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OF VARIOUS

PUBLIC OFFICERS AND INSTITUTIONS

FOR THE YEARS

1870-71.

AUGUSTA:
SPRAGUE, OWEN & NASH, PRINTERS TO THE STATE.
1871.

FOURTH REPORT

OF THE

COMMISSIONER OF FISHERIES

OF THE

STATE OF MAINE,

FOR THE YEAR

1870.

AUGUSTA:
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REPORT.

To the Governor and the Executive Council:

I have the honor to submit a report of my doings as Commissioner of Fisheries for the year ending December 31, 1870.

The time that I have devoted to my duties as Commissioner has been chiefly occupied with the planning of fishways and the inspection of those already built. The artificial propagation of salmon, as a means of restoring the species to rivers where it is now extinct, and of adding to its natural increase, has received much attention. And, finally, the condition of the fisheries as an industry, the modes employed, and the manner and degree of the enforcement of the laws regulating them, have been subjects of examination.

In general the statement may be made that the progress toward a restoration of the river fisheries during the past year has been satisfactory. The period of preliminary examination has ended and the period of experiment is drawing toward a close. The past season has seen the fishways built by direction of the Commissioner for the first time subjected to the test of actual use. Until now I have been forced to content myself with promises of what might be done, supporting them by arguments drawn from the workings of fishways planned by other men, and from the piscicultural operations of other countries. Deprived, by the death of Mr. Foster, of the services of a practical man, the State was compelled to trust the decision as to the necessity of fishways, as to their location, form and capacity, in the hands of an officer who was without any practical experience in the matter,—who could only claim the possession of common sense and a fund of information drawn from observation and from the teachings of books and of his former colleague,—who could not open his mouth in reply when charged with being a "theorist." Although the conviction that the fishways would be successful almost amounted to a moral certainty, there could but be a feeling of anxiety, lest among the many conditions to be considered in the location and form of them, there might have been some unthought-of difficulty that would destroy their usefulness. It is therefore with a feeling of relief that I am

able to report the entire success of all the fishways built in accordance with the Commissioners' plans, that have been tested. Among these may be mentioned the fishway at Union Mills on the Saint Croix, several on the Penmaquan river in Pembroke, and at Warren. In all these the fish ascended in numbers that delighted the public and astonished the incredulous. Others have been built but not yet tested. In several cases alterations were made in old fishways and improvements in natural passage-ways around dams, all with good results.

As in previous reports I must still give special prominence to the construction of fishways, without which the species that ascend our rivers to lay their eggs will in many cases be utterly unable to reach their proper breeding grounds; but the artificial incubation of certain species, among which are salmon and shad, is assuming new importance and promises to take its place by the side of the fishway as a practicable means of resuscitating our river fisheries.

I am able to refer with much satisfaction to the result of the shad-hatching on the Connecticut river, undertaken by the States of Massachusetts and Connecticut in the summer of 1867. From what was known of the growth of shad it was calculated that the fish hatched in 1867 would reappear as full-grown shad in 1870. There was much skepticism as to the matter, but the result has surpassed the hopes of the sanguine. The shad came into the river during the last summer in far greater numbers than had been known before for many years. This demonstration of the practicability of applying the artificial process to shad was so convincing that the Connecticut commissioners have decided to continue that mode of incubation yearly. They inform me that the operations in this department during the past summer were very successful, about fifty-six millions of shad having been hatched and turned into the river.

Another successful effort in the artificial breeding of fish, worthy of notice, is the salmon hatching at Newcastle, Ontario. This was first undertaken by Mr. Samuel Wilmot as a private experiment, and is now managed by the same gentleman under the auspices of the Canadian government. Early last spring I visited this establishment, for the double purpose of informing myself as to the modes in use and of purchasing eggs of salmon. The success of Mr. Wilmot in multiplying the brood of salmon that frequents the creek on which the works are situated is so remarkable that I de-

termined to ascertain if possible whether there is within our own borders a place where the requisite facilities exist for the maintenance of a similar establishment. For this purpose I made two excursions up the Penobscot, one on the main river, and the other on its east branch, the Mattagamon. I think there are several points where a sufficient number of breeding salmon could be obtained at the right season to furnish a large number of eggs, part of which could be used in restocking exhausted rivers, and part in increasing the brood of the Penobscot itself. This matter will be discussed further on, under the head of "Artificial Propagation."

The enforcement of the laws wherever wardens have been appointed has been satisfactory. But there were, during the last fishing season, only three wardens under pay in the whole State, viz., Thaddeus H. Spear of Gardiner, Francis Blackman of Bradley, and Caleb Gilman of Meddybemps. These men were faithful, but they cannot of course enforce all the public laws regulating the fisheries. They were expected to give special attention to the enforcement of the laws regulating the fisheries for salmon, shad and alewives. In this they have succeeded. Several wardens have also been appointed to serve without pay in districts where fishing is followed as an amusement, and hardly rises to the rank of an industry. I think wardens of this class could be appointed in several other districts to advantage, for instance, one on the Sebago waters, and one on the west branch of the St. Croix. The State should only pay those wardens who are to guard the industrial fisheries, such as those for salmon, shad, alewives and smelts, and these should receive a sufficient sum to remunerate them for the time necessary to a faithful performance of their duties.

To revert to the matter of fishways. The arguments in their favor have been so often presented in previous reports that I will not here repeat them. A statement of their uses, their cost, the amount of water they require, of the beneficial results from their construction, and some interesting comparisons between our own rivers and some of those in Ireland and Scotland, will be found on the first pages of the report for 1869. In appendix "A" of this report will be found a paper by an English engineer on the fishways in use in the British Isles. We are happy to see that the only form of fishway that has stood the test of use there is nearly identical with that in use in this State. Plate I. shows two of the most successful fishways in Ireland; one, a short one in the river

of Galway, through which have passed *forty thousand salmon in a single year;* the other, a larger fishway, around a precipitous natural fall of *nineteen feet.* This last is on a river which had originally no salmon, but was stocked with them by means of this fishway. Plate II. represents a number of fishways and parts of fishways that have been built in this State during the last two seasons, together with two imaginary plans, contrasting a good plan with a bad one.

My experience thus far has convinced me that the most important point about a fishway is its *location.* Its lower end, where the fish enter, must be so placed that they will readily find it. When ascending a stream, all fish with whose habits I am acquainted stem the main body of water until they meet a serious obstruction. If this obstruction be a dam too high to get over, they seek some way around it. If the fishway have its entrance very near the dam, and readily accessible from the main channel, they will soon find it and pass up. If the entrance is far down the stream it will be long before they will drop back far enough to find it.

For this reason, when the dam is high, and the fishway consequently long, it is desirable to make a "return fishway," or, as it might well be called, an "elbow fishway." The fishway at Ballisodare (Pl. I., fig. 1,) is of that form. So is the fishway at Warren (Pl. II., fig. 5). The location of the latter is most admirable. Compare it with the position of the old fishway, shown in the same figure.

So various are the shapes of rivers and dams and their surroundings, that the fishways cannot be built on a uniform pattern. Each dam requires a special plan, only to be determined by a careful examination of the premises. Sometimes repeated examinations are necessary.

Considerable interest has been excited in our own State as well as in Massachusetts, by a case which has been some time before the courts of Massachusetts, involving the obligation of the Holyoke Water Power Company to build a fishway over their dam on the Connecticut river. The case was important from the extreme nature of its conditions. The Supreme Court has recently rendered a decision, of which the following are in brief the main points.*

By its charter the company was allowed to build a dam on con-

*Communication of Theodore Lyman, Esq., of Massachusetts Com'rs Inland Fisheries.

dition of paying all fishery owners *above* the dam. This they did. The court, however, thereupon decided nearly as follows :

1. Dam owners are required by common law to maintain fishways.

2. Chartered rights are to be construed against the grantees; i. e. where a grant is not *stated* in the charter it is supposed to be withheld.

3. There is no exemption from a fishway granted by this charter, and no *implication* of such a grant can be considered. Therefore the Holyoke Water Power Company is liable to build a fishway.

The company was very confident, but the bench was unanimous against them. The fishway is now nearly finished, it having been built by the commissioners, the question who should pay for it being left to the decision of the court.

No principle of law is better established than that owners of dams are liable to build fishways, unless they are expressly relieved. No neglect on the part of the public to enforce their rights can be pleaded in favor of the proprietor; for this liability, or limitation, being for the public good, no individual can prescribe against it.

Besides several matters of local interest, which will be presented in their proper place, I desire to suggest to you, and through you to the Legislature, two important alterations in the general law relating to the fisheries, that it seems desirable to make at the coming session.

The first is the increase of the number of the Commissioners to *three*. The duties of the Commissioner are of a complex character. He is constantly called upon to decide questions involving the liabilities and rights of private parties, and it is not in accordance with the previous practice of the State to trust so much to the opinion of one man in cases involving considerable interests. Further, there are times in each year when the presence of the Commissioner is demanded at so many points that some of them must be neglected. In other States the boards of Commissioners of Fisheries consist in each case of two or more persons. The increase does not necessarily imply an increase of the appropriation, and with respect to that I refrain from making any recommendation.

The second recommendation is that the weekly close-time, as a general regulation, be abolished. I have before expressed the opinion that this was a very unsatisfactory mode of protecting the

fisheries from depletion. It is a regulation which rogues will easily find means to evade, to the great discontent of honest men who would like to obey the law, but wish it to be effective as well upon their unscrupulous neighbors. The clause restricting the depth of weirs is more effective than would be a weekly closetime of twice its present length. The experience of the past season and the testimony of wardens and others, convinces me that it is not wise to retain this time-honored regulation any longer on the statute book, except in certain special cases. On the Penobscot river it is now the only restriction upon the weirs; it should be retained there until some other regulation can be framed to take its place. There are some smaller rivers, as the Saint George, where it may not be practicable to apply any other regulation; these may have special acts.

Fishways and Other Matters in Detail.

Saint Croix River.

I was able, in my last report, to announce the construction of fishways over the dams at Calais and Baring. I am now able to report the success of the experiment.

The fishway in the dam at "Middle Landing," or Union Mills, the first obstruction met by fish in ascending the river, was completed in 1869, and has thus been tested during one season, and through several freshets of unusual violence. When, in the month of June, the alewives came, they readily found the entrance to the fishway, and passed up through it in great numbers. Crowds of people gathered to witness their ascent. On one occasion when Mr. Curran, the Canadian fishery officer at St. Stephen, was watching the operation of the fishway, he informs me that each of the seven pools which the fishway contains was so full of alewives that a stick could not be drawn through the water because of them. There is no reason to doubt that salmon also passed through the fishway, although I am not informed that any were actually seen in it. At any rate they passed this and the other dams. Before this fishway was in operation there were some fears lest mill-rubbish, unlawfully thrown into the river, and other floating material might choke the fishway up so often as to interfere seriously with the ascent of the fish, and cause the owners much trouble in clearing it out. But on trial it is found that the head of the fishway is so happily located that nearly all floating material is carried past, to one side or the other, by the current. Only two or three times

during the summer was it necessary to shut off the water and clear away the rubbish. Another point to be noticed about this fishway is its location. It will be seen by reference to Plate II, Figs 1 and 2, that the upper end would be exposed to the full force of the falling water, were not the wing dam, through which the fishway opens, built higher than the main dam. In its present condition the wing dam is several feet higher than the rest of the structure, and it might easily be raised so as to prevent water falling over it into the fishway even in the highest freshets. The proprietors, however, did not think it worth their while to take these ready means of ensuring the safety of the fishway, believing that it was strong enough to withstand the force of the water in any event. Their opinion seems justified by the experience of one season's freshets; for the fishway was not injured by them in the slightest degree. Fishways are not necessarily cobweb affairs. They can be made to stand wherever a dam will stand, without unreasonable expense. This fishway at Union Mills was seventy feet long, eight feet wide, inside measure, built up from the bottom in deep water to a hight of ten feet above the surface, was of solid timber bolted together, except the foundation, which was of timber and stone; and it was built by contract for $600.

