. About this point it remained until the last week in December, when it sunk to 33°, the temperature of the air outside being —19°. During the rest of the winter it generally stood at 33½° or 34°, occasionally rising to 36°. In the spring it sunk instead of rising, the water being colder during the first half of April than at any other time during the season. This I attribute to the abundance of snow and ice-water running into the brook at that time. No difficulty was experienced in keeping the building warm enough to avoid any injurious freezing, although on several occasions, when the night was extremely cold and the fires dull, ice formed in some of the troughs.

In this extremely cold water, of course the development of the eggs was very slow. In the first lot the heart of the embryo was beating December 16, but the eyes were not black until January 9, seventy-three days from fecundation. In spring-water the same stage would be reached in about thirty days. On the 7th day of February the circulation was barely established in the embryos taken November 21. In those taken November 14 it was distinct and the embryos active; in those of November 9 the circulation was stronger and the embryos larger, but there was still no sign of color in the eyes, although ninety days had passed since fecundation. The only disadvantage in this slow

development is the additional expense attending it, and I think this is fairly counterbalanced by the longer time afforded for packing up and distributing the eggs, and by having the hatching delayed until the natural period, when all the conditions existing in the water may be supposed to be best adapted to the healthy growth of the young fish. The water in the streams where salmon naturally spawn is quite as cold as that used in this hatching-house, and the incubation of eggs there goes on quite as slowly. During incubation one man can, under ordinary circumstances, take care of several millions of eggs. There is little to be done except to pick out those that die and turn white, before they decay and contaminate the water. In water of 34° F. decay begins so tardily that once a week is often enough to take out the dead eggs. This was done in the present case with wire-pointed wooden pliers, without removing the trays from the trough. Some fish culturists remove the trays to a table, where the work can be done easier, but my own experience leads me to believe that at certain stages of development the eggs will not endure the disturbance involved without injury.

The number of dead eggs taken from the troughs was not larger than ordinary until about the 1st of January. At that time the number dying from day to day suddenly increased, and was very large during the rest of the season. The percentage lost in this way at Orland the previous season was but a little over 2 per cent. of the number of eggs taken. At the same rate the number this year should have been only about 32,000. Actually it reached the large total of about 318,000 or 20 per cent. of the whole. This extraordinary mortality requires explanation. It was due to a variety of causes. First, the windows had been curtained only with cotton cloth, and this admitted an amount of light that encouraged the rank growth of a species of confervoid vegetation which spread over the eggs like a blanket, shutting them out from a due supply of water from the current flowing above them, and exposing them to the influence of the water beneath the trays. Second, the space underneath the trays was too narrow for so long troughs as 60 feet; there was little or no current through it, and the *conferva* prevented a circulation through the trays. Thus this space was occupied by stagnant water, which soon became surcharged with noxious substances, the exudations from the wooden troughs and the decay of eggs that accidentally slipped down beneath the trays, playing an important part. With a suitable current of water all these injurious substances would have passed off before they had accumulated sufficiently to do harm. But in the stagnant water they rapidly accumulated, and, coming in contact with the eggs above them, destroyed them by thousands. Third, a long stove-pipe ran above one of the troughs; the liquid condensed within it in cold weather was carried away in a gutter, but on several occasions considerable quantities of this poisonous liquid found its way into the troughs.*

* The causes second and third might have been avoided by the use of covers to the troughs, and these have since been made.

The first difficulty was remedied by darkening the windows, which was soon followed by the entire disappearance of the *conferva;* the second by raising the trays so as to establish a current underneath them. By prompt action the eggs that had not yet been affected were saved, but a large proportion of those that retained life long enough to be packed up and sent away had been so seriously injured as to perish, either during incubation or soon after hatching.

11.—PACKING AND SHIPMENT AND DISTRIBUTION OF EGGS.

During the early part of the season of incubation, with the co-operation of Mr. E. A. Brackett of the Massachusetts commission, I tried a series of experiments designed to determine the period when salmon eggs can be transported with safety. Ten successive packages, each containing eggs from five separate lots of widely different ages and stages of development, were sent by express to Winchester, Mass., where Mr. Brackett unpacked them and noted the result. The first package was sent on the 14th of November, and the last on the 7th of January. The results observed were very uneven, almost total loss attending some shipments, while in others the average ratio of loss was quite small. In the first two packages, the germ of the oldest eggs was in process of expansion over the surface of the yolk, while in the youngest eggs that process had not begun; in the former the loss was several fold greater than in the latter. In the second package the percentage of loss in the several lots, beginning with the oldest and running down to the youngest, was as follows: 62, 45, 36, 21, zero. In the third lot it was 20, 8, 8, 2, 8. In the fourth lot, the development was but little advanced over the former ones, and the percentage of loss in the several lots remained substantially the same, being, in the order of the age of the lots, 88, 84, 10, 8, zero. The next two packages were badly frozen, and the result therefore indecisive. On the 17th of December, another package was sent, in which the oldest eggs were so far advanced that the heart of the embryo could be seen beating, while the younger eggs had arrived at the same stage as the older ones had in the earlier packages. The relative losses were now reversed, the percentage being from oldest to youngest, zero, zero, 2, 42, 2. A week later another package resulted as follows: percentage, zero, zero, 36, 8.

The general conclusion drawn from the result of these experiments was this: that the critical period, during which salmon-eggs cannot be transported without danger of great loss, begins with the first expansive movement of the germ, and ends with the establishment of the circulation. In our earliest eggs this period was, approximately, from the fifteenth day after fecundation to the thirty-fifth day, ending thirty-seven days before the appearance of black eyes. In the later lots, owing to the lower temperature of the water, it was long deferred. In water having a uniform temperature of 44° F. I should think the critical period would begin as early as the tenth day from fecundation, and last two weeks.

Either before or after this period, eggs can be transported with much greater safety, although I do not think it yet established that any time is quite so favorable as that succeeding the first appearance of dark color in the eyes.

The general shipment of eggs began February 3d, and continued weekly until late in the spring, the last lot being sent away in April. The whole number distributed was 1,291,800. There were retained and hatched at Bucksport about 150,000 eggs, being part of the share falling to the lot of Maine. The remainder, 1,091,800, were packed up in moss and sent away; 152,000 going on a sled to Bangor and thence by rail to Dixfield, Me.; the rest all going from Bucksport to Boston by steamer, and from that point by rail to their several destinations.

Several modes of packing were adopted. The first was the use of trays similar to the hatching trays in use at Bucksport, made of iron wire cloth with wooden frames around the edges. One or two layers of eggs were placed on each tray, with layers of sphagnum-moss below, above, and between them. In most cases pieces of mosquito-netting were spread beneath and above each layer of eggs, between them and the moss, for convenience in unpacking, the trouble of separating the eggs from the moss when nothing intervenes being very great. After packing, the trays are set, one on another, in a box large enough to receive them; the frames, coming in contact, sustain all the weight, entirely relieving the eggs from any pressure except such as the packer may choose to give them; this box is then inclosed in a larger one, with saw-dust, tow, or some other non-conductor of heat, to protect against extremes of temperature. This mode of packing is very economical of space, and thus far appears to be safe, unless the eggs and moss be placed in the tray so loosely as to slide down together to one side if the box be placed in any other than an upright position. The second method is the use of cylindrical tin boxes about five inches deep and six inches in diameter, in which the eggs are placed in layers alternating with layers of moss. Each layer of eggs lies between two disks of mosquito-netting sewed to brass rings of just the right size to go into the box easily. Six or eight layers of eggs, numbering from 1,600 to 3,000 eggs, are placed in each box. The tins are then placed, as in the other method, in a large box, with a protective packing. I prefer this mode to any other for long distances, and all the eggs sent to the Middle and Western States were so packed. Some of the parties receiving the eggs objected to the size of the boxes and the pressure that the eggs sustained in them; but I think that the loss which they attributed to this cause was really the result of the general injury of the eggs, in the troughs at Bucksport, as explained above. In all cases sphagnum-moss, gathered from bogs, without any special care to keep out dirt, was used, and excess of moisture, more than the moss could hold without dripping, avoided.

The eggs hatched out for the State of Maine, in the Bucksport hatch-

ing house, numbering about 150,000, suffered a loss of 62,500 during incubation, being 41.66 per cent. A very few of them hatched in March, but the fall of temperature in April retarded the others, so that but a small number of fish came out until the last week in April. The temperature then rose from 34° to 40°. On the thirteenth day the hatching was at its height, and before the 10th of May all the eggs were hatched. The distribution of the young fish took place the 1st of June, the absorption of the yolk-sack being then complete. In the preliminary trials at transportation 10,500 salmon were lost. The remaining 77,000 were turned alive into the Penobscot and Saint Croix Rivers, the former receiving 67,000 and the latter 10,000. The remainder of the eggs allotted to Maine, to the number of 152,000, were transported to Dixfield, Oxford County, and hatched by Mr. Stanley, of the board of commissioners, in spring-water. The fish came out early, with a loss of about 22,000, or about 15 per cent., leaving 130,000. These, after a loss not reported, were all set free in the Androscoggin River and its tributaries.*

The eggs sent to New Hampshire numbered 21,400, the loss in incubation was between 30 and 40 per cent., and the young fish were placed in the head-waters of the Merrimac, about the time the sack was absorbed.†

To Vermont were allotted 10,000 eggs. They were hatched by Seth Green, at Rochester, New York, with a loss of 30 per cent., and the fish placed in the Winooski and Lamoille Rivers, tributaries of Lake Champlain.‡

Massachusetts received 232,800. They were hatched out by Mr. E. A. Brackett, of the board of commissioners, at Winchester, in spring-water. The loss in incubation was about 24 per cent., amounting to 55,800. The young fish were healthy and vigorous; 165,000 of them were placed in the head-waters of the Merrimac, soon after the absorption of the yolk-sack; and into the Mystic River and Red Brook, about 11,000 each.§

The share of Rhode Island numbered 100,000 eggs. They were hatched at Poneganset, by Mr. J. H. Barden, of the board of commissioners, in water of 46° F. The total loss was 36,000, being 36 per cent. The 64,000 young fish obtained were distributed in the Blackstone, Pawtuxet and Pawkatuck Rivers. They appeared strong and healthy.‖

To Connecticut were sent 264,000 eggs; 204,000 of them were hatched at Poquonnoc, by Mr. Clift; 50,000 at North Branford, under the auspices of the Waltonian Society, of New Haven, and 12,000 at Westport. The eggs sent to Poquonnoc suffered a loss of 20,200 in transportation and unpacking, and a further loss during incubation of 33,175, leaving

* Distribution in detail as follows: into Swift River, 30,000; into Rangely Lake, a few thousand; into the Androscoggin and tributaries, near Dixfield, the remainder. Letter of H. O. Stanley.)

† Letter of W. W. Fletcher.

‡ Letter of M. C. Edmunds.

§ Letter of E. A. Brackett.

‖ Letter of J. H. Barden.

151,625, which hatched out. The rate of mortality was very uneven among these eggs, in some lots being as high as 75 per cent., and in others as low as 6 per cent. The eggs sent to Westport and North Branford suffered an equal loss with the above. The young fish, numbering in the aggregate, at all the establishments, 198,000, were set free as soon as the absorption of the yolk-sack was complete, in various streams in Connecticut.*

William Clift, of Mystic Bridge, Conn., agent for the Poquonnoc Fish-breeding Company, received 64,000 eggs. A small number of them were sold, and the remainder hatched at Poquonnoc, with a loss of 33 per cent. The young fish were turned into Great Brook, which the company is trying to stock with migratory fishes as a private venture. The foreman of this establishment, Mr. A. A. Anderson, reported the young fish from these and the eggs belonging to the State, under his charge, as uniformly weaker on first coming out than any salmon fry he had ever seen. Afterward, however, they looked better.

To New York there were allotted, from the share belonging to the United States, 80,000 eggs. They were sent to Seth Green, Rochester, and hatched at the State establishment. The loss was 26,000, † being 32½ per cent.; 25 per cent. of this occurred during incubation, and the rest soon after. As soon as the yolk-sack was absorbed the young fish were set free; 24,000 of them were placed in tributaries of the Hudson; 15,000 in tributaries of Salmon River; and 15,000 in a tributary of the Oswego.

New Jersey received 40,000 eggs, which turned out to be in a condition much better than average. They were hatched out at Dr. J. H. Slack's establishment at Bloomsburg. Only 10 per cent. were lost in incubation. Of the 36,000 young fish, the Delaware River received 18,000, the Raritan 15,000, and 3,000 were sent to Long Island.‡

Pennsylvania was awarded 40,000 eggs. They were received by Mr. Thaddeus Norris, of Philadelphia, who had made arrangements to have them hatched at private expense, at Heitzman's Springs two miles above Easton, on the New Jersey side of the Delaware. On unpacking these eggs they appeared in remarkably fine condition, but the average mortality attended them before they hatched, 37½ per cent. or 15,000 eggs perishing.§ The remainder, 25,000, produced fish, which were turned into the Delaware River.

There were sent to Dr. E. Sterling, of Cleveland, Ohio, a small package of eggs, numbering 5,200. They were hatched by Mr. John Hoyt, at the Castalia Springs, near Sandusky. The loss in incubation was 2,700,

* For further details of distribution see Table 11.

† Mr. Green attributed the loss in great part to the large size of the tins in which the eggs were packed, which caused too great pressure on the lower layers.

‡ Dr. Slack reports 18,000 put into the Delaware, 13,000 put into the Raritan, and 3,000 sent to Long Island, making 39,000 in all, which exceeds the number of fry computed above by 3,000. This discrepancy might come from an error in counting either eggs or fry.

§ Letter of T. Norris.

or 52 per cent. The remaining eggs produced 2,500 young salmon, and they were turned into the Castalia Ponds, which discharge by a stream three or four miles long, into Sandusky Bay. The water of these ponds and of the springs which supply them, is very warm, between 50 and 60 degrees,* is of remarkable transparency, and highly charged with mineral matter in solution.

The eggs sent to Michigan numbered 43,200. They were received by N. W. Clark, who hatched them out for the Commissioners of Fisheries, at Clarkston. The eggs were packed up March 10, and despatched on the 11th, but did not reach their destination until the 17th. Not over 5 per cent. of them were found dead on unpacking.† The temperature of the water was 34° F. at the time the eggs were placed in the boxes, and it continued about the same until March 25, after which it grew gradually warmer until it attained the ordinary summer temperature of 60° F. The fish were all out about the middle of April, to the number of 30,000, there having been a loss of 30 per cent. in hatching. The distribution of the young commenced May 14, the number having meanwhile become reduced to 19,500, making a total loss of 23,700, or 55 per cent. The 19,500 fish distributed were put into the Kalamazoo, Saint Joseph, Grand, Muskegon, and Manistee Rivers, tributary to Lake Michigan, and the Au Sauble River, tributary to Lake Huron, also into Orchard, Walled, Whittemore, Diamond, and a few smaller lakes. Some of them are reported to have been since seen in Diamond Lake in good condition.

The eggs awarded to Wisconsin, 40,724, were sent by express in three packages, that were dispatched as follows, viz: 9,324 February 24; 18,400 March 3; and 13,000 March 10. In the first package 100 eggs died on the way; in the second 350; and in the third 1,000; in all 1,450. The subsequent loss in eggs and newly-hatched fry was about 19,500. There were hatched and saved about 19,000 fish. The first of them came out on the 13th of March, and all were out the first week in April. The hatching was conducted by Mr. H. F. Dousman, at Waterville, Waukesha County, in spring-water having a temperature of 48° F. Early in the spring the young salmon were distributed; 7,000 were put into Menomonee River, tributary to Green Bay; 1,000 into Oconomowoc Lake; and 11,000 into Milwaukee River. The latter were intended for the Kewaunee River, which lies one hundred miles farther north, but an ice blockade compelled the change.‡

* Letter of John Hoyt.

† Letter of N. W. Clark. Mr. Clark remarked that the large cans contained more dead eggs than the small ones, and concluded that the pressure on the under layers, consequent on the large size of the boxes, caused the injury.

‡ Letter of H. F. Dousman. Mr. Dousman reports that one of these fish is supposed to have been caught late in August, on the Menomonee River, one hundred and fifty miles above its mouth, by one Cruickshank, a native of Nova Scotia, who was acquainted with the species and pronounced the fish a salmon, on the strength of its appearance and taste, ignorant of the fact that young salmon had been distributed there. The specimen was estimated to weigh 6 ounces.

Thus it appears that the young salmon set free as the net product of the season's work was 876,000, being 71 per cent. of the eggs distributed, and 57 per cent. of those originally taken from the fish. This result, though it compares favorably with previous operations of the kind both in this country and abroad,* is far below what may be expected under favorable circumstances. When the influences that occasioned the serious injury to the eggs during their development at Bucksport are avoided, as they evidently can be, there seems no reason to doubt that the aggregate losses can be reduced to 10 or 15 per cent. of the eggs taken from the fish. The latter number can also be largely increased by improvement in the mode of handling and transporting the adult salmon, and the use of more efficient means for recapturing them in the fall. That there is room for improvement does not, however, alter the fact that the season's operations were positively successful, and, moreover, successful to an extent which, for the first time, placed in the hands of the commissioners having the matter in charge adequate material for the re-establishment of broods of salmon in the exhausted rivers of New England.

C—Tabular statements embodying observations on salmon and salmon rivers in Maine.

The following tabular statements embody nearly all the facts observed in connection with the breeding of salmon on the Penobscot River.

In regard to the records of temperature, it should be stated that the observations were made with ordinary instruments, and, for the most part, by persons little accustomed to their use. Yet the results in these cases accord so well with my own observations that I have confidence in their general correctness.

Table I.—*Record of temperature at Craig's Pond Brook, Orland, Me.*, 1871.

Date.	Temperature, (Fahrenheit.)						Wind.	Remarks.
	Air.		Brook.		Allamoosook Pond.*			
	5½ a. m.	3½ p. m.	5½ a. m.	3½ p. m.	5½ a. m.	3½ p. m.		
1871. June 9	60	70	.....	61	.....	.....	Southwest, heavy	Clear.
10	58	65	52	54	.....	.....	Southerly	Cloudy, and rain in p. m.
11	64	.....	52	.....	.....	.....	.....	.....
12	56	66	52	52	.....	.....	Calm	Rain.
13	60	65	51	55	.....	.....	.....	A. m. clear; p. m. rain.
14	56	68	50	54	.....	.....	Calm	Cloudy; showers.
15	60	74	51	56	.....	.....	Southwest, heavy	Shower.
16	62	65	50	54	.....	.....	Southwest	Cloudy.

* Taken near the surface, in the pound where the salmon were confined.

*At the famous fish-breeding establishment at Hüningen, during the season of 1871–'72, the first year of the German management, out of two and a half millions of eggs collected, one million were lost before they were distributed, and it is stated on good authority that the loss was equally great while the establishment was under French control. [R. Hessel, MSS.]

TABLE I.—*Record of temperature at Craig's Pond Brook, Orland, Me., 1871*—Continued.

Date.	TEMPERATURE, (FAHRENHEIT.)						Wind.	Remarks.
	Air.		Brook.		Allamoosook Pond.			
	5½ a. m.	3¼ p. m.	5½ a. m.	3¼ p. m.	5½ a. m.	3¼ p. m.		
1871.								
June 17	50	74	50	55	.....	.....	North	Clear.
18	62	65	50	54	.....	.....	Southwest	Cloudy.
19	60	75	50	55	.....	.....	Calm	Do.
20	65	80	50	56	.....	.....	West	Clear.
21	60	84	50	55	.....	.....	North	Do.
22	51	80	50	55	.....	.....	....do	Do.
23	54	83	50	55	.....	.....	....do	Shower.
24	52	67	50	54	.....	.....	Northwest	Clear.
25	52	70	50	55	.....	.....	....do	Do.
26	64	84	50	56	.....	.....	....do	Do.
27	60	76	50	53	.....	.....	South	Do.
28	60	65	.....	.....	60	60	Southeast	Cloudy.
29	64	76	.....	.....	65	70	South	Do.
30	54	75	.....	.....	65	68	Northwest	Clear.
Sums ...	1284	1527	908	989	.....	.....		
Means ..	58. 2	72. 7	50. 4	54. 9	.....	.....		
July 1	52	76	.....	.....	68	70	South	Clear.
2	52	75	.....	.....	65	68	South-southwest	Do.
3	58	60	.....	.....	64	75	North	
4	60	80	.....	.....	70	77	....do	
5	61	82	.....	.....	70	77	Calm	
6	62	84	.....	.....	70	78	Southwest	
7	61	82	.....	.....	74	78	South-southwest	
8	60	77	.....	.....	70	77	North	
9	68	80	.....	.....	70	76	South	
10	70	89	.....	.....	70	78	North	Clear.
11	68	80	.....	.....	70	72	.....	Cloudy; rain.
12	70	82	.....	.....	70	75	Calm	Clear.
13	62	82	.....	.....	74	80	....do	
14	64	80	.....	.....	74	76	Southwest, strong	
15	68	74	.....	.....	72	76	....do	
16	68	80	.....	.....	75	75	North	Clear.
17	67	76	.....	.....	72	78	West	Shower.
18	72	75	.....	.....	70	73	Southwest	Do.
19	65	74	.....	.....	70	72	....do	
20	65	78	.....	.....	70	70	Northeast	Rain.
21	56	75	.....	.....	70	70	Southwest	Clear.
22	55	75	.....	.....	70	70	Southeast	Cloudy.
23	58	76	.....	.....	72	74	North	Clear.
24	65	76	.....	.....	75	77	Southwest	Do.
25	60	72	.....	.....	75	74	....do	Cloudy.
26	60	70	.....	.....	65	74	East and southeast	Do.
27	62	76	.....	.....	65	78	Southwest	Do.
28	64	78	.....	.....	70	82	....do	Clear.
29	64	80	.....	.....	75	82	Southeast	Cloudy.
30	65	78	.....	.....	72	80	....do	Do.
31	66	68	.....	.....	74	76	Calm	Do.
Sums ...	1948	2181	.....	.....	2191	2338		
Means ..	62. 8	80	.....	.....	70. 7	75. 4		
Aug. 1	68	68	.....	.....	72	72	Southwest	Clear.
2	66	80	.....	.....	72	80	West	Do.
3	65	80	.....	.....	69	78	Southwest	Do.
4	64	79	.....	.....	72	82	Northwest	Do.
5	70	75	.....	.....	72	74	.....	Cloudy; shower.
6	75	76	.....	.....	72	74	.....	
7	60	80	.....	.....	70	75	South	
8	65	70	.....	.....	71	72	....do	Cloudy.
9	68	84	.....	.....	72	72	Northwest	Clear.
10	59	68	.....	.....	70	72	....do	Do.
11	62	80	.....	.....	70	76	....do	
12	62	82	.....	.....	72	78	....do	Clear.
13	58	72	.....	.....	70	76	....do	Do.
14	54	78	.....	.....	70	72	....do	Do.
15	58	80	.....	.....	70	76	South-southwest	Do.
16	60	68	.....	.....	71	76	.....	Fog.
17	65	84	.....	.....	70	77	Northwest	Clear.
18	49	72	.....	.....	70	72	Southwest, heavy	Do.
19	54	76	.....	.....	70	76	Northwest	Do.

TABLE I.—*Record of temperature at Craig's Pond Brook, Orland, Me.*, 1871—Continued.

Date.	TEMPERATURE, (FAHRENHEIT.) Air. 5½ a. m.	Air. 3½ p. m.	Brook. 5½ a. m.	Brook. 3½ p. m.	Allamoosook Pond. 5½ a. m.	Allamoosook Pond. 3½ p. m.	Wind.	Remarks.
1871.								
Aug. 20	56	72	.....	.....	64	72	Northwest	Clear,
21	56	78	.....	.....	68	76	....do	Do.
22	48	80	.....	.....	68	76	Southwest	Do.
23	50	78	.....	.....	69	76	Southwest, heavy	Do.
24	54	76	.....	.....	68	74	.....	
25	60	90	.....	.....	70	76	Calm	
26	50	80	.....	.....	66	70	....do	
27	60	67	.....	.....	70	70	....do	
28	60	80	.....	.....	66	70	Northwest	Cloudy.
29	60	70	.....	.....	70	70	South-southeast	Do.
30	62	70	.....	.....	70	72	South	Do.
31	60	78	.....	.....	68	75	Southwest	Clear.
Sums	1858	2371	.....	.....	2162	2307		
Means	59.9	76.5	.....	.....	69.7	74.4		
Sept. 1	52	76	.....	.....	70	74	North	Clear.
2	58	64	.....	.....	64	66	....do	Rain.
3	60	66	.....	.....	65	65	South	Clear.
4	64	78	.....	.....	65	70	....do	Do.
5	60	78	.....	.....	65	72	Southwest	Do.
6	74	78	.....	.....	70	74	....do	Foggy.
7	74	76	.....	.....	70	74	....do	Do.
8	48	64	.....	.....	64	66	North	
9	50	66	.....	.....	58	66	South	
10	58	67	.....	.....	62	66	Calm	Clear.
11	48	72	.....	.....	62	70	West	Do.
12	44	65	.....	.....	62	68	Southeast	Do.
13	58	70	.....	.....	60	69	North	Do.
14	40	66	.....	.....	59	65	....do	Do.
15	32	60	.....	.....	60	64	Southeast	Do.
16	52	58	.....	.....	60	62	.....	Rain.
17	56	58	.....	.....	60	62	.....	Overcast.
18	44	62	.....	.....	60	62	North	Clear.
19	56	60	.....	.....	60	60	South	Cloudy.
20	58	62	.....	.....	60	61	North	Clear.
21	52	60	.....	.....	58	60	....do	Do.
22	32	60	.....	.....	56	61	....do	Do.
23	44	60	.....	.....	60	60	Southeast	Do.
24	50	58	.....	.....	56	60	North	Do.
25	44	60	.....	.....	58	60	Southeast	Do.
26	48	58	.....	.....	60	60	....do	Cloudy.
27	58	62	.....	.....	57	60	....do	Do.
28	52	58	.....	.....	60	60	....do	Do.
29	42	57	.....	.....	60	60	North	Clear.
30	42	56	.....	.....	57	59	....do	Do.
Sums	1550	1935	.....	.....	1838	1936		
Means	51.6	64.5	.....	.....	61.2	64.5		
Oct. 1	42	56	.....	.....	58	58	Southwest	Clear.
2	50	56	.....	.....	58	58	....do	Do.
3	50	55	.....	.....	58	58	....do	Do.
4	54	56	.....	.....	58	58	....do	Do.
5	50	60	.....	.....	56	60	....do	Do.
6	58	64	.....	.....	59	60	....do	Cloudy.
7	54	64	.....	.....	60	60	Northwest	Do.
8	42	63	.....	.....	54	60	North	Clear.
9	44	60	.....	.....	58	60	.....	Clear in afternoon.
10	56	58	.....	.....	58	60	West	Clear.
11	59	64	.....	.....	60	60	South	Cloudy; showers.
12	65	63	.....	.....	60	60	Southeast	Do.
13	42	67	.....	.....	58	61	Northeast	Clear.
14	50	62	.....	.....	59	60	....do	Cloudy.
15	55	62	.....	.....	58	58	South	Do.
16	50	60	.....	.....	56	58	Northwest	Clear.
17	34	.....	.....	.....	54	.....	.....	
18	42	55	.....	.....	56	60	North	
19	35	54	.....	.....	54	59	South	

TABLE I.—*Record of temperature at Craig's Pond Brook, Orland, Me.*, 1871—Continued.