The passage at Milltown was kept in operation as a fishway. At one time, late in the fish season, it became clogged for a few days with rubbish, and salmon were seen to collect in a pool below it. The obstructions were removed and the salmon passed up.

At Baring the fishway was not finished until September last. But the fish reached this point at a favorable stage of water and were able to pass the dam without the fishway. The latter has now been put in good order and will undoubtedly work well when the time comes for its trial.

Above Baring there are no obstructions in the river until we reach Vanceboro', on the East or boundary branch, and Princeton on the West branch.

At Vanceboro', a short distance below the outlet of Chepedneck lake, is the dam connected with the tannery of F. Shaw & Brothers. A fishway was planned here by Mr. Curran, and has been constructed, so that with ordinary success on the river below, the alewives will pass this dam and reach Chepedneck lake next season. In June or July last a man fishing for suckers with a small dip-net just below this dam, dipped up an alewife. It is thus cer-

tain that these fish reached this point the very first year of the existence of a fishway at Union dam; and would have entered Chepedneck lake had there been at the time a fishway at Vanceboro'. Whether salmon would pass this point or not, there is a great extent of breeding ground below as well as above.

Chepedneck lake is an exceedingly irregular sheet of water, about twenty miles in length. It contains a vast area of spawning ground for alewives, and a few years of open fishways would bring them back again somewhat after the fashion of olden times. There are also many smaller tributary lakes, and not a few gravelly streams wherein salmon probably once bred and would again.

Above Chepedneck is a still larger body of water called "Grand lake," discharging it waters into the former by a rapid stream less than a mile in length. At the outlet of Grand lake is the isolated village of Forest City, built up around a tannery and a sawmill. A dam crosses the river here, and a fishway has been planned for it and promptly built by the proprietors, Messrs. Shaw of Maine and H. N. Hill of New Brunswick. Its construction completes the opening of this branch of the St. Croix. The only dam remaining unprovided with a fishway on the whole river is that at Princeton on the west branch, entirely within our borders. But a fishway has been planned for that, and the owners have recently assured me of their determination to build it the coming winter. It will be a cheap affair; but its construction is quite important, as the admission of alewives to this chain of lakes is at least of as great importance as their admission to Chepedneck lake.

I have been informed by Mr. Curran that numbers of salmon have been seen playing up the river this fall, and there is good reason to believe that this season's work is a good beginning toward a revival of the fisheries of this river. Now let us have the laws enforced and the fishways kept in operation, and we shall in a few years see the results.

Penmaquan River.

Fishways were laid out over the four dams on this river in the fall of 1869, as stated in the last report. They were not, however, built until the spring of 1870. The fishway over the lower dam, owned by G. W. Leavitt, is merely an inexpensive gap cut through the ledge. In its present shape it does not fully meet my views, but as alewives are said to have found little difficulty in passing this point this year, it may prove sufficient.

The fishway over the second dam, known as the "gang-saw-mill dam," owned by the Pembroke Iron Company, was built from drawings submitted to them by the commissioner. The drawings required a fishway sixty feet long, eight feet wide inside and having an incline of one in six, divided into eighteen compartments. As built by the company it was a little longer, had one or two more compartments, was a trifle less steep, and in other respects according to the design. The extreme steepness, one in six, was designed to bring the foot of the fishway as near as possible to the dam, since the narrow space available did not allow the construction of a "return" fishway; and to counteract the effect of the steepness on the water, the cross-walls were placed very near together. The proportions of the compartments were altogether different from any other fishway that I know of. (See Plate II, Figs. 3 and 4.) Very soon after it was finished the alewives came to try it. They played about for several days before entering it, probably repelled by the bright new wood of which it was made; but after once entering it they went like sheep. The success was complete. I think the compartments might safely have been larger, without any other change. The cost of the fishway was about $90.

The fishway at the third dam is made by appropriating crevices in the ledge which forms the natural bed of the stream. Part of this work was done by the company and part by the town, since certain natural obstacles were to be overcome. I have no minute account of the passage of alewives over these falls; only knowing that they did so and appeared at Little falls, which commands the outlet of Penmaquan lake. Something was done at Little falls toward the construction of a fishway, but as it was to be ascertained only by trial what would answer the purpose, and the alewives were later than formerly, (it is many years since they were here before) the entrance for the water was not put low enough, and probably no alewives passed into the lake. There will be less difficulty in making a fishway here than I at first feared.

It was supposed, when the general laws relating to river fisheries were enacted, that there was in force a special act regulating the manner of taking fish on the Penmaquan, but it now appears that all the laws for this river were repealed by a general repealing act, in 1841, and that there are now no regulations on the subject at all. It is quite essential that there should be proper regulation of the fishing, and I think the most satisfactory mode will be to empower the town of Pembroke to provide for the capture of such

fish as may be taken for food, and to enforce the laws for the protection of those that are left to spawn. The construction of fishways, however, should be kept in the hands of State officers. When the power to erect fishways or order their erection has been placed in the hands of towns, experience has shown it to be a prolific source of discord.

Walker's Pond.

This little sheet of water, lying mostly in the town of Brooksville, is the spawning ground of a remarkable breed of alewives,—remarkable principally for their small size, a barrel holding 750 of them. A barrel of alewives of ordinary size will count out 400. I am not inclined to regard these Brooksville fish as specifically distinct from other alewives, for the species varies remarkably in different localities; but the habits of these fish as reported to me by old observers are different in some respects from anything that I have heard from other places.

Formerly these fish were very abundant, and of considerable value to the citizens. A dam without a fishway nearly destroyed them. For twelve or fourteen years all the fish that reached the pond were carried up in baskets. Sometimes ten barrels were thus carried past the dam, sometimes not more than one barrel. The legislature has placed the construction of fishways in these waters on the same footing as elsewhere, and on petition of citizens of Brooksville I visited the stream in the spring and directed the owners of the only dam there to make a fishway. It was an easy task, only requiring a ditch which had formerly served the same purpose to be reopened, at a trifling expense; yet even this would not have been done by the proprietors had they not anticipated the presence of the commissioner. It worked very satisfactorily, and if kept in order a revival of the alewife fishery may be confidently expected.

This fishery would be of more value to the people in the vicinity if the town were empowered to regulate the capture of fish, to appoint officers to take them and sell to the public. Yet the matter of fishways should be reserved for the decision of the commissioner, for the reasons given in the case of Penmaquan river.

Penobscot River.

More attention was given to this river than to any other in the State. Several visits were made to the dams, in order to judge of

the effect of different stages of water upon the ascent of fish over the obstructions. An extended tour was made through the fishing districts in the last days of June to inspect the weirs and nets employed in taking river fish. A portion of the upper waters was explored with the purpose of finding the breeding grounds of salmon; and lastly a successful attempt was made to restock with alewives a tributary of the Penobscot, Blackman's or Nichols' stream in Bradley, where formerly alewives bred in great numbers.

The visits to the dam were made on the 9th and 25th of June, 2d of July, 29th of August and 13th of September. The result of these observations is a modification of my opinion as to the effect of these obstructions on the ascent of fish. Up to the 9th of June none of the dams were impassable to salmon, unless the extraordinary obstruction of jams of logs made them so. Even shad, I think, would pass them, if there *were* any shad, but not with ease. As late as June 25th, and possibly as late as July 2d, the facilities already existing for the passage of salmon over all these dams, except that at Basin Mills, were fully equal to any that could be provided by fishways made expressly for the purpose.

At the easterly end of the Veazie dam there is a natural passage-way through the ledge, which has received the name of the "fishway," and at such a pitch of water as prevails during the greater part of the fish season, makes an admirable salmon way. It is, however, liable to be filled up and rendered temporarily useless, by jams of logs. This did actually happen this year, and for two weeks in June the passage-way was blocked up.

There is a similar way at the east end of the dam at Basin Mills; but the amount of water flowing through it is much less than at Veazie, and it is sooner rendered useless by the falling of the water. It needed to be cut deeper, and protected from drift stuff. At the time of my last visit these improvements were in progress. This fishway has also been much obstructed by jams of logs.

The dam at Great Works is, at the point furthest up river, so low that salmon and shad can easily surmount it at a fair stage of water. This year salmon had no trouble here up to July 2d.

The degree to which the dams hinder salmon may readily be inferred from the character of the fishing just below them. The best fishing this year was near the Basin Mills dam. After the logs were cleared away from the Veazie dam, the fishing at that

point and at Eddington bend, fell off to almost nothing, and many of those accustomed to fish there went to Basin Mills. From these facts we infer that at Basin Mills was the greater obstruction. At Great Works there has never been any fishing of consequence. Nobody pretends to fish there now; and on this ground the proprietors of the dam claim, with very good reason, that it does not hinder the fish materially. At Oldtown there is very little fishing, the middle of the river being open.

The above remarks have reference to salmon, and will apply only to a limited extent to shad, and not at all to alewives. The latter are practically unable to surmount the fall at Veazie. That some improvements can be made there so that alewives can ascend is probable, but in what way it shall be done I am at a loss to know. The best way to determine the matter is by experiment at the time when the fish are running.

Well, then, it may be asked, if the views above stated are correct, what becomes of the hue and cry about the dams destroying all the fish? As for alewives, this query is answered by the fact that they cannot pass the Veazie dam. As for shad, it is probable that this has been only one of several causes of their disappearance. As for salmon, it is asserted that the Veazie dam when first built was impassable by salmon, and that it remained so several years. If this is true, it is a sufficient cause for the rapid diminution of salmon a few years after the building of that dam. But when the passage-way was formed on the east side of the river it should have enabled the salmon to soon recruit their numbers, if the lack of it was the sole cause of their decrease. But there was other mischief. The dam, although no longer quite insurmountable, checked all the salmon in their journey and held them there in hesitation just long enough for the fishermen to sweep them out with their drift-nets or dip them out in the very passage of the falls. A dam makes a good fishing place where none existed before. In England this is frequently one of the objects, and sometimes the main object of the construction of a dam. This fishing in the immediate vicinity of the dams is beyond question one of the principal abuses that keeps the salmon fishery of the Penobscot in its present lamentable condition. If it were not for that I believe every salmon that succeeds in getting so far on the journey as Eddington bend would pass all of the dams and reach the natural breeding grounds on the upper waters. It is then absolutely necessary to protect the salmon at these points. If the present

law is thoroughly enforced throughout the whole river and bay, a decided improvement may be expected. Even the effect of its enforcement during the last two seasons, about the dams, will be seen I hope, when the young from those seasons' breeding are of age.

The inspection of the weirs and nets was made by coasting in a small boat along the shores of the river and bay, running in alongside the weirs when conveniently situated, measuring the depth of water at the outer extremity, estimating the length of the "leader" or "hedge," and collecting such other information as could be gleaned from observation and conversation with the fishermen fallen in with. From Orrington to Lincolnville on the one side and to Castine on the other, all the weirs except a few in Eastern river and near Searsport were personally examined, as well as the nets on the Lincolnville and Northport shore, and some of those in Islesborough. The limit of the river fishery is near Camden on the west shore and Brooklin on the east. I have, however, authority* for saying that salmon have been caught this year in a weir on Gotts' Island, near Mt. Desert, and brought to Belfast. These were probably Penobscot salmon.