Date.	TEMPERATURE, (FAHRENHEIT.)						Wind.	Remarks.
	Air.		Brook.		Allamoosook Pond.			
	6 a. m.	4 p. m.	6 a. m.	4 p. m.	6 a. m.	4 p. m.		
1871.								
Oct. 20	44	40	.....	.....	56	58	North.....	
21	23	38	.....	.....	50	56	.....	
22	22	40	.....	.....	52	52	South.....	
23	40	60	.....	.....	50	54	.....	
24	40	52	.....	.....	50	55	.....	
25	30	.....	.....	.....	48	.....	.....	
26	48	.....	.....	.....	50	.....	.....	
27	48	.....	.....	.....	50	.....	.....	
28	50	.....	.....	.....	49	.....	.....	
29	.....	.....	.....	.....	.....	.....	.....	
30	38	.....	.....	.....	49	.....	.....	
Sums...	1315	1309	.....	.....	1596	1343		
Means..	45.3	56.9	.....	.....	55	58.4		
Nov. 1	40	.....	.....	.....	60	.....	.....	
2	41	.....	.....	.....	58	.....	.....	
3	35	.....	.....	.....	56	.....	.....	
4	40	.....	45	.....	.....	.....	.....	
5	34	.....	46	.....	.....	.....	.....	
6	.....	.....	46	.....	.....	.....	.....	
7	.....	.....	45	.....	.....	.....	.....	
8	.....	.....	45	.....	.....	.....	.....	
9	.....	.....	45	.....	.....	.....	.....	
10	.....	.....	44	.....	.....	.....	.....	
11	.....	.....	44	.....	.....	.....	.....	
12	.....	.....	44	.....	.....	.....	.....	
13	22	36	44	.....	.....	.....	.....	
14	25	.....	44	.....	.....	.....	.....	
15	.....	.....	44	.....	.....	.....	.....	
16	.....	.....	44½	.....	.....	.....	.....	
17	.....	.....	46	.....	.....	.....	.....	
18	.....	.....	46½	.....	.....	.....	.....	
19	.....	.....	45	.....	.....	.....	.....	
20	.....	.....	44	.....	.....	.....	.....	
21	.....	.....	44	.....	.....	.....	.....	
22	.....	.....	44	.....	.....	.....	.....	
23	.....	.....	40	.....	.....	.....	.....	
25	.....	.....	41	.....	.....	.....	.....	
26	.....	.....	40	.....	.....	.....	.....	
27	.....	.....	42	.....	.....	.....	.....	
28	3	.....	41	.....	.....	.....	.....	
29	5	.....	42	.....	.....	.....	.....	
30	8	.....	41	.....	.....	.....	.....	
Sums...	.....	.....	1137	.....	.....	.....		
Means..	.....	.....	43.7	.....	.....	.....		
Dec. 1	9	.....	40	.....	.....	.....	.....	
2	16	.....	41	.....	.....	.....	.....	
3	.....	.....	41	.....	.....	.....	.....	
4	38	.....	43	.....	.....	.....	.....	
5	8	.....	41	.....	.....	.....	.....	
6	14	.....	39	.....	.....	.....	.....	
7	16	.....	40	.....	.....	.....	.....	
8	19	.....	40	.....	.....	.....	.....	
9	20	.....	41	.....	.....	.....	.....	
10	24	.....	42	.....	.....	.....	.....	
11	20	.....	41	.....	.....	.....	.....	
12	0	.....	40	.....	.....	.....	.....	
13	.....	.....	40	.....	.....	.....	.....	
14	.....	.....	41	.....	.....	.....	.....	
15	1	.....	40	.....	.....	.....	.....	
16	0	.....	40	.....	.....	.....	.....	
Sums...	183	.....	650	.....	.....	.....		
Means..	14	.....	43.7	.....	.....	.....		

TABLE II.—*Record of temperature at Salmon Pond, Bucksport, Me., in 1872.*

Date.	Temperature of the air.					Temperature of water.										Wind.	Remarks.
						Bottom.*					Surface.						
	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872.																	
June 20	52	61	71	60	64	60	60	60	..	60	71	72	72	71	71. 7	Southwest	Clear.
21	51	52	70	60	60. 7	60	60	60	..	60	70	71	72	72	71. 7	Southerly, brisk	Foggy morning, then clear.
22	56	62	80	68	70	60	60	61	60	60. 3	61	70	79	73	73. 74	Northwest in morn'g.	
23	60	62	74	60	65. 3	60	61	61	61	61	70	71	80	80	77	Southerly	Foggy.
24	60	61	70	60	63. 7	60	61	61	60	60. 7	71	71	72	76	73	Southwest	Fogs and clouds.
25	56	59	74	61	64. 7	60	61	61	60	60. 7	68	71	76	70	72. 3	Southe'st to southw't	Do.
26	51	62	70	60	64	60	62	60	61	61	65	71	72	72	71. 7	Southeast	Cloudy.
27	60	61	68	60	61	60	60	61	60	60. 3	70	71	73	72	72	Southerly	Do.
28	58	59	64	59	60. 7	60	61	61	60	60. 5	68	70	72	71	71	....do	Foggy.
29	58	59	80	60	66. 3	60	60	61	60	60. 3	68	70	78	70	72. 7	....do	Foggy, then clear.
30	58	63	90	68	73. 7	61	62	62	61	61. 7	72	73	79	74	75. 3	....do	
Means ..					65. 2					60. 6					72. 9		

Date.	Temperature of the air.					Temperature of water.										Wind.	Remarks.
						Bottom.					Surface.						
	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872.																	
July 1	61	68	89	72	76. 3	60	61	63	61	61. 7	72	73	81	75	76. 3	Variable	Cloudy.
2	57	60	78	67	68. 3	60	60	61	60	60. 3	65	69	76	75	73. 3	Northeast	Do.
3	60	61	61	58	60. 7	60	60	60	60	60	68	68	71	72	70. 3	Southeast	Hazy.
4	60	62	62	72	65. 3	60	62	61	62	61. 7	67	78	70	72	73. 3	....do	Cloudy; heavy thunder-shower.
5	63	70	81	72	74. 3	60	60	61	61	60. 7	70	76	72	71	73	Easterly	
6	68	72	80	74	75. 3	61	61	61	61	61	72	73	74	71	72. 7	Northwest	Clear.
7	69	71	81	72	74. 7	61	61	62	61	61. 3	70	72	78	71	73	Southwest	Do.
8	68	70	79	64	71	61	61	61	61	61	72	73	73	70	72	Variable	Do.
9	60	63	72	68	67. 7	60	60	61	61	60. 7	70	71	73	70	71. 3	Southwest, brisk	Do.
10	68	69	71	66	68. 7	60	60	60	60	60	72	72	72	70	71. 3	Southwest	Foggy morning.
11	73	74	78	76	76	60	60	60	60	60	75	76	73	75	74. 7	Westerly	
12	69	73	78	63	71. 3	60	60	61	60	60. 3	73	75	73	72	73. 3	Variable	
13	61	65	76	64	*8. 3	60	60	60	60	60	70	72	72	72	72	Northwest	Clear.
14	62	63	74	60	65. 7	65	65	65	65	65	70	74	74	73	73. 7	Southerly	Do.
15	66	62	76	64	66. 7	67	67	67	67	67	71	72	73	72	72. 3	Southeast	Fog.
16	70	73	89	71	74. 3	68	68	70	70	69. 3	72	73	78	74	75	Southerly	Clear.
17	7:	76	78	70	74. 3	70	70	70	70	70	73	73	76	73	74	Southeast	Cloudy.
18	66	63	63	60	62	70	70	70	70	70	73	74	76	73	74. 3	... do	Fog and clouds.
19	66	61	85	65	70. 3	71	71	71	71	71	73	73	78	73	74. 7	Southwest	Rain.
20	61	68	80	65	71	71	71	71	71	71	73	73	76	72	73. 7	Northwest	Clear.
21	61	68	75	68	70. 3	71	71	71	71	71	72	73	76	75	74. 7	Southwest	Do.
22	56	58	61	69	62. 7	71	71	71	70	70. 7	72	72	72	73	72. 3	Southerly	Rain.
23	56	58	70	60	62. 7	68	68	71	70	69. 7	70	70	73	71	71. 7	Northwest	
24	60	63	71	65	66. 3	70	70	70	70	70	71	72	74	73	73	Southerly	Rain.
25	62	68	78	68	71. 3	71	71	71	71	71	72	75	76	76	75. 7	Northwest	Clear.
26	58	60	65	60	61. 7	71	71	71	71	71	73	73	73	72	72. 7	Southeast	Cloudy.
27	56	58	62	60	60	68	68	70	70	69. 3	70	70	71	70	70. 3	Northwest	Rain in morning.
28	58	60	68	64	64	68	68	71	70	69. 7	70	70	74	73	72. 3	....do	Clear.
29	59	60	70	68	66	68	70	71	70	70. 3	70	71	73	72	72	Variable	Cloudy and showers.
30	55	58	70	65	61	67	67	71	70	69. 3	69	70	73	73	72	Northwest	
31	57	59	68	63	63. 3	68	70	70	70	70	70	73	74	72	73	Westerly	Clear.
Means ..					68. 1					65. 9					73. 1		

*The observations on the bottom temperature were obtained by sinking a closed tin can to the bottom and keeping it there at all times except at the moment of observation, when it was drawn up, the cover removed, and the bulb of the thermometer inserted in the water. The depth at the point of observation was from eight to ten feet. The surface temperature was measured at the same place as the bottom temperature, and the position was changed several times during the summer.

TABLE II.—*Record of temperature at Salmon Pond, Bucksport, Me., in* 1872—Continued.

Date.	Temperature of the air.					Temperature of water.										Wind.	Remarks.
						Bottom.					Surface.						
	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872.																	
Aug. 1	60	62	70	58	63. 3	68	68	71	70	69. 7	70	70	73	72	71. 7	Northwest	Clear.
2	60	63	70	59	64	65	68	70	70	69. 3	70	72	73	71	72	Southwest	
3	55	52	63	59	58	60	68	70	70	69. 3	68	70	72	71	71	Southeast	Fog and showers.
4	56	60	60	58	59. 3	68	70	70	70	70	70	72	73	71	72	Northwest	Cloudy.
5	58	61	63	57	60. 3	67	70	70	70	70	70	71	72	71	71. 3	Variable	Clear; rain ½ inch.
6	60	63	72	63	67. 7	68	70	70	70	70	71	74	75	71	74	Southerly	
7	58	60	68	65	64. 3	60	61	70	70	67	69	70	72	71	71	Southeast	Foggy morning.
8	59	60	70	67	65. 7	60	62	71	71	68	68	70	73	72	71. 7	....do	Fog and clouds.
9	62	68	70	68	68. 7	70	70	71	70	70. 3	73	74	75	74	74. 3	....do	Clear.
10	60	63	72	69	68	68	69	70	70	69. 7	70	70	73	72	71. 7	....do	Do.
11	68	70	78	72	73. 3	71	71	70	71	70. 7	70	74	75	73	74	....do	Cloudy; rain ½ inch.
12	67	69	70	70	69. 7	70	70	70	70	70	72	73	75	73	73. 7	Southerly	Cloudy.
13	68	69	72	67	69. 3	70	70	70	70	70	73	74	74	72	73. 3	Southeast	Rain ½ inch.
14	68	71	76	68	71. 7	70	71	71	71	71	72	76	77	74	75. 7	Southwest	Foggy.
15	63	65	67	68	66. 7	70	70	70	70	70	72	73	74	73	73. 3	Southeast	Cloudy.
16	68	70	73	68	70. 3	70	70	70	70	70	73	74	75	73	74	Northeast	Do.
17	67	68	70	69	69	70	70	70	70	70	73	74	73	72	73	Southerly	Rain 1 inch.
18	67	69	73	69	70. 3	70	70	70	70	70	74	75	76	73	74. 7	Southeast	
19	67	78	85	72	78. 3	70	70	71	70	70. 3	73	74	78	76	76. 7	Variable	
20	67	78	83	72	77. 7	70	71	71	71	71	73	76	75	75	75. 3	Northwest	Clear.
21	68	79	70	68	72. 3	70	70	70	70	70	74	75	75	75	75	Southeast	Foggy.
22	65	68	69	67	68	70	70	70	70	70	73	73	74	74	73. 7	....do	Rain ¼ inch.
23	67	68	70	67	68. 3	70	70	70	70	70	73	74	74	73	73. 7	Northwest	Clear.
24	64	66	67	68	67	70	70	70	70	70	74	75	74	73	75	Southerly	Do.
25	66	71	73	69	71	70	70	70	70	70	76	78	76	74	76	....do	
26	68	70	78	70	72. 7	70	70	70	70	70	77	78	78	74	76. 7	....do	
Means					68. 3					69. 8					73. 6		

Date.	Temperature of the air.					Temperature of water.										Wind.	Remarks.
						Bottom.					Surface.						
	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872.																	
Sept. 17		61					63					68				Variable	Cloudy.
18		63					63					67				Southerly	Do.
19		62					63					66				Southeast	Cloudy; rain.
20		59					61					63				Westerly	Cloudy; rain 1 inch.
21		63					60					65				....do	
22		61					60					64				Southerly	Clear.
23		60					58					60				Northwest	Do.
24		58	60				57					60				Southeast	Thunder-shower.
25		58	62				58					60				Southerly	Cloudy.
26		58	61				57					59				Southwest	Rain and fog.
27		59	60				58					60				Southerly	Cloudy.
28		50	60				59					60				Northwest	Rain 2 inches.
29		60	62				55					60				....do	Clear.
30		52	60				54					59				Southerly	Rain.
Means							59. 0					62. 2					

TABLE II.—*Record of temperature at Salmon Pond, Bucksport, Me., in* 1872—Continued.

Date.	Temperature of the air.					Temperature of water.										Wind.	Remarks.
						Bottom.					Surface.						
	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872. Oct. 1																	
2	58	61				54					59					Southwest	Cloudy.
3	52	60				55					59					Westerly	Rain 1 inch.
4	50	60				59					59					Variable	Clear.
5																Northwest	Do.
6	50	51				53					59					Southwest	Do.
7	42	52				52					59					do	Cloudy.
8	50	51				51					57					Southeast	Do.
9	50	53				51					57					Westerly	Rain 1¼ inches.
10	43	50				50					53					Northwest	Clear.
11	42	53				50					52					Variable	
12	40	51				49					50					Northwesterly	Rain ½ inch.
13	31	48				48					49					Variable	Clear.
14	42	50				49					50					Easterly	Rain.
15	50	52				49					50					Southerly	Do.
16	40	51				45					49					Westerly	
17	40					45					48					do	Cloudy and rain.
18	40	49				49					50					Southerly	Clear.
19	41	50				48					50					Southeasterly	Cloudy; rain.
20	41	51				49					49					Northwesterly	Cloudy.
21	49	52				53					55					do	Clear.
22	30	53				48					49					Variable	Do.
23	31	53				48					48					Southeasterly	
24	26	38														Variable	Rain.
25	36	40														Northwest	Clear.
26	28	31														Variable	Do.
27	32	34														Easterly	Rain.
28	23	28														Northwesterly	Do.
29	30	35														Northerly	Clear.
30	35	38														Northwesterly	Do.
31	36	39														do	Do.
	23	35														do	Rain.
Means	39.4	46.5				50.3					54.3						

Date.	Temperature of the air.					Temperature of water.										Wind.	Remarks.
						Bottom.					Surface.						
	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872. Nov. 1																	
2	30	38															
3	32	37															
4	33	35															
5	30	30															
6	21					30½					38						
7	29					40					32						
8	45					41					41						
9	39					41					41						
10	39					41					41						
11	31					40					40						
12	26					40					32						
13	43					41					40						
14	38					41					41						
15	28					41					41						
16	38					41½					41						
	23					41					32						
Means	32.8					40.7					38.3						

TABLE III.—*Record of temperature at hatching-house of Penobscot salmon-breeding works, Bucksport, Me., 1872 and 1873.*

Date.	Temperature of air.				Temperature of water.				Wind.	Weather.
	7 a. m.	1 p. m.	9 p. m.	Mean.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872.										
Nov. 1	30	38	.....	.....	44	44	44	44	Northeasterly	Rain.
2	32	37	.....	.....	44	44	43	43.7	Northeast	Do.
3	33	35	.....	.....	43	43	42	42.7	Northerly	Rain and snow.
4	30	37	24	30.3	37	41.5	40	39.5	....do	Clear.
5	21	40	28	29.6	37	42.5	41	40.1	....do	Do.
6	29	43	44	38.6	40	41	41	40.6	Southerly	Cloudy; rain. } 2.7 in.
7	45	49	38	44	42	42	42	42	Easterly	Rain }
8	39	45	40	41.3	41	42	42	41.6	Southwest	Cloudy }
9	39	47	39	41.6	41	42	41	41	Westerly	Cloudy.
10	31	40	32	34.3	40	40	39	39.6	Northwest	Clear.
11	26	40	37	34.3	39	40	39.5	39.8	Southerly	Do.
12	43	47	45	45	40	41	41	40.6	Southeast	Cloudy; rain.
13	38	46	33	39	41	42	41	41.3	Westerly	Clear.
14	28	42	42	37.3	40.5	41	41	40.8	Variable	Rain.
15	38	42	26	35.3	41	42.5	40.5	41.3	Northwest	Clear.
16	23	36	30	29.6	41	40	40	40.3	Southerly	Do.
17	26	37	23	28.6	39	40	38	39	Northwest	Do.
18	22	35	34	30.3	38	39	38	38.3	Southerly	Cloudy.
19	24	40	30	31.3	38	38.5	37.5	38	....do	Clear.
20	32	36	27	31.6	37.5	38	37	37.5	Southwest	Snow in morning.
21	20	29	27	25.3	35	36.5	36	35.8	Southerly	Clear.
22	32	38	32	34	36	37.5	37	36.8	Variable	Snow.
23	29	34	27	30	35	36	36	35.6	....do	Cloudy.
24	29	42	29	33.3	36	36.5	36	36.1	....do	Do.
25	36	45	41	40.6	36	37	36	36.3	Southwest	Do.
26	28	37	33	32.6	36	37	37	36.6	....do	Do.
27	28	32	33	31	36	36.5	36	36.1	Northwest	Do.
28	26	30	20	25.3	36	37	35	36	....do	
29	27	31	35	31	36	36	37	36.3	Northeast	Snow.
30	20	25	17	20.6	36	36	35.5	35.9	Southwesterly	Do.
Means	.....	.....	.....	37.3	.....	.....	.....	34.4		
Dec. 1	15	29	27	23.6	36	36.5	35.5	36	Southwesterly	Clear.
2	30	37	31	32.6	36.5	36.5	36.5	36.5	Variable	Cloudy; rain and snow.
3	34	36	34	34.6	36.5	36.5	36	36.3	Westerly	Slight snow.
4	31	31	21	27.6	36	36.5	36.5	36.3	Variable	
5	20	35	27	27.3	36	36.5	36	36.2	....do	Snow.
6	19	35	23	25.6	36	36.5	36	36.2	....do	Clear.
7	10	26	8	14.6	35.5	36.5	35.5	35.8	Westerly	Do.
8	28	37	33	32.6	35.5	35.5	35.5	35.5	Easterly	Snow and rain.
9	34	33	30	32.3	36	36	35.5	35.8	Northerly	Snow.
10	15	18	10	14.3	35	35.5	35.5	35.3	Northwest	Do.
11	10	20	8	12.6	35	35.5	35.5	35.3	Westerly	Clear.
12	− 9	12	8	3.6	35	36	35.5	35.5	....do	Clear in morning, clouds in evening.
13	5	16	6	9	35	36	35.5	35.5	Northerly	Clear.
14	21	32	20	24.3	35.5	36.5	35.5	35.8	Southwest	
15	32	38	21	30.3	35.5	35.5	35.5	35.5	....do	Rain in morning, clear in evening.
16	6	24	23	17.6	35	36	36	35.6	Southeast	Snow.
17	20	28	0	16	35.5	36	36	35.8	Northerly	Do.
18	− 7	26	27	15.3	35.5	36	36	35.8	Variable	Do.
19	19	23	9	17	36	36	35	35.6	Westerly	Clear.
20	15	26	17	19.3	35	35.5	35	35.2	Northeast	Snow.
21	18	26	− 2	14	35	36	35.5	35.5	Westerly	Clear.
22	23	16	0	13	35	34.5	34.5	34.6	Northwest	Snow 10 inches.
23	− 8	16	5	4.3	34.5	35	34.5	34.6	Easterly	Snow.
24	− 1	3	−10	−2.6	34.5	34.5	34	34.3	Northwest	Clear.
25	−16	− 1	− 8	−8.3	34	34	34	34	West	Do.
26	− 9	2	1	−2	33.5	34	33.5	33.6	Northeast	Snow.
27	− 5	9	4	2.6	33	34.5	33	33.5	Northwest	Do.
28	− 5	6	− 3	−0.6	33.5	34	33.5	33.6	Westerly	Clear.
29	−19	10	5	−1.3	33	34	33	33.3	....do	Do.
30	− 3	10	0	2.3	33.5	34	33.5	33.6	Northwest	Do.
31	−10	12	3	1.6	33.5	34.5	34	34	Variable	Snow.
Means	.....	.....	.....	14.6	.....	.....	.....	35.17		
1873.										
Jan. 1	−10	22	− 8	1.3	33.5	34.5	33.5	33.8	Northwest	Clear.
2	−12	20	20	9.3	33.5	34	34	33.8	Variable	
3	32	38	33	34.3	34.5	34.5	34.5	34.5	....do	Rain.
4	23	36	20	26.3	34	34.5	34.5	34.3	Westerly	Clear.

TABLE III.—*Record of temperature at hatching-house, &c.*—Continued.

Date.	Temperature of air.				Temperature of water.				Wind.	Weather.
	7 a. m.	1 p. m.	9 p. m.	Mean.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1873.										
Jan. 5	7	28	32	22.3	34	34	34	34	Easterly	Snow and rain.
6	34	30	11	25	33.5	35	36	34.8	Westerly.....	Clear.
7	− 5	15	− 2	2.6	33.5	33.5	33.5	33.5	Northwest....	Do.
8	8	29	31	22.6	34	35	33.5	34.1	Variable	Cloudy.
9	33	31	22	28.6	33.5	33.5	33.5	33.5	....do	Rain.
10	12	22	− 2	10.6	33	34	33.5	33.5	Southwest.....	Clear.
11	−11	10	3	0.6	33.5	34	33.5	33.6	Westerly.....	Do.
12	− 3	7	− 1	1	33	33.5	33	33.1	Northwest	Do.
13	−14	20	30	12	33	33.5	33.5	33.3	Southeast	Snow.
14	34	46	15	31.6	33.5	33.5	33	33.3	Variable	Cloudy.
15	1	15	30	15.3	33	33.5	33.5	33.3	Northwest	Clear.
16	33	39	39	37	33.5	33.5	33.5	33.5	Southerly	Cloudy.
17	41	42	32	38.3	33.5	33.5	33	33.3	....do	Rain.
18	20	22	22	21.3	33	33.5	33.5	33.3	Northeast	Sleet.
19	22	34	27	27.6	33.5	34	33.5	33.6	Westerly.....	Rain.
20	14	27	28	23	33.5	34	34	33.8	Southerly	Clear.
21	32	36	32	33.3	34	34	34	34	Northwest	Snow.
22	32	34	25	30.3	34	34	34	34	Westerly.....	Do.
23	14	15	9	12.6	33.5	34	33.5	33.6	Northwest	Clear.
24	1	9	12	7.3	33	34	33.5	33.5	Northeast.....	Snow.
25	14	22	15	17	33.5	34	33	33.5	Northwest	Clear.
26	2	24	14	13.3	33	33.5	33	33.1	Easterly	Do.
27	28	26	22	25.3	33	33.5	33	33.1	Variable	Cloudy.
28	15	28	23	22	33	33.5	33	33.1	....do	Do.
29	− 1	4	−15	−4	33	33.5	33	33.1	Northwest	Clear.
30	−22	19	14	36	33	33.5	33.5	33.3	Variable	Do.
31	18	28	13	19.6	33.5	34	33.5	33.6	Northerly	Do.
Means ...	.....	.....	.....	18.4	.....	.....	.....	34.6		
Feb. 1	19	23	9	17	33.5	34	34	33.8	Northerly	A little snow.
2	− 7	7	3	1	33.5	34	33.5	33.7	Northwest	Pleasant.
3	−13	22	21	10	33.5	34	33.5	33.7	Northerly	Do.
4	17	35	32	28	33.5	34	33.5	33.7	Southerly	Foggy.
5	22	25	9	18.7	33.5	34	33.5	33.7	Northerly	Pleasant.
6	− 3	32	28	19	33.5	34	34	33.8	Southerly	Do.
7	29	40	34	34.3	34	34.5	34	34.2	South-southe'st	Pleasant in morning, cloudy in evening.
8	24	40	30	31.3	34	34.5	34	34.2	Northeast and westerly.	Snow in morning, pleasant in evening.
9	18	33	9	20	34	34.5	34	34.2	Northerly	Pleasant.
10	0	11	0	3.7	34	34.5	34	34.2	....do	Wind strong; clear.
11	−11	19	13	7	33.5	34	34	33.8	Northeast	Snow.
12	12	22	0	11.3	34	34.5	34	34.2	Northerly	Cloudy in morning, clear in evening.
13	− 4	17	− 2	3.7	34	34.5	34	34.2	Northwest	Clear; wind strong.
14	− 1	15	0	4.7	34	34.5	34	34.2	Northerly	Clear.
15	− 8	26	− 1	5.7	33	34	33.5	33.5	Southerly	Cloudy and pleasant.
16	− 6	36	30	20	33.5	33.5	33.5	33.5	Northerly and southerly.	Cloudy; wind variable.
17	29	36	27	30.7	33.5	34	34	33.8	Northerly	Clear.
18	12	27	15	18	34	34.5	33.5	34	Northwest	Do.
19	22	31	32	28.3	34	34.5	34	34.2	Southeast.....	Snow.
20	29	32	10	23.7	34	35	33.5	34.2	Northwest	Clear.
21	− 4	27	20	14.3	33	34.5	34	33.8	Northeast.....	Cloudy; wind variable.
22	27	28	17	24	33	34	33.5	33.5	.....	Heavy snow.
23	10	27	8	15	33.5	34	33.5	33.7	Westerly and southerly.	Clear.
24	− 4	13	6	5.0	33.5	34	33.5	33.7	Southwest	Do.
25	−13	34	24	15	33	34.5	34	33.8	Southerly and westerly.	Do.
26	22	30	26	26	33.5	34.5	33.5	33.8	Northwesterly	Do.
27	6	38	29	24.3	33.5	34	33.5	33.7	Northerly	Cloudy; wind strong.
28	27	40	29	32	33.5	34	33.5	33.7	....do	Cloudy.
Means ...	.....	.....	.....	17.6	.....	.....	.....	33.5		
March 1	27	40	29	32	33.5	34	33.5	33.7	.....	Cloudy.
2	26	40	16	27.3	33.5	34.5	33	33.7	Northerly	Clear.
3	24	32	26	27.3	33	33	32.5	32.8	....do	Snow; wind strong.
4	21	26	12	19.7	32.5	34	33	33.2	Northwest	Clear; wind strong.
5	− 4	28	9	11	33	34.5	33	33.2	.....	Clear, calm.
6	−13	29	25	13.7	33	34.5	33	33.2	Northerly and southerly.	Clear.

TABLE III.—*Record of temperature at hatching-house, &c.*—Continued.

Date.	Temperature of air.				Temperature of water.				Wind.	Remarks.
	7 a. m.	1 p. m.	9 p. m.	Mean.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1873.										
March 7	22	36	28	28.7	33	34.5	33	33.2	Southwesterly	Clear.
8	30	38	36	34.7	33	35	33	33.7	Southeast	Do.
9	35	41	20	32	33	34	33	33.3	Westerly	Snow-squall in morning, clear in evening.
10	23	26	15	21.3	33	32.5	32.5	32.7	Northeast	Heavy snow.
11	— 4	40	32	22.7	32.5	34	32.5	33	Easterly	In evening snow.
12	30	40	24	31.3	33	35	33.5	33.8	do	Clear.
13	6	43	26	25	33	35	33.5	33.8	Northerly and westerly.	Do.
14	25	41	30	32	33	35	33	33.7	Northerly	Do.
15	29	42	36	35.7	33	35	33	33.7	Southeasterly	Cloudy, snow in evening.
16	34	43	31	36	33	34	33	33.3	Southwest	Clear and cloudy.
17	22	40	27	29.7	33	35	33.5	33.8	Northerly	Clear.
18	18	41	30	29.7	33	35.5	33.5	34	Southerly and easterly.	Clear morning, cloudy evening.
19	30	42	26	32.7	33	35	33.5	33.8	Northeast	Cloudy.
20	10	36	30	25.3	33	35	33	33.7	do	Cloudy, snow in evening.
21	32	37	31	33.3	32.5	34	33.5	33.3	Northeast to southwest.	Heavy snow last night, snow in evening.
22	26	36	29	30.3	33	35.5	33.5	34	Northwest	Clear.
23	25	46	22	31	33	35.5	33.5	34		Cloudy.
24	16	40	11	22.3	33	35.5	33.5	34	Northwesterly	Clear.
25	4	34	23	20.3	32.5	35	33	33.5	Northerly	Do.
26	—24	39	35	32.7	33	35.5	33.5	34	Northeast	Rain in evening.
27	24	32	25	27	33	35.5	33.5	34	Northwest	Snow in morning.
28	6	34	32	20.7	33	35	33.5	33.8	Southeast	Clear.
29	32	44	36	37.3	33	35	33.5	33.8	Southerly and easterly.	Cloudy and rain.
30	36	43	32	37	33	34	33	33.3	Easterly and northerly.	Rain.
31	30	36	34	33.3	32.5	34	32.5	33	Northeast	Snow.
Means				28.1				33.9		
April 1	36	48			32.5	34			Northerly	Clear in morning, cloudy in evening.
2	33	32			32.5	34			Easterly	Rain and sleet.
3	34	42			32.5	34			Southerly	Cloudy.
4	37	48			32.5	33.5				
5	32	49			32.5	33.5			Westerly	Clear.
6	33	42			32.5	33.5			Easterly	Cloudy and rain.
7	34	40			32.5	33			Southerly	Do.
8	34	37			32.5	33			do	Rain.
9	34	40			32.5	33			do	Cloudy and rain.
10	35	43			32.5	33			Southerly and northerly.	Rain in morning, clear in evening.
11	32	46			32.5	33				Clear.
12	34	45			32.5	33			Northeast	Partly clear; rain in evening.
13	34	39			32.5	33.5			do	Cloudy and rainy.
14	32	38			32.5	33.5			do	Snow in morning, then rain.
15	32	45			32.5	34			do	Rain.
16	35	45			33	34			Westerly	Clear.
17	36	48			33	34				Do.
18	37	49			33	34			Easterly	Rain.
19	34	36			33	33			Northeast	Snow.
20	41	50			34	35			Westerly	Clear.
21	35	38			33	33.5			Northeast	Rain.
22	40	50			33	34			West	Clear.
23	36	47.5			33	35			Northwest	Do.
24	43	57			34.5	36			Northeast	Cloudy.
25	44.5	59			34.5	35.5			do	Do.
26	41.5	49			36	37			Northwest	Mostly clear.
27	40	55			38	39			Westerly	Clear.
28	42	58			38	42			do	Do.
29	39	60			38	43			Southerly	Clear and some cloudy.
30	38	61			39	43			do	Clear.
Means	36.3	46.5			33.7	34.6				
May 1	45	65			41	48			Northerly	Clear.
2	44	60			45	49			Southerly	Cloudy.
3	34	35			44	44			Northeast	Snow.
4	39	49			42	47			North	Clear.

TABLE III.—*Record of temperature at hatching-house, &c.*—Continued.

Date.	Temperature of air.				Temperature of water.				Wind.	Remarks.
	7 a. m.	1 p. m.	9 p. m.	Mean.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1873.										
May 5	46	50	.....	.....	45	47	.....	.....	Northerly	Showery.
6	42	55	.....	.....	45	52	.....	.....	Westerly	Clear.
7	44	58	.....	.....	47	54	.....	.....	....do	Do.
8	44	59	.....	.....	47	55	.....	.....	Southwest	Do.
9	48	64	.....	.....	48	54	.....	.....	....do	Mostly clear.
10	49	51	.....	.....	51	52	.....	.....	Southeast	Cloudy; evening rainy.
11	53	55	.....	.....	51	53	.....	.....	....do	Cloudy; some rain, in evening thunder.
12	52	60	.....	.....	50	55	.....	.....	Southwesterly	Cloudy; showery.
13	45	66	.....	.....	52	56	.....	.....	Westerly	Clear.
14	42	55	.....	.....	51	55	.....	.....	Northwest	Cloudy; little rainy in morning.
15	42	58	.....	.....	50	56	.....	.....	....do	Clear and cloudy.
16	45	60	.....	.....	52	56	.....	.....	Northerly	Cloudy.
17	48	52	.....	.....	52	56	.....	.....	Northwest	Clear and cloudy; showery.
18	45	60	.....	.....	53	58	.....	.....	Westerly	Mostly clear.
19	50	56	.....	.....	53	57	.....	.....	Northerly	Clear.
20	48	64	.....	.....	53	59	.....	.....	North	Do.
21	43	61	.....	.....	53	58	.....	.....	Southwest	Do.
22	45	48	.....	.....	53	54	.....	.....	Southerly	Rainy.
23	51	71	.....	.....	54	58	.....	.....	Southwest	Cloudy.
24	52	69	.....	.....	54	58	.....	.....	....do	Clear evening; thunder-shower.
25	58	72	.....	.....	56	64	.....	.....	Northwest	Clear.
26	56	74	.....	.....	58	64	.....	.....	Southerly	Do.
27	57	72	.....	.....	59	61	.....	.....	....do	Rain in morning, clear in evening.
28	52	76	.....	.....	58	64	.....	.....	Southwest	Mostly clear.
29	69	79	.....	.....	63	68	.....	.....	Northerly	Clear.
30	57	59	.....	.....	64	68	.....	.....	....do	Do.
31	47	62	.....	.....	61	66	.....	.....	Northwest	Do.
Means ...	48.1	60.5	.....	.....	51.4	56.3	.....	.....		

TABLE IV.—*Observations on temperature of Penobscot River, at and near Bucksport.*

[Station 1 is in the entrance of the "Thoroughfare" that separates Bucksport from Orphan Island, and receives, with the flood-tide, a great deal of water from over extensive muddy flats, which warm it up in sunny weather, and on cool nights may have the opposite effect. Being on the east side of the river, the morning sun has less effect than it would on the western shore. Depth, about 30 feet.

Station 2 is in the main channel, opposite Fort Knox, and the tide was so strong that no satisfactory observations of bottom-temperature were secured.

Station 3 is at the southern end of Orphan Island, (town of Verona.) in close proximity to a good salmon-weir in the current, that sets up and down the western or main channel of the Penobscot. Depth, about 30 feet at low water. Observations here made at or a little before low water, each day.]

Date.	Hour.	State of tide.	Time since high water.	Weather.	Temperature of water.				
					Station 1.		Station 2.	Station 3.	
					Bottom.	Surface.	Surface.	Bottom.	Surface.
1872.			*Hrs.*						
June 17	3½ p. m.	Low slack	8½	Clear	46	63	.....	.....	.....
17	5½ p. m.	Flood	10½	....do	.....	67	.....	.....	.....
18	5½ p. m.	....do	9¼	Shower	49	61	61	.....	.....
18	10 a. m.	Ebb	2	....do	45	55	61	.....	.....
18	4 p. m.	Flood	8	....do	45	63	62	.....	.....
19	8 p. m.	High slack	12	....do	47	62	54	.....	.....
19	5 a. m.	Low water	.....	Clear	.....	.....	.....	45	5
19	8½ a. m.	Low slack	8½	....do	46	62	61	.....	.....
		High slack	12	....do	47	62	.....	.....	.....

TABLE IV.—*Observations on temperature of Penobscot River, &c.*—Continued.

Date.	Hour.	State of tide.	Time since high water.	Weather.	Temperature of water.				
					Station 1.		Station 2.	Station 3.	
					Bottom.	Surface.	Surface.	Bottom.	Surface.
1872.									
June 19	10 a. m.	Ebb	1	Clear	46	53	56		
20	a. m.	Low water		....do				44	57
20		High slack		....do	49	64			
21	a. m.	Low water		....do				54	58
21	7 p. m.	Flood	8½	....do	50	66	65		
22	a. m.	Low water		....do				57	64
22	8 a. m.	Low slack	8	....do	62	67	67		
22	1 p. m.	High water	1	....do	51	58			
22	a. m.	Low water		....do				46	53
23	9 a. m.	Low slack	8½	....do	63	69			
23	1½ p. m.	Early ebb	½	....do	52	59			
23	p. m.	Low water		....do				46	60
24	a. m.	....do		Cloudy				47	55
24	1½ p. m.	Early ebb	0	....do	52	59			
25	8½ a. m.	Low water	6	....do	61	66		46	57
25	1½ p. m.	High water	12	....do	53	66			
25	8 p. m.	Low water	5½	....do	51	58			
26	10 a. m.	Low water past	6½	Misty and showers	61	63			
27	10 a. m.	Low water	6	Clear	57	64		49	61
27	4 p. m.	Early ebb	0	....do	50	60			
28		Low water		Cloudy	55	63		50	60
28	5 p. m.	Early ebb	0	....do	51	59			
29		Low water		Clear				48	59
29	1 p. m.	Low water past	7	....do	49	65			
29	6 p. m.	Just turned high water	0	....do	50	65			
30	6½ a. m.	Early ebb	0	....do	49	59			
30		Low water		....do				47	57
July 1	8 a. m.	High water	½	Cloudy	50	60			
1	2 p. m.	Low water	6½	....do	50	65			
2	11 a. m.	High water	2½	....do	48	60			
2	3 p. m.	Low water	6½	....do	49	65			
3	9½ a. m.	High water	½	Hazy	50	61			
3	p. m.	Low slack		....do	53	63			
4	11 a. m.	Early ebb	0	....do	50	60			
4	p. m.	Low water		Clear, with thunder-shower.				48	57
5	Noon.	Early ebb	1½	Clear	51	62			
5	p. m.	Low water		....do				50	58
6	Noon.	Early ebb	2½	....do	52	60			
6	p. m.	Low water		....do				46	56
7	7 a. m.	Between low water and low slack.	7½	....do	50	64			
7	p. m.	Low water		....do				46	56
8	6 a. m.	....do	6	....do	50	61		46	55
8	1 p. m.	Early ebb	0	....do	51	61			
8	7½ p. m.	Low slack	6½	....do	50	65			
9	a. m.	Low water		Clear after fog				46	54
9	9½ a. m.	Low slack	8½	....do	50	67			
9	2 p. m.	Early ebb	½	....do	51	62			
10		Low water		Thunder-shower				45	57
11		....do		Clear after haze				50	60
12		....do		Clear				47	57
13		....do		....do				46	57
14		....do		....do				47	56
15		....do		Clear after fog				49	56
Mean during June					51.4	62.3	60.9	48.1	56.3
Mean during July					50.3	62.5		47.2	56.6
General mean					51.0	62.4	60.9	47.7	57.6

TABLE V.—*Observations on temperature of water in Eastern River and Dead Brook, Orland, Me.*

[Depth of water in Eastern River, 16 feet; in Dead Brook, 5½ feet. Dead Brook is a long, shallow stream, and the observations were taken at the point where salmon were kept in 1871. Eastern River comes from large ponds, and the temperature was observed within one-half mile of the outlet of one of them.]

Date.	Air.			Water in Eastern River.						Water in Dead Brook.					
				Bottom.			Surface.			Bottom.			Surface.		
	6 a. m.	2 p. m.	Mean.	6 a. m.	2 p. m.	Mean.	6 a. m.	2 p. m.	Mean.	6 a. m.	2 p. m.	Mean.	6 a. m.	2 p. m.	Mean.
1872.															
Aug. 27	.....	68	.....	.....	75. 5	.....	.....	75	.....	.....	68. 5	.....	.....	.....	.....
28	52	81	66. 5	72	73	72. 5	70	74	72	62	71	66. 5	61	68	64. 5
29	44	76	60	70	74	72	71	73	72	63	63	63	62	68	66
30	56	56	56	70	67	68. 5	70	68	69	63	61	62	63	60	66. 5
31	51	68	59. 5	67	69	68	66	68	67	57	62	59. 5	57	62	59. 5
Sept. 1	54	69	62. 5	67	69	68	67	68	67. 5	57	62	59. 5	57	62	59. 5
2	52	68	60	67	68	67. 5	66	69	67. 5	60	61	60. 5	60	62	61
3	52	62	57	66	66	66	66	66	66	59	62	60. 5	59	62	60. 5
4	44	61	52. 5	64	65	64. 5	64	65	64. 5	59	61	60	59	61	60
5	43	70	56. 5	63	67	65	63	68	65. 5	53	63	58	53	63	58
6	46	77	62. 5	64	67	65. 5	64	68	66	55	64	59. 5	56	61	58. 5
7	45	70	57. 5	63	67	65	63	68	65. 5	55	60	57. 5	55	60	57. 5
Means..	49	68	59. 1	66. 6	68. 9	67. 5	66. 3	69	67. 5	58. 4	63. 2	66. 6	58. 3	62. 6	66. 5

TABLE VI.—*Observations on temperature in Sandy River, at New Sharon, made by J. F. Pratt, M. D.*

[Station 1 is above the dam one-half of a mile; depth of water, 15 feet. Station 2 is below the dam four rods; depth of water, 10 feet.]

Date.	TEMPERATURE OF THE AIR, (FAHR.)		TEMPERATURE OF WATER, (FAHR.)							
			Station No. 1.				Station No. 2.			
			Bottom.		Surface.		Bottom.		Surface.	
	8 a. m.	2 p. m.	7 a. m.	2 p. m.	7 a. m.	2 p. m.	7 a. m.	2 p. m.	7 a. m.	2 p. m.
1872.										
September 2	64	77	63	62	.....	.....	62	63	.....	.....
3	52	66	62	.....	62	.....	61	62	.....	.....
4	49	50	62	.....	.....	.....	61	62	.....	.....
5	48	78	61	62	.....	65	60	63	61	66
6	51	79	62	62	62	65	61	64	62	65
7	65	70	64	65	64	65	63	64	64	64
8	79	88	65	66	68	70	65	68	66	68
9	61	70	67	68	68	70	66	68	67	70
10	52	74	68	69	68	71	67	.....	68	70
11	57	60	67	68	69	67	.....	67	68	69
12	64	74	66	66	68	69	.....	68	.....	68
13	65	71	.....	66	69	68	66	66	66	68
Sums	707	851	707	654	596	610	632	715	522	608
Means	58. 9	70. 9	64. 2	65. 4	66. 2	67. 7	63. 2	65	65. 2	67. 5

TABLE VII.—*Observations on temperature of water in the west branch of the Little Androscoggin River, at Norway, Me., made by A. B. Crockett.*

[The place where the observations were made was about one-eighth of a mile from the falls, in water eight to ten feet deep, being the deepest to be found. The bottom temperature was obtained by sinking a can and raising it by a line attached, as in the other cases. This stream drains Pennesseewassee Lake, a body of water of about 200 acres in area, deep and pure, and the place of observation was some distance below the outlet, but before reaching that point the water passed through numerous mill-wheels.]

Date.	TEMPERATURE OF THE AIR, (FAHR.)		TEMPERATURE OF WATER, (FAHR.)			
			Bottom.		Surface.	
	6 a. m.	2 p. m.	6 a. m.	2 p. m.	6 a. m.	2 p. m.
1872.						
August 23				75		77
24			65	77	70	78
25			71	76	72	78
26			72	76	72	76
27			76	76	76	74
28		48	70	74	70	72
29	55	55	66	72	66	68
30	51	70	68	68	69	65
31	70	72	61	67	62	
Sums	76	245	549	661	557	616
Means	25.3	61.2	68.6	73.4	69.6	68.4

TABLE VIII.—*Statement of salmon bought alive at Bucksport in* 1872.

[The weights recorded in this statement were obtained, not by actual measurement, but by judgment at sight, a method which is liable to error, but when passed by an experienced person generally comes very near the true weight. In the third column are given the initials of the persons who furnished the salmon. The number of weirs controlled by each person varied largely, J. A. W. having the salmon from only two, J. W. from four or five times as many. J. A. W.'s salmon were brought only from the northern part of Orphan Island, a distance of less than half a mile; A.'s from three miles down the river; J. W.'s from points still farther down, distant about four miles; still farther, about five miles from Bucksport, around the south end of Orphan Island, were the weirs that furnished A. H. W.'s salmon. The number brought each time generally included the catch of all the tides that had intervened since the last delivery recorded—commonly two tides, sometimes one, sometimes three or more.]

Date.	Hour.	Whence received.	Number of salmon.	Weights of salmon in pounds.	Aggregate weight.	Average weight.	Total for each day.	Average weight for each day.	Price per pound.
1872.					*Lbs.*	*Lbs.*			
June 1	— p. m.	J. A. W.	1	11	11	11	1	11	$0 30
3	— p. m.	J. A. W.	2	10, 11	21	10.5	2	10.5	28
6	— p. m.	J. A. W.	7	10, 10, 11, 12, 14, 14, 20½	91½	13.1	7	13.1	25
7	9.30 p. m.	A.	8		96	12	8	12	25
8	11 a. m.	J. A. W.	1	19	19	19	7	11.6	25
8	11 a. m.	A. H. W.	3		32	10.6			
8	11 a. m.	J. W.	3		30	10			
10	11 a. m.	J. A. W.	5		51½	10.3	23	10.8	25
10	11 a. m.	J. W.	11		116½	10.6			
10	11 a. m.	A.	6		70	11.7			
10	7.30 p. m.	J. A. W.	1		12	12	48	12	25
11	7 a. m.	J. A. W.	2		24	12			
11	11.30 a. m.	A.	16		200	12.5			
11	1 p. m.	A. H. W.	15		173	11.5			
11	1 p. m.	J. W.	11		114	10.4			
11	8.30 p. m.	J. A. W.	4	10, 12, 20, 20	62	15.5			
12	1.30 a. m.	A.	9		125	13.9	29	13.6	21½
12	1 p. m.	A. H. W.	10		117	11.7			
12	1 p. m.	J. W.	10		121	12.1			
13	10 a. m.	J. A. W.	11	10, 10, 10, 11, 11, 12, 12, 12, 20, 20, 21	149	13.5			
13	— p. m.	A.	7		85	12.1	40	11.9	20
13	— p. m.	A. H. W.	8		87⅞	10.9			
13	— p. m.	J. W.	14		156	11.1			
14	10.30 a. m.	J. A. W.	4	12, 16, 16, 21	65	16.2			
14	3 p. m.	A. H. W.	7	9, 10, 10, 10, 12, 18, 24	93	13.3			
14	3 p. m.	J. W.	12	10, 10, 10, 11, 11, 12, 14, 18, 19, 22, 24, 28.	189	15.4	32	14.2	20
14	3 p. m.	J. W.	9	10, 10, 10, 10, 11, 12, 12, 12, 20	107	11.9			
15	11.30 a. m.	J. A. W.	5		65	13			
15	4 p. m.	A. H. W.	12	21, 10, 9, 2, 18, 15, 16, 9, 12, (3=49)	161	13.4			
15	4 p. m.	J. W.	10	12, 11, 10½, 11, 11½, 9, 12, 11, 11½, 12½.	112	11.2	29	11.6	20
15	4 p. m.	A.	7	20, 11, 10, 9, 9, 9, 7	75	10.7			

TABLE VIII.—*Statement of salmon bought, &c.*—Continued.

Date.	Hour.	Whence received.	Number of salmon.	Weights of salmon in pounds.	Aggregate weight.	Average weight.	Total for each day.	Average weight for each day.	Price per pound.
1872.					*Lbs.*	*Lbs.*			
June 17	5.30 a. m.	A.	15	20, 18, 17, 16, 12, 12, 12, 12, 12, 11, 11, 10, 10, 9, 9.	191	12.7			
17	6 a. m.	A. H. W.	12	22, 22, 22, 18, 15, 12, 11, 11, 11, (3=32.)	176	14.6	36	13.9	$0 19
17	6 a. m.	J. W.	5	22, 21, 20, 11, 11	85	17			
17	3 p. m.	J. A. W.	4		48	12			
18	6 a. m.	A. H. W.	11	17½, 14, 10, 11, 10, 15, 15, 11, 12, 11½, 12.	139	12.6			
18	6 a. m.	J. W.	17	16½, 15, 10½, 11½, 10½, (12=133)	197	11.5	38	11.9	19½
18	6 a. m.	A.	8	20, 12, 12, 13, 11, 10, 6, 11	95	11.8			
18	6 a. m.	J. A. W.	2	9, 15	24	12			
19	7 a. m.	A. H. W.	6	9, 10, 10, 10, 11, 12	62	10.3			
19	7 a. m.	J. W.	5	11, 11, 12, 9½, 10½	54	10.8	16	10.8	19
19	7 a. m.	A.	5	9, 9½, 10, 10½, 18	57	11.4			
20	9 a. m.	A.	5	11, 11, 16, 17, 21	76	15.2			
20	9 a. m.	A. H. W.	3	10, 12, 13	35	11.6			
20	9 a. m.	J. W.	7	9, 10, 10, 10½, 11½, 12, 22	85	12.1	19	13.4	19
20	3 p. m.	J. A. W.	4	11, 12, 16, 21	60	15			
21	3 p. m.	A. H. W.	10	(6=67), 9, 10, 10, 11	107	10.7			
21	3 p. m.	J. W.	10	8½, 10, 10, 10½, 10½, 11, 11, 11½, 20, 20.	123	12.3	21	11.7	19
21	3 p. m.	J. A. W.	1	16	16	16			
22	10 a. m.	A.	7	9, 10, 10, 10, 11, 12, 23	85	12.1			
22	10 a. m.	A. H. W.	9	18, 18, 20, 20, 20, (5=49)	125	13.8			
22	10 a. m.	J. W.	20	9½, 10, 10, 10, 10, 10½, 10½, 11, 11, 11, 11, 11½, 11½, 11½, 14, 20, 21, 22, 23.	261½	13.1	41	13.1	18
22	10 a. m.	J. A. W.	5		65	13			
24	10 a. m.	A. H. W.	10	9, 11, 12, 12, 16, 16, 18, 18, 20, 20	152	15.2			
24	10 a. m.	J. W.	16	10, 10, 10, 10, 10½, 10½, 10½, 11, 11, 11, 11, 11, 11½, 11½, 12, 12.	176½	11.3	34	12.4	18
24	10 a. m.	A.	5	9½, 10, 10½, 14, 16	60	12			
24	10 a. m.	J. A. W.	3		35	11.6			
25	10 a. m.	J. W.	7	9, 10½, 10½, 11, 11½, 11½, 20	84	12			
25	10 a. m.	A. H. W.	2	11½, 12½	24	12			
25	10 a. m.	A.	7	9, 9, 11, 12, 12, 19, 22	94	13.4	19	12.4	18
25	7 p. m.	J. A. W.	3	10, 12, 13	35	11.6			
26	7 p. m.....	J. W.	13	9½, 10, 10, 10½, 10½, 11, 11, 11, 11, 11½, 11½, 18, 20.	155½	11.9			
26	7 p. m.....	A. H. W.	4	9, 9, 10, 12	40	10	17	11.5	18
27	7 p. m.....	A.	8	8½, 9, 9, 10, 10, 10, 11, 14	81½	10.2			
		J. W.	4	9½, 10, 10½, 12	42	10.5	14	13.3	18
		A. H. W.	2	9, 14	23	11.5			
28	7 p. m.....	J. A. W.	4		59	14.7			
28	7 p. m.....	A.	4	9, 10, 11, 22	52	.....			
28	7 p. m.....	A. H. W.	8	9, 9½, 10, 11, 12, 16, 18, 20	105½	13.2	25	12.9	19
28	7 p. m.....	J. W.	9	13, 13, 13, 22, 22, 22½, 22½, 23½, 23½.	107	11.8			
29	7 p. m.....	A.	7	8½, 9½, 11, 12, 18, 20, 21	100	143			
29	7 p. m.....	A. H. W.	14	8, 9, 10, 10, 10, 10½, 11, 12, 12, 12, 12, 13, 18, 18.	184½	13.2	29	13.4	20
July 29	7 p. m.....	J. W.	8	9, 9, 10, 10½, 20, 22, 23, 23	103½	12.9			
1	7 p. m.....	A.	9	9, 9, 10, 10, 10, 12, 12, 20, 24	116	12.9			
1	7 p. m.....	A. H. W.	10	10, 10, 11, 11, 12, 12, 12½, 13, 18, 22.	131½	13.1			
1	7 p. m.....	J. W.	15	9, 10, 10, 10½, 10½, 10½, 11, 11½, 11½, 12½, 12½, 13, 20, 20, 22.	194½	12.9	34	13	20
2	7 p. m.....	A. H. W.	6	9½, 10, 10, 11, 12, 12½	65	10.8			
2	7 p. m.....	J. W.	5	8½, 10½, 10½, 11, 12½	53	10.6	11	10.7	21
3	7 p. m.....	A. H. W.	3	10, 10, 11½	31½	10.5			
3	7 p. m.....	J. W.	10	9, 10½, 10½, 11, 11½, 11½, 14, 14½, 14½, 18.	123½	12.3	19	11.4	22
3	7 p. m.....	A.	6	9, 10, 10, 10, 11, 12	62	10.3			
4	7 p. m.....	A. H. W.	10	9, 10, 10, 11, 11, 12, 14, 14½, 15, 17.	123½	12.3			
4	7 p. m.....	J. W.	10	9½, 9½, 10½, 11, 11, 11, 11½, 14, 15, 19.	122	12.2	25	12.1	22
4		J. A.	5	10, 10, 12, 12, 12	56	11.2			
5	7 p. m.....	A. H. W.	6	9, 10, 10, 10½, 13, 14	66½	11.1			
5	7 p. m.....	J. W.	13	8, 10, 10½, 11, 11, 12, 13, 13, 13½, 14½, 16½, 18, 20.	171	13.1	25	12.1	20
5		A.	6	9, 9½, 10, 10, 10½, 15	64	10.7			
6	7 p. m.....	A. H. W.	5	3½, 10, 11, 12½, 22	59½	11.8			
6	7 p. m.....	J. W.	6	11, 11, 15, 16, 21, 22	96	16	11	14.1	18
8	7 p. m.....	A. H. W.	9	10, 10, 10½, 11½, 12, 12, 12½, 13, 16.	107½	11.9			
8	7 p. m.....	J. W.	15	10½, 10½, 11, 11, 11, 11½, 12, 12, 12, 12, 14, 14, 14, 15, 15.	185½	12.3	27	12	19
8	7 p. m.....	A.	3	9, 9½, 13	31½	10.5			

SUMMARY.

Date.	Salmon bought.	Aggregate weight.	Average weight.
	Number.	*Pounds.*	*Pounds.*
June 1 to 15, 1872, inclusive	231	2,830½	12.2
June 15 to 30, 1872, inclusive	309	3,880½	12.5
July 1 to 8, 1872, inclusive	152	1,859½	12.2
Total	692	8,570½	

General average weight, 12.3 pounds.