In this fishery, within the river, and on the eastern shore of the bay, and on the west shore as far as Belfast, weirs are used altogether. From Belfast to Camden, and on the shores of Isleborough the fishery is carried on by means of nets, constructed on the principle of the weirs, and differing from them mainly in being constructed entirely of netting, dispensing with stakes, secured in their places by anchors, and supported by buoys that rise and fall with the tide. A long straight net is run out from the shore, answering to the "leader" or "hedge" of a weir. At its outer end is a pair of "hooks" and a "pound," answering to the pounds of a weir. The "hooks" form that enclosure which the fish first enter. The "pound" is that enclosure in which the fish are finally entrapped, and from which they are taken by the fisherman. The pound has a bottom of netting, being in short a bag, which is hauled up when the fish are taken out. The mesh in general use is three inches square, and the nets are forty meshes deep, sometimes forty-two. Generally several complete nets (consisting each of a long straight net or leader, a pair of hooks and a pound) are set on the same line, running directly out into the bay one after the other. Such a series is called a "string of nets" or a "gang

* Mr. Crosby of Lewis & Crosby, Belfast.

of nets." The ordinary number of nets in a gang is three. Such a gang is said to have "three nets" or "three hooks." Some gangs have four or five hooks or nets. To moor a single net eight anchors are generally employed, and these, after they are once planted, are not disturbed until the fishing season is over and the whole apparatus taken up. At French's beach the date of setting these nets is May tenth, and they are taken up about the fifth of July. At Duck creek the fishing begins sooner, because the salmon strike in there earliest. The mesh is large enough to mesh the salmon, but a small part of them are thus caught. They are wary, searching diligently for a hole by which to escape, when they find themselves enclosed in the pound, pushing their noses into the meshes to try their size, but only now and then far enough to get caught. Another fact which strikes me as more singular is, (if the fishermen are right in their opinion,) that very few of the salmon escape by jumping over the top of the net, although this rises barely to the surface of the water. In a weir at Verona I have seen a salmon jump over a board that was fastened on edge to the floor of a pound, and rose above the surface of the water, and then, finding itself still inside the netting, jump back again. Another observer says that he has seen a salmon repeatedly jump over a stick that was floating on the surface of the water diagonally across the corner of a pound, thinking, no doubt, that that was the boundary of his prison, instead of being a loose floating stick.

The number of nets and weirs in use on the river and bay during the past season is very nearly as follows:

WEIRS.

Above Bucksport		15
Between Bucksport and Fort Point:		
West shore	20	
In Verona	25	
In Bucksport and Orland	39	
		— 84
Total in the river		99
From Fort Point to Belfast	26	
In Penobscot and Castine	35	
East of Castine*	13	
		— 74
Total weirs		173

* Statement of Capt. J. West, Belfast.

NETS, GANGS.

From Belfast to Camden*	25
In Islesborough	13
Total gangs of nets	38
Total number fishing establishments	211

Each gang of nets had on the average three pounds, and there were twelve or fifteen weirs that had each two sets of pounds. Making allowance for these extra pounds, we have as the total number of enclosures where salmon met their doom, 304. Besides these are the drift nets above Bangor.

The weirs and nets of the Penobscot are not subject to the clause in the general law that restricts such structures and implements to water not deeper than two feet when the tide is out. The depth in which the weirs are built varies according to the site. Out of some ninety, whose depth was ascertained mostly by direct measurement, several are entirely laid bare by the receding tide, while the deepest stand in about twenty-two feet at low water. The floors of all these, however, are near low water mark.

Above Bucksport the weirs are mostly shoal, although two of the longest hedges on the river are here. Between Fort Knox and Sandy Point fifteen weirs average eleven feet deep at the outer extremity; deepest fifteen feet, shoalest seven feet. On the island of Verona eighteen weirs average thirteen feet each; deepest twenty-one feet, shoalest five feet. In Eastern river the weirs are shoal. From Fort point to Belfast twenty-five weirs average fifteen feet; deepest twenty-two feet, shoalest eight feet. On the Eastern shore of the bay twenty-seven weirs, mostly in the towns of Penobscot and Castine, average twelve feet; deepest twenty feet, shoalest near low water mark. These measurements are not very exact. Part of them were made at low water, and others at various stages of the tide, allowance being made in each case for the height of the tide.

The length of the hedges varies as much as the depth of the water. On a bold shore they are naturally short. On that part of the river between Bucksport and Sandy point, are several hedges containing less than fifty stakes, two and a half or three feet apart. But there are some on this side of Verona, with about two hun-

* I think my list here is defective, and that there are more nets.

dred stakes, perhaps four or five hundred feet long. On Cape Jellison, too, the cliffs are bold, and the beach descends quickly into deep water. In Searsport there is very little steep shore, and the hedges are generally long, several hundred feet, one of them said to be a third of a mile. In Orland, Penobscot and Castine, the hedges are ordinarily three or four hundred feet long, but some of them would measure twice that. The inclination of the shore is uniform and gentle.

When the Committee on Fisheries of the last Legislature was considering the question of limiting the depth of water in which weirs should be built, the statements were made to them, by persons representing the interests of the fishermen, that at Fort point, and westward from there all along the Cape Jellison shore, the descent into the water was almost precipitous—so that if limited to eight feet depth, these weirs could not be built at all; any limitation whatever, as to depth, would destroy the majority of them. It was further stated that immediately in front of the light-house at Fort point, a weir was yearly built, to which there was no access except by boat, the cliff at this point descending perpendicularly several feet below low water mark. I am able to say that these statements are at variance with the facts. All of these weirs are built on a shelving bottom, having in no case less than sixty stakes, or one hundred and sixty feet in the length of the hedge. Were the limitation so severe as to low water mark even, every one of these weirs could be built. As to the weir said to be located in front of Fort point light-house, there is none there. The attempt was made once, and only once, to build a weir on this spot, and failed.

There is nothing in the character of the shores to forbid the application to the weirs of the Penobscot of a limitation similar to that in the general law. It is, however, questionable whether the limitation of depth can be applied to the nets used in Northport, Lincolnville and Islesborough. The section requiring all nets to be removed from the water during the weekly closetime, was framed in ignorance of the existence of nets of this character. It would indeed be preposterous to expect these fishermen to take up these great nets each week. There is a great deal of weather when it would be impossible to do so, and at all times it would be very laborious. These nets are on the same principle as the weirs, and the spirit of the law would be met were there an opening in each pound large enough to allow the fish to pass out, or better

still, were the pounds triced up, or the entrances closed. The law should be modified, so that obedience to the letter as well as the spirit may be practicable.

The enforcement of the laws on the Penobscot, owing to the ill health of the warden, Mr. Blackman,* was not so thorough as his commencement last year gave us reason to hope. He was unable to visit the lower river and bay as early and as often as is desirable. The protection of the fish, while passing the dams, was, however, well looked after, and I am convinced, both from the information obtained near the falls, and from the observations made on the spawning grounds in November, that a much larger number of salmon than usual escaped destruction. To guard well the river between Eddington bend and Oldtown, is enough to occupy one man's attention, and his whole time could well be thus expended during the months of May and June. An additional warden should be appointed, if the law regulating weirs and nets is retained in its present shape. The extension of the application of the law to the bay as well as to the river, has a good effect. Nearly all of the fishermen concede the justice of it.

The yield of the fisheries of the Penobscot during the past season cannot be estimated with any satisfactory decree of accuracy from the data at command. The fishermen all agree that the salmon catching has been far inferior to that of 1868. Compared with last year it was in some places a little better, in others (and I think in the majority) it was not so good. The dealers in salmon, in Bangor, Belfast and other places, reported the salmon unusually plenty; but it is probable that this opinion originated in the fact that owing to the low price of salmon in Boston, more of them were put upon the local markets. Maine prices are ruled by Boston prices, and these in turn depend upon the supply from Canada. The number of salmon caught on the Penobscot in 1868 was estimated in the report for that year to be 8,000. Facts lately brought to my knowledge tend to show that that estimate was at least not too high. It may have been too low. For instance, one weir on Cape Jellison is said to have caught that year over 200 salmon; another 130; another 120; five weirs a little further west took 550 —better than those five weirs have done before since 1850. In illustration of this years' luck it may be stated, that one gang of nets (4 hooks) in Lincolnville took over 100, against 64 last year;

* Francis Blackman has since died. He was a faithful officer, and his place can not be easily filled.

another gang, of three hooks, caught over 115, better than ever before in this berth; another gang was tended fourteen days without getting a salmon.

Some of the fishermen having expressed the opinion that comparatively few of the salmon caught in the weirs contained spawn, but that the "mother fish" went up river and were caught principally there, I made some inquiries among market men touching this point, and elicited the following statements:

Out of fifty salmon opened by Silsby and Whitmore of Bucksport, they only noticed eggs in one; the rest had white roe, and two had the "hooked bill."

Low, market-man in Bangor, says that two-thirds or three-quarters of the salmon that he buys come from down river from Bucksport, and even as far as Castine; the rest come from up river, Ayer's Falls, Veazie and Eddington Bend; about one in four of the salmon he cuts up have eggs in them, the rest have white roe; average weight about twelve pounds; no general difference in size between the up-river and down-river fish, although occasional schools from both districts are remarkably large or small.

Bickford of Bangor, says about one in four of the salmon he cuts up has eggs; twelve pounds is the average weight, no perceptible difference in size between down-river and up-river fish.

Lewis & Crosby of Belfast receive most of their salmon from Brigadier's Island and Verona. Of those cut up this year, three-quarters have eggs in them, the rest have white roe; but they think the proportion of spawn fish is not usually so great.

W. M. Frost of Belfast gets his supply of salmon from Sandy Point and Islesborough. The former sends more large salmon (20 pounds and upward); occasionally fish of that size come from Islesborough. Those he has cut up this year will average fifteen pounds weight, which is two or three pounds more than ordinary; three-fourths of them have spawn, the rest white roe. The spawn fish are those that pass for the fattest, having a larger belly. The salmon caught this year are remarkably fine.

I have said so little about shad and alewives because they are so few. A shad caught in a weir on the Penobscot is looked upon as a curiosity. Alewives are not caught in numbers enough to make them of any account to the fishermen, except in Eastern river and on the eastern shore of the bay. The ponds that they reach through Orland appear to have been for some years their only breeding place.

The introduction of alewives to Chemo or Leonard pond, the source of Blackman's stream, was accomplished by Francis Blackman, fish-warden, the expenses being paid from the commissioner's fund. Mr. Blackman first tried to transport them from Orland on a wagon, but was unsuccessful, every one of a large and promising lot dying on the road. He then hired a man to dip the fish at Veazie, and in spite of the meddling of some ill-disposed persons, who repeatedly let loose the fish he was collecting, and the opposition and ridicule of neighbors and friends who prophesied that nothing would ever come of it, he persevered until about one hundred alewives were carried into Chemo pond. This was all accomplished in the latter part of June. On the eleventh day of September their progeny was seen coming down the stream into the Penobscot in myriads. Everybody was astonished at the immense numbers of young from so few parent fish. These young fish were then four and five inches long, very plump and healthy looking. Within seventy-five days, at most, the eggs, no larger than pin-heads, had been laid, the young had hatched and had grown to the length of five inches, several thousand times their original weight. This first school was two or three days in passing the road that crosses the stream. Several weeks later came another detachment of greater size and in greater numbers. It is almost beyond question that these fish will when grown seek to return to their native lake, and if the way shall be open to them the permanent restoration of alewives to this stream and pond is assured. I trust that before their first return the falls can be provided with fishways suitable to them. To construct ways by the dams on the stream would be neither difficult nor expensive.

Before leaving the Penobscot river, I wish to bear testimony to the readiness evinced by the dam-owners to give the fish a passage. One of my visits to the Veazie dam was by special request of the proprietor, John W. Veazie, who desired further instructions in relation to the fishway.

St. George River.

The fishway at the lower falls in Warren was built in the fall of 1869. The past season has tested it. Its location is in a narrow triangle between a mill, a street and a flume. (See plate II, Fig. 5.) In building it, it was found necessary to contract its length. This changed slightly the proportions of some of the pools. At

the point furthest from the dam, where the fishway turns with a sharp angle back toward the river, (at F) the ascent was so difficult that the alewives were unable to pass it, and this little fault threatened to destroy the usefulness of the fishway. The Commissioner was at a distance, and could not be summoned until it was too late. In this dilemma the selectmen of the town very properly took the responsibility of making such alterations as were found necessary. These were soon made, and although compelled to turn many summersets before reaching the top, the alewives went up in great numbers, and, the fishway at the upper dam having been put in good order, they passed that also, and were seen and heard in the ponds above. It was the impression of all with whom I talked on the subject, that no alewives had passed the upper dam for several years; but during the past season there seems to have been a greater run than usual at Warren, owing, I think, to the general abandonment of fishing with weirs and nets below; and less being caught by the town of Warren, and the fishway at the lower dam being in a more accessible location, an abundance of them passed into the ponds.