TABLE IX.—*Statement of operations in the spawning season of* 1872 *at Bucksport.*

Lot.	Date.	Mother salmon. Number.	Mother salmon. Length in inches.	Mother salmon. Weight, including eggs.	Eggs. Weight.	Eggs. Number.	Eggs. Percentage fecundated.	Remarks.
	1872.							
1	Oct. 28	1	.....	.....	.....	7,600	100	
2	Oct. 28	1	.....	.....	.....	8,700	97½	
3	Oct. 28	1	.....	.....	.....	10,300	100	
4	Oct. 28	1	.....	.....	.....	12,400	97½	Female very large; one or both eyes lost.
5	Oct. 28	1	.....	.....	.....	9,200	97½	
6	Oct. 28	1	.....	.....	.....	7,600	97½	Heavily milted from one male.
7	Oct. 28	1	.....	.....	.....	7,600	100	
8	Oct. 28	1	.....	.....	.....	9,800	100	
9	Oct. 28	1	.....	.....	.....	12,400	100	Large female.
10	Oct. 28	1	.....	.....	.....	10,300	100	Do.
11	Oct. 28	1	.....	.....	.....	300	95	Eggs came hard; female supposed unripe, and reserved.
12	Oct. 28	1	.....	.....	.....	700	100	Female small.
13	Oct. 28	1	36	.....	.....	10,900	100	Abundantly milted.
14	Oct. 28	1	.....	.....	.....	10,300	100	Female large and yielded eggs easily.
15	Oct. 28	1	.....	.....	.....	11,400	87½	
16	Oct. 28	1	31	.....	.....	7,600	100	Milt not very plenty.
17	Oct. 28	1	41	.....	.....	13,000	100	
18	Oct. 28	1	.....	.....	.....	6,500	97½	Milted heavily.
19	Oct. 28	1	.....	.....	.....	1,000	22½	Female appeared unripe, and reserved.
20	Oct. 28	1	.....	.....	.....	6,500	97½	Turned into troughs while adhering hard together.
21	Oct. 28	....	.....	.....	.....	6,500	100	
22	Oct. 28	1	.....	.....	.....	8,200	97½	
23	Oct. 28	1	.....	.....	.....	8,700	97½	
24	Oct. 28	1	.....	.....	.....	8,200	95	
25	Oct. 28	1	.....	.....	.....	3,800	40	Kept in one pan and not stirred.
26	Oct. 28	1	.....	.....	.....	7,600	100	Stirred 5 minutes; set in three pans.
27	Oct. 28	1	.....	.....	.....	13,100	100	
28	Oct. 28	1	.....	.....	.....	7,600	97½	Milt scanty; stood in three pans.
29	Oct. 28	1	.....	.....	.....	7,600	97½	
30	Oct. 28	1	.....	.....	.....	7,000	97½	Stirred in one pan.
31	Oct. 28	1	.....	.....	.....	13,000	100	Stirred in three pans.
32	Oct. 28	1	.....	.....	.....	13,000	100	Female large; male small; milt scanty; stirred 2½ minutes, then watered heavily, and let stand in three pans.
33	Oct. 28	1	.....	.....	.....	7,000	100	Stood in one pan.
34	Oct. 29					2,700	100	Usual way. The two following lot of eggs are from same fish.
35	Oct. 29	1	.....	.....	.....	1,600	0	Watered first, then stood 2 minutes, then milted by pouring in water and milt from pan containing lot 34.
36	Oct. 29					1,100	20	Watered first, stood 2 minutes, then milted direct from male.
37	Oct. 29	12	.....	.....	.....	81,700	99	Usual way.
38	Oct. 28	1	.....	.....	.....	3,300	95	Female that was thought unripe yesterday. Eggs came hard, with some blood, and some eggs left in fish; milt abundant.

TABLE IX.—*Statement of operations in the spawning season of* 1872, *&c.*—Continued.

Lot.	Date.	Mother salmon. Number.	Length in inches.	Weight, including eggs.	Eggs. Weight.	Number.	Percentage fecundated.	Remarks.
39	1872.							
40	Oct. 29	3	.....	.....	.....	5,900	100	Well milted from two males.
41	Oct. 29	1	.....	.....	.....	4,400	100	
42	Oct. 29	1	.....	.....	.....	7,600	100	
	Oct. 29	1	.....	.....	.....	300	85	Female was stripped yesterday; eggs of this lot came with much blood; milt fresh.
43								
44	Oct. 30	1	.....	.....	.....	3,300	100	
45	Oct. 31	1	.....	.....	.....	900	100	Milted as usual; handled with care.
46						900	95	Milted as usual, handled carefully till after adhesion, then poured heavily.
47						900	100	Milted as usual, then poured heavily before adhesion.
48						1,500	100	Watered immediately after milting.
49						1,100	100	Milt taken in water.
						1,100	7½	Eggs; water; 4 minutes; milt. (Formulas of this sort indicate the exact order of procedure and the time that elapses at each interval; thus in the above instance, the eggs were taken first, then water was added, then, after the lapse of 4 minutes, milt was added.)
50								
51						700	100	Dry method, but milt taken first.
52						700	100	Milt; water; 1 minute; eggs.
53						500	100	Milt; water; 3 minutes; eggs.
54	Oct. 31	1	.....	.....	.....	300	100	Milt; water; 2 minutes; eggs.
55						1,000	100	Milt; water; eggs.
56						400	0	Not milted at all.
57						2,700	100	Usual way.
58	Oct. 31	1	.....	.....	.....	4,400	100	Carried to hatching-house during adhesion.
59						2,000	100	Water; milt; stir a few seconds; eggs.
60	Oct. 31	1	.....	.....	.....	4,100	100	
61	Oct. 31	1	.....	.....	.....	8,200	100	
62	Oct. 31	1	28⅛	.....	.....	7,800	97½	
63	Oct. 31	2	28 28	.....	.....	14,200	100	
64	Oct. 31	1	31	.....	.....	7,600	100	
65	Oct. 31	2	30 29	.....	.....	10,900	100	
66	Nov. 1	1	32	.....	.....	9,800	100	
67	Nov. 1	1	28	.....	.....	6,500	100	
68	Nov. 1	1	.....	.....	.....	7,600	100	Stood long before milting or watering.
	Nov. 1	60	.....	.....	.....	16,300	77½	This lot comes from a second stripping of all the females used before.
69								
70	Nov. 1	1	.....	.....	.....	8,700	97½	
71	Nov. 1	1	36½	.....	.....	10,900	97½	
72	Nov. 1	1	28½	.....	.....	4,900	100	
73	Nov. 1	1	31	.....	.....	8,200	100	
74	Nov. 1	1	27	.....	.....	3,300	95	
75	Nov. 1	1	28½	.....	.....	6,500	100	
76	Nov. 1	1	28½	.....	.....	6,500	92½	
77	Nov. 1	1	30	.....	.....	6,500	92½	Milt; 10 minutes; eggs; then as usual.
78	Nov. 1	1	30	.....	.....	6,500	100	
79	Nov. 1	1	30½	.....	.....	9,300	100	
80	Nov. 1	1	35	.....	.....	8,700	97½	
81	Nov. 1	1	36	.....	.....	13,000	100	
82	Nov. 1	1	29½	.....	.....	9,000	100	
83	Nov. 1	1	30	.....	.....	6,500	100	
84	Nov. 1	1	29½	.....	.....	6,500	100	
85	Nov. 1	1	30½	.....	.....	7,100	100	
						600	100	Milt taken from fish several hours in advance and kept in open dish.
86	Nov. 1	6	30 31 36 30 31½ 29½	.....	.....	5,200	100	Five males used.
87	Nov. 1	1	35½	.....	.....	11,400	100	After standing 1 hour, in two pans, these eggs were still adherent, and were carried to hatching-house in that condition.
88	Nov. 1	4	28 29 34 30	.....	.....	30,300	100	

TABLE IX.—*Statement of operations in the spawning season of 1872, &c.*—Continued.

Lot.	Date.	Mother salmon. Number.	Length in inches.	Weight, including eggs.	Eggs. Weight.	Number.	Percentage fecundated.	Remarks.
	1872.							
89	Nov. 1	1	32	.....	.....	10,900	100	
90	Nov. 1	10	31 31 29 31 29 29 28 35½ 31 30	.....	.....	92,600	98	
91	Nov. 1	1	34½	.....	.....	12,600	100	
92	Nov. 1	1	32	.....	.....	9,300	100	Stood without milt, while eggs of 93 were taken and milted.
93	Nov. 1	1	30	.....	.....	8,200	97½	
94	Nov. 2	8	29 31½ 30 30 31 30 30 37	.....	.....	70,800	100	
95	Nov. 2	1	27	.....	.....	5,600	100	Eggs came hard.
96	Nov. 2	1	29	.....	.....	6,500	100	Female caught at Redman's bridge and brought down alive.
97	.....	.....	.....	.....	.....	200	95	Female had been used before.
98	Nov. 2	1	37	.....	.....	10,800	100	
99	Nov. 2	1	27	.....	.....	4,100	97½	
100	Nov. 3	1	30	.....	.....	500	100	A spent fish that appeared to have just come out of the pond.
101	Nov. 3	1	32½	.....	.....	8,500	97½	
102	Nov. 3	1	28	.....	.....	7,600	100	
103	Nov. 3	1	29	.....	.....	5,400	100	
104	Nov. 3	1	31	.....	.....	9,200	100	
105	Nov. 3	1	31	.....	.....	8,800	100	
106	Nov. 3	1	31	.....	.....	10,000	100	Eggs very small; came hard; female has been kept over; supposed unripe.
107	Nov. 3	1	31½	.....	.....	9,300	100	Eggs came hard; female was tried before, and supposed unripe.
108	Nov. 3	1	31	.....	.....	7,600	100	Female in very fine, plump condition; eggs came hard.
109	Nov. 3	1	31	.....	.....	10,000	100	
110	Nov. 3	1	30	.....	.....	6,000	97½	
111	Nov. 4	1	29½	.....	.....	6,700	100	
112	Nov. 4	1	32	.....	.....	5,000	97½	
113	Nov. 4	1	.....	.....	.....	500	87½	Eggs came with much blood and water.
114	Nov. 4	1	28½	7 12	2 2	5,900	100	
115	Nov. 4	1	29	8 4	2 2	6,800	100	
116	Nov. 4	1	31	12 10	3 2	8,200	100	
117	Nov. 4	1	30	9 6	2 11	7,100	97½	Female caught in pond to-day and lost a few eggs then.
118	Nov. 4	1	37¾	18 11	4 13	13,000	100	
119	Nov 4	1	30½	9 9	2 9	7,900	100	Had lost a few eggs.
120						500	0	Eggs; water; 2 or 3 minutes; milt.
121	Nov. 4	1	31	8 0	2 11	6,800	100	
122	Nov. 5	1	31	9 5½	2 8½	7,100	100	
123	Nov. 5	1	27	7 1	1 12	6,100	100	
124	Nov. 5	1	31½	12 8	3 4	9,300	100	Eggs brought down to hatching-house while yet strongly adherent.
125	Nov. 5	1	31	.....	.....	3,300	100	Rinsed immediately after milting.
126						3,800	100	As usual.
127	Nov. 5	1	28½	8 6	2 4	2,700	100	Rinsed immediately.
128						3,800	100	As usual.
129	Nov. 5	1	30	8 6	2 4	1,100	100	Milted and watered as usual and carried to hatching-house in ½ hour.
130						900	100	Milted but not watered until poured into troughs after standing dry ½ hour.
131						1,100	100	Milt; 5 minutes; eggs carried to hatching-house without water.
132						1,100	100	Milt; 5 minutes; eggs carried to hatching-house with water.
133						1,600	90	Eggs; ½ hour; milt; water; 1 hour; carried to hatching-house.
134						1,600	80	Eggs; ½ hour; milt; 1 hour; carried to hatching-house without water.

TABLE IX.—*Statement of operations in the spawning season of* 1872, *&c.*—Continued.

Lot.	Date.	Mother salmon. Number.	Mother salmon. Length in inches.	Mother salmon. Weight, including eggs.	Eggs. Weight.	Eggs. Number.	Eggs. Percentage fecundated.	Remarks.
135*	1872.							
136*						1,600	97½	Eggs; milt, &c.
137*						1,600	100	Eggs; water; 1 minute; milt, &c.
138*	Nov. 5	1	31			1,100	100	Eggs; water; 2 minutes; milt, &c.
139*						1,600	100	Eggs; water; 3 minutes; milt, &c.
140*						1,600	92½	Eggs; water; 4 minutes; milt, &c.
141						1,600	65	Eggs; water; 6 minutes; milt, &c.
142	Nov. 6	1	29	8 11	2 6	7,600	100	
143	Nov. 6	1	30½	10 1	2 10	7,100	100	
144						4,400	58⅓	Female was killed in a rack at hatching-house dam. Eggs taken 2 hours after death.
145	Nov. 9					2,700	95	Sundry spent females.
146	Nov. 9	1		13 10	2 5	6,400	100	
147	Nov. 9	1	37	18 13	5 2	14,800	97½	
148	Nov. 9	1		9 6	4 6	10,400	100	
149	Nov. 9					2,700	97½	Sundry spent fish.
150	Nov. 9	1	30½	9 11	2 12	8,100	97½	
151	Nov. 9	1	31	10 13	2 5	7,200	100	
152	Nov. 9					1,600	100	Sundry spent females.
153	Nov. 9	1		9 14	2 14	8,700	100	
154	Nov. 9	1	38½	20 8	5 12	13,200	97½	
155	Nov. 9					3,800	100	Do.
156	Nov. 9	1		10 13	1 13	7,100	87½	
157	Nov. 9	1	31½	11 14	2 12	8,200	97½	
158	Nov. 9	2	30½		2 2	5,400	100	Milt rather scant.
159	Nov. 9	1	35½	15 12	2 12	6,000	95	
160	Nov. 9	1	35⅔	17 11	5 6	14,200	100	
161	Nov. 9	1	37	19 13	5 1	9,700	100	
162	Nov. 9	1	37½	18 5	4 13	13,000	97½	
163	Nov. 9	1	30⅔	10 10	2 11	8,500	100	
164	Nov. 9	1	30½	10 2	2 14	9,300	100	
165	Nov. 9	1	32	13 00	3 9	9,400	100	
166	Nov. 9	1	32½	14 9	3 10	8,700	100	
167	Nov. 9	1	30	9 7	2 3	6,500	67½	
168	Nov. 9	1	31½	11 4	2 11	7,600	100	
169	Nov. 9	1	29	9 12	2 8	8,700	97½	
170	Nov. 9	1	30½	8 4	1 3	3,300	100	
171	Nov. 9	1		24 2	3 15	8,200	100	
172	Nov. 9	3			2 7	6,500	100	
173	Nov. 9	2				700	85	Two spent females.
174	Nov. 9	1	31¾	11 7	2 14	8,000	100	
175	Nov. 9	1	36	16 6	3 4	8,200	100	
176	Nov. 9	1	35⅔	17 13	5 1	12,000	100	
177	Nov. 9	1	36⅔	18 1	3 15	8,700	100	
	Nov. 10	15				28,300	97½	Rich's Brook; fifteen living females; three or four of them nearly full, the rest nearly spent; one dead.
178	Nov. 10	2				9,300	67½	Two dead females from Rich's Brook.
179	Nov. 10	1				6,500	2½	Female ripe and good; milt, about a teaspoonful from a dead fish, taken before the eggs.
180						6,500	97½	Usual way, except milt taken from new male that yielded abundantly and kept in dipper until used—say 10 minutes. Same milt fertilized all the rest to 189, inclusive.
181								
182								
183	Nov. 11	1	37½	15 3	2 11	285	92½	Eggs; water; ½ minute; milt.
184						220	95	Eggs; water; 1 minute; milt.
185						163	77½	Eggs; water; 2 minutes; milt.
186						151	80	Eggs; water; 3 minutes; milt.
187						175	85	Eggs; water; 4 minutes; milt.
188						202	87½	Eggs; water; 5 minutes; milt.
189						170	85	Eggs; water; 6 minutes; milt.
190						435	0	Eggs; water; 8 minutes; milt.
	Nov. 11	1	36½	16 10	4 10	413	2½	Eggs; water; 10 minutes; milt.
191						11,400	95	Usual way; was poured into pail a little harder than usual; poured from four to five inches.
192	Nov. 11	1	33	11 9	1 9	4,000	95	

* In these lots, which were taken at the same time, the milt was first taken in a dish dry. Eggs then taken, divided, and watered. Then, after the lapse of time specified in each case, the milt poured in and eggs stirred. All then stand till free.

TABLE IX.—*Statement of operations in the spawning season of* 1872, *&c.*—Continued.

Lot.	Date.	Mother salmon. Number.	Mother salmon. Length in inches.	Mother salmon. Weight, including eggs.	Eggs. Weight.	Eggs. Number.	Eggs. Percentage fecundated.	Remarks.
	1872.							
193	Nov. 11	13	.....	.....	.....	48,900	100	Collected at Rich's and Lake's Brooks.
194	Nov. 11	4	.....	.....	.....	2,200	0	Taken from specimens killed on 9th inst.
195	Nov. 11	1	.....	.....	.....	2,400	52½	Brought from Rich's Brook.
197 to 207	Nov. 13 to Nov. 13	1	.....	.....	.....	4,000	97½	
208	Nov. 13	2	.....	.....	.....	1,100	35	From two dead females.
209	Nov. 13	....	.....	.....	.....	13,000	100	From Rich's Brook.
210	Nov. 14	1	.....	.....	.....	4,400	100	
211	Nov. 14	1	.....	.....	.....	3,500	100	Usual way.
212 to 221	Nov. 14 to Nov. 14	1	.....	.....	.....	2,700	.....	Experiments.
222	Nov. 14	3	.....	.....	.....	300	92½	From three spent fish.
223	Nov. 14	1	.....	.....	.....	200	0	Not milted.
224	Nov. 14	1	.....	.....	.....	9,500	90	
225	Nov. 14	....	.....	.....	.....	200	90	Eggs kept in a pan without water 12 hours before milting.
226	Nov. 14	....	.....	.....	.....	200	0	
227	Nov. 15	....	.....	.....	.....	400	0	From a fish that has been dead 15 hours.
228	Nov. 15	....	.....	.....	.....	100	0	Eggs kept in a pan without water 30 hours before milting; milt from male that has been dead two days.
229	Nov. 15	....	.....	.....	.....	200	87½	Eggs kept in a pan without water 30 hours before milting; milt fresh.
230	Nov. 15	....	.....	.....	.....	500	92½	Eggs from dead fish.
231	Nov. 15	1	.....	.....	.....	10,500	95	From Rich's Brook.
232	Nov. 15	....	.....	.....	.....	250	91	Picked from bottom of Rich's Brook.
233	Nov. 16	....	.....	.....	.....	200	.....	Picked up from brook near hatching-house.
234	Nov. 16	....	.....	.....	.....	300	75	Eggs kept two days without water, and then milted with fresh milt.
235	Nov. 16	1	....	.....	.....	7,000	100	Usual way.
236 to 245	Nov. 16 to Nov. 16		....	.....	.....	1,000	.....	Experiments.
246	Nov. 16	....	.....	.....	.....	700	90	From Rich's Brook.
247	Nov. 16	....	.....	.....	.....	1,000	0	Do.
248	Nov. 18	....	.....	.....	.....	80	0	Eggs kept four days without water, then milted with milt from dead fish.
249	Nov. 18	....	.....	.....	.....	50	0	Eggs kept four days without water, then milted with milt kept four days.
250	Nov. 18	....	.....	.....	.....	100	12½	Eggs kept four days without water, then milted with new milt.
251	Nov. 18	....	.....	.....	.....	300	30	Eggs from dead fish.
252	Nov. 19	....	.....	.....	.....	100	52½	
253	Nov. 19	....	.....	.....	.....	150	12½	Eggs taken from dead fish yesterday; milt now.
254	Nov. 19	....	.....	.....	.....	200	0	Not milted.
255	Nov. 21	....	.....	.....	.....	200	0	
256	Nov. 21	1	.....	.....	.....	3,300	72½	Eggs came with more water than usual.
257	Nov. 21	....	.....	.....	.....	500	0	Not milted.
						1,560,044		

TABLE X.—*Experiments in transportation of salmon-eggs, from Bucksport, Me., to Winchester, Mass.*

[These eggs were sent in small lots, by express, and received the common treatment of article transported in that way, the battered condition of the boxes often attesting the rough way in which they had been handled. All except the last lot were packed on disks of mosquito-netting, sewed on to brass rings, in alternate layers, with wet bog-moss, in tin boxes, and the latter were inclosed in larger tins, the space between, ¾ inch to 1 inch, being filled with sawdust. In some cases, coarse paper was wrapped in several layers around the whole parcel. The packages left Bucksport on the steamer Katahdin, and generally reached their destination the following day. Being exposed to a severe temperature on several occasions, while in the delivery-wagon at Winchester, some of the parcels were penetrated by frost.]

Mark.	Number of eggs.	Date.	Age since fecundation.	Lot.	State of development.	Died on way.		Remarks.
						Number.	Percentage.	
216		1872.						
217	50	Dec. 5	38 days..	1	.....	9	18	}
218	50	Dec. 5	34 days..	80	.....	16	32	
219	50	Dec. 5	30 days..	125	.....	36	72	} Package frozen badly.
220	50	Dec. 5	26 days..	175	.....	49	98	
221	50	Dec. 5	21 days..	210	.....	45	90	}
222	50	Dec. 9	42 days..	1	.....	35	70	}
223	50	Dec. 9	38 days..	80	Embryo covers yolk	3	6	
224	50	Dec. 9	34 days..	125	.....do	17	34	} Frozen so that the moss was all stiff.
225	50	Dec. 9	30 days..	175	Embryo covers ½ of yolk.	35	70	
226	50	Dec. 9	25 days..	210	Embryo not expanded...	38	76	}
227	50	Dec. 17	50 days..	1	Heart beating.....	0	0	}
228	50	Dec. 17	46 days..	80	Embryo covers yolk	0	0	} Package inclosed in paper, which protected against cold, and against the jar of rough handling.
229	50	Dec. 17	42 days..	125	.....do	1	2	
230	50	Dec. 17	38 days..	175	Embryo covers 4-5 of yolk	21	42	
231	50	Dec. 17	33 days..	210	Embryo covers ⅘ of yolk.	1	2	}
232	50	Dec. 24	57 days..	1	.....	0	0	}
233	50	Dec. 24	53 days..	80	.....	0	0	
234	50	Dec. 24	49 days..	125	.....	0	0	} Some frost in the box.
235	50	Dec. 24	45 days..	175	Embryo covers yolk	18	36	
1	50	Dec. 21	40 days..	210	.....do	4	8	}
80	100	Nov. 14	17 days..	1	Embryo expanding	100	100	
125	100	Nov. 14	13 days..	80	Embryo beginning to expand.	100	100	
196	100	Nov. 14	9 days..	125	.....	97	97	}
210	100	Nov. 14	2 days..	196	.....	96	96	} Nearly all died afterwards.
401	100	Nov. 14	½ hour..	210	.....	41	41	}
402	100	Nov. 20	23 days..	1	Embryo covers 4-5 of yolk	62	62	
403	100	Nov. 20	19 days..	80	Embryo covers ½ of yolk	45	45	
404	100	Nov. 20	15 days..	125	Embryo just beginning to expand.	36	36	
405	100	Nov. 20	11 days..	175	.....	21	21	
406	100	Nov. 20	6 days..	210	.....	0	0	
407	50	Nov. 21	24 days..	1	.....	10	20	
408	50	Nov. 21	20 days..	80	.....	4	8	
409	50	Nov. 21	16 days..	125	.....	4	8	
410	50	Nov. 21	12 days..	175	.....	1	2	
411	50	Nov. 21	7 days..	210	.....	4	8	
412	50	Nov. 25	28 days..	1	Embryo covers whole yolk.	44	88	
413	50	Nov. 25	24 days..	80	Embryo covers ½ yolk...	42	84	
414	50	Nov. 25	20 days..	126	Embryo slightly expanded.	5	10	
415	50	Nov. 25	16 days..	175	.....	4	8	
235	50	Nov. 25	11 days..	210	.....	0	0	
236		1873.						
237	1,500	Jan. 7	71 days..	1	Eyes black.....	12	¾	}
238	1,500	Jan. 7	71 days..	1	.....do	31	2	} Packed with moss on wire trays, and inclosed in sawdust.
239	500	Jan. 7	67 days..	80	.....	5	1	
240	500	Jan. 7	63 days..	125	.....	23	44	
241	500	Jan. 7	59 days..	175	.....	211	42	}
242	50	Jan. 7	71 days..	1	.....	0	0	}
243	50	Jan. 7	67 days..	80	.....	2	4	} Packed in tins as usual, inclosed in sawdust and paper.
244	50	Jan. 7	63 days..	125	.....	0	0	
245	50	Jan. 7	59 days..	*175	.....	35	70	
	50	Jan. 7	54 days..	210	.....	5	10	}

*The excessive mortality in the eggs belonging to lot 175 I attribute in part to their being in an unhealthy state.

TABLE XI.—*Statement of the distribution and hatching of the salmon-eggs collected at Bucksport in the season of 1872, and of the distribution of the young fish.*

Party receiving.	Number of eggs received.			Loss.		No. of young salmon distributed.	In what waters distributed.
	Own account.	Allotted by United States.	Total.	Percentage.	Amount.		
Maine	74,000	228,000	302,000	31	95,000	207,000	Penobscot River and tributaries, 67,000; Saint Croix River, 10,000; Androscoggin and tributaries, 130,000.
New Hampshire	.....	21,400	21,400	35	7,400	14,000	Merrimac and tributaries.
Vermont	.....	10,000	10,000	30	3,000	7,000	Winooski and Lamoille Rivers.
Massachusetts	202,000	30,000	232,000	19	45,000	187,000	Merrimac River, 165,000; Mystic River, 11,000; Red Brook, 11,000.
Rhode Island	90,000	10,000	100,000	36	36,000	64,000	Blackstone, Pawtucket, and Pawcatuck Rivers.
Connecticut	124,000	80,000	264,000	25	66,000	198,000	Saugatuck River, 4,500; Southport River, 4,500; tributaries of the Connecticut River, 115,000; Mystic River, 5,000; tributaries of Thames River, 10,000; Housatonic River, 70,000; stream at North Branford, 35,000.*
William Clift	64,000	.....	64,000	33	21,000	43,000	
New York	.....	80,000	80,000	32½	26,000	54,000	Peat Wig Creek and Inglesby Creek, tributaries of the Hudson, 24,000; Beaver Creek, tributary to Salmon River, Oswego County, 15,000; Glass House Creek, Cayuga County, tributary to Oswego River, 15,000.
New Jersey	.....	40,000	40,000	10	4,000	36,000	Tributary of Delaware River, 18,000; tributary of Raritan River, 18,000; Long Island, 3,000.*
Pennsylvania	.....	40,000	40,000	37½	15,000	25,000	Delaware River.
Ohio	.....	5,200	5,200	52	2,700	2,500	Cold Creek, tributary to Sandusky Bay.
Michigan	.....	43,200	43,200	55	23,700	19,500	Kalamazoo, Saint Joseph, Grand, Muskegon, Manistee, Au Sable Rivers, about equal numbers; Orchard, Walled, Whittemore, Diamond, and a few smaller lakes.
Wisconsin	.....	40,000	40,000	52½	21,000	19,000	Menomonee River, 7,000; Oconomowoc Lake, 1,000; Milwaukee River, 11,000.
Totals	614,000	627,800	1,241,800	29.4	365,800	876,000	

* The sums of the fish reported distributed in the several streams in Connecticut and New Jersey exceed the computed number in the preceding column; the discrepancy may have arisen from an error in counting out the young fish, which cannot be done accurately without a deal of labor.

D—LOCAL HISTORY OF SALMON AND SALMON-FISHING IN NEW ENGLAND RIVERS.

1.—GENERAL OBSERVATIONS.

The sea-going salmon of eastern North America, *Salmo salar*, Linn., is native to nearly every river tributary to the Atlantic north of the Hudson. If we apply the term "river" only to streams of fresh water of sufficient size to afford full-grown salmon ample room to move and lie in during the summer drought, we shall find that the only exceptions to the former universal prevalence of the species within the district named are those rivers that do not contain suitable breeding-grounds, or whose breeding-grounds are inaccessible to salmon by reason of the intervention of impassable falls between them and the sea.

In all rivers frequented by them they are found successively in all parts from the mouths upward, their migrations extending nearly to the head-waters both of the main rivers and their tributaries, always with the same limitations mentioned above as to the presence of breeding-grounds and their accessibility. To this statement, however, there appears to be one important exception in the case of the Saint Lawrence. Such evidence as I have been able to gather relating to the migration of salmon in this river tends to the conclusion that few, if any, ascend it so far as Lake Ontario, and that the salmon inhabiting that lake and its tributaries make the lake their sea and the limit of their downward migrations.* Though extensive salmon-fisheries are carried on on both sides of the Saint Lawrence below Quebec, the capture of a salmon in that part of the river above Montreal appears to be a rare event. In the lower tributaries of that river the migrations of salmon are precisely similar to those observed in rivers emptying directly into the sea, and extend to all accessible upper waters where suitable places for the deposit of their eggs are to be found.

The researches of which the results are embodied in the following notes did not extend to any rivers beyond the limits of the United States. It will be seen that nearly every river, from the eastern border to the Housatonic, is known to have been formerly frequented by salmon, and it is not unlikely that the list would be increased by the addition of quite a number of minor streams were the history of the latter known. Of the twenty-eight salmon rivers mentioned below, lying wholly or in part in the United States, there are barely eight where salmon are now regular visitors. These are the Saint Johns, Saint Croix, Denny's, Little Falls, (a small stream in Edmunds, Me.,) East Machias, Wescongus, Penobscot, and Kennebec. They are sufficiently numerous to support a regular fishery in the

*There is also some doubt about the migration of the salmon formerly inhabiting Lake Champlain and its tributaries. Further research is required on both these points.

Saint John's, and its larger tributary, the Aroostook, Saint Croix, Denny's, Penobscot, and Kennebec. Beside the rivers regularly visited by them, they are occasionally observed in the Machias, Narraguagus, Sheepscot, Androscoggin, Presumpscot, and Saco; but in all these, as well as the remaining fifteen rivers, the ancient brood of salmon was long ago extinguished, and the rare specimens occasionally observed must be regarded either as strays from some of the better-preserved rivers, or as early-returning members of the new broods established by artificial culture in several rivers. The latter appears to be the most probable explanation of the recent occurrence of salmon in Southern New England.

The disappearance of salmon from so many rivers appears to have been entirely the result of artificial causes, chief among which is the obstruction of the way to their breeding-grounds by impassable dams. Excessive and ill-timed fishing has had a due share of influence in depleting the original supply and in preventing its speedy recovery in cases where other circumstances were favorable, but, unaided by the formidable works of the manufacturer, the fisherman's nets and spears and pounds would hardly have sufficed to extinguish the brood of salmon in a single river. Commonly these two classes of destructive agencies co-operated. The dams held the fish in check while the fisherman caught them out. This has been the case for many years, and is the case to-day with the Saint Croix, Denny's, Penobscot, and several others, where, though impeding the ascent of salmon, the dams have not wholly prevented it. There are, however, other rivers, where the dams alone would have sufficed to exterminate the species. As instances may be mentioned the Androscoggin, Saco, and Merrimac, where the dams so completely exclude salmon from all suitable spawning-grounds that, without the intervention of any other agency, they would have extinguished the broods that naturally frequented those rivers.

2.—TRIBUTARIES OF THE SAINT JOHN RIVER.

Salmon ascend the Saint John as far as Grand Falls, where they find an impassable obstacle to their further progress. Nearly all the tributaries below this point, on both sides, were originally frequented by them, and in these their spawning-grounds are supposed to have been mainly situated. The complete closing of some of these tributaries by dams, and the partial closing of others, has tended to the decrease of the species. But large numbers are still found in the main river and such of the tributaries as are accessible. Of the tributaries lying partly in the State of Maine, the Aroostook, Presque Isle, and Meduxnekeag were naturally frequented by salmon. With regard to the Aroostook and Meduxnekeag, there is no doubt of their having ascended both streams beyond the border-line. Such was probably the case with the Presque Isle River, as is assumed by Mr. Venning, inspector of

fisheries for New Brunswick and Nova Scotia,* although I have not succeeded in obtaining direct testimony to the fact.

Aroostook River.—The ascent of salmon is seriously impeded by a natural fall, known as "Aroostook Falls," about four miles above the junction of the river with the Saint John, and just within the borders of New Brunswick. So great is the difficulty of ascent that in Perley's report on the fisheries of New Brunswick in 1851 it was stated that no salmon ever passed it. It appears that he was by no means correct, although it may readily be believed that a small proportion of the salmon that come to this fall succeed in surmounting it. The banks of the river here approach each other and form a narrow gorge; down this the water rushes swiftly for three-quarters of a mile, and at last makes a perpendicular plunge of fifteen feet, into a broad smooth basin on a level with the Saint John. In this basin the salmon naturally accumulate while hesitating to attempt the fall, and many are there speared by torchlight. Near the most difficult part of the fall is a little pool of still water into which salmon frequently drop exhausted, and stay a short time to rest. At favorable stages of the water it is said that more salmon are caught in this little pool than in all the rest of the river.†

Above Aroostook Falls, the river is smooth and gentle for many miles, and the facilities for taking salmon are consequently poor. A few are, however, caught with nets and spears all along. The number of nets is very small, nearly all the fishing being done with spears. There are no artificial obstructions on the main river, and salmon can run quite to its headwaters. They have been caught a hundred miles above its mouth. Their favorite stream in old times was the Big Machias. A dam built near its mouth about thirty years ago shut the salmon out almost completely, but occasionally one leaps the dam. From the tributaries below this point they are likewise shut out by dams. In Presque Isle Stream and Salmon Brook they were formerly abundant.

The data at my command do not furnish a sufficient basis for an estimate of the number of salmon caught on the Aroostook. One correspondent estimates that in 1873, which was the best year for a long time, 125 were caught within two miles of Caribou. Another says that in the vicinity of Salmon Brook and Machias 200 were speared the same season; and that one net just above Fort Fairfield took eleven in one night. Three years ago the fishing is thought to have been at its lowest ebb.

The average weight of the salmon caught in the Aroostook is estimated by one correspondent to be ten pounds; by another twelve pounds. Grilse are occasionally seen, but not often. They are caught in August. The first run of adult salmon reaches Caribou and Castle Hill about the first of July; their appearance at Aroostook falls is said to be from

* Annual Rept. (Canadian) Dept. Marine and Fisheries for 1869, p. 79.
† Letter of F. M. Everleth.

the middle of June to the first of July. The main run reaches Caribou about July 20, and the last run the last of August.

Meduxnekeag River.—In 1816 salmon were very plenty on this river in the vicinity of Houlton. They continued so until 1826, when they were shut out by dams that were built across the stream at different points. Since that time few have been caught above Woodstock, where the first obstruction is encountered. Alewives also formerly frequented this river, and have shared the fate of the salmon. A fish-way was built over the dam at Woodstock in 1868, and both salmon and alewives are reported to have passed through it the following year.*

3.—SAINT CROIX RIVER.

This river once yielded large numbers of salmon. The principal fishery previous to 1825 was that carried on at Salmon Falls in Calais, a short distance above tide-water. The whole river is here compressed into a narrow and steep passage, which, although difficult, was in its natural state surmounted by great numbers of salmon, shad, and alewives. There were several side-channels into which the fish crowded in order to avoid the furious current of the main channel, and here they were easily taken with dip-nets. The following statements, reported by Perley, illustrate the abundance of salmon. A boy of fifteen has been known to take 500 salmon at these falls with a dip-net in a single year, and a man has taken 90 to 100 salmon two days in succession in the same mode. Another man, standing on a jam of logs a short distance below the falls, took 118 salmon in one day. Such occurrences do not appear to have been common, and afford no basis from which to compute the total yield.

Above Salmon Falls there has been very little salmon-fishing done at any time. The extent of the range of salmon on the upper waters at that time cannot be now ascertained. I have it from an intelligent Indian of the Passamaquoddy tribe, Piel Toma, who lives near Princeton, that fifty years ago they were caught at Grand Lake stream on the west branch. The Indians call the sea-salmon *Pl-láhm*, in distinction from the *land-locked* salmon, which they call *Tag-e-wah-nahn*.

Dams were built on this river probably a century ago, but previous to 1825 they were all provided with ways for the passage of migratory fish, of such a character that the dams did little or no harm to the fisheries. But in 1825 the Union dam in Calais was built, and remained for many years without an adequate fish-way. Being situated in tide-water, it completely shut out from their breeding-grounds all the migratory fishes, except such as could surmount it at high water, in exceptionally high tides. That this was occasionally possible with salmon there is no doubt. But so long were the fish kept in waiting for a favorable oppor-

* Letters of T. P. Packard, J. R. Weed, Bernice Royal.

* Annual Rept. (Canadian) Dept. Marine and Fisheries, for 1870, p. 289.

tunity to ascend, that they were too much exposed to be taken by the spears and nets that were constantly plied both within and without the lawful limit, and they rapidly diminished in numbers. In 1850 it was estimated by Mr. Perley's informants that the number of salmon caught on the whole river did not exceed 200 yearly. From that time for fifteen years the catch remained very small; some seasons it was estimated to have been only about 100. In 1866 and 1867 there was a marked increase, and at the present time the salmon appear to be gaining in numbers.

In 1869 fish-ways were built over the dams at Union Mills and Baring, which were the only ones on the lower part of the river that were without suitable provision for the passage of fish. The dams at Milltown were built out from either shore obliquely up stream, and, at the point of meeting, a gap several feet wide answered the purpose of a fish-way admirably except when choked with logs, a contingency not seldom occurring. The fish-way at Union Mills was built after a design by the late N. W. Foster, who was chairman of the State board of commissioners of fisheries in 1867 and 1868. Alewives were seen passing up through this fish-way in great number the first season it was opened, and salmon are supposed to have accompanied them, quite a number being seen above that point. The dam at Baring was passable not only by means of the legal fish-way, but also by a broad stream of water that was allowed to run around one end during all the early part of the fish season. In 1873 salmon were seen at Vanceborough on the east branch, and one was hooked there by Mr. Commissioner Stanley. The dam at Vanceborough and also that at Forest City, twenty miles above on the same branch, were also provided with fish-ways in 1869; and the only dam on the river now without a fish-way is that at Princeton, on the west branch.

The aboriginal mode of catching salmon was with the spear, and this implement was still in use near the lower dam in 1850. The whites use dip-nets on the falls, drift-nets on the rapids wherever the bottom is smooth enough, and weirs in the tidal parts of the river. The dip-net has not been much used since salmon became scarce, but until very recently dip-nets have been used with fatal effect just below the Union Dam, in Calais. Weirs are built at several points in tide-water. Since 1860, they have increased in number. At the present time there are built six or seven of all kinds. Mr. Lewis Wilson, who has built a weir on the American side of the river since 1850, has given me much valuable information. From one of his letters I extract the following:

"The yield of salmon, judging from the production of our weir and what I hear, is very irregular, five times as many some years as in others. I estimate the range in different years from 100 to 500, averaging perhaps 300 or 350 annually. I think they are rather on the increase, comparing our catches latterly with those fifteen or twenty years ago. Though we take only about the same number that we formerly did, or a slight

increase, then there was no weir to interfere with ours. For the last ten years or so, there has been a weir a mile or two below ours, which probably diminishes our catch from what it otherwise would be. Last season there were below the 'ledge' three weirs of the kind which retain the fish at high water, and three or four half-tide weirs above the ledge, two of which, of each kind, were on the American side. For several years previous there were none on the eastern side. And from about 1850 to to 1860 our weir was the only one of the kind on the river. Prior to that for a number of years there were none.

"The principal fish caught in them, more particularly in ours, naming them in the order in which they first come, though the different kinds run into each other, are herring, codfish, alewives, salmon, sea-shad, (but very few river-shad,) a kind of sea-alewife called blue-back, and formerly small mackerel, but of late they seem to have forsaken the river. Many other kinds in smaller quantities, but all help to make fares. Salmon and alewives pay the best. The latter has increased a hundred fold, I think, in the last ten years.

"The salmon run larger some years than in others, perhaps an average of two pounds in weight. Last season they ran large. With regard to grilse my information is confined to our weir; we occasionally catch what we call young salmon, perhaps three or four a year, weighing about three to five pounds. We also catch another kind, about the same number, which were called grilse by those who fished here before us, but which I think is a species of trout, unlike the young salmon, weighing perhaps from one to two and one-half pounds; large head, lean body, dark color, and very inferior to young salmon for food; some of these have spawn. Twelve or fifteen years ago, more or less, Mr. Upham Treat, of Eastport, put several salmon, perhaps ten, from our weir into Shattuck's Lake, in the lower part of this town, the outlet of which is in the upper part of Robbinston. One season several years afterward, (I cannot recall dates,) we caught more salmon than in any season before or since—more than our usual proportion, compared with those caught at the head of the tide, as far as we learned, and of an unusual uniformity in size. Our theory at the time was that they were the offspring of Treat's salmon; that the stream being too small for them to enter, and they not being inclined to go up the river, they dallied about in that vicinity and got entrapped."

The weir built by Mr. Wilson consists of a "hedge" and two inclosures, the "big" and "little" pounds. The hedge runs from the shore out to the entrance of the big pound, and is made of stakes, brush, and net. The big pound is about sixty-two feet long and thirty feet wide, and its entrance is sixteen feet wide. It is of the same material as the hedge. From the big pound the fish pass through a passage-way, nine inches wide at the bottom and fourteen at the top, into the little pound. The little pound is circular in shape, about fourteen feet in diameter; has a board floor raised several feet above the ground and walls of net-

ting. The pounds are near low-water mark, and at high water of ordinary tides the floor of the little pound is sixteen feet under the surface. The distinguishing feature of this weir, when compared with those built on the Penobscot, is the position of the second pound, which is on the lower or down-river side of the first pound; on the Penobscot it is always on the upper side.

Mr. Wilson has furnished a statement of the catch of salmon in his weir for the last ten years, together with some explanatory remarks which are herewith submitted:

"With regard to the number of salmon caught here last summer and how it compares with other years, owing to the operation of the fish-law, there seems to be no basis for an intelligent estimate. The prohibition covers nearly all the fishing-ground at the head of the tide where most of the salmon used to be caught, and but comparatively few are caught there now unless by stealth. I can inform you how our number compares with other years, but how much, if any, this number is increased by salmon falling back, that would have been caught at the head of the tide were there no restriction more than heretofore, I have no grounds for even a guess. That some drop down is quite certain, for we have caught several showing unmistakable marks about the gills of having been meshed, when nets were used only at or near the head of the tide.

"During the last ten years our 'catches' have been as follows, the place and plan of the weir the same every year:

Year.	No. of salmon.	Year.	No. of salmon.
1864	30	1869	22
1865	27	1870	35
1866	109	1871	117
1867	104	1872	55
1868	93	1873	84

"In 1871 and 1872 we observed the two weekly close-days to July 15. The other two weirs, one on each side of the river, two to three miles below ours, have caught each, I estimate, nearly as many as we have. The several half-tide weirs may have caught not to exceed a half dozen. I can make no estimate of the number caught at Union Mills, the head of the tide. If I could it would be no test, as there would be no clew to the number diminished by the protective law.

"The average weight of the salmon we caught in 1870 and 1871 would not exceed 10 pounds each, about 9½ pounds according to our accounts; in 1872 and 1873 about 12½ pounds."

4.—DENNY'S RIVER.

Salmon abounded in this river in its primitive state. The Cathance, the principal tributary, was more frequented by them than was the main river above the mouth of the former. But the Cathance has been utterly closed up by dams, and for some years subsequent to

1840 an impassable dam was maintained on the main river about a mile above the head of the tide. As a natural result the salmon became comparatively scarce. A sufficient breeding-ground, however, remained open to them to prevent their utter extermination, and they have continued to frequent the river in fluctuating numbers until the present time. In 1858 the impassable dam on the main river fell into disuse, and for a dozen years presented no obstacle to the ascent of fish. Since the river was thus re-opened, the principal hinderance to the increase of salmon has been the unreasonable persecution that they have received at the hands of a lawless class of citizens. So unrelenting has been the pursuit, with set-nets, dip-nets, spears, stones, and clubs, that, in spite of the improved facilities for ascending the river, there has been no marked increase.

Salmon in the earlier stages of growth have been observed in the Denny's much oftener than in rivers farther west. One observer who has been familiar with the river and its fisheries for many years, says that in his boyhood, when salmon were plenty, he and his comrades used to catch both salmon-smolts,* from five to seven inches long, and parr, in great numbers. One or both of these are also now caught at Dennysville by anglers, but in less numbers than formerly. Grilse are sometimes taken in this river, but are not abundant. Mr. Lincoln says that among thousands of salmon caught there that came under his own observation, there were only five or six grilse. Even at this rate, however, they appear to be more plenty than in the Penobscot. The average size of the adult salmon in 1873 Mr. Lincoln estimates to be about ten pounds of the preceding year.

The total yield of Denny's River for 1873 is estimated to have been one thousand salmon. It was somewhat larger than in 1872. They were caught, as they have been for many years, in set-nets, at the narrows, in tidal water, a short distance below Dennysville village, and with dip-nets and spears in the vicinity of the dams. The number of set-nets employed is ordinarily ten or twelve. They are simple straight nets, forty feet long and about six feet deep, and take salmon by meshing them. When set they run from the shore obliquely down stream, making an angle of about forty-five degrees with the shore, the upper edge of an eddy being a favorite place. They are fastened to the bottom, and being only six feet high the tide covers them completely in two or three hours after it begins to flow. The salmon are supposed to ascend without any hinderance from the nets during flood tide, but on the ebb they are thought to drop back into the eddies and get caught in the nets.

* Letter of Benjamin Lincoln. Mr. L. says: "We used to catch great numbers of what we boys then called young salmon, little fellows from five to seven inches long, with little silvery scales like a miniature salmon, and also a little fellow with red spots and bars, like a trout, only lighter colored; these we also called young salmon. But as the salmon have decreased with us I notice that the boys catch less of these."

This is the only river in New England, except the Narraguagus, where fly-fishing for salmon has ever been practiced. In 1867, and for several years before and after that date, several gentlemen from Portland and Boston fished it for some weeks each season, and met with fair success.

Salmon are caught occasionally near Eastport, and these are probably Denny's River salmon, although it is quite possible that they are to be referred to the Saint Croix or the Saint John. It is stated on good authority that the drift-net fishery for salmon outside the harbor of Saint John extends very far toward Grand Manan, the boats and nets of the fishermen being sometimes swept by the tide in a single night quite to that point, and sometimes catching salmon there. The salmon caught near Eastport are mostly taken in the herring weirs. Capt. U. S. Treat, who has fished here since 1841, has sometimes taken as many as thirty salmon in his weir; in other seasons but a single salmon. He once took one in January, and found it to be in perfect condition. The same gentleman has found in the stomachs of salmon caught here herring five inches long.* It also occasionally happens that salmon are taken on the hooks of pollack-fishermen. These hooks are baited with herring, and kept near the surface of the water.

5.—LITTLE FALLS RIVER.

This is a very small river near the Denny's. It lies wholly in the town of Edmunds, rises in a small sheet of water called Edmund's Lake, and is not over ten miles in length. Salmon ascend it every year. It has been observed that they enter it from the salt water of Cobscook River in the fall, and competent observers think that this is their ordinary course, very few of them entering the stream in early summer at the ordinary season for the ascent of rivers. That they breed in it is attested by the common occurrence of salmon-parr. They appear to be increasing in numbers.

6.—ORANGE RIVER.

Salmon once frequented this river, but it does not appear that they were ever very numerous. Three dams near the mouth of the river cut them off from all breeding-grounds, and they were exterminated. In 1870 several hundred young salmon, hatched from eggs obtained from the Canadian establishment at Newcastle, Ontario, were placed in this river. In October, 1873, a single salmon was caught at the lower dam and placed in the river above. This is the only specimen seen for many years. The dams are all provided with fish-ways for alewives, and through them it is probable that salmon would ascend at the proper season.

7.—EAST MACHIAS RIVER.

Though better adapted, by its extensive lakes and gentle current, to the production of alewives, this river has always afforded salmon, and

*Captain Treat formerly carried on the salmon fishery at Cape Jellison, Penobscot Bay, but never found fish in their stomachs, nor anything else that he recognized.

formerly they are said to have abounded. Owing to the exertions of the late N. W. Foster, of East Machias, both alewives and salmon were preserved from destruction which almost overtook them about 25 years ago. Several dams had been built on the river, and the fish-ways allowed to fall out of repair. Mr. Foster introduced some improvements in the fish-ways, and prevailed upon his fellow-townsmen to have them kept in order and the laws protecting the fish enforced. A gratifying increase rewarded these efforts, but Mr. Foster was never able to carry out fully his plans of improvement. Some of the fish-ways remained defective, and the greed of the fishermen took too great a share of the ascending fish. There was never, therefore, a complete recovery of the fishery from its depletion.

Salmon-parr are frequently caught with the hook in Chase's stream near the outlet of Gardiner's Lake, and it is inferred that in this stream the adults are accustomed to spawn. No information has been received as to the number of salmon taken in the river recently. Several years since it was estimated at 50 adult salmon annually. Smolts are occasionally taken in the winter by dip-nets, along with tom-cods and smelts.

8.—MACHIAS RIVER.

This river, unlike the East Machias, has a small extent of lake surface, and is not so well adapted to the growth of alewives. For salmon, however, it appears to be much the better stream of the two, and this species is described as having been in old times extremely abundant. There was no market for the surplus, and a ten-pound salmon could be had for fifty cents. Even as late as forty years ago, they are said to have been as plenty as that. A man with a dip-net could take 60 salmon in a day at the lower falls. As in other cases, insurmountable dams were built, and salmon disappeared from the river. For twenty years or more, not one was seen. A weir built for alewives in 1870 and several preceding years never caught a salmon. In 1873, however, they reappeared in considerable numbers. They were first observed in the summer at the ordinary season, below the dams, in the tide-water. Not many were seen at that time, and it is not known that any passed up into fresh water. In September and October they appeared in larger numbers, and made great efforts to pass the lower falls. Many of them succeeded, and some were taken with a dip-net below the dam, and placed above it. The fish-warden observed that part of these salmon were "hook-bills," and part were "round-nosed," from which it may be inferred that the sexes put on their distinguishing marks even when kept in salt or brackish water.*

There are three dams on the Machias River. The first, at Machias village, at the head of tide-water, is not impassable. The second, also at Machias, is a high dam, and completely stops the ascent of fish. It was provided with a Foster fish-way some years ago, but there being

* Letters of M. H. Wilder, esq.

very few alewives in the river and no attempt having been made to introduce salmon, the fish-way was neglected, and went to decay. The third dam is at Whitneyville, five miles above the first This is also too high for salmon to pass. It was provided with a fish-way at the same time as the second dam, and as in that case the structure became useless by neglect.

9.—WESCONGUS, OR PLEASANT RIVER.

About seventy-five salmon are, it is estimated, caught in this river yearly. In 1872 the high state of the water enabled a greater proportion than usual to pass the lower falls at Columbia, where they are usually caught, and reach their breeding-grounds. The catch of that year was consequently light. They are taken altogether with dip-nets, the use of other nets being forbidden by law. One is now and then caught six or seven miles below Columbia Falls, in some one of the weirs built for herring in the estuary into which the river flows. The fishing at Columbia Falls begins about the middle of June and lasts until September; by this time their quality here has deteriorated so that the inhabitants do not consider them edible, and take more pains to give them a passage up the river. They are not supposed to ascend the river more than six miles, where all, or nearly all, of them are stopped by difficult falls. In the spawning season they are frequently seen in a small branch that enters the main river about three miles above Columbia Falls. In size the salmon of this river appear to be not far from the average of other rivers—perhaps a little smaller—"averaging," says my informant,* "from seven to twelve pounds." Occasionally one of five pounds is taken, very rarely one of three pounds, and one smaller than this is hardly ever seen or heard of.

There are six dams across the main river, in height varying from five to seven feet; one of them is out of use. Two of them are in close proximity to each other at Columbia Falls; one of these is provided with a fish-way, and salmon find means to pass them both.

10.—NARRAGUAGUS RIVER.

This river once yielded great numbers of salmon and alewives. They were plenty until forty or fifty years ago. One old gentleman testifies to having once, with the assistance of two others, taken at Cherryfield forty salmon one morning between daylight and sunrise. Other similar feats are told. Small vessels came here to load with fish. Salmon were caught with drift-nets, spears, and dip-nets. They were mostly taken between May first and the middle of July, in the lower part of the river, within a mile of the head of the tide, but they were frequently caught at Beddington Lake, sixteen miles farther up. At the spawning season a great many used to be seen at the mouths of Salmon and Schoodic Brooks, which appear to have been favorite spawning-grounds.

Dams were built in the river at an early day, but until within about fifty years there was none that seriously hindered the ascent of salmon.

* Mr. Gowin Wilson, of Columbia Falls.

A better dam was then built. For a time a fish-way was maintained in it, but it was by and by neglected, and the fish left to their fate. They rapidly diminished, and were in a few years almost utterly extinct. For twenty-five or thirty years, say from 1840 to 1871, but few were seen each season and none taken. For two or three years past more have come, and during the summer of 1873 perhaps two or three dozen were seen trying to pass the lower dam, and four or five of them clubbed to death. An equal number has not been killed in any season for many years.

The number of dams now in existence on the river and branches is eleven, of which four are out of use and falling into decay. Five of the remainder are within a mile of tide-water.*

11.—UNION RIVER.

This was formerly a very productive salmon river, but has not yielded a single specimen for sixteen years.† The fishery used to be carried on with nets. No weirs were ever built in the river;‡ and in the absence of both weirs and nets at the present day it is quite probable that salmon occasionally enter the river in very small numbers without attracting attention. It would be remarkable, indeed, if not a single individual should stray from the Penobscot, which lies so near. Their ascent to their ancient breeding-grounds is, however, effectually prevented by the formidable dams at Ellsworth. Of these there are six, all located within three miles of tide-water. Above them the main river is open to its head-waters.

12.—PENOBSCOT RIVER.

The Penobscot River, besides being the largest between the Saint John and the Connecticut, is distinguished from nearly all others within those limits by the manner in which it discharges its waters into the sea, namely, through a large bay or estuary, narrow at its head, where it receives the waters of the river, but widening gradually to its junction with the open sea. This feature is also characteristic with the Saint Croix, Union, Pawtuxet, and some other smaller rivers, but all the large rivers within the specified limits, with the exception of the Penobscot, discharge their waters abruptly into the sea. This fact may or may not be of importance in its bearing on the distribution and habits of the migratory fishes frequenting the several rivers, but at any rate is not to be neglected.

The estuary of the Penobscot, called Penobscot Bay, has on the seaward side natural limits tolerably well marked, not only by the numerous islands embracing some of large size, that guard its entrance, but by two prominent capes of the main land, Owl's Head on the west, and Waskeag Point on the east. The width of the bay here is nearly thirty

* Letter of C. J. Milliken, esq.
† Letter of S. Dutton.
‡ Letter of K. K. Thompson.

miles, but it narrows rapidly as we proceed upward, and at Cape Rosier, thirteen miles above, it is only seven miles wide. Above this point it widens a little at Belfast, and then contracts at Fort Point to a width of between two and three miles. Three miles above this is the mouth of the river, which enters the bay by two channels, one on either side of Wetmore Island, sometimes known as Orphan Island, and constituting the town of Verona. The total length of the bay is about thirty miles, being but little more than its greatest breadth. Its area may be roughly estimated at 400 square miles, exclusive of islands. Into this broad bay the Penobscot River discharges about 320 billions of cubic feet of water per year,* or about 873 millions per day. Assuming the mean depth of the bay to be 60 feet, its capacity is 400 millions of cubic feet, and it follows that the volume of fresh water discharged into it is sufficient to renew the whole volume of the bay in a little more than a year. Probably the actual depth is greater than that assumed, and the time required to replace the salt water with fresh would be considerably longer. That part of the bay above Castine, which first receives the water of the river, has an area of perhaps 60 square miles, and, if we assume the average depth to be 8 fathoms, the river could not fill it in less than three months.