In the figure the position of the old fishway is indicated by the dotted lines at *o. f.* (Plate II, Fig. 5.) When this was first built there is said to have been a deep lead directly to its lower end. But in the course of time this lead got filled up, and the deepest channel being nearer the west side of the river the alewives passed up in a body toward the upper angle of the dam, and lay in a deep place near G. The most of them would be caught before they found the fishway. Now, however, a school of fish swims directly for the fishway.

Figures 6 and 7 (Plate II) show two other peculiarities of the same fishway, that were added by the builders and repairers. The first is a board standing upright as a check to the water near the outlet of each pool (*c.*) I think it would do more good if placed at *c'*. The second is another board seen at *n* in both figures, placed like a shelf, over which the water runs as it leaves each passageway. The bottom of the latter is blocked up six or eight inches, so that the bottom of each pool is lower than the passageway by which the water leaves it. These two features were introduced into the fishways on this river some years ago, and were found to work well.

Kennebec River.

The principal point of interest on this river is the dam at Augusta. As soon as it was evident that the ice freshet of last winter had made a breach in the dam, I withdrew the plans that had been submitted to the proprietors for the construction of a fishway. While the breach remained of course there was no use for a fishway, and the manner in which the new dam was completed must determine whether the former plan would be applicable. Since the completion of the dam the matter has again been opened, and the interested parties are now considering new plans that have been submitted to them.

The extraordinary opposition on the part of the owners of the Kennebec dam, and of the citizens of Augusta, to the construction of a fishway there, I can only attribute to certain misrepresentations that were made to the proprietors when they were negotiating for the purchase, and to a general ignorance as to what a fishway is, what is its cost, and what is its influence on the dam and the water power. The statement was made to Messrs. Sprague, that in Maine fishways were a thing of the past; that although there was in the charter of the Kennebec dam a provision expressly requiring the construction of a fishway, there was no probability of their ever being required to build it; that provision was a dead letter. This statement was made in 1867, by parties who knew that the Legislature had just passed a resolve looking toward the restoration of "sea fish" to our inland waters; that the Governor had already appointed Commissioners to consider the feasibility of the project, and that the fishway was one of the means by which it was expected that this restoration should be accomplished. Who had the right thus to ignore the action of the Legislature,—to relieve the proprietors of this dam from their obligations to the public?

The charter of the Kennebec Dam Company, granted March 7th, 1834, contained the following clause:

"It shall be the duty of said corporation to construct and maintain, from the twentieth of April to the twentieth of July in each year, a good and sufficient passage-way up, through or over said dam, and at the most suitable part of the same, so as to render the passage of salmon, shad and alewives, practicable and easy, so that the same may go up the said river into the fresh water ponds, streams and other waters connected with the Kennebec river above said dam."

Again, in section 16:

"Be it further enacted that unless said dam, lock or locks, fishway and slope shall be completed and fitted for use within five years from the passing of this Act, all the powers herein granted to said company shall be rescinded and held void."

There are several other allusions to the fishway in the act of incorporation, all going to show that the obligation to construct and maintain it was as imperative as the obligation to construct and maintain a lock. Under this charter the present owners hold.

A fishway at this dam, such as I have planned would use not more than the *one hundred and fiftieth part of the water*, would necessitate cutting into the dam not deeper than eighteen inches on the crest, could be made as secure as the dam itself is now, and its entire cost, including the erection of a pier to guard it from ice and logs, would not exceed three thousand dollars. Mr. Samuel Parker of Skowhegan examined the plan submitted last year and offered to execute it and warrant it, and take care of it for three years for three thousand dollars. His statement to this effect was before the Committee on Manufactures of the last legislature. He further stated, that in his opinion the fishway would strengthen rather than weaken the dam. Mr. Parker has built seventeen dams on the Kennebec; has once repaired the dam at Augusta, putting in a section whose whole height from the bottom of the river to the top of the dam was *fifty-two feet*, and which has stood intact until the present day; and did this for several thousand dollars less than the estimated cost.

To allow this dam to escape the plain requirements of the law would be a robbery of the public on the whole length of the Kennebec river, for the benefit of Augusta.

The law has, I think, been as well enforced on the Kennebec this year as one officer could enforce it. The warden, T. H. Spear of Gardiner, has expended a great deal of time in looking after the weirs. His policy was one of persuasion, and was more successful than one of compulsion would have been. Mr. Spear said he aimed to convince the fishermen that his object was simply to see that the law was obeyed, and not to get their money by penalties. It is one of the strongest objections to making an officer dependent for his pay on the fines he can recover, that it creates such a feeling of hostility among the fishermen, who regard the warden as a sordid individual, bent only on lining his own pockets and ready to take every advantage of them, and to prosecute even

the man who has innocently offended. The wardens who are to care for all these river fisheries should be paid, as they are now.

Mr. Spear advises in very strong terms the abolition of the weekly close time. His experience of one season has convinced him that it is almost impossible to enforce it against unscrupulous fishermen. Law-abiding, honest men are ready to observe it, but even they will not long be contented to see rogues catching the fish that might have been their's but for the law, and their own compliance with its terms. The restriction to two feet depth of water is, however, a very effective rule. These opinions agree with those of the most experienced and candid fishermen with whom I have talked on the subject. Indeed, I do not remember to have heard any fisherman approve the weekly close time; while the most intelligent among them are generally in favor of the two-feet limit.

Androscoggin River.

In response to repeated petitions from citizens of Brunswick and others, I visited the falls at Brunswick several times during the summer, and finally, after hearings, directed the proprietors of the dams to build fishways. That over the lower dam was located on the north channel directly against Shad island. It would be cheaply built of wood, and in that location would be quite secure. The upper dam is about eighteen feet high, and a wooden fishway would cost two or three thousand dollars. But there is an admirable site for a fishway, to be partly cut in the ledge and partly built up of rough stone, at the northwest end of the dam on the Topsham shore. Such a fishway would be exceedingly durable, and would cost probably less than a thousand dollars.

The Androscoggin was formerly a salmon river, but one of these fish is now rarely seen in it. This fact is a very strong confirmation of the accepted theory that adult salmon return to the river, and even to the branch, where they passed their infancy. A large number of salmon yearly enter the Kennebec and are caught all the way from Hunnewell's Point to Augusta. Yet rarely does one turn aside into the Androscoggin, although that river is at least as good a breeding place for them, naturally, as the Kennebec.

Artificial Breeding.

The multiplication of fish by artificial incubation is, as I have already said, assuming new importance through the successful result of several experiments. The most prominent of these are the shad-hatching on the Connecticut, the main facts in regard to which have been given above, and the breeding of salmon at Newcastle, Ontario, of which a complete history will be found in Appendix B.

In previous reports accounts have been given of experiments tried in this State in the hatching and rearing of several species. These have never been on a large scale, for various reasons. The propagation of fresh water fishes promises so much less than that of the migratory species, that I think it wisest for the State to engage only in the latter. Our two most valuable migratory fishes, salmon and shad, are both, it appears, capable of indefinite multiplication by means of artificial incubation.

The observations on shad in the Kennebec in the summer of 1868, led us to think that the number of shad to be found in proper condition was too small to enable us to carry on their multiplication on a respectably large scale. If, however, it is found practicable to confine shad in enclosures while their eggs are maturing, there will be no difficulty in procuring the requisite number of eggs at some point on the Kennebec—say in Merrymeeting bay. There is no other river in the State that approaches the Kennebec in the number of its shad. The yearly operations on the Connecticut may, and probably will, develop methods of which we can by and by avail ourselves.

For the breeding of salmon we have facilities which I think should be at once improved. The salmon's habits have been studied closer (since our salmon is the same species that inhabits European rivers and has there received so much attention) than the habits of shad. We know that nearly or quite every river in the State can be made a salmon river. Most of them were salmon rivers in a state of nature, but have ceased to be such because impassable dams put a stop to the reproduction of the species. To re-stock these rivers it is necessary to introduce salmon to the upper waters while yet very young; for where a salmon's infancy is passed thither he will return when he is of age. But where to get the young salmon? Many of the rivers of Canada abound in salmon, and there the eggs can be obtained, brought here and hatched. We could fit out an expedition to one of these rivers, the Mira-

michi, for instance, and with the permission of the Canadian government, capture the spawning fish and take their eggs, or catch them in the summer season and impound them until the arrival of the spawning time. In the former case we should be required to maintain an establishment through the winter and hatch out for the benefit of the river a portion of the eggs; this portion in instances that I happen to know about, has been one half. In either case the enterprise would be surrounded by many difficulties, and would involve the outlay of a considerable sum of money. Again, salmon eggs are for sale. The Canadian government sells them at Newcastle, and parties who obtain them from New Brunswick have been offering them for several years. But the prices asked are extremely high. Forty dollars, gold, was the price at the Newcastle establishment last spring. Twenty dollars, currency, has been the price of the parties operating in New Brunswick. The latter price is not deemed exorbitant by the pisciculturists of New England, since the ordinary price of a single thousand of trout's eggs is ten dollars. It may, however, be instructive to compare these with the prices prevailing several years since at two of the leading establishments in Europe, Hüningue and Munich, for various kinds of eggs; they were as follows, per thousand:

Species.	*At Huningue.*	*At Munich.*
Ombre chevalier	$1.37	$1.20
Danube salmon	1.00	.80
Rhine salmon	1.00	1.00
Lake salmon	1.17	1.00
Trout	.75	.80
Grayling	.75	.40
Sturgeon	1.17	

These are government establishments, and it is not stated in connection with the above prices whether they were intended to cover the cost of collecting, or more or less. We however have the statement, that in 1861 there were collected by the French establishment at Hüningue 19,449,400 eggs, of eight different species, at a cost of 2200 pounds sterling,* or a little more than fifty cents per thousand. This may be taken as representing the ordinary cost in Europe, in an establishment well under way. Here in America it would be greater, and the inauguration would in any country be more costly than the subsequent operations.

* T. Ashworth.

I have twice given orders to parties offering the eggs from the Miramichi, but have in both cases failed to get the orders filled, owing to accidents at the scene of operations. There are many difficulties in the way of an enterprise conducted at such a distance from those who assume the pecuniary risk. The failure to get the salmon eggs has materially retarded the re-stocking of our rivers.

Anxious to begin the introduction of salmon to rivers where it is necessary, I purchased a small lot—8,000 eggs—from the Canadian works at Newcastle. The greater part of these were hatched by Mr. Pottle in Alna, and he has now 7,000 of them in a small artificial pond. There they have been tended and fed since May, and there they will be kept until next spring, when we may expect them to be ready to go to sea, and may turn them into the river it is desired to stock with them.

The use of the hatching works and apparatus at Grand-Lake stream, belonging to the Commissioners of Maine and Massachusetts, and the right to take spawn of Schoodic salmon, was granted this year to Rev W. Clift of Connecticut, on condition that one-third of the eggs taken should be hatched out and turned into Grand-Lake stream. The operations were very successful, about 150,000 eggs being obtained, and the most of them appearing to be impregnated. There will thus be about 50,000 for the share of the stream. This will undoubtedly be far better for it than for all the fish to be allowed to deposit their eggs in the natural mode.

Search for Salmon Ridds.*

For the purpose of ascertaining whether the salmon spawn on the Penobscot river or its tributaries in an accessible locality, and in sufficient numbers to warrant the attempt to collect the eggs and subject them to artificial incubation, both for the purpose of restocking exhausted rivers and of increasing the yield of the Penobscot itself, two expeditions were undertaken, one up the main river and the other to the Mattagamon or East branch.

The first trip was performed between the 5th and 14th of October, and included an examination of the main river as we ascended it in a birch canoe, from Mattawamkeag to Ambejeejis falls, (except a short portion that is unnavigable, just above Grand

* This word appears to be in common use in Scotland as a name for the salmon's nest It is of Scandinavian origin, (Danish *rede*, a nest.)

falls,) and of Nahmakanta, Joe-Merry, Nallesemuc and Millinocket streams, and several smaller tributaries. The uncommonly low state of the water at this time afforded an excellent opportunity of examining the beds of the water courses.