These figures are nearly all rough approximations, but they serve to show, in a general way, the small comparative volume of the inflowing fresh water, and prepare us to believe that what with the tides, currents, winds, and other forces tending to bring in fresh supplies of seawater, the river can exert little influence in changing the constituents of the water, except in the extreme upper end of the bay. The flow of the tide turns the current of the river as far as Bangor in the summer, and above Bucksport always. The water is quite salt at the latter place, and in the summer it is brackish at the former.

The result of the action of the river-water in displacing or altering marine forms of life in the bay, cannot be told with precision without more extensive observations than I have been able to make; but the statement of a few facts will illustrate the degree of its influence.

In several points of the bay are good hake grounds. Off Castine is a good ground for haddock, and cod are also caught in that part of the bay, both of them with their stomachs well filled with marine mollusks and other animals. Near Brigadier's Island is a favorite place for catching menhaden, and this species is common enough in its season about Bucksport. In the smelt-nets set from October to March, on the Bucksport and Verona bridge, there are caught not only smelts and tom-cods but great numbers of flounders, sculpins, skates, &c., and at times, especially in the early part of the season, shrimps and other small crustacea. Jelly fishes are not rare at the same point. The shores, even as far up as this, are covered with a growth of fucus, and species of littorina abound. On the other hand, I cannot recollect of ever seeing a

* Wells's Water-power of Maine, p. 105.

proper fresh-water fish caught in this part of the river or any part of the bay, except a single specimen, caught in Verona, of trout, (*Salmo fontinalis*,) which is known to often run into salt water.

The works of man have interfered less with the migration of salmon in the Penobscot than in any other large river south of the Saint John. Owing to its great volume and other favorable circumstances, dams, quite impassable by salmon, have never been in existence many years at a time. The four points on the lower part of the river at which dams have been built are Veazie, Ayer's Falls, Great Works, and Oldtown. At Oldtown the center of the river has never been closed, and salmon ascend there with considerable ease. At Great Works two long wing-dams, running from the mills on either side up the river nearly parallel with the banks, are joined at their upper ends by a low cross-dam, which is not a serious obstacle at the season of the year when the main body of the salmon are ascending the river. At Ayer's Falls the dam that crosses the river is low, and at its eastern end abuts upon a ledge, over which the water runs down an irregular inclined plane to the level of the main channel below. This assisted the salmon in surmounting the dam, and was, to a certain extent, an abatement of the evil, but at best the structure was so serious an impediment that it was necessary to construct a fish-way, an inexpensive affair, made by merely enlarging a crevice in the ledge at the east end of the dam. The dam at Veazie, built in 1834 or 1835, was at first quite impassable, and so remained for several years. Since then, however, the water has wasted away the bank at the east end of the dam, and disclosed a large crevice in the ledge, through which so large an amount of water is generally flowing that salmon have little difficulty in passing the dam.

Above Oldtown the main Penobscot is entirely free from artificial obstructions for 70 miles; the Mattagamon, or East Branch, for nearly 100 miles; the Mattawamkeag, for 45 miles; the Piscataquis, for 50 miles. Of the tributaries, the lower ones are nearly all effectually closed against salmon by dams, and have been in that condition for many years; in few of them, however, if in any, was the species ever abundant. In the upper tributaries there are comparatively few obstructions, and there the salmon have access to their original spawning-grounds. The dams built there for service in floating timber, or, in the vernacular, "driving" it to the mills below, are generally of such a character that they do not prevent the passage of salmon, and hinder it only for short periods in the spring and early summer. The dam at the outlet of North Twin Lake is of this character. It serves to raise the surface of Ambojegis, Pamedumcook, and the Twin Lakes to a point some thirteen feet above their ordinary level, both for the purpose of facilitating the passage of the "drives" of logs across the lakes, and to store water, to be let out when wanted to float them over the shallow rapids below. The gates of the dam are closed in June, and kept shut for several weeks, while the lakes are filling up. During this time no salmon can

pass. In July they are opened again, and for several weeks more they are pouring out a flood of water, in which salmon can ascend. At the outlet of Chesuncook Lake there is a similar dam, but it is opened much earlier in the season. Such is the case with nearly all driving dams.

Besides the building of dams there is one other artificial change in the condition of the river worth mentioning. For half a century past the principal occupation of the population along the Penobscot River has been the cutting and manufacturing of timber. For this purpose, indeed, most of the dams were built. The refuse from the saw-mills, consisting of slabs, edgings, shavings, and saw-dust, was, until very recently, all thrown into the river, as the easiest way of getting rid of it. Lately the throwing of the coarser sorts of refuse into the river has been forbidden by law; but saw-dust may still legally be disposed of in that way, and the throwing in of refuse of the coarser kinds is not entirely stopped. This practice has not affected the upper part of the river materially, since there are no extensive lumber-mills above Oldtown; but from the latter place to the sea the refuse has accumulated to such an extent as to encroach alarmingly on the channel, and fill up extensive coves and bays with a deposit of decaying saw-dust, mixed with earthy sediment, while great quantities of the former are, through the greater part of the year, to be constantly seen floating on the tide, or swimming at all depths beneath the surface. The extensive deposits have in some instances so altered the configuration of the bottom as to interfere with the success of certain fishing-stations; but beyond that I see no evidence that the discharge of the mill refuse into the river has had any injurious effect on the salmon. It does not seem to deter them from ascending, and, being thrown in below all the spawning grounds, it cannot affect the latter.

The Main Penobscot, above Oldtown, with the exception of two "dead-waters," so called, has, throughout its entire length, a strong current, broken at intervals by falls. The two dead-waters are the Sunkhaze Dead-Water, which commences some two miles above Oldtown and extends from six to eight miles, and a similar one occupying a space between Piscataquis Falls, near the mouth of the Piscataquis River, and Lincoln. The last has a stronger current than the Sunkhaze Dead-Water, and has a gravelly bottom for the most part. The principal falls between Oldtown and Nickerton, at the mouth of the Mattagamon, or East Branch, are the Cook, Olamon, Passadumkeag, Piscataquis, and Five Island Falls. The bottom for the whole distance above Sunkhaze Dead-Water, is rocky or gravelly, though not in many places ledgy. From Mattawamkeag to Nickerton is a beautiful, gravelly bottom, with a uniformly strong current, well adapted, it is supposed, to form spawning-beds for salmon, although it is not positively known that they ever spawn there.

Of the lower tributaries the finest and most extensive breeding-grounds lie in the Piscataquis and its branches, to many of which sal-

mon have access now, visiting them yearly and often showing themselves at Brownville on the Pleasant River. The Passadumkeag probably contains good breeding-gounds, but to a less extent than the Piscataquis. They find suitable ground in some of the tributaries of the Mattawamkeag, and in several small streams directly tributary to the Penobscot. Three of the latter have received the name of "Salmon Stream." In one of them which joins the Penobscot, a few miles above Mattawamkeag, I have, myself, found the nests of salmon.

Above the entrance of the Mattagamon the Main Penobscot, commonly called the West Branch, gradually changes its character, has less gravel, larger bowlders and more ledge in its bottom, and the uniformity of its current is interrupted by numerous falls and extensive lakes; but there is no serious natural obstacle to the ascent of salmon throughout its entire length; and the dams at North Twin and Chesuncook do not wholly prevent salmon reaching the upper waters. At both these dams they are frequently seen and sometimes caught. One informant has known of two instances, in a single spring, of salmon throwing themselves upon the piers at Chesuncook Dam, and being taken by the river-men.* Of the tributaries of this part of the Penobscot, the Millinocket, Nahmakanta, Souadnehunk, Caribou, and Caucomgomoc Streams are particularly well fitted to be the breeding-grounds of salmon.

It is believed that the Mattagamon or East Branch is a better salmon-river than the Main Penobscot, and that a much greater number of salmon resort to it. They can ascend it as far as Grand Falls, thirty-five miles from its mouth, and find extensive spawning-grounds not only in the Mattagamon itself, but in the Wassaticook and Seboois Streams and their tributaries. The Wassaticook is an impetuous mountain-stream, draining the northern and eastern sides of Mount Katahdin. The Seboois traverses a more level district, and is a very fine, gentle, gravelly stream, with numerous rapids of sufficient force to form admirable spawning-beds. In this stream and in the Mattagamon I have, myself, seen many salmon-nests.

The industrial modes of fishing employed in the Penobscot Bay and river are three: first, drift-nets; second, pound-nets; third, weirs. With very few exceptions the use of each mode is confined to a particular district. Drift-nets are used only in the swift water of the river above the flow of the tide; pound-nets in the more open parts of the bay; weirs in the tidal part of the river and the upper part of the bay.

The drift-net is a simple straight net, buoyed on the upper, and and weighted on the lower edge, which is thrown out from a boat and allowed to float down the current, intercepting any upward-bound salmon that may come in the way, and which are caught by thrusting their

*Mr. Manly Hardy, of Brewer, is authority for this statement, as well as for numerous others in relation to the Upper Penobscot. Mr. Hardy says that he knows of a salmon, weighing half a pound, being taken on a fly-hook more than thirty miles above Chesuncook in September, 1872.

heads into the meshes in the endeavor to break through the net. A considerable number of these nets are every summer in use on the shallow rapids below the Great Works, Basin Mills, and Veazie dams. Occasionally one of them is used at some point above Oldtown. The Mattagamon, near the mouth of the Wassaticook, is one of these points; the North Twin dam is another.

The pound-net, in use on the Penobscot, consists of the "run," the "inner pound," and the "outer pound." The run is a straight net, running out into the water at right angles to the shore. It is 11 or 12 feet deep, and its length depends somewhat on the character of the site; 25 fathoms is the common length, but in very "bold" water 18 or 20 fathoms will answer. At the extremity of the run is the inner pound, which is shaped like an obtuse arrow-head, the two barbs being styled "hooks." The entrance of this inner pound, 6 feet wide, is between the barbs or "hooks," and at its tip is an opening 1 foot wide, which leads into the outer pound, an inclosure about 18 feet square. Both pounds have bottoms, and are of the same depth as the run, 11 or 12 feet. The whole is supported by wooden floats, so that it rises and falls with the tide, and is held in place by anchors planted at the extremities of long "warps." A pole placed perpendicularly at the point of each hook, and another at the outer angle of the outer pound, brace the bottom down. The latter is called the "spring-pole," and, in "springing" the net, it is cast loose at the upper end and allowed to swing loose while the bottom of the pound is drawn up. The mesh employed is 6 or 6½ inches long, being 3 or 3¼ inches square. The 6½-inch mesh is too small to mesh a 22-pound salmon and too large to catch one of 6 pounds. It is supposed that if small salmon ever enter these nets, they pass out through the meshes. The majority of the medium-sized and large salmon do not mesh but remain free in the pound, being too wary to strike the meshes. The bottom of the net is commonly several fathoms above the ground; and were not the salmon that encounter its run persistent surface-swimmers, they would dive under it, and escape without entering the pounds.

The three parts first described constitute what the fishermen call a "hook of nets." Sometimes from the outer extremity another "run" is set, with pounds at the end of it, constituting another "hook of nets," and this combination is termed a "gang of nets." Sometimes as many as four hooks are set in a single gang.*

The invention of this style of net is ascribed by the fishermen to one Halliday, an Englishman. The net in use before it had only one pound, corresponding to the inner pound. It was much inferior to the modern style, as a great many salmon escaped by the entrance, which had to be wide to induce them to enter at all, and in this way the very largest salmon were lost, being too large to mesh.

A Penobscot fish-weir generally consists of a leader and three pounds.

* Illustrations of these nets are given in the appended plates.

The "leader" corresponds with the run of the pound-net described above. It is built of stakes and brush loosely driven. Its length is governed by the shape of the river-bed and some other circumstances, such as the character and direction of the currents. Most fishermen aim to have their pounds located entirely beyond low-water mark, and frequently the water where they are situated is 15 or 20 feet deep when the tide is out. The leader extends thence to the shore. The first or great pound is a heart-shaped inclosure, about 60 feet wide, having an entrance 22 feet wide, nearly in the middle of which is the outer end of the leader. Stakes and brush compose the walls of the great pound. At the apex of this inclosure is an entrance 3 or 4 feet wide to the second pound, which resembles the first in shape, but is commonly provided with a board floor near low-water level, and has walls of netting instead of brush. An opening only a foot wide leads into the fish-pound, which is also provided with a floor.* Fish swimming along the shore, whether ascending or descending the river, encounter the leader, and in trying to get around it are led into the great pound, and the shape of this is such that they rarely escape out by the way they came in, but readily find the entrance to the next pound, from which, in like manner, they pass on to the fish-pound, where they are left by the retreating tide on the bare floor.

Both weirs and pound-nets depend for their success on the disposition of fish to move in straight lines when there is no obstacle in the way. On being turned from their course by the leader, they swim, in the direction it gives them, straight into the great pound, whose entrance is so wide that they see only one side of it at once. Were the opposite side of the entrance or of the pound in sight, the fish might be deterred from entering and turn back. Once within the great pound, they swim straight to the opposite side, meeting which, they turn and follow it. If frightened at the narrowness of the passage into the second pound, they turn back and follow the side of the great pound back toward the entrance, but by the time they reach that point the curve of the pound has given them a new direction, which carries them directly past the entrance. Thus they rarely find their way out, and, becoming soon familiar with the walls of their inclosure, venture through the gap that leads them into the second pound.

The weirs of the Penobscot are not very expensive. It is estimated that one can be maintained at a cost of $60 a year. They generally occupy the same site year after year. The site is fixed by experience in each individual case, and hardly any rule can be given that will guide in the selection of one on an untried shore. There are long stretches of shore where no one attempts nowadays to build weirs, but in most cases these sites have been tried in former times and found unprofitable. Weirs are built in the river as early in the spring as the state of the water will permit, and are for the most part in operation before the close

* See illustration in the appended plates.

of April. On the shore of the bay they are built a little later, the salmon not making their appearance so early as in the river.

The district within which these weirs are almost the sole mode of taking salmon extends from Orrington, on the river, to Belfast, on the west side of the bay, and Castine on the east side; and with a very few exceptions no weirs have ever been built outside those limits. The number built within this district in 1873 was 114, of which all but one caught salmon. In 1870 there were 160 weirs, of which five or six caught no salmon, depending for their profits on the capture of menhaden and alewives. The last season having been a profitable one, a greater number of weirs will be built in 1874. Thus the number varies from year to year.* In some parts of the river as many weirs are built now as ever, while in other localities there has been a marked falling-off.

The limits within which salmon-fishing is regularly carried on as an industry in the Penobscot River and Bay at the present day, may be fixed at Oldtown above, and at Rockport, Long Island, and Castine below. Many years ago there were fisheries on the eastern side of the bay as far out as the upper or northwest end of Eggemoggin Reach and at the extreme lower end of Long Island. But these outer stations were not profitable, and were abandoned after a few years' trial. One at Buck's Harbor yielded about fifty salmon a year. One near Cape Rosier was more productive, and the last year it was in operation yielded 102 salmon.

For the last two years (1872 and 1873) a weir for the capture of herring has been maintained on Western Pond Island, about two miles below Cape Rosier. It caught 30 salmon in 1872 and only 8 in 1873. It is probable that, were similar weirs maintained in favorable places still farther down the bay, salmon would be taken in them in small numbers. I have learned of the existence of only one weir in any part of the bay outside of Long Island and Rockport. This is a weir built for the capture of alewives at the outlet of Fresh Pond in North Haven. In former times there have been weirs maintained at five or six different points on the same island for the capture of herring and mackerel;† but I cannot learn that a salmon was ever caught there. This fact, however, is not a fair test of the presence of salmon in those waters, since the structure and location of the weir are not favorable for their capture Probably the salmon caught was a native of the Penobscot; for all the breeding-grounds of the Union River, to which we should naturally refer it, have for many years been inaccessible.

The capture of salmon in the Lower Penobscot Bay and in the open sea adjoining, with nets and hooks, is of rare occurrence; but there are several instances worthy of record. Off the northeast breaker of Seal

* On the appended map of Penobscot Bay and River are represented all the weirs of which I have obtained information, both those built recently and many that were abandoned years ago.

† Statement of A. Waterman.

Rock, a certain Captain Eldridge, of Bucksport, caught a salmon on a hook while "drailing" for pollack; that is, dragging a seven or eight fathom line with a baited hook after a schooner under sail. This was over fifty years ago, when salmon were plenty in the Penobscot, yet it was considered a great wonder; and the old gentleman who told the story,* though he was seventy-six years of age, and had been all his life engaged in fishing, had never heard of another instance of the kind. There are several stories of salmon being taken on trolling-lines, but no exact statements in regard to those occurrences have been obtained. Inhabitants of the island of Matinicus, fifteen miles seaward from Owl's Head, report that salmon are sometimes taken in seines drawn for mackerel in that vicinity.

About eight years ago, in the month of July, a small salmon, (grilse,) weighing two or three pounds, was caught by Mr. William L. Howe, of Lincolnville, in a net set for menhaden at Wooden Ball Island,† which lies between Matinicus and Seal Rock, and is therefore but a few miles from the locality where the salmon was caught on the pollack-hook, as stated above.

On the western shore of the bay, salmon-fishing begins about seven miles above Owl's Head, at Rockport, where it has been regularly carried on for more than sixty years. For many years past, four nets have been set there. For the past five years the fishery of 1873 was the best; that of 1871 and 1872 the poorest. The average of late has been about 150 salmon a season in all of the nets; this is pronounced a small catch in comparison with that of years ago.†

Above Rockport there are no salmon-fisheries up to a point below the harbor of Camden, where two nets are set. From this point northward, within ten miles, there were, in 1873, twenty-one gangs of nets, comprising thirty-seven hooks. The greater part of these are in the town of Lincolnville, and a large number of them are crowded into the small bight into which empties Duck Trap Stream.

The most northerly net-berth is in the town of Northport. In all, there were set along the western shore of the bay forty-three hooks, in twenty-seven separate gangs. The whole number of salmon caught in them in 1873 was 1,561,‡ being an average of 36.3 a hook, and of 58 a gang.

The best catch was 175 salmon in three hooks, and the poorest 12 salmon in two hooks.

In the vicinity of French's Beach, Lincolnville, the nets are generally set about May 10, and taken up early in July. It is within these dates only that fishing is generally profitable. Some fishermen catch consid-

* James S. Collins, of Castine.

† Letter of H. H. Page.

‡ The most of the data of this statement were furnished me by Ayres & Miller, fish-dealers of Camden. Mr. Job Pendleton, of Lincolnville, from entirely separate but less complete data, estimated the catch at a little over 1,583.

erable numbers of salmon both earlier and later; but whether their success is owing to exceptional situations or to lack of competition is a matter of doubt. It is believed that salmon can be caught each year earlier near the mouth of Duck Trap Stream than at any other point in the western bay, and this alleged fact is attributed to the attraction of the fresh water.

In the middle of the bay the capture of salmon is followed every year on Long Island at twelve or fifteen stations scattered along its western side. Nets alone are now used. A single weir was built at the southern extremity of the island, for about ten years, ending in 1868. About thirty salmon a year were caught in it. Like ordinary salmon-weirs, it was made of netting fine enough to catch herring, and besides these it took also menhaden and mackerel. On the western side of the island no salmon-nets are set. The reason for their absence I have not investigated, but the land slopes down the shore more gradually on that side than on the other, and it may be inferred that there is a corresponding difference in the inclination of the bottom, which may affect either the course of the salmon in their migrations or the facilities for setting and working nets.

In Belfast Bay no salmon are caught within four miles of the port of Belfast on the north shore, and 14 miles on the south shore; so that from the upper limit of the net-fishery there is a reach of 18 miles where no salmon-fisheries are carried on. The fishery begins again near the harbor of Searsport. Here, and at all points above, it is carried on with weirs instead of nets. The yield is much better than it is in the net-fishing below. This may in part be attributed to the greater efficiency of the weirs, but I think, after making all allowances on that score, there is still a difference that can only be attributed to the presence of a greater number of salmon near shore. The weirs on Sear's Island and on Cape Jellison are among the most productive in the whole bay and river. In 1873 there were fewer weirs built here than usual; on Sear's Island only one instead of six, and on the south side of Cape Jellison only seven instead of ten. It may be mentioned, as illustrating the vicissitudes of the business as well as the occasional irregularities of the movements of the salmon, that while some of the weirs on the south side of Cape Jellison caught fewer salmon than ordinary, one on the west side, in Stockton Harbor, (No. 61,) caught twice as many.* The average catch of the former in 1873 was 91 salmon a weir.

It is worthy of remark that the weir that had such exceptional luck was built on a gently-declining bottom, with a long leader, and was in a somewhat sheltered position, while the others were built on a steeply-inclined shore at the base of a precipitous bank, with short leaders, and exposed to the force of southerly and easterly storms, which sometimes render these weirs almost inaccessible. The bottom is, for the most

* Letter of James M. Treat.

part, so hard that considerable parts of the weirs are supported by stakes, not, as in ordinary cases, driven in the ground, but planted like masts in great wooden frames, which are sunk and kept in place by a heavy ballasting of stone.

On the east side of the bay, opposite Cape Jellison, is a shore much better adapted to the construction of weirs in the ordinary way, having a gentle slope and a bottom of only moderate hardness. This is known in the vicinity as the "Dashen shore," and includes all the shore in the town of Penobscot and all in Castine except those in the harbor. Its salmon-fishery has not so high a reputation as that of Cape Jellison. In 1873 the catch was larger than usual, averaging 83 a weir. At the same time the three weirs in Castine Harbor, which are generally among the best in the whole bay or river, caught far fewer than usual, averaging only 69 a weir. Thus the experience of the Cape Jellison fishermen is repeated. Weirs on a gently-sloping shore with a western exposure have a successful season, while those on a steep shore with an easterly exposure are unsuccessful. The number of weirs built on the Dashen shore in 1873 was 23. In two cases two weirs were built on the same hedge; all of the others were on separate hedges. Thus there were 21 hedges. In 1870 there were 24 hedges and 33 weirs. The decrease in number was doubtless owing to the poor success of the fishery in that and the two following years. With the salmon are taken, in these weirs, herring, menhaden, shad, and alewives. The herring and menhaden are quite irregular in their occurrence; alewives have been decreasing in numbers for many years; and shad have almost disappeared.

Penobscot River enters the bay by two mouths, on either side of Wetmore Island. The western is the main channel, and the route by which by far the greater portion of the salmon enter the river. Its shores are for the most part bold, and at the "Narrows" the water in midchannel is about ten fathoms deep, which exceeds by two fathoms the general depth of that part of the bay west and north of Long Island. This increased depth is doubtless owing to the strength of the tides, which sweep with great force through a narrow channel. The approach to the Narrows is a tunnel-shaped estuary two miles wide at its entrance opposite the southern extremity of Wetmore Island. On both sides of this estuary, salmon-fishing is carried on extensively. As the width of the river decreases the number of weirs increases, and just below the narrowest point there have been eight or ten built within a single mile on the west shore. These weirs have short leaders, and in many cases the entrance to the second pound is on the upper instead of the outer side of the first pound.*

In general, the season of 1873 was a very successful one with the fishermen of this district; yet several weirs, most of them in the Narrows, had exceptionally bad luck.

* This is the second style of Penobscot salmon-weirs, represented in the appended illustrations.

The eastern mouth of the river is of a different character, discharging a much smaller volume of water, which is mainly received from the main Penobscot by the Thoroughfare, a broad, shallow passage around the north end of Wetmore Island, but is considerably augmented in the early part of the season by the water of Eastern River. The latter is not a salmon-stream, but is the principal nursery of the alewife, which finds in its many ponds admirable breeding-grounds. It flows to its junction with the Thoroughfare through a broad estuary, in which its scanty waters are insufficient to delay long the setting-in of the upward current that accompanies the flood-tide; while in the Penobscot and in the Thoroughfare the current sets down near two hours after low water. Hence we have the phenomenon of a down-current in the Thoroughfare at the same time that there is an up-current in the estuary of Eastern River, and the water from the former fills the latter for some distance above the point of junction. This is a sufficient explanation of the fact that while the salmon rarely attempt to ascend Eastern River, those that come in by the eastern mouth passing into the main Penobscot through the Thoroughfare, yet they frequently pass the mouth of the latter and are caught in weirs some distance up the estuary of Eastern River. Thus, in 1873, No. 185 (see appended map of fisheries of Penobscot Bay and River) caught 60 salmon, and No. 168 caught 30. This explanation accords well with the theory that salmon find their way back into their native rivers, not through any knowledge of topography but by recognizing in some way the qualities of the water. In the weirs of Eastern River farthest up salmon are seldom caught; and indeed neither in any portion of it, nor in the Thoroughfare, nor in the common river below, is the catch at all to be compared with that in the western channel of the Penobscot.

Above the port of Bucksport but few weirs have been built for many years, and the number has of late diminished. In 1870 there were 15; in 1873, only 9. The latter year was quite profitable, the increase in the number of salmon being remarkable. Three weirs in Marsh Bay caught 250 salmon, 5 shad, and 6 barrels of alewives. Weir-fishing has never been practiced in the Penobscot above Orrington. It is, however, known that as early as 1780 there was a rude half-tide weir in the town of Hampden.

Within this district, on the eastern side of the expansion of the river called Marsh Bay, are Dram Point Flats, the history of whose fisheries is very interesting. In 1812 there was a single half-tide weir built on these flats; it was of triangular shape, one side being formed by the shore and the other two being built of stakes and brush. On the up-river side the brush-work was built higher than high-water mark. The down-river side, which, however, was exposed to an eddy-current on the ebb-tide, was, for the outer half of its length, built to an equal height with the upper side, while the part next the shore rose only to half-tide mark. Over this low part of the inclosure the fish swam at

high water. Left inside by ebbing of the tide, they would gather in a small compartment at the outer corner, whence they were dipped by the fishermen. This was the highest style of contrivance for the capture of fish then in use on the Penobscot. It took immense quantities of shad and alewives.

The first trap-weir was built in 1815 at Treat's Point, on the west side of Marsh Bay, built by one Hollis Emerson, from the Kennebec. It worked on the same principle as those now in use, but had only one pound. In 1816 a similar one was built on Dram Point Flats. The new weirs were so successful that large numbers of them were built all along the river immediately. In 1820, however, and for several years thereafter, fish were scarce. In 1822 only two weirs were built on Marsh Bay, one on Dram Point Flats and one on the opposite side. That year was a very poor one with the fisheries in this part of the river, but was better in the bay and as far up the river as the northern end of Wetmore Island, there being an extraordinary catch of salmon about the 1st of July. From 1822 to 1836 there was an improvement in the river-fisheries, especially in the salmon-fishery. The year 1836 was marked by a great run of salmon.

In the appended illustrations are two plans of Dram Point Flats,* representing the fish-weirs built on it; the one in 1832, the other in 1873. In 1832 there were, on this short stretch of shore less than a mile long, five fishing-stations, maintaining 17 weirs, each with several pounds. No exact statistics in relation to their yield can be obtained, but it is described as being enormous. Alewives were sometimes so plenty as to be given away by the cart-load. The most of the fish were shipped on small vessels that came from Portland and Southern New England to buy.

One of the men in this business† states that he remembers of six vessels being there at one time loading; they would probably carry away fish to the value of $37,000, and this but part of the season's catch.

The prices of those ladings were, for salmon, 5 to 7 cents a pound; for shad, $6 to $7 a barrel; and for alewives, $2½ a barrel.

In 1873, instead of the seventeen weirs, there were only three, and these probably were less productive than the same number of weirs in 1832. It should be remarked that the abandonment of these fisheries was due more to the loss of the shad and alewife fishery than to the decrease of the salmon. It is not, therefore, to be inferred that a similar falling off in the fishing-industry has occurred in districts where the salmon-fishery was relatively of greater importance. Another source of injury to the fisheries is the deposit of sawdust and mud on the flats. It will be observed that in 1873 the flats extended considerably farther into the

* These plans and accompanying facts were furnished by Mr. John Arey, of Bucksport. The preceding statements about the fluctuations of the fisheries are on the authority of Mr. Amos Treat, of Frankfort.