From Mattawamkeag to Nicatou, where the east and west branches unite, is twelve miles. In all this distance there is not more than half a mile where a paddle can be used to advantage. The rest is all poling. The current is mostly gentle, sometimes rapid; hardly ever sluggish. Near Mattawamkeag the bottom is all gravelly, and for many miles we were passing continually over spots that were to the eye the fittest imaginable for the spawning ground of salmon. The freshets and the logs, probably the latter more than anything else, disturb the bottom of this part of the river so much that I think they would obliterate all traces of salmon ridds within a year after they are made. This may possibly explain why we noticed no traces of old ridds as we passed along, making no delay for the sake of examining the bottom. There are not many boulders here, but as we proceed up the river they become abundant and of large size.

Above Nicatou the character of the river is less uniform. There are more violent rapids and fewer gravel beds; and the huge boulders, constantly increasing in size until you reach Ambejeejis falls, are the most prominent feature of the river bed and the lake shores. Nevertheless, there is much spawning ground all the way to Grand falls, twenty miles above Mattawamkeag, and the gravels on this part of the river are, as a general thing, less liable to disturbance, by floods and logs, than those near Mattawamkeag.

Grand falls is formed by a precipitous ledge in a narrow chasm. The total height of the fall is about ten feet, but in time of very low water there is one point where a considerable body of water gets down to the deep pool at the base of the fall without leaping more than six or eight feet. Here I think an agile salmon would be able to ascend at any time of year. In spring and early summer, and again in July when the logs are driving down from North Twin lake, there is an abundance of water, and this fall can then present no hindrance to salmon. Old observers say that shad passed these falls, but they are in doubt about alewives. Just below Grand falls the river spreads out over beautiful gravelly shallows, that deepen at last into Shad pond, which contains less than a square mile of area, and is nowhere very deep. On these

shallows, in the autumn of a recent year, a Frenchman named Rancout speared a large salmon. It is not unlikely that salmon spawn here every year.

Nallesemuc stream, which enters the Penobscot here, at the upper end of Shad pond, was explored only for a short distance. A driving dam, with closed gates, was found, and above that an extensive bog which so colors the water of the stream that it is difficult to examine the bottom where the water is more than six inches deep.

Millinocket stream enters Shad Pond on its northern side. For the two miles that we ascended it the bottom is very uniform, a clean coarse sand, verging into gravel as we ascend; but at no place coarse and firm enough, one would think, for the use of salmon. Further up the stream it is described as being coarser, and is probably well adapted there to their use. The water is of remarkable purity and its flow is so even that should salmon be found to spawn here in sufficient numbers it would be easy to construct works for their capture.

From Millinocket stream the ordinary route up the Penobscot lies over a carry of two miles, taking the river again several miles above Grand falls. From this point to North Twin dam is but a short distance, and a great part of this through the still water of Quakish lake.

North Twin dam has been referred to in previous reports as being in all probability a very serious hindrance in the way of salmon. I am happy to state that it is by no means so bad as I anticipated. It flows North Twin, South Twin, Pamedumcook and Ambejeejis lakes. Over all this surface, estimated by Mr. Wells* to measure twenty-two square miles, it raises the water for the purpose of driving logs, to a height of about twelve feet above the lowest summer level. To effect this all the gates are shut down, thus shutting up all the water except what leaks through crevices. This is never done until some time in June, and the gates remain closed, as I am informed by Mr. Johnston who has charge of this dam yearly, only about three weeks, that being sufficient time for the accumulation of the requisite head of water. While the gates remain shut no fish can pass. Salmon are seen every summer below the dam. Last year Mr. Johnston borrowed a net and caught four; but there is not ordinarily any fishing here. Some time in

* Water Power of Maine, p. 109.

July the drive of logs has been warped across the lakes, one or more of the gates are opened, and the sluicing of the logs begins. Salmon are now seen leaping both below and above the dam; for there is no longer anything to prevent their passing up freely.

Ambejeejis falls was next examined, but its appearance was not promising. It is a bed of large boulders, over and among which the water tears with a force that sweeps all gravel and small stones away.

Above this point I only know from others that there is a long succession of falls, rapids and dead waters, to Chesuncook lake. Salmon are known to ascend further than this. Joel M. Lane of Oldtown informs me that twenty-eight years ago, one blustering night in November, he speared nine large salmon on Ripogenus falls. This place is a few miles below Chesuncook lake, and the fall is so difficult that Mr. Johnston thought that no salmon could pass. But Mr. Lane has seen them in October at the mouth of Hall brook, and my guide, Joe Francis, has seen them in Penobscot brook near the head of the river.

At the west end of Pamedumcook lake enters Nahmakanta stream, the outlet of Nahmakanta and several smaller lakes. This stream is seven or eight miles long, and in its course has a considerable amount of gravelly bottom with gentle or rapid current. It was here that I expected to find facilities for the breeding of salmon. Beyond the character of the stream itself, its situation is very favorable, lying as it does at the extremity of a series of lakes in which many salmon would be likely, it was thought, to pass the summer and early autumn, ready to shoot up at the right season into their native stream and deposit their eggs.

On rivers where there are no lakes the salmon are known to lie through the time intervening between their ascent of the river in early summer and the spawning season, in deep pools. Should it be practicable to establish salmon breeding works here, we should have a situation not unlike that of Mr. Wilmot on a tributary of Lake Ontario, (see Appendix B,) although the river and the lake are both on a much smaller scale. The young hatched and reared in this stream would, on attaining maturity, be likely to come back here to lay their eggs. Nahmakanta stream is a suitable place for them. There are many spots on its lower portion where we might expect to see their ridds at the proper season; but the date of our visit, October 11th, was altogether too early to see any of their operations for this year. I had expected, indeed, to find

them beginning their spawning as early as this, but subsequent observations on the Mattagamon convince me that for the season of 1870, at any rate, they did not begin until the very last of October. The appearance of the banks of Nahmakanta stream indicates an excessive volume of water at times, enough probably to smooth down any hillocks that salmon might have made together. Yet I have little doubt that salmon spawn there. Mr. Manley Hardy of Brewer, is authority for the statement that white fish (*Coregonus*) resort to this stream in the fall to spawn, and that it is the only breeding place of that species that he knows on the Penobscot.

On the way down the lake we touched at the mouth of Joe-Merry stream, but found its aspect less encouraging than that of the Nahmakanta. The latter is the larger of the two, and indeed the largest tributary between the Millinocket and Chesuncook lake.

At various places during this trip we tried to catch small fish, hoping to see a few young salmon. We caught a very few small chubs, at Grand falls two or three trout, (which were returned to the water,) but nowhere was there anything to be seen of young salmon. This was disappointing, since I had counted upon finding them. There was not, however, much leisure for fishing, and the result may be nothing surprising. The only young salmon I have known to be caught in the Penobscot are two in the possession of Dr. A. C. Hamlin of Bangor.

The exploration of the Mattagamon (East Branch of Penobscot) was made by canoe with same guide as before. We reached the mouth of Wassaticook stream, thirty-four miles above Mattawamkeag, and began our examination on the 28th of October. Less than a mile below this point is the old Hunt farm, connected with the civilized world by a practicable road to Sherman, ten miles distant. Nearly every summer for many years there has has been more or less fishing for salmon in the vicinity of this farm. Not a great many salmon are caught, for the fishing is only occasional, and with nets from sixty to eighty feet long, indifferently rigged. In fact there is little inducement to fish except for one's own supply, since purchasers are too far away. A deep hole just above the farm house, and another near the mouth of Wassaticook stream, are places where the salmon are said to lie. The first is at least twelve or fifteen feet deep, and the brightest torch will not penetrate to the bottom. The other hole is not so deep.

At the time of our arrival snow covered the ground, the nights were cold, and ice was making in the ditches and sluggish brooks. I supposed salmon would be at the height of their spawning. The first examination was discouraging. The water was so low that every spot where salmon could lay their eggs was easily inspected. In passing up and down some two miles of the river, and the lower part of the Wassaticook, not a single trace was found of salmon's nesting this season, and only two or three holes and heaps that looked like old half-washed-away ridds.

A succession of windy days and nights prevented our pushing the exploration as fast as I had intended. It is impossible to see the bottom of the river distinctly unless the surface of the water is tolerably smooth. In the remaining days of October we did not find a single new ridd, and only three or four old ones. On the 31st, fell ten inches of snow, and that night the dead waters froze over, so that the next day we found it impossible to ascend the river in a canoe more than a mile from our camp near the Wassaticook.

On the second day of November I travelled by land to Seboois stream, and by following its banks, climbing trees and wading shallows, was able to examine the bottom for several miles. Here for the first time I saw unmistakable evidences of the recent spawning of salmon. Bright patches of newly upturned gravel caught the eye, and a close inspection revealed the excavated basin and the little mound of material below it that mark the works of the salmon family. There were not many of them—not more than half a dozen to be seen. Of old ridds there was a larger number.

I can hardly imagine a more beautiful stream than the Seboois. The portion that I followed had a smooth gravelly bottom, very uniform, and showing no certain marks of the furious floods that tear up the bottom in many streams. The current is for the most part gentle, sometimes almost dead, and often hurrying down an incline to a lower level. My canoe-man says he can pole a canoe twenty miles up this stream, and in all that distance its character does not change. Its lower portion is through extensive intervals heavily grown with elm, silver-leafed maple, (*Acer dasycarpum,*) yellow birch and brown ash. I returned to camp in the evening on a raft extemporized out of two cedar poles, a plank found in the ruins of an old camp, and a few birch withes. The sun had been shining brightly all day, the snow had been melting and the

water slowly rising, so that the ice closed the river in only two or three places, and there I was able to break through easily. From the point where I embarked to the mouth of the Seboois was a continual succession of rapids. Unfortunately I could not hold a torch and manage my raft at the same time, so I failed to gain any additional information about the salmon. In several instances however, there could be seen in the moonlight the wakes of some large fishes frightened at the approach of the raft. In four hours' time I was in camp.

The next morning, (Nov. 3d,) we set out on our descent of the river. I was agreeably surprised to find in every eligible spot newly made salmon ridds, where several days before we had seen nothing of the kind. The rapids, or rather the gravel on the verge of the rapids, close by the farm-house, was well scarred with them. Between Wassaticook stream and Whetstone falls we saw, as we glided swiftly along, twenty-five or thirty of these new ridds, and of course we could not see them all. There were others below Whetstone falls, and several at the very foot of the falls; but soon after we passed this point it began to rain so heavily as to completely obscure everything below the surface of the water.

We camped that night near Grindstone falls. The rain had continued all day and into the night, carrying off nearly all of the snow; and before morning the river had risen several feet. We saw that our search for salmon spawn on the Mattagamon was at an end for the present, and nothing remained but to return to Mattawamkeag.

On our way we stopped at Salmon stream. From the inhabitants of the vicinity we learned of the existence of certain excavations in the bed of the stream, of whose character they were ignorant, but which were without doubt salmon ridds. But the water was high, and so dark red that we could see nothing. Just below the mouth of this stream is an eddy and a deep hole where was once a good place to catch salmon.

When we passed Mattaceunk rips, (or as the Indian pronounced it, *Manceunk*,) near the mouth of the stream bearing the same name, the sun was shining so brightly that we could see the bottom quite distinctly in many places, and an hour was expended in searching for salmon ridds, without result.

So far as these two trips enable me to judge, it would be economically practicable to collect and hatch salmon eggs here for the benefit of the Penobscot and for use in re-stocking other rivers.

The extraordinary lateness of the date when the salmon began to spawn this year having prevented my seeing anything of them or their works on the main river above Nicatou, it is impossible to say whether they are to be found there in sufficient numbers. On the Mattagamon, however, there were salmon enough this year to ensure the success of the undertaking to breed them, if there be no other cause for failure.

To conduct such an enterprise successfully requires in the first place a building near the scene of operations, in which those eggs that are to be removed to other rivers can undergo partial incubation, and those that are to be turned into the Penobscot can undergo complete incubation. This can be fed with water either from a spring, a brook or a river. There should also be a pool of running water in which the salmon may be kept when not ready to yield their eggs at once, and the size of this pool and the volume of water required for its supply would depend upon the number of salmon and the length of time they were to be confined. If they were caught in the fall just before the time when they would naturally deposit their eggs, a comparatively small pool would answer the purpose. But if they were taken in the summer during their ascent of the river (and at that time doubtless a greater number of fish could be secured), they must have plenty of room and a bountiful supply of water to ensure their survival of the drought and heat of August and September.

Facilities for the building of pools and a hatching house, and supplying them with river water, exist between the Mattagamon and Wassaticook stream, near their junction. The bed of the latter rises, as one goes up stream, much more rapidly than that of the former, and a ditch could easily be made to bring any desired amount of water out of the Wassaticook and discharge it into the Mattagamon. Indeed, there is already a natural stream thus flowing across the low land between the two rivers, where water flows at all seasons of the year. The character of this part of the Mattagamon and of the Seboois is such that salmon caught many miles above the mouth of the Wassaticook or within three miles below it could be easily brought in to headquarters.

The cost of the necessary works and appliances for the carrying on of such an enterprise would not be very great. A suitable house with fixtures could be built for a hundred and fifty dollars. The cost of the ponds and ditches would depend upon the character of the site, and at the Wassaticook would be small. Other

items are the nets and other equipment, and the pay and support of the necessary number of men. An experienced fish culturist estimates the entire expense of an expedition to the Miramichi river for the same purpose at one thousand dollars.

It would be difficult to estimate the results in dollars and cents, if, as is proposed, the young salmon obtained from the hatching be used to improve the fisheries of the State. It may, however, be useful to consider what would be their value at prevailing rates. For the 8,000 eggs bought at the Canadian establishment at Newcastle last spring, I paid $358.40, or $44.80 per thousand. Parties who have operated on the Miramichi river have for several seasons offered salmon eggs, warranted to be fecundated and in good condition, at $20 per thousand. A female salmon of average size may be assumed to yield about 8,000 eggs, and allowing for losses, perhaps 5,000 good eggs can be obtained from each gravid fish. At $20 per thousand these would be worth $100. It would thus take only the eggs from ten spawning fish to defray the entire cost of such an expedition as it was proposed to send to the Miramichi river. As I have stated above, we saw the nests of twenty-five or thirty pairs of salmon while paddling down three miles of the Mattagamon river.

The idea has suggested itself of catching the salmon at some more accessible point, on the Penobscot or some other river, and thus avoiding the disadvantages incident to an establishment in the wilderness. The main objection to this would be the necessity of catching the salmon in June and keeping them in confinement until November, while on the upper part of the river the works would be in close proximity to the spawning grounds, and we could choose our time for catching the fish. Still, it is not quite clear but it would be better to find some suitable location for a hatching house near Augusta, or near one of the dams on the Penobscot, or even near the salmon weirs on the latter river, catch the salmon there and carry them to some small pond where they could lie until the maturity of their eggs. Within five miles of Fort point, in Penobscot bay, several hundred live salmon could be obtained yearly by purchase from the fishermen.

Financial Statement.

The following is a summary of expenditures during the year:

For fish culture, (salmon eggs, &c.)	$445.00
" pay of Commissioner	560.00

For	travelling expenses	446.39
"	guides	87.30
"	drawings	25.00
"	sundries, (postage, exchange, photographs, &c.)	56.96
	Total	$1,620.65

The law allows $2,000 for the use of the Commissioner, and $1,000 for the pay of fish-wardens; but through a clerical error the appropriation bill of this year specified only $2,000 for both purposes.

All of which is respectfully submitted.

CHARLES G. ATKINS,
Commissioner of Fisheries.

AUGUSTA, December 31, 1870.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. Fishway for salmon at Ballisadore, Ireland, over a precipitous water-fall of 19¼ feet; no salmon had ever previously ascended these falls, but since the erection of the fishway many thousands of salmon have been annually caught above them. *E*, where the water enters; *G*, where the salmon enter. The arrows show the direction of the flow of water. (See Appendix A.)

Fig. 2. Fishway for salmon at Galway, Ireland. This is over a dam erected for purposes of milling and navigation, and the most of the water passes off in the conduits. The fishway uses only the one hundred-sixtieth part of the water in the summer season. *D*, dam; *E*, entrance for water; *G*, entrance for salmon. This fishway has been in operation sixteen years, and during that time the annual produce of the fishery in the river has risen from 1,603 salmon to 20,512 salmon. (See Appendix A.)

PLATE II.

The figures are uniformly lettered, thus: *D*, dam; *W*, wing dam; *E*, upper end of the fishway where the water enters; *G*, lower end of fishway where fish enter; *F*, angle or elbow of a "return" fishway; *M*, mill; *a*, *a*, side walls of fishway; *b*, *b*, cross walls, or bulkheads; *c*, *c*, check to the water; *d*, *d*, passageways from pool to pool; *f*, floor of fishway; *n*, shelf to assist alewives in getting through the passageways. Course of the water shown by arrows.

Fig. 1. This fishway newly built and successful. (See p. 8.)

Fig. 2 shows location of above fishway.

Fig. 3. Part of fishway at Pembroke. (See p. 11.)

Fig. 4. Section of same through *A B*, (fig. 3.)

Fig. 5. Lower dam at Warren, showing old fishway, *o f*, and new fishway, *E*, *F*, *G*; *fl*, flume, broken away to show the shore line at *G*. (See p. 22.)

Figs. 6 and 7. Details of fishway at Warren. (See p. 22.)

Figs. 8 and 9. Two imaginary designs. Fig. 8 is better than fig. 9, because the lower end of the fishway, *G*, is nearer the dam, and will be sooner found by the ascending fish.

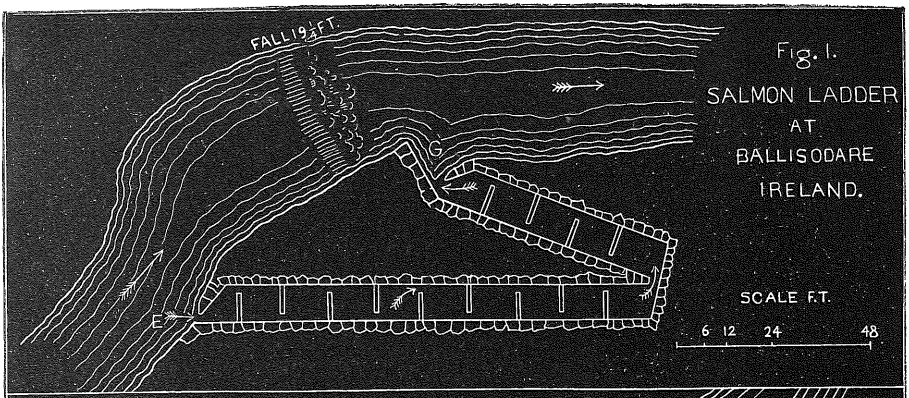

Fig. 1.
SALMON LADDER
AT
BALLISODARE
IRELAND.

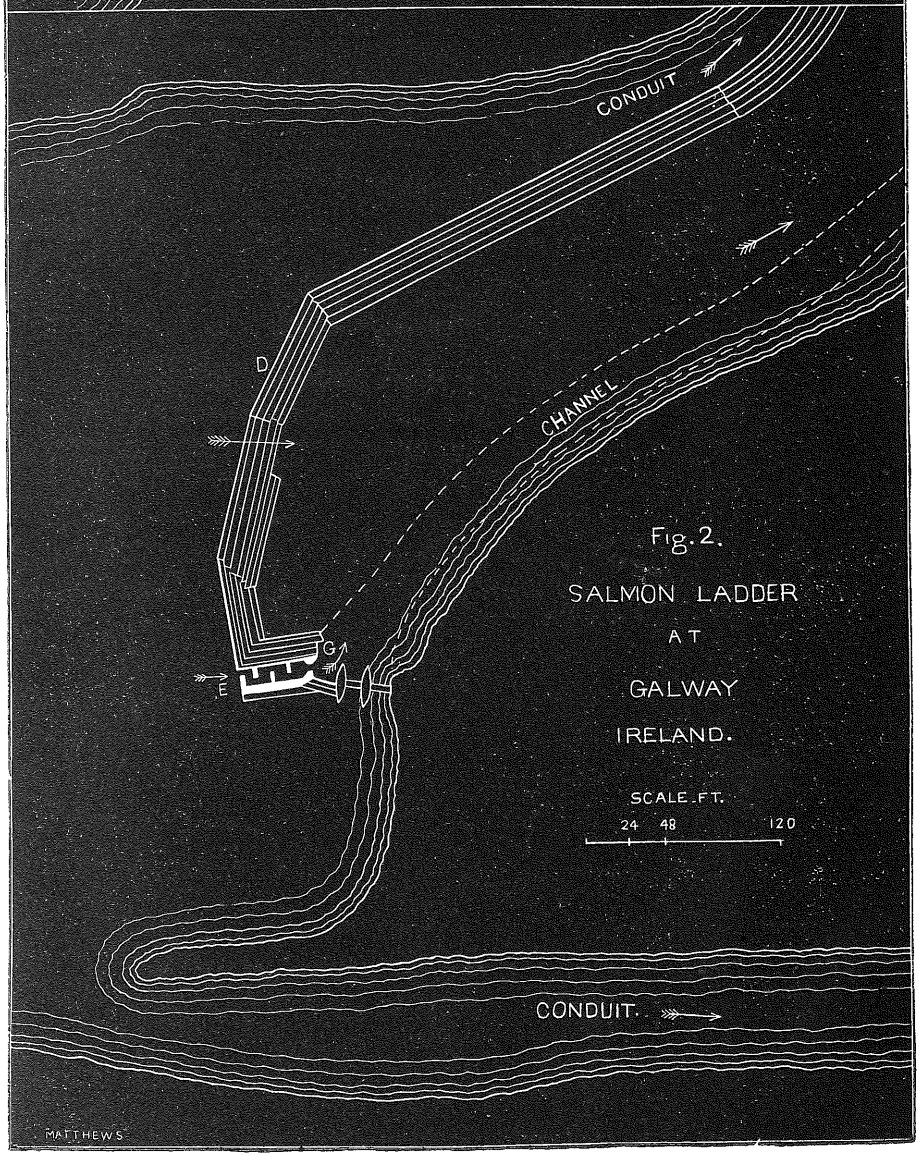

Fig. 2.
SALMON LADDER
AT
GALWAY
IRELAND.