† Mr. Frederick Twombly, of Portland.

bay than in 1832. This is caused mainly by the accumulation of sawdust, which has not only moved the low-water line farther out, but has greatly lessened the depth of the water for a long distance outside of this line.

13.—TABULAR STATEMENT OF THE CAPTURE OF SALMON ON THE PENOBSCOT RIVER.

The following statement of the number of salmon caught in 1873 is based, for the most part, on the statements of the fishermen themselves; the number caught in each weir and net having been reported in nearly every case:

TABLE XII.—*Statement of salmon caught in Penobscot Bay and River in* 1873.

District.	Implements.	No. of salmon.
Rockport to Northport	Pound-nets; 27 gangs, comprising 43 hooks	1,561
Long Island and Western Pond Island	Pound-nets; 14 gangs, comprising 17 hooks and 1 weir.	1,008
Castine and Penobscot	26 weirs	2,143
Orland	7 weirs	378
Searsport and Stockton	35 weirs, 1 gang-net	3,377
Verona, (Wetmore Island)	30 weirs	2,468
Bucksport, Prospect, and Winterport	15 weirs	771
Bangor to Oldtown	Drift-nets, number unknown	1,984
Totals	114 weirs, 42 gangs of nets, &c	13,690

Nothing is known of the number of salmon caught above Oldtown. A due allowance for this omission, and for certain fishing-stations where it was impossible to obtain correct statements, would probably swell the total to 15,000 salmon.

In comparison with the yield of many preceding years, this is a very large increase; though unfortunately, in the absence of data for an exact estimate, no very precise statement can be made as to the degree of increase. At Rockport, the past season was the best since 1868, the catch of four nets being 300 salmon in 1868, 130 in 1870, and 190 in 1873.* In Camden and Lincolnville it was better than usual. On Long Island the catch was one-third above the average.† The two weirs in Searsport were comparatively unsuccessful, while the single one on the western side of Sear's Island did much better than usual. On the west side of Cape Jellison, as has been already stated, salmon were caught in greater numbers than usual, while some of the weirs on the south side caught fewer.‡ In Castine Harbor the catch was far below the average, while from this point up the east shore of the bay it was considerably above average. In all parts of the river, except here and there a weir, the increase was very marked. In the vicinity of Bucksport it is commonly

* Statement of J. McIntire.

† Statement of Benjamin Ryder.

‡ Statement of James M. Treat.

thought to have been the most successful season for twenty years. An inspection of the record of weirs Nos. 161 and 162, at the south end of Wetmore Island, (given below,) shows that it was the most successful season during all the time (eighteen years) covered by the record. In some localities, where in ordinary years very few salmon are caught, they appeared in large numbers. The drift-nets above Bangor were unusually successful; and after all the decimation the ranks of the salmon suffered on the way, an uncommonly large number was observed on the upper waters and near the breeding-grounds.

The following statement exhibits the yield, for thirteen years, of two of the best weirs on the Penobscot, the owner of which (Hon. A. H. Whitmore, of Verona) has with commendable public spirit offered it for publication. Each entry is made at the time of sale, and includes all the salmon caught since the previous sale:

TABLE XIII.—*Record of salmon sold* from weirs Nos. 161 and 162, south end of Wetmore Island.*

Date.	Number of salmon.	Aggregate weights.	Average weights.
1860.			
April 21	1	18½	18.5
April 30	1	16¾	16.7
May 1	1	25¾	25.7
May 9	1	21⅝	21.5
May 12	2	33	16.5
May 14	2	18½	9.2
May 17	1	17½	17.5
May 18	3	33	11.0
May 22	2	29½	14.7
May 24	2	21½	10.7
May 26	9	109	12.1
May 30	7	120	17.1
May 31	7	87	12.4
June 4	1	11	11.0
June 7	10	122	12.2
June 8	2	20	10.0
June 9	11	146	13.2
June 11	9	105	11.6
June 14	12	145	12.0
June 15	6	72	12.0
June 18	12	172	14.3
1860.			
June 19	2	31	15.5
June 21	4	79½	19.8
June 23	5	71	14.2
June 25	19	229	12.0
June 26	2	17	8.5
June 27	4	47	11.7
June 30	8	98½	12.3
July 1	4	39½	9.8
July 2	5	56⅝	11.3
July 5	4	43¼	10.8
July 11	2	.....	.....
SUMMARY.			
April	2	.....	17.6
May	37	.....	13.9
June	107	.....	11.9
July	15	.....	10.7
Total	161	.....	12.3
1862.			
May 5	2	38	19.0
May 18	1	19½	19.5
May 19	3	59	19.6
May 22	1	19¾	19.7
May 24	6	77	12.8
May 25	1	9	9.0
May 26	2	21	10.5
May 29	2	28	14.0
June 2	4	38	9.5
June 9	7	102½	14.6
June 12	12	156	13.0
June 14	4	34½	8.6
June 19	7	116	16.5
June 23	19	239⅝	12.6
June 26	14	159½	11.4
June 30	30	329	10.9
July 1	8	88¼	11.0
1862.			
July 3	12	150	12.5
July 13	24	244	10.2
July 20	1	11½	11.5
July 25	3	32¼	10.8
August 5	2	25¼	12.6
SUMMARY.			
May	18	271¼	15.0
June	97	1,175	12.1
July	48	526¾	10.3
Aug	2	25¼	12.6
Total	165	1,968¼	12.1

* These salmon were sold within a few days after catching, commonly within three days.

Record of salmon sold from weirs Nos. 161 *and* 162, *south end of Wetmore Island*—Cont'd.

Date.	Number of salmon.	Aggregate weights.	Average weights.
1863.			
May 14	1	8¾	8.7
May 25	2	29	14.5
May 28	9	103	11.4
May 30	6	75	12.5
June 1	9	111¾	12.4
June 4	4	43	10.7
June 6	9	102	11.3
June 11	5	44	8.8
June 13	10	106	10.6
June 15	5	56	11.2
June 16	8	77	9.6
June 22	14	137½	9.1
June 25	12	124½	10.3
June 27	10	107½	10.7
June 29	10	82	8.2
July 2	24	250	10.4
July 3	6	55	9.1
July 4	1	8	8.0
July 5	2	22	11.0
1863.			
July 7	3	27½	9.1
July 9	11	120	10.9
July 13	26	160½	6.1
July 15	2	18	9.0
July 17	5	49½	9.9
July 18	3	27½	9.1
July 22	4	46½	11.6
July 24	5	46	9.2
July 27	1	9¾	9.7
SUMMARY.			
May	18		11.9
June	96		10.3
July	93		10.1
Total	207		9.8
1864.			
May 9	1	18	18.0
May 10	2	34½	17.2
May 11	1	20	20.0
May 18	1	10	10.0
May 21	2	27½	13.6
May 26	3	38½	12.8
May 30	5	85½	17.1
June 2	3	35½	11.8
June 4	5	65	13.0
June 6	5	49½	9.9
June 9	4	35½	8.8
June 11	3	35½	11.8
June 13	10	113½	11.3
June 16	13	164	12.6
June 18	6	81	13.5
June 20	1	6	6.0
June 23	7	98	14.0
June 24	5	50	10.0
June 27	6	63½	10.5
1864.			
June 30	9	107	11.9
July 2	5	46½	9.3
July 4	2	16½	8.2
July 7	2	23½	11.6
July 6	2	16½	8.2
July 9	2	17	8.5
July 11	5	80½	16.1
July 23	1	7	7.0
SUMMARY.			
May	15		15.5
June	77		11.7
July	19		10.9
Total	111		12.1
1865.			
April 17	1	13¾	13.7
May 6	1	18	18.0
May 18	1	18	18.0
May 22	3	28½	9.4
May 24	3	40	13.3
May 29	2	19	9.5
June 1	2	28	14.0
June 5	3	44½	14.8
June 8	12	194	16.1
June 10	6	66½	11.0
June 11	1	11½	11.2
June 12	7	94	13.4
June 15	3	33	11.0
June 19	18	196	10.8
June 22	10	118½	11.8
June 26	16	200	12.5
June 28	9	105	11.6
June 29	19	115	6.0
July 1	16	172	10.7
July 3	9	107	11.8
1865.			
July 4	14	140½	10.0
July 6	3	30	10.0
July 7	3	32	10.6
July 10	3	26½	8.8
July 14	1	9¾	9.7
August 4	1	16	16.0
August 5	1	10	10.0
SUMMARY.			
April	1		13.7
May	10		12.3
June	106		11.3
July	49		10.5
August	2		13.0
Total	168		11.2

Record of salmon sold from weirs Nos. 161 *and* 162, *south end of Wetmore Island.*—Cont'd.

Date.	Number of salmon.	Aggregate weights.	Average weights.
1866.			
April 22	5	66½	13.3
May 17	5	70	14.0
May 24	3	33¾	11.2
May 28	4	42	10.5
May 29	4	49½	12.3
May 31	2	16	8.0
June 2	6	61½	10.2
June 8	4	31¼	7.8
June 11	13	147½	11.3
June 14	8	83¼	10.4
June 15	5	75¼	15.0
June 18	10	105½	10.5
June 21	17	213	12.5
June 23	8	103½	12.9
June 25	19	205	10.7
June 26	7	62½	8.9
June 27	6	62	10.3
June 30	1	8¾	8.7
1867.			
April 27	1	18	18.0
May 3	1	20½	20.5
May 13	4	69	17.2
May 16	1	19	19.0
May 21	1	15	15.0
May 23	5	66	13.2
May 27	13	138	10.6
May 30	5	55½	11.1
June 1	13	161	12.3
June 3	11	134½	12.2
June 6	10	110	11.0
June 8	4	57	14.2
June 10	17	190½	11.2
June 12	28	321½	11.4
June 15	20	254	12.7
June 17	32	383	11.9
June 18	3	28¼	9.4
June 19	19	231	12.1
June 20	1	9	9.0
June 22	9	90	10.0
June 24	20	233	11.6
1868.			
May 9	1	21½	21.5
May 14	1	19½	19.5
May 18	2	30	15.0
May 22	3	50½	16.6
May 26	2	21	10.5
May 27	1	10½	10.5
May 28	4	51	12.7
June 1	6	81	13.5
June 4	7	78½	11.2
June 4	9	128½	14.2
June 6	15	177	11.8
June 8	7	73½	10.5
June 9	1	7½	7.5
June 10	4	54	13.5
June 12	15	177	11.8
June 13	6	66½	11.0
June 14	5	70	14.0
June 16	17	245	14.4
June 17	9	116	12.8
June 18	11	132¾	12.0
June 19	10	126½	12.6
June 20	4	53½	13.0
June 23	4	45	11.2
June 25	1	8	8.0
June 26	2	37½	18.7
June 28	8	113	14.1
June 29	14	165	11.7

Date.	Number of salmon.	Aggregate weights.	Average weights.
1866.			
July 2	4	30¾	7.5
July 3	5	57	11.4
July 5	4	34	8.5
July 10	1	9	9.0
July 12	2	19	9.5
July 15 to 25	14	151	10.7
SUMMARY.			
April	5		13.3
May	18		11.7
June	104		11.1
July	30		10.0
Total	157		11.0
1867.			
June 25	6	53¼	8.8
June 27	21	239¼	11.4
June 28	12	112	9.3
July 1	17	150	8.8
July 3	3	31	10.3
July 4	3	35	11.6
July 6	1	10	10.0
July 10	1	9	9.0
July 13	5	52½	10.5
July 21	1	11	11.0
SUMMARY.			
April	1		18.0
May	30		12.7
June	226		11.5
July	31		9.6
Total	288		11.4
1868.			
July 1	22	240¼	10.9
July 2	5	52½	10.4
July 3	4	48½	12.0
July 5	8	104	13.0
July 7	8	85¼	10.6
July 9	4	53½	13.3
July 12	12	132	11.0
July 15	5	51	10.2
July 16	4	43½	10.0
July 19	5	62½	12.5
July 31	5	54	10.8
August 2	1	10½	10.5
August 7	1	9½	9.7
August 10	3	24	8.0
August 12	1	8½	8.5
SUMMARY.			
May	14		14.5
June	155		12.6
July	82		11.3
August	6		8.7
Total	257		12.1

Record of salmon sold from weirs Nos. 161 *and* 162, *south end of Wetmore Island*—Cont'd.

Date.	Number of salmon.	Aggregate weights.	Average weights.
1869.			
April 17	1	19¾	19.7
April 21	1	18½	18.2
April 29	2	37½	18.7
April 30	1	17½	17.5
May 3	3	55⅝	18.5
May 13	1	.....	.....
May 16	1	18	18.0
May 24	1	9¾	9.7
May 26	2	32¾	16.3
May 30	1	7½	7.5
June 2	2	36½	18.2
June 4	1	10½	10.5
June 6	7	85½	12.2
June 8	1	10¼	10.2
June 11	15	207	13.8
June 13	8	90½	11.3
June 15	4	45	11.2
June 16	2	20½	10.2
June 17	3	36½	12.1
June 18	9	111	12.3
June 19	1	8	8.0
June 20	6	59½	9.9
June 22	4	44½	11.1
June 24	5	65	13.0
June 25	6	81	13.5
1870.			
April 10	1	21½	21.5
April 27	2	29½	14.8
May 11	1	17	17.0
May 12	1	14½	14.5
May 18	2	28½	14.2
May 19	1	10	10.0
May 20	4	57¾	14.4
May 23	1	19	19.0
May 25	2	31½	15.7
May 26	1	12½	12.5
May 27	5	81	16.2
June 1	5	59½	11.8
June 2	7	88½	12.6
June 6	17	226	13.2
June 7	7	115½	16.5
June 9	5	57	11.4
June 12	3	43	14.3
June 13	1	14	14.0
June 14	1	10	10.0
June 15	9	124	13.7
June 16	4	65	16.2
June 17	3	41	13.6
June 20	23	298	12.5
June 22	7	97	13.8
June 24	13	198½	15.2
June 25	6	90	15
June 26	2	27¾	13.8
June 27	5	60½	12.1
June 29	3	35	11.6
June 30	1	11¾	11.7
July 1	11	139	12.6

Date.	Number of salmon.	Aggregate weights.	Average weights.
1869.			
June 27	9	98	10.8
June 29	5	59	11.8
July 3	5	42½	8.5
July 4	6	55¼	9.2
July 5	5	54¼	10.8
July 7	2	17¾	8.8
July 9	3	28¼	9.4
July 11	4	41½	10.3
July 12	14	161	11.5
July 14	5	53¼	10.6
July 15	2	25	12.5
July 17	2	30½	15.2
July 23	1	8¼	8.2
SUMMARY.			
April	5	.....	18.6
May	9	.....	15.4
June	88	.....	12.1
July	49	.....	10.5
Total	151	.....	12.0
1870.			
July 3	2	23¾	11.8
July 4	5	67½	11.0
July 5	2	24	12.0
July 8	3	36	12.0
July 12	1	10	10.0
July 15	1	11	11.0
July 16	1	10	10.0
July 18	2	30	15.0
July 22	2	23½	11.6
July 26	1	9¼	9.0
August 2	4	39	9.7
August 4	2	20	10.0
August 5	1	10¾	10.7
August 7	1	10	10.0
August 10	1	10¾	10.7
August 11	2	18½	9.3
August 12	1	10	10.0
August 18	3	22½	7.5
SUMMARY.			
April	3	.....	17.0
May	18	.....	15.0
June	122	.....	13.6
July	31	.....	12.3
August	15	.....	9.4
Total	193	.....	12.5

Record of salmon sold from weirs Nos. 161 *and* 162, *south end of Wetmore Island.*—Cont'd.

Date.	Number of salmon.	Aggregate weights.	Average weights.
1871.			
April 17	1	21	21.0
April 20	1	22	22.0
April 30	1	18	18.0
May 13	2	40	20.0
May 15	1	9	9.0
May 16	1	9¾	9.7
May 19	1	20	20.0
May 22	3	29¾	9.9
May 24	2	18¾	9.3
May 26	5	60	12.0
May 27	1	13¾	13.7
May 29	2	30	15.0
May 30	6	72	12.0
June 31	1	12	12
June 2	2	24	12.0
June 3	1	10	10.0
June 5	3	37	12.3
June 8	3	38	12.6
June 9	3	40	13.3
June 10	4	67	16.7
June 11	5	63	12.6
June 12	7	82¼	11.7
June 14	3	50	16.6
June 15	4	61½	15.3
1872.			
May 1	3	58	19.3
May 6	2	42½	21.2
May 10	1	9½	9.5
May 13	3	62½	20.8
May 20	2	45½	22.7
May 30	5	81	16.2
June 1	1	11¾	11.7
June 4	4	58½	14.6
June 5	8	94	11.7
June 8	2	23	11.5
June 10	2	20	10.0
June 11	13	155	11.9
June 12	4	59	14.7
June 13	7	75	10.7
June 14	6	81	13.5
June 15	9	131	14.5
June 17	7	113½	16.2
June 18	11	139	12.6
June 19	4	43	10.7
June 20	3	35	11.6
June 21	6	67	11.1
June 22	10	146½	14.6
June 24	10	152	15.2
June 25	2	24	12.0
1871.			
June 17	4	54	13.5
June 19	8	75	9.3
June 20	8	123	15.3
June 22	2	29½	14.7
June 23	5	57	11.4
June 25	2	43¾	21.8
June 26	8	96½	12.0
June 28	2	24	12.0
July 1	2	30	15.0
July 3	1	9	9.0
July 4	2	30	15.0
July 6	2	26	13.0
July 10	3	37	12.5
SUMMARY.			
April	3	.....	20.3
May	24	.....	12.6
June	75	.....	13.1
July	10	.....	13.1
Total	112	.....	13.2
1872.			
June 26	2	17	8.5
June 27	2	23	11.5
June 28	8	105	13.1
June 29	14	.....	14.1
July 1	9	127½	10.4
July 2	5	52	10.5
July 3	3	31½	12.3
July 4	10	123½	11.0
July 5	6	66½	18.2
July 6	2	30½	12.1
July 8	8	97½	12.1
July 10 to 19	23	279	14.0
July 20	2	28	
SUMMARY.			
May	16	.....	18.6
June	135	.....	13.0
July	68	.....	12.3
Total	219	.....	13.2

Record of salmon sold from weirs Nos. 161 *and* 162, *south end of Wetmore Island*—Cont'd.

Date.	Number of salmon.	Aggregate weights.	Average weights.
1873.			
May 1	3	54½	18.1
May 5	2	39½	19.7
May 8	3	50½	16.8
May 9	1	12½	12.5
May 12	1	9½	9.2
May 15	2	36½	18.2
May 19	3	49½	16.4
May 21	3	29½	9.8
May 22	3	51½	17.1
May 26	2	21½	10.7
May 27	1	13½	13.5
May 28	4	53½	13.4
June 2	9	127	14.1
June 5	12	158	13.1
June 7	12	176½	14.7
June 9	3	41	13.6
June 11	9	121	13.4
June 12	8	123	15.3
June 13	6	76	12.6
June 14	8	99	12.1
June 16	16	202	12.6
June 17	11	156	14.1
June 18	9	108½	12.0
June 19	5	71½	14.3
June 20	7	85	12.1
June 21	38	.....	.....
June 23	10	144	14.4
June 24	40	.....	.....
June 25	5	68½	13.7
June 26	15	203½	13.5
June 27	31	416	13.4
June 28	2	26½	13.2
June 30	14	179	12.7
July 1	20	160½	8.0
July 2	31	402½	12.9
July 3	9	113½	12.6
July 4	10	123½	12.3
July 7	27	320½	11.8
July 8	15	185	12.3
July 9	6	91½	15.2
July 10	5	.....	.....
July 13	5	59	11.8
July 15	4	54½	13.5
July 16	2	32½	16.2
July 17	4	.....	.....
July 17	6	78	13.0
July 26	3	40	13.3
July 30	3	42½	14.2
July 31	1	17	17.0

SUMMARY.

May	28	421½	15.0
June	270	2,581½	13.4
July	151	1,720½	12.1
Total	449	4,723½	10.5

14.—SAINT GEORGE RIVER.

Salmon were plenty in this river fifty years ago, and considerable numbers were caught twenty-five years later. But they gradually ceased to frequent the river, and for the last ten or fifteen years they have rarely been seen in it.* Since the building of the dams that have mainly contributed to the extermination of the salmon, fish-ways have been maintained for alewives, and have answered their purpose passably well, but they do not appear to have met the requirements of salmon.

15.—MEDOMAC RIVER.

This river was originally the breeding ground of the salmon and alewives, but not of shad. Salmon were abundant, more so than in the Saint George. Sixty years ago the inhabitants used to dip them below the lower dam at the head of the tide. More recently, the owner of a mill further up the stream, at the upper dam in Waldoboro' Village, used to catch them by shutting his gate and taking as many as a dozen at a time from a basin in the rock below the dam, in which they were left by the subsidence of the water. For the past forty years it is be-

* Letter of A. M. Wetherbee.

lieved that not a single salmon has been taken in the river above the flow of the tide, but occasionally, within twenty-five years, one has been caught in a weir nearer the mouth of the river. Three dams at Waldoboro' Village, one at the head of the tide and the other two within a third of a mile of the first, effectually prevent the ascent of all migratory fish.*

16.—SHEEPSCOT RIVER.

This river appears to be well fitted for the production of salmon, and in old times they frequented it in great numbers along with alewives and shad; but, as in other cases, the construction of impassable dams has cut them off from their main breeding-ground, and nearly exterminated them. This happened at an early day. For many years, however, salmon have come in small numbers each year to the dam at Alna. Twelve or fifteen are said to have been caught there in 1872 and 1873—a larger number than usual. Probably they find a very small breeding-ground below the dam.

17.—KENNEBEC RIVER.

In its original condition, this river was the second in the State of Maine in the number of salmon yielded by its fisheries, and in the facilities it afforded for their reproduction. No serious natural impediment exists to their ascent up the main river as far as Carratunk Falls, in the town of Solon. At this point there is a precipitous fall, 16½ feet high, which was a serious hinderance to them, but was not impassable. The whole river falls into a chasm in the ledge less than 60 feet wide and of great depth. Leaping obliquely from this chasm, the salmon would rise into the air to a height of 10 or 12 feet, and strike the body of falling water at a point where its velocity was so small that they could stem it successfully. This was often witnessed, but it is supposed that only salmon of exceptional strength could accomplish the feat. Once above Carratunk Falls, a vast extent of breeding-ground lay open to them in the main Kennebec and its tributaries. Of the lower tributaries, their principal resorts were in the Carrabassett and Sandy Rivers. The Messalonskee was closed by a precipitous fall of 40 feet a few miles above its mouth. The Sebasticook, though an excellent shad and alewife river, was not well fitted for salmon. Tradition says that they ascended the Cobbosseecontee.

In the days of their abundance, the main fisheries for salmon were within 20 miles of the mouth of the river, at Waterville 60 miles above, and at Carratunk Falls. At the latter place, dip-nets were used on the falls and drift-nets just below. It was easy for two men to load a boat with salmon here in a day. At Waterville, just below Ticonic Falls, a large number of drift-nets were plied every season. As many as 82

* Letter of F. M. Everleth.

have been counted at work at one time; but the average was not over 40. They took several thousand salmon in a season. Other drift-net fisheries existed at Augusta and various other points on the river. The fisheries near the mouth of the river were carried on with set-nets and weirs, the former coming into use much earlier than the latter. No exact statistics of their catch have been obtained. The use of nets was not confined to the river. Several were set quite outside its mouth on Hunnewell's Beach. At Cape Small Point, 6 miles west of the river, there were several nets set, and one trap or pound-net is still in use at Bald Head, for the capture of various species, among which salmon are accounted of considerable importance. The salmon-fisheries of the Kennebec were in a flourishing condition in 1873, when the dam at Augusta was completed. For a few years after that they continued plenty, and then rapidly declined until they almost disappeared. The drift-net fishery at Augusta was for some years abandoned because of the scarcity of salmon. The decade from 1850 to 1860 is generally believed to have been the period of greatest scarcity. In 1866, 1867, and 1868 there was a marked increase, the latter year being by far the best since 1850. After that there was another decline, 1870 and 1871 being poor years. In 1872 and 1873 there has been another increase, which far surpasses that of 1868. It was also remarked on the Kennebec as on the Penobscot, that the salmon of 1873 were of an uncommonly large size on the average.

At the present day, salmon are caught in weirs in the lower part of the river and drift-nets at Augusta. The drift-nets, rarely over two or three of them in operation at once, are plied solely for salmon, and, the Augusta dams holding them firmly in check, the number caught in favorable seasons probably amounts to several hundred. The weirs are all below Richmond. They are in general built more for the capture of alewives and shad than for the salmon. Those that yield the most of the salmon are below Merrymeeting Bay; the best of all being near the mouth of the river. The number built below Bath in 1873 was 23, just the same number as in 1867, but a falling off from the next succeeding years; there having been 33 in the same district in 1868, and 26 below Lee's Island in 1869. These weirs are in no essential particular different from those in use in the Penobscot. In Merrymeeting Bay, however, the kind of weir in common use is more like the herring-weir of the eastern part of the State, the fish being captured with a seine in a large pound.

The inquiries made in regard to the number of salmon caught in 1873 elicited the following items of information. One estimate places the number caught below Bath at 700.* From another source† I have a list of the fishermen below Phippsburgh Center, 14 in number, probably

* Thomas E. Scott, of Georgetown.

† D. D. Swazey, of Fort Popham.

building about that number of weirs, and a statement of the catch of each. The sum-total is 645, which would indicate that the preceding estimate was too small. Thirteen of these fishermen caught during the last three years the following numbers of salmon:

	Salmon.
1871	154
1872	237
1873	575

Mr. S. W. Cushing, of Bath, dealer in fish, states that, in his opinion, the catch of salmon in the Kennebec, in 1873, is more than double that of any previous season for fifteen years excepting 1872, and very largely in excess of that year. On the basis of these several statements the following estimate of the catch of 1873 is submitted:

Salmon caught below Bath	900
Salmon caught above Bath	600
Total	1,500

This is believed to be an approximation, though a rough one, to the true number. The yield of 1871, if we may take the experience of the lower part of the river as indicating the true ratio between that and other years, must have been less than 500.

The artificial obstructions to the ascent of salmon as well as other fish are numerous and formidable. There are six dams across the main river below Carratunk Falls. Three of them are formidable obstructions. The dam at Augusta is 18 feet high, and would be absolutely impassable were it not for the lock provided for navigation. Through this a greater or less number of salmon passes each year. Almost every summer a few of them pass the second, third, and fourth dams, and are seen at Skowhegan; and not infrequently they pass this point also. None of the dams are now provided with fish-ways.

18.—ANDROSCOGGIN RIVER.

In the natural adaptation to the growth of salmon, the Androscoggin is supposed to have been scarcely inferior to the Kennebec. In purity of water it is superior, and it has a much greater extent of gravelly river-bottom, swept by brisk currents, where salmon like to lay their eggs. Its disadvantages were its difficult falls. That at Lewiston, though it may have turned back the greater part of the salmon, was, nevertheless, scaled by some that appeared at the foot of East Rumford Falls, where they encountered a series of cataracts quite insurmountable. Direct testimony has been obtained only to the fact of one or two salmon being taken here more than fifty years ago; but tradition has it that they were once very plenty in Swift River, a tributary that enters the Androscoggin just below the falls. They must have been early shut out from that part of the river. At Lewiston they were taken as late as 1815.

Early in the present century the dams at Brunswick shut them out from all their breeding-grounds. Probably the Androscoggin salmon were utterly exterminated; for the few specimens now and then seen in the river are no more then we should expect to stray into it from the Kennebec. These two rivers unite their waters in Merrymeeting Bay, into a broad arm of which each of them flows. In the southwest arm, or that leading to the Androscoggin, are commonly built about six weirs, in which shad and alewives are caught. Sometimes several years have passed without a single salmon being taken by any of them. In 1873 there were four weirs in operation. One of them caught four salmon, another caught one, and two more were taken at the mouth of Cathance River, which point they probably reached without leaving the Androscoggin waters.* A single smolt, six inches long, was caught in the middle of the Androscoggin Bay,† a thing quite unprecedented in the experience of the fishermen of this region. Other specimens, supposed to be smolts, were caught near the falls at Brunswick.