MATTHEWS

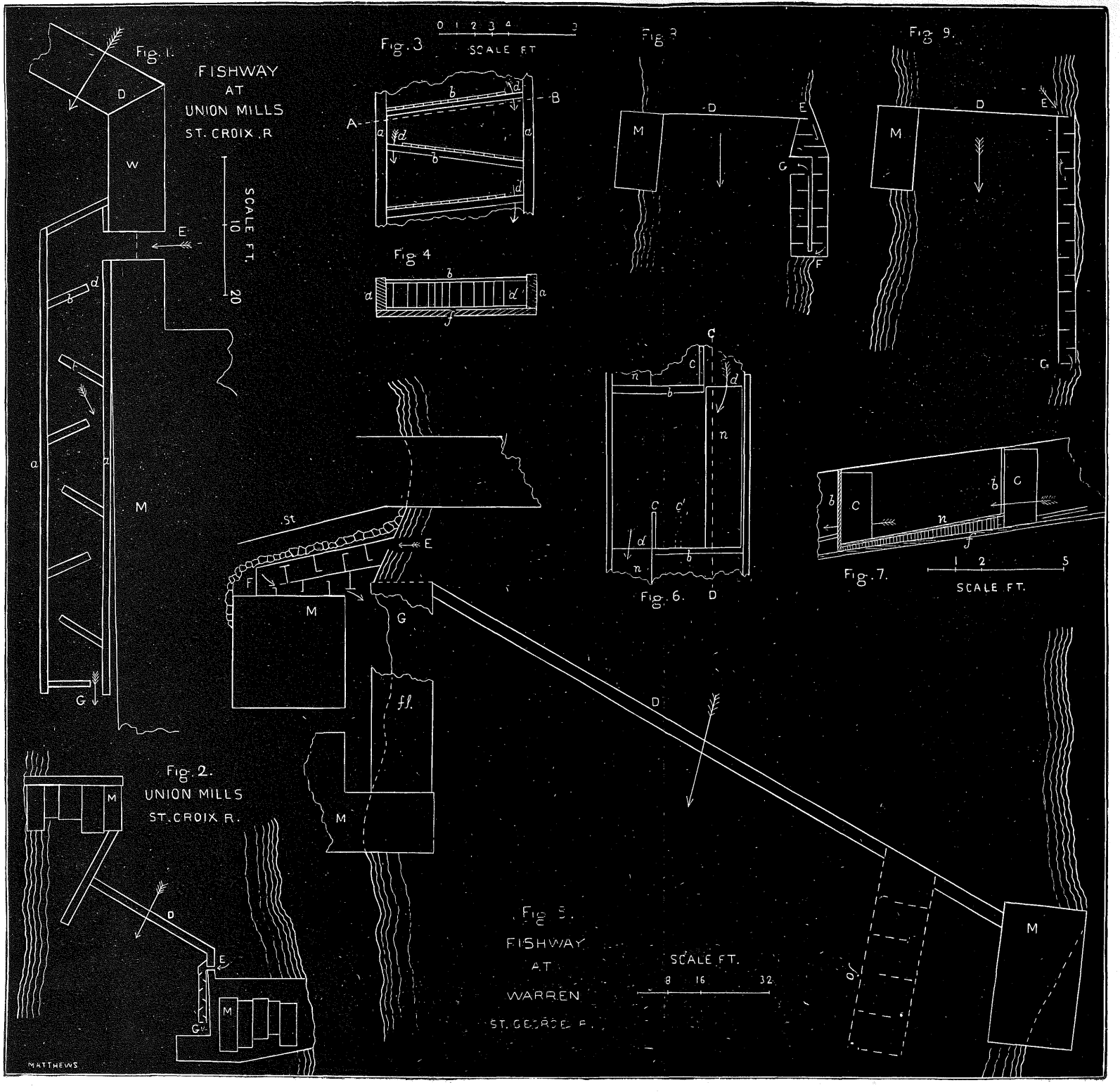
Fig. 1.
FISHWAY
AT
UNION MILLS
ST. CROIX R.
SCALE FT.
10
20
Fig. 3
0 1 2 3 4
SCALE FT
Fig 4
Fig 8
Fig 9.
Fig. 6.
Fig. 7.
SCALE FT.
Fig. 2.
UNION MILLS
ST. CROIX R.
Fig 5.
FISHWAY
AT
WARREN
ST. GEORGE R.
SCALE FT.
8 16 32
MATTHEWS

APPENDIX A.

Salmon Ladders in Ireland.

Statements on the form and construction of Fish-Passages over Mill and Navigation Weirs for the Preservation of Salmon Fisheries. Description of some which have been executed for many years and found successful, and suggestions as to the mode of determining and regulating the Supply of Water for Fish-Passages, under variable circumstances.

The form and construction of salmon ladders, in weirs built on rivers for navigation or mill power purposes, is a subject to which I have for the last twenty years given much attention, having been engaged in the construction of a great number of them, and having had an opportunity of observing, for many years, the beneficial results of others. The indispensable necessity of enabling salmon to ascend the upper rivers, and to reach their spawning grounds in proper season, where alone they can be reproduced, cannot be over-estimated, as their exclusion from these streams has been found to extinguish the species. It is strange that although the Legislature provided ample means for the protection of all other vested interests in connection with the rivers of the country, that of the salmon fisheries should have been in a great measure overlooked. This is the more to be regretted because experience has proved that by the execution of judiciously designed works, combined with proper regulations of the water, a sufficient quantity of water may in every case be allocated for salmon ladders in weirs, so as to admit of the easy and free migration of fish without injury either to mill power or navigation.

In consequence of its having been necessary in the execution of the extensive arterial drainage operations which were carried out under the direction of the Irish Board of Works in this country, to make suitable passages for the migration of fish in all weirs made in connection with mill power and navigation works, and in some cases for the improved cultivation of fisheries. The form and construction of salmon ladders was very carefully considered, and has been very successfully carried into effect. The experience thus

acquired has established certain principles which may be usefully applied in other cases. I annex drawings of three salmon ladders, which will illustrate the principle, and may serve as examples, showing how ladders may be applied so as to admit of the free passage of fish over weirs, waterfalls, or obstructions of any height.

Drawing No. 1, (Pl. I, Fig. 1, of this Report), is a plan of the ladder on the Ballysodare fishery, in the county of Sligo. The obstruction here consists of a natural rock; the ascent is 19¼ feet, and almost vertical, over which no salmon had ever previously passed. The length of the salmon ladder from inlet to outlet is 174 feet. It is divided into 15 pools, each of which are 10 feet wide and 11 feet long, and the average depth of water ponded in them is 15 inches. The inlet to this ladder is only 10 inches wide, with a depth of 2½ feet water flowing through it at the ordinary level of the river.

Drawing No. 2* is a plan of the ladder at Collooney on the same river, where a similar obstruction to the passage of fish exists in a natural rock, over which the river flows. The ascent here is 16 feet, the length of the ladder 150½ feet, which is divided into 14 pools, each being 10 feet square, and the average depth of water ponded in them is 14 inches. The inlet is 15 inches wide, with a depth of 10 inches of water flowing through it at the ordinary level of the water.

Drawing No. 3, (Pl. I, Fig. 2, of this Report), is a plan of the ladder in the weir at Galway on the river Corrib. This weir was formed for the purpose of maintaining the level of the water for navigation and mill power. The ascent at the ordinary level of the river is 5 feet. The length of the ladder is 46 feet, which is divided into 5 pools, each being nearly 10 feet square; and the average depth of the water in them is 14 inches. The inlet is 2 feet wide, with a depth of 2 feet of water flowing through it at the ordinary summer level.

These ladders are admitted to be most perfect and successful. The rivers upon which they have been constructed are largely stocked with salmon. At Ballysodare and Collooney all the fish ascend by the ladder, as there is no other means by which they can pass up. At the weir on the river Corrib, at Galway, the ladder has been erected 16 years, and it is not unusual to count the sal-

* This drawing is not reproduced in this report. It is almost a copy of the Ballysodare fishway.

mon passing up at the rate of 140 or 150 per hour; and I have no doubt but that at night they ascend in much larger numbers. It is essential that a salmon ladder should carry a sufficient body of water to admit of large and heavy fish passing up it with ease. The pools should in no case be less than 6 feet or more than 10 feet square, and they should hold a depth of from 14 to 18 inches of water. The inclination of the ladder, measured from the level of the upper to the lower water should not exceed 1 in 6, and not be more than 1 in 12. The inlet or opening through which the water enters the ladder should not be less than 8 inches wide, with a depth of 18 inches of water flowing through it at the ordinary summer level of the river, and need not in any case exceed 3 feet in width, with a depth of 2 feet of water flowing through it.

In the construction of salmon ladders in connection with mill and navigation weirs in Ireland, the quantity of water allocated to the purpose varied considerably, and no fixed principle was established for the apportionment of any certain quantity.

The volume of water flowing down the river Corrib at Galway during the summer season is 120,000 cubic feet per minute, and of this quantity 720 cubic feet per minute pass down the salmon ladder; or say the 1-160 part of the summer discharge of the river. The length of the weir in which this ladder is constructed is 600 feet, and the width of the inlet or opening into it from the upper waters is 2 feet, or the 1-300 part of the length of the weir.

The length of a weir, particularly when constructed in connection with drainage works, will depend upon the depth of water which may without injury to the property above be allowed to pass over it, and as this will vary in many cases, I do not think the length of a weir, or the breadth of a river, is the correct basis upon which to fix the size of the inlet, or the quantity of water to be allocated to a salmon ladder or fish-pass.

The Galway river is peculiar. Of the summer discharge of 120,000 cubic feet per minute, 100,000 cubic feet are diverted from the main river above the weir for the use of the mills and navigation, and only the remaining 20,000 cubic feet flow down the main channel, until the water from the mills again unite with it immediately above the tide-way.

As before stated, the least quantity which will supply a salmon ladder efficiently is that which will pass through an opening eight inches wide, with a depth of 18 inches of water flowing through

it, and the maximum quantity need not exceed that which will flow through an opening three feet wide, with the same depth.

I am of opinion that between these two limits a scale may be formed which will secure an adequate supply for salmon ladders. It occurs to me that the fair basis on which to regulate the quantity is *the extent of the rain basin of the river*, and I am of opinion that on all new weirs constructed on rivers, whether for navigation or mill power purposes, the minimum opening to be provided should not be less than 8 inches in width, the sill being 18 inches below the apex or top of the weir. That the depth should be fixed in all cases at 18 inches, but that the width should increase in the following proportions :—

When the rain basin exceeds 50 square miles, the width to be increased at the rate of one inch for every additional 50 square miles until it amounts to 12 inches. When it exceeds 250 square miles, the width to be increased at the rate of one inch for every additional 100 square miles until it amounts to 18 inches. When it exceeds 850 square miles, the width to be increased at the rate of one inch for every additional 200 square miles until it amounts to three feet, which may be fixed as the maximum breadth required.

There would be, of course, some difficulty in applying this regulation to existing weirs, where, in ordinary dry seasons, the entire water of the river is used for the purposes of mill power. In such cases arrangements should be made, so that when the mills stopped working, or during the night, or on Sundays, a sufficient supply would be diverted to the salmon ladder; no difficulty will be found in arranging the mode of effecting this, so soon as the law establishes the principle. Of course in such cases whenever there may be a surplus of water in the river, there would be an ample supply in the fish-pass; but it will be desirable to secure the power to use a sufficient quantity of all the water not now used by any mill power for the purposes of a fish pass.

On some rivers the quantity of water flowing into and over a salmon pass during floods may be so great that fish cannot ascend or swim against the torrent. In such cases a guard wall should be placed over the inlet to the fish pass to prevent an excessive body of water flowing into it.

In constructing fish ladders one of the most important points to bear in view is to place the lower entrance to the ladder over a deep pool at the foot of the weir, and as near as possible to the place where the greatest number of salmon congregate, and if

requisite it may be curved, so as to deliver its water over the fish, otherwise they may not discover the entrance. Thus at Ballysodare and Collooney the ladders are formed in two inclines to admit of the entrance being placed at the foot of the rocky barrier, up to which point fish will run and remain seeking at the foot of the fall some means of ascending. In this position the entrance to the ladder is easily discovered, when the fish ascend without difficulty.

At the ladder on the weir at Galway, on the river Corrib, the lower entrance is also similarly placed at the upper end of the fall and every fish trying to ascend is led by means of the current flowing from the fish pass into its entrance.

A very serious injury is caused to fisheries in many instances by millers ponding the water in dry seasons. To guard against this it will be desirable to obtain power to compel the mill owners in such cases to divert for a certain number of hours every night, on Sundays, and during every idle day a sufficient supply for the fish pass.

In many instances it will be found of great advantage to divert the surplus waters flowing over weirs in certain directions by means of boards placed on the weirs, or below them, either to supply a fish pass or form a leading current that will direct the fish to it, and power ought to be obtained to do so, under such restrictions as will protect the mill power from injury.

SAMUEL U. ROBERTS, M.I.C.E.

THOMAS ASHWORTH, Esq.

Galway, January 2, 1869.

Galway, January 28th, 1869.

MY DEAR SIR,—I am glad to find that you consider my Report on Salmon Ladders satisfactory. There can be no question but that the plan of the ladders at Galway is the most perfect that has been applied to a weir in this country. No other arrangement that I have seen has answered so well, and I think every form and plan that could be suggested has been tried. I hope, therefore, that you may be able to induce whoever is preparing the plans for the Severn Salmon Ladders, to adopt the arrangement which has been found to work so successfully here.

The pool-system, which was tried at Athlone, was a complete

failure; and a little consideration will convince any experienced person that such an arrangement will not answer. During high floods the volume of water flowing into and through the pools will be so large and its action such that every fish that attempts to ascend will be swept out of them. In low water, the thin sheet of water flowing over the apex of the weir, and over the dividing walls between the pools below, will not induce fish to ascend. In light floods, fish may pass up, but the condition of the water suited for such construction of a fish pass will be of short duration.