The two lower dams in the Androscoggin, both at Brunswick, have been provided with fish-ways.

19.—ROYALS RIVER.

Salmon frequented this river regularly and in considerable numbers sixty years ago; but they have been shut out by several dams, the first of which is at the head of the tide. The last salmon seen in the river were taken twenty years ago in a weir. There having been no river-fishing there since that time, it is not known whether any salmon have entered the river.‡

20.—PRESUMSCOT RIVER.

This is a river of uncommon purity, draining, as it does, the second lake in size in Maine, and receiving few tributaries below. Salmon, shad, and alewives originally ascended the river. Salmon were practically destroyed by the dam on Presumscot Falls, near the mouth of the river, very early in the present century. That dam was afterward abandoned, and of late years salmon have occasionally been caught. In 1866 four were caught at the Presumscot Falls with a dip-net. In 1873 a weir was maintained in the tidal part of the river, but took no salmon. In October two salmon were seen below the dam at Cumberland Mills, and, the flood-gates being open soon after, they probably passed up, and spawned near Sacarappa. A spent female salmon, of 13 pounds weight, was killed in November at the latter village, and a spent male of 14 pounds above the dam at Cumberland Mills about the same time.§

There is a large number of dams on the Presumscot, but few of them are formidable.

* Letter of William Rogers.
† Letter of Robert Waid.
‡ Letter of Frank Seabury.
§ Letter of G. W. Hammond.

21.—RICHMOND'S ISLAND.

This island is midway between the Presumscot and Saco Rivers, about three-fourths of a mile from the town of Cape Elizabeth. Between the island and the main-land is a sand-bar at times bare at low water. On the western side of the same for about twenty years a pound, or large fish-net, (a seine,) has been set, extending from the island to the main shore. Every spring and summer each year, a few salmon (from six to twelve) have been taken with other fish, shad, alewives, &c.*

These Richmond Island salmon can hardly be referred to the Presumscot or Saco; for were these rivers to produce salmon enough to afford so many at a point so far distant from their mouths, there would certainly be a larger number found in the rivers themselves. The Kennebec is the nearest river that produces any salmon, and was probably the native river of those caught at Richmond's Island, though this implies a wide range along the coast, the distance being 26 miles.

22.—SACO RIVER.

Salmon used to ascend this river as far as Hiram Falls, and a good many were taken there in old times.

The Great and Little Ossipee Rivers, the principal tributaries, were also frequented by them. The brood has been extinct for many years, and had become much reduced at least eighty years ago.

There are many dams on the river; and those at Saco and Biddeford render the falls at that point, which were always difficult, quite insurmountable.

Since 1860 there have been four salmon taken in the mouth of the river in shad-nets. One of these was caught in 1873.

23.—MOUSAM RIVER.

This small river was once very productive of salmon. The date of their disappearance cannot be fixed exactly, but it was doubtless very early.

A dam was built across the river in Kennebunk in 1675, and since 1720 there has been a dam at that point all the time. Alewives and shad are now caught near the mouth of the river, but no salmon have been seen for many years.

24.—PISCATAQUA RIVER.

Formerly salmon were very abundant in this river, breeding in the Salmon Falls River in preference to other branches, although some of them ran up the Cocheco.

It is over two hundred years since the Salmon Falls and some other branches were obstructed by dams, and some authorities date the falling-

* Letter of N. Cummings, esq.

off of the supply of salmon as early as 1660. They were, however, by no means exterminated till a more recent date.

As late as 1830 stray salmon have been known to ascend the river up to Salmon Falls dam, and to a lower point within twenty-five years. About thirty years ago a large-sized salmon was caught within a few rods of the dam at the head of tide-water by one Moses Varney. Fishermen near the mouth of the river say that in drawing their seines for other fish they have occasionally taken salmon, but it is not reported that this has occurred recently.

25.—MERRIMACK RIVER.

Salmon originally ascended the Merrimack, and its main branch, the Pemigewassett, 150 miles, branching off into only one tributary, Baker's River, which enters the Pemigewassett at Plymouth.

It is also reported that they frequented the Contoocook in small numbers. They were very abundant before the obstruction of the river. Their extinction was gradual. In 1796 a good deal had been done in the way of dams, but they were either low or were wing-dams. By 1814 there was great falling off as compared with twenty-five years before. By 1830 they were quite scarce. In 1847 the Lawrence dam extinguished them, except a few each year that perhaps straggled from the Maine rivers. This river was the first to receive attention from the commissioners of fisheries first appointed in 1866. In that and the two following years the two dams in Massachusetts, at Lawrence and Lowell, and most of those in New Hampshire, were provided with fish-ways. The greatest difficulty was experienced at Lawrence, where the dam is very high.

In its first form, the fish-way was unsatisfactory. It has since been remodeled, and various kinds of fish ascend it; but the difficulties in the way of getting a sufficient supply of spawn, delayed for some years the re-establishment of a brood of salmon in the river.

26.—PAWTUXET AND PAWCATUCK RIVERS.

The only information received about the former occurrence of salmon in these rivers is obtained from the reports of the Rhode Island commissioners of fisheries, who state that salmon were plenty in them both. Vigorous measures are being taken to restore them, some 70,000 young salmon having already been distributed in their branches and those o the Blackstone.

27.—THAMES RIVER.

Salmon formerly frequented this river and several of its tributaries. On the Shetucket they used to be taken in considerable numbers thirty or forty miles above Greenville, but a dam at the latter place shut them out about thirty-five years ago.* In the Willimantic they were caught

* Letter of William Story.

until 1822, when a dam was built across the stream, which prevented their coming up. Since then dams have been built across the other tributaries, and finally one across the Thames itself, which completely destroyed the salmon-fishery in the river and its tributaries.*

28.—CONNECTICUT RIVER.

Salmon ascended this river in the last century to a distance of three hundred miles from its mouth,† breeding in its headwaters and in various tributaries, in New Hampshire and Vermont. They were plenty up to 1797. In 1798 the Upper Locks and Canal Company put a dam 16 feet high across, just below the mouth of Miller's River. Within ten or twelve years this extinguished the fish; that is, when all the *then* living fish had died.‡

The States of New Hampshire, Vermont, Massachusetts, and Connecticut have since 1866 been making joint efforts to restore salmon to the river. Small lots of salmon-fry have, from time to time, been placed in it, and within two years several young salmon have been taken in the lower part of the river. It was not, however, until 1873 that any planting was made on an extensive scale. In the spring of that year there were distributed, by the State of Connecticut, a large number of fry in some of the lower branches of the river. The opposition of the proprietors of the Holyoke dam, in Massachusetts, to the erection of a fish-way, entailed tedious litigation, which delayed the construction of the way until 1873. It is, however, now completed, and the commissioners of the several States interested are to place several hundred thousand salmon-fry in the Connecticut and its tributaries in the spring of 1874.

29.—HAMMONASSETT RIVER.

In this little river, salmon were caught from 1663 to some date in the present century.§

30.—QUINNIPAICK RIVER.

Salmon used to frequent this river, but disappeared at some date not ascertained. In the spring of 1872 a salmon weighing five and a half pounds was caught in a gill-net, set for shad near Wallingford. Another, weighing over four pounds, was caught with a hook in the summer of 1873 by Mr. Stephen P. Northrop, who was fishing for pickerel, with live bait.‖ These specimens were probably grilse that came from some of the broods of young fry introduced in recent years.

* Letter of J. Brown, of Willimantic.

† Letter of Dr. W. W. Fletcher.

‡ Letter of T. Lyman.

§ Letter of William H. Burgis. Hon. William H. Buell, of Connecticut, is authority for the statement of their actual presence.

‖ Letter of O. J. Martin, esq.

31.—HOUSATONIC RIVER.

Salmon disappeared from this river many years ago. One correspondent says they disappeared about 1800, and were plenty fifty years earlier, not only in the main Housatonic, but also in the Naugatuck, its largest tributary.* Some four or five years ago there was one of seven or eight pounds caught below the dam at Stratford, and returned by a Mr. Shelton to the river above the dam.†

E—NOTES ON THE GROWTH AND MIGRATIONS OF SALMON

1.—INTRODUCTORY REMARKS.

It is the purpose of this paper to present such facts as have been observed regarding the growth and migration of the anadromous salmon of Maine, adding some facts about the salmon of Canada by way of illustration, no attempt being made to compile from published authorities. This statement will serve to explain the meagerness of the narrative. In fact, the data for a history of the life of a Maine salmon are so exceedingly scanty, that, but for assistance afforded by observations made in other countries, it would be largely an unguessed riddle. This paucity of material is in great part due to the early decline and present scarcity of the species, but, as regards some phases of growth, is believed to be owing to some peculiar conditions, climatic or other, which affect the growth and habits of the fish.

2.—THE NAMES APPLIED TO CERTAIN STAGES OF GROWTH.

The nomenclature of the various stages of salmon-growth in use among sportsmen and naturalists in America is of British origin. Its application to American salmon presupposes an identity of habits in general, and so far as these have been investigated there is nothing to forbid that supposition. As it will be convenient to use several of these imported terms in this paper, their signification requires a word of explanation. "Parr" is the term used to designate a young salmon not yet prepared for its first migration to the sea; its most obvious external characteristics are the dark transverse bars and red spots on the sides. In Scotland this stage lasts for a year in general, and sometimes for two years, and the length of the fish at its completion may be put down roughly at five to eight inches. "Smolt" is the name applied to salmon in the next stage, the commencement of which is marked by the disappearance of the bars and spots of the parr and the assumption of the silvery coat of the adult salmon. The smolt proceeds immediately

*J. W. Webster, of Waterbury; his testimony corroborated by William A. Clarke, of Monroe, and R. S. Peck, of Newtown.

†Letter of P. P. Curtys.

to sea and is seen no more until it returns to the river of its birth, weighing several pounds, say from two to six, when it receives the name of "grilse." It requires another journey to the sea and another season of feeding to produce the adult salmon. After each visit to the rivers for the purpose of spawning, the adult salmon returns to sea in an emaciated condition, when it is termed a "kelt."

3.—THE EGG STAGE.

The eggs of salmon are, in the rivers of Maine, deposited in October and November, in water whose temperature, through the winter and spring, cannot be much above 33° Fahrenheit, and does not rise materially until the snow is melted from the ground and the ice from the lakes. In the interior of the country, about the headwaters of the Penobscot and other large rivers, the ice in the lakes does not disappear until May, and I am confident that the general hatching of salmon-eggs cannot occur earlier.

4.—THE PARR.

Of the infancy of salmon in our rivers very little has been observed. The specimens of parr and smolts that had come into the hands of naturalists previous to last summer may almost be counted on one's fingers. On the Denny's River, when salmon were abundant, a good many parr and smolts (parr 4 to 10 inches long) were caught on hooks by the boys at Dennysville, but, the number of adult fish having declined, the young fell off in a corresponding degree. Young salmon (parr or smolts) have also been taken in Little Falls Stream, in Edmunds, and parr in the East Machias. In Alna, in June, 1869, a parr was taken in the Sheepscot River, and, being confined in a trout-pond, it was, in December following, 6½ inches long, and still retained vermilion spots on the sides, and dark transverse bars only a little less distinct than the spots. In the Penobscot River specimens of parr are occasionally met with. The State commissioners, in the course of a tour of inspection on the upper Penobscot, from July 22 to 28, 1873, found them rising to the fly in almost every pool from the mouth of the Mattagamon to Grand Falls, the upper limit of the ascent of salmon. At Medway, where the Mattagamon joins the Penobscot, they found the people catching them very commonly when fishing for trout.* Mr. Stilwell remarked that they seemed as plenty as he ever knew them on the Miramichi in the course of several seasons of fly-fishing. These fish were about six inches long, and retained the transverse bars and brilliant vermilion spots of the parr.

The salmon-rivers on the west side of the Gulf of Saint Lawrence abound with parr. They take the large salmon-fly intended for the adult to such an extent as to be often a nuisance to the angler.† Mr.

* Seventh Report of the Commissioners of Fisheries, of the State of Maine, p. 5.

† Statement of Jos. Carr, E. M. Stilwell, W. M. Brackett, and others.

Norris* has observed that in rivers whose salmon are of large size the parr are also large; for instance, that they are much larger in the Grand Cascapediac than in the Nepissiguit. In the Miramichi specimens 6 or 8 inches long can be taken at almost any time during the fishing season.† In the rivers of the Gaspé district they are, in July, about six inches in length, and the smolts, of which a smaller number is caught than of the parr, are a little larger, and commonly retain some faint traces of the parr marks.‡ Some observers failed to find any specimens that had reached the smolt stage.§

5.—THE SMOLT.

Immediately on assuming the smolt coat, the young salmon is believed to go down to sea. In the Penobscot, smolts 6 or 8 inches long are taken in some of the weirs near Bucksport in May or early June, almost every year; but they are so rare that many a man has followed salmon-fishing for a life-time without seeing one. In the Miramichi, Mr. Stone says that he saw thousands of smolts going to sea in July. In Nova Scotia, in the tide-way of Bedford River, near Halifax, five young salmon were taken on the 20th of May, 1865. They were from 6 to 8 inches long, and were perfect miniature salmon in all respects, save a blunt nose and a vermilion spot or two, and some of them had spawn in them.‖ At Eastport, Capt. U. S. Treat takes a number of young salmon in his herring-weir every fall, mainly in September. They are then 6 or 8 inches long. Captain Treat supposes them to come from Denny's River. In the East Machias River, at the head of the tide, young salmon are often taken in dip-nets along with tomcods in December and January. A single specimen that I have seen was a smolt.

From the common occurrence of parr at Dennysville, very near the mouth of the river, and at Bedford bridge, in the tide-way of Bedford River, and from the facts stated about parr and smolts in Canadian rivers, it may be inferred that they reach the sea, in some cases, before the transformation into smolts. This would very naturally occur in short rivers, where all the breeding-grounds lie within a few miles of the sea; and, though it is known that parr have been killed by experimental immersion in salt water,¶ there is nothing to forbid the supposition that the internal change which prepares the fish for life in the sea may precede the external change by which its new condition is recognized.

The facts stated above are quite insufficient to establish the period of the young salmon's stay in fresh water, but it is perhaps admissible to point out their tendency. It seems that those of different rivers do not

* T. Norris, letter.
† Statement of Jos. Carr, esq.
‡ Statement of W. M. Brackett.
§ Letter of T. Norris.
‖ Dr. J. B. Gilpin, letter.
¶ Bertram's Harvest of the Sea, p. 195.

all reach the sea at the same time. In some cases, as at Eastport, they arrive in September, and if these specimens came from the Denny's they may have left it in the summer. In the East Machias they are seen at the head of tide-water in the winter, and they reach the mouth of the Penobscot in the spring. In the latter river the parr observed on its upper waters in considerable numbers late in July were uniformly about six inches long, (this is only an estimate made from memory by the observers,) and can hardly have been less than fourteen months old, and it is quite reasonable to suppose that they should make their appearance at the mouth of the river the next spring, about two years from the time they hatched. But this theory cannot be confidently advanced on the strength of the disconnected phenomena thus far observed.

6.—THE GRILSE.

In the next stage of growth, that of grilse, there appears to be a marked difference between the habits of our salmon and those of more northern salmon. In the rivers of Canada, in general, grilse occur in great numbers, coming in from sea at a later date than the adults, but ascending like them to the upper waters, mingling freely with them, rising to the same fly, and caught in the same weirs. The mesh of the nets is limited by law to a minimum size of 5 inches *in extenso*, and this being too small to hold grilse few of the latter are taken in the nets. To this circumstance it is in part owing that by the time the fish have reached those portions of the rivers suitable for angling, there is commonly, if it be late enough in the season, a great preponderence of grilse, so that more of the latter than of the former are taken by the angler.*

In Nova Scotia† many grilse are taken in the Shubenacadie River, from August to late in the fall. On the Miramichi, in New Brunswick, grilse make their appearance about July 1, and from the middle of that month till the end of August they constitute the main body of the salmon entering the river. Their weight is on the average about three pounds.‡

Some sportsmen report the grilse caught to exceed the adults in the ratio of five to one.§ In the month of August in the Nepissiguit, Restigouche, and Saint John, of Gaspé, grilse exceed the adults in the ratio of three to one.‖ They run into the Nepissiguit mostly between July 25 and September 1. Their scarcity during the early part of the angling season, or say previous to July 20, is attested by numerous fishing scores.¶ A series of scores of salmon-fishing in the Godbout River, on the north shore of the Saint Lawrence, shows that previous to July 15

* Letter of W. H. Venning, esq.

† Letter of Dr. J. B. Gilpin.

‡ Statement of E. M. Stilwell.

§ Statement of N. Cummings, esq

‖ Statement of W. M. Brackett.

¶ Mr. Norris found no grilse "in the angling season" in the Restigouche and Grand Cascapediac, but at what date he closed his fishing I do not know.

or 20 the adult salmon taken with the fly in that river exceed the grilse in the ratio of 10 to 1, or more.

In our rivers grilse are seldom seen. Three or four per year is the number caught in a weir in the Saint Croix, which takes about 70 adults.* In the Denny's the ration of grilse to salmon caught is not more than one to 500.† In the Penobscot they are quite as rare, many a man having grown old in the salmon-fishery without seeing a single specimen.‡ Adult salmon running in this river several weeks earlier than in those of Eastern New Brunswick, we should naturally expect the advent of grilse early in July in considerable numbers; but some of the weirs are often kept in operation until the middle or last of July, and sometimes even through August, when they take menhaden; but no grilse enter them. During the latter part of the summer the water at the several falls between Bangor and Oldtown is generally at a low stage, and the attempt of grilse, even in small numbers, to ascend the river, could hardly fail to be frequently detected. A similar state of things exists in the Kennebec. There is no escaping the conclusion that the great run of grilse, which is so prominent a feature in the history of the salmon of the northern rivers, is almost entirely wanting in the rivers of the United States.§ It by no means follows from this that our salmon do not pass through the same phases of growth, or that the growth is more rapid; but merely that when in the grilse stage they generally lack the instinct that impels their more northern relatives to seek fresh water.

Of the characteristics of grilse, as ascertained in the rivers they frequent, it will be sufficient to say that they exhibit to a great degree the characteristics of the adult; that the main external differences are, a shorter head, slenderer form, and a difference in the color and markings; that they are remarkably active and agile, leaping to great heights; that the male is sexually well developed and mates with the adult, but that the female is immature; and that, like the adult, they abstain from food and consequently lose flesh during their stay in fresh water.

Of the length of the interval between grilse-hood and maturity our rivers afford no data for an estimate; and we must therefore be content with the supposition that it is nearly the same as in the case of Scottish salmon, and that this year's grilse is next year's adult salmon. If we also accept the Scottish conclusions as to the rate of growth of parr and smolts, we must assign to the growth from the egg to maturity, a period of two or three years. This must, however, await further observations.

* Letter of L. Wilson.

† Letter of B. Lincoln, esq.

‡ One old fisherman says that at Veazie he has caught, in a dip-net, salmon only a foot long, with hooks on their jaws. Such instances are certainly rare.

§ Dr. Gilpin has called my attention to the statement by Couch in "British Fishes," that grilse do not frequent the rivers of Cornwall or, for the most part, those of Devon.

7.—THE ADULT SALMON.

(7 *a.*) *The size of the salmon.*—We come now to the adult fish, which is the only form known to most of our fishermen. When in prime condition, they range in weight from 6 or 7 pounds upward. In the Penobscot and Kennebec, and I think in other Maine rivers, this minimum is rarely met with. In the Penobscot very few weigh less than 9 pounds, and the most common size is from 10 to 12. The maximum cannot be definitely fixed. Salmon of 30 pounds are rare, not one out of a thousand weighing so much; but occasionly one of 40 pounds or more is caught. In different rivers there is a variation in size. Those of the Grand Cascapediac, in Canada, are believed to be the largest of their species in America. Those of the Restigouche are large, those of the Miramichi smaller, and those of the Nepissiguit smaller still. In the Clearwater, a small tributary of the Miramichi, they never exceed 6 or 8 pounds.*

(7 *b.*) *The migration up the rivers.*—Salmon ascend the rivers of Maine in April, May, June, July, and August. Arranged according to the comparative abundance of salmon in them, these months would stand thus, viz: June, July, May, April, August; but perhaps in some cases May and July will change places. A great majority, perhaps two-thirds of the salmon, enter the rivers in June. Outside of the five months mentioned there are very few salmon ascending, but, judging from the specimens caught, it seems pretty certain that salmon in prime condition are running in from the sea every month in the year. They have been taken in a gill-net set for them at Buck's Ledge, near Orrington, and the smelt-nets at Bucksport and Winterport take now and then some prime salmon, together with some kelts, in January and February. Off the coast of Nova Scotia, Dr. Gilpin has remarked that there is a large catch of prime salmon in November.

All the adult salmon that enter our rivers in early summer yield mature eggs and milt in the ensuing fall. Nearly 700 specimens caught in June and early July and kept at Bucksport for breeding until fall afforded not a single exception to this rule. The salmon taken outside the rivers in the summer appear to be in the same condition as those in the rivers, and are probably bound on the same errand. The examination of a single specimen, caught at Western Pond Island, the outside limit of the salmon-fishing on the east side of Penobscot Bay, disclosed the existence of spawn in the same stage of developments as in the salmon taken in the river; and it is a well-known fact that the salmon caught in either bay or river have empty stomachs, a sufficient proof that they have left their feeding-grounds, and ground for the conclusion that they are all on their way to the breeding-grounds.

As a general rule, the early migratory salmon are the largest. An average for the several months, from April to July, at least, shows a

* Statement of E. M. Stilwell.

steady depreciation in size. There are comparatively few salmon of ten to thirteen pounds weight caught in April and early May; but this is the ruling size of those coming late in June and in July, constituting what are called the "school-salmon," from their apparent tendency to move in considerable bodies.

Of the sexes, there appears to be a greater proportion of females in the early part than in the late part of the season; but the similarity of the sexes among the early salmon is so great as to generally prevent their separation by external characteristics. By the end of June the males have assumed so much of the peculiar characteristics that mark them at the breeding-season that the sexes can be distinguished with tolerable certainty. In the month of June the females are, in the Penobscot River, largely in excess of the males.

In approaching the rivers, salmon swim near the surface, and are not inclined to leap into the air. In the early part of the season they appear to move at a greater distance from the shores than they do afterward, so that they frequently pass all the pounds and weirs of the estuaries and are first taken in the rivers, where the contracted breadth of the water or some other cause induces them to run near shore. At the height of the salmon season, however, they appear to be coasting along very near the shore, so that where two weirs are built on the same hedge that near shore takes more salmon than the other.

It seems that the main body of the salmon proceeds at once to the vicinity of the spawning-ground. In general, this may be said to be on the headwaters of the large rivers, but in the middle course of such as the Denny's. The earliest reach the limits of their upward migration on the Penobscot before mid-summer.

(7 c.) *Changes in the appearance of salmon while in fresh water.*—From that time until the spawning-season, they lie in deep, quiet pools, and frequently, no doubt, in the lakes traversed by the rivers. Meanwhile, a complete change takes place in their appearance. Both sexes lose the brightness of their silvery sides. The female becomes dark-colored, tinged to a slight extent with some shade of red or orange, and with irregular spots of the same color. All parts of the body fall away in flesh, except the abdomen, and that becomes distended with the growing spawn. The change in the males is more marked. They become very thin from side to side, so that the widest part is near the gills. At the same time their depth increases, and the head lengthens. The jaws become curved, and the lower one is tipped by a large hook that shuts into a cavity in the roof of the mouth; sometimes, indeed making itself a hole quite through the upper jaw, and projecting above The curvature of the jaws is so great that they do not close except a the tips. The fins become very thick and fleshy, the adipose dorsa greatly enlarged, and the whole body covered by a thick mucous coat

that almost conceals the scales. In color the males differ greatly both from each other, and from their own condition in early summer. Some are very light and some very dark. All are curiously mottled on the back with brown, green, or blue, and some shade of red. On the sides are groups of angular red spots, generally vermilion, but sometimes approaching scarlet. The whole lower part of the body is generally suffused with a tinge of vermilion or salmon-red, with occasionally a tendency to purple. The toughening of the fins and the growth of the mucous coating occurs also with the female, but to a less extent. This is their external condition when the spawning-season arrives.

(7 *d.*) *Habits of salmon during the spawning-season.*—In the Penobscot spawning appears to begin during the last week in October. Such, at least, is known from direct observation to have been the time in 1870, in the Mattagamon. In the Miramichi the season is earlier, commencing about the middle of October.* Its progress, if the stage of the water is favorable, is very rapid. In the Miramichi, in 1868, Mr. Stone found most of the salmon had spawned by October 20. Judging from what I saw on the Mattagamon, and during three seasons of artificial spawning at and near Bucksport, I should say that very few salmon would wait until after the 10th of November. But a good deal depends on the stage of the water. If the water is low the salmon will often wait till rains raise it. A female salmon can retain her eggs for three weeks after they are ready to be laid, with little or no injury to them.

The place generally selected for a spawning-bed is just above the verge of a rapid. Frequently, nay, commonly, there is a pool just above it, where the salmon can lie during the day-time. From the behavior of salmon at Bucksport, I should say that, at the spawning-season, they would run down quite as soon as up, to find a suitable place to deposit their spawn, and that they would never perform the operation by day, unless on a dark, cloudy day. Having never observed a salmon of this species in the act of depositing the eggs, † I can only describe the appearance of the nest after it is made. It is a simple excavation, two or three feet in diameter and rarely over a foot deep, with the material that came from it piled by the swift current in a heap below.

(7 *e.*) *Habits of salmon at the end of the spawning-season.*—Having finished spawning, part of the salmon probably drop immediately down river to the sea, and it is certain that part linger in the rivers until spring and descend then. In the weirs on the Penobscot a few of these descending salmon are every year caught, generally early in May. Of

* L. Stone, p. 216 of this report.

† A fresh-water Schoodic salmon excavates the nest by turning on the side and flopping violently against the bottom with the tail. The female alone does the work, the male lying near her, driving off rivals and predacious fishes, and now and then taking his place for a moment close by her side.

the salmon placed in the pond at Bucksport and not caught out again in the fall, many staid of their own accord through the winter in the pond, and only left on occasions of floods in the spring. In the rivers of Nova Scotia the same phenomenon is observed.*

(7 *f*.) *The kelt.*—The salmon seen on their return to the sea are always in miserable condition, thin, black, and weak, and poorer than at the completion of the act of spawning. The fish kept over winter in the pond at Bucksport lost in weight meanwhile, but had regained, to a great degree, the bright, silvery color of the fresh-run fish.

(7 *g*.) *Habits of salmon after leaving fresh water.*—Of the movements of the salmon after this there is as little known as there is of their movements during the growth from smolt to grilse, and from grilse to adult. It can be safely said that they are feeding; but of the location of their feeding-grounds and of the nature of their food scarce anything is known. At their disappearance and at their re-appearance their stomachs are alike empty of food, except in rare instances. At Eastport, Captain Treat has found herring as long as five inches, in the stomachs of salmon, and on the Penobscot some old fishermen tell of having occasionally found their stomachs full of "shrimps," by which term they doubtless mean some small crustacean. They are also known to occasionally bite at the baits on cod and hake hooks on soundings.

The length of their stay in the sea between the visits to the rivers is a matter of entire uncertainty; though it would hardly seem possible for the emaciated kelts that descend in the spring to recover condition soon enough to return the same year to the rivers. As some hundreds of specimens have been marked and dismissed in good health, as detailed in the narrative of the work at Bucksport, it is confidently anticipated that some of them will be taken on their return, and afford data for an estimate of the length of their stay in the sea, and of the rate of growth meanwhile.

* Letter of Dr. J. B. Gilpin.

TABLE OF CONTENTS.