In the case of the Galway Ladder, it does not matter what the state of the river is, as in high floods, light floods, or summer water, the fish can ascend. There never is an excessive quantity of water, and there is always sufficient flowing through the ladder, and the action of the water is that of a *continuous winding stream*, with the velocity here and there increased, while in the corner of the pools there is a sufficient depth of water and a sufficient diminution in its velocity to enable a heavy fish to rest for a short time. There is no boiling rotary current, such as there must be in a succession of pools separated by walls, as was the case at Athlone.

I have watched and studied the working of the Galway salmon ladder for hours, and have seen the *ease with which fish ascend it.* I doubt much if its form can be improved on,—it has answered its purpose admirably; and I hope your Inspectors will not risk failure on the Severn by trying costly experiments which our experience in this country has proved to be worthless.

I am, yours faithfully,

SAMUEL U. ROBERTS, M.I.C.E.

THOMAS ASHWORTH, Esq.

MY DEAR SIR,—I have read Mr. Roberts' report on the construction of salmon ladders. It is one of the most able documents of the kind published, and gives us more information, in a short space, than anything I have yet read.

I have closely watched the fish passes in Ireland for nearly twenty years. As a general rule, the ladders at Galway, Ballisodore and Calloony, are decidedly the best form. Mr. Roberts

gives in his report the quantity of water necessary for a fish pass, and the means to be adopted to prevent too great a rush of water in times of floods. I take these details to be quite correct. No fish pass will be effective if not skillfully applied, and discharging the water at foot of weir.

This form of ladder was the invention of Mr. James Smith of Deanstone, Scotland.

You have no good fish passes that I have seen in England.

Yours very faithfully,

THOMAS F. BRADY,

Inspector of Irish Fisheries.

To THOMAS ASHWORTH, Esq.

APPENDIX B.

[From Annual Report Department Marine and Fisheries, Canada.]

REPORT OF SAMUEL WILMOT ON FISH CULTURE.

Operations on Wilmot's Creek.

By an order in Council issued at my solicitation in 1866, Wilmot's Creek near Newcastle, in the township of Clarke, was set aside for the natural and artificial breeding of salmon. Formerly salmon frequented this stream in vast numbers; so abundant was this fish within the memory of the older settlers in the neighborhood, that, small as the creek is, as many as a thousand and upwards have been taken by torch and spear in one night. So plentiful indeed was the supply, that not only large quantities were preserved by the inhabitants for domestic use, but a large and profitable trade was carried on both in our own cities and in Rochester in the United States. Gradually, as might be expected, the numbers diminished until scarcely a fish could be obtained. Famous as this stream was for the purity of its water, flowing over a gravelly bed from its fountain head, some ten miles distant, thus admirably adapting it for the formation of spawning beds, and making it a favorite resort of salmon for the purpose of depositing their ova—yet no other result than its utter depletion could be looked for, when by taking these fish at the only time they can be taken in such streams—that is their spawning season—no opportunity was afforded them for the increase of their kind.

This cruel and untimely destruction was, until within a few years ago, not only permitted, but to a certain extent legalized. The law as it now stands affords ample protection to the fish in its spawning season, and if rigorously enforced will tend to prevent the destruction of the few fish that remain. The law, however, came too late; there is not now a sufficiency of parent stock to ensure any great amount of reproduction in the way of nature—art must be employed—not only must the fish be protected and increased by artificial means, but suitable streams must be reserved

for their especial accommodation. From the causes just assigned salmon became so scarce as to make it a matter of great difficulty to obtain a sufficient number of parent fish, when operations were begun by me in the fall of 1866. In that year I began as an amateur to carry out the plans I had formed, with the view of replenishing the stream, in the hope of being able, by artificial methods of breeding, very materially to add to the numbers of fish hatched in the course of nature.

In the prosecution of this design, I erected a small building on a branch of the creek, for entrapping the fish, if perchance any yet remained, and by constructing a temporary barrier across the main channel to prevent their passage upwards, compelling them to ascend the channel leading to the reception house, where by a simple arrangement of wire gratings, they could easily enter, but out of which they could not escape. In this way I secured in the fall of 1866, some fifteen salmon, male and female.

The undertaking being obnoxious to several people in the vicinity, who considered it an infringement of their rights of poaching, some of the more evil disposed among them forced an entrance into this building, and destroyed eleven out of the fifteen fish, all of which were just ripe for manipulation. Thus the four uninjured fish were the first stock for breeding taken from the creek. From these about fifteen thousand ova were obtained, which were impregnated by the artificial process. These eggs were placed in small boxes, which I had arranged in the cellar of my dwelling house, through which streams of spring water were made to run. In about seventy days a large proportion of the ova came into life, and after being carefully watched and nursed into their parr state, most of them were turned out into the creek, a few being reserved for experiment and observation.

In the fall of 1867, I procured twenty-five or thirty salmon in a reception house which I had enlarged and improved upon the former, with the aid and sanction of the Fisheries Department. From these salmon I obtained about 50,000 ova, many of these unfortunately proved immature, and therefore not susceptible of impregnation; on this account my success this year was not as full or satisfactory as the previous year. However, the cause being ascertained and understood, failure on the same account is not likely to occur again. These ova were also placed in the hatching boxes, in the cellar of my dwelling house, in spring water. A large number hatched out, and were in due time like their prede-

cessors turned into the stream. In the spring of 1868, I found on examination that the few I had retained of the previous year's hatching, for experiment and observation, had become smolts. From this circumstance, it may be safely assumed that those turned out into the stream the year before had arrived at this state as well.

My operations in the fall of 1868, being assisted by your department, were on a larger scale, and will in all probability be attended by greater and more satisfactory results. Further improvements were made in the reception house, and in the breeding house, now almost completed on the banks of the creek—hatching troughs and other appliances were provided, with a view to test the artificial process, with the water of the creek itself. Hitherto all the experiments had been made with pure spring water, in the cellar of my dwelling house. This water differs in many respects from the other. First, as regards temperature—while this ranges from 40° to 44°, the other during the winter stands at 32½° to 33°, or just above freezing point. Now, as this is the hatching season, the time required to bring out the young fry would differ of course proportionately. Thus, in water at the lower temperature, 150 to 180 days will elapse before the little fish emerges from the egg, while in the higher temperature the same process will be completed in 60 to 70 days. Besides this difference, spring water will be found almost entirely free from any deposit or sediment, and to contain no insects, nor the larvæ of flies, &c. Creek water, on the other hand, gathers in its course and holds in suspension a large amount of alluvial deposit, and other injurious substances. With these dificulties to contend with, above and beyond those which I had already encountered, I began the work of testing the efficiency of the arrangements I had made for last fall's and this winter's experiments.

As early as the month of September, nearly a month earlier than any former season, I observed that a Grilse had found his way into the reception house. No such occurrence has taken place within my knowledge for the last fifteen or twenty years. In a few days others followed in succession, until by the middle of October eighty or ninety had taken up their quarters in the house provided for them. They continued to come until about one hundred and fifty Grilse were safely housed. This novel sight attracted numbers of visitors. Among the whole of these Grilse, I found on close and particular examination only three female fish. During the time

these Grilse remained in the building, a large number were observed scattered throughout the creek below the fish house, as far as the lake, a distance of one and a half miles. On one occasion, at night, with the aid of a light, I counted forty within the distance of half a mile. The weight of these young salmon is from two and a half to three pounds each, and measuring about twenty-two inches in length.

In addition to these Grilse about thirty adult salmon were obtained, varying in weight from eight to thirteen pounds, and from which I procured a considerable amount of spawn. This, after being impregnated, was laid down in the hatching boxes, in the breeding house adjoining. Some of these salmon, as well as some others that did not enter the building, deposited ova upon the natural spawning beds in the creek below.

From this brief account of my operations from the beginning, it will be observed that results of a most satisfactory and encouraging character followed.

First, a large increase in the number of salmon visiting the stream was observable during the fall of 1868. At no former time for a period of twenty years were so many seen nor so early. The definitely ascertained increase from the fall of 1866 to that of 1868, was quite large.

Secondly, the number of Grilse seen last fall was larger than had ever been seen before even by those who have lived in the vicinity of the stream from their childhood. Testimony from fishermen in the neighborhood to the same effect was voluntarily given. This circumstance points to an important fact in connection with the experiments that have been made with a view to the repopulating the creek. Some special cause must exist for the sudden appearance of these young salmon, which did not exist for the last fifteen or twenty years, and no probable or reasonable cause can be assigned but the one that leads to the supposition that they are part of the product of the first brood which were hatched and set at liberty in the spring of 1867. To this conclusion we may very fairly arrive, from our knowledge of the nature and habits of the fish ; for it has been ascertained positively that the period intervening between the time these young fry were let loose, and the appearance of the Grilse alluded to, is exactly the time required for their growth to that state of their existence. To be more explicit. These little fish let loose in the spring of 1867,

would have to remain as parrs in the creek until the spring of 1868, when after assuming the form and livery of smolts, they would take their first migration to salt water, and return in September, October, and November of the same year to their native stream as Grilse; and the proof that these were the result of the artificial process commenced by me in the autumn of 1866, is, to my mind, and to the minds of others, conclusive, and almost amounts to a demonstration.

An opinion prevails that the salmon caught here are not the migratory salmon of the sea, but that they are natives of Lake Ontario. In order to settle this question if possible, I have marked all of the salmon and Grilse entrapped at the Grafton creek, and at this place, by cutting off the second dorsal or adipose fin. Should any salmon, therefore, be taken below Quebec by fishermen without this fin, it will prove the contrary, and corroborate the opinion generally maintained, that the salmon of Lake Ontario are the true migratory salmon of the sea. It is possible that the Ontario salmon no doubt originally coming from salt water may have become acclimatised. If this can be satisfactorily shown, then immediate steps should be taken to introduce them into lakes Huron and Superior, the waters of which no doubt contain all the requisites for the wants of the salmon, even in a greater abundance than Lake Ontario.

Results of the Operations in Fish-Breeding at Wilmot's Creek, from the Fall of 1868.

Salmon.—Upwards of one hundred thousand salmon fry were hatched out in April last, in the breeding establishment on this creek. These were the brood raised from the stock of eggs laid down in the fall of 1868. After the absorption of the umbilical sac by the fry, (which requires a period of about thirty or forty days,) they were turned into a pond hurriedly prepared for them. In this pond they were fed daily, the food used being thickened or curdled milk, and beef's liver well boiled and dried, and then finely pulverized. They have a great preference for the latter food. This pond being about fifteen rods long, by two rods wide, and shallow in depth, proved quite too small for the number of fry placed in it. A very much larger surface of water than the above is required for so great a number of fish, as it would produce a correspondingly greater amount of surface and insect food, which

being their natural food, is much better adapted for the nourishment and growth of the young fry.

A great disparity was observable in their growth, for in the month of December some had only reached two inches in length, whilst others had grown to be three and a half and four inches long. This inequality of growth, however, corresponds with observations made under similar experiments at the Stormontfield nursery in Scotland.

The apparent loss of fry during this season was very trifling indeed, and from all appearance (judging from size and general development) a very large proportion would have become smolts, and migrated from the stream in the spring of 1870. I was prevented, however, from ascertaining whether their migration would have actually taken place, by the breakage of the dam.

The unusually heavy rains which fell during the winter caused heavy freshets in the creek, overflowing everything and causing a breakage in the pond, by means of which the fry were liberated some months earlier than I had desired.

This untoward circumstance, though discouraging to me, cannot, I think, have had a serious or damaging effect upon the young fish, as they escaped into the larger body of the stream, where they would no doubt (as in the natural way) procure the required food and shelter. I am of opinion that it would be advisable in future, to distribute the young fry in the various streams of the country, so soon as the umbilical sac becomes absorbed, keeping on hand, however, at all times a considerable number in a suitable pond for experiment and observation.

White Fish (Corregonus Albus).

In November, 1868, a number of white fish eggs were laid down in the hatching troughs for experiment. In the following March and April a large number of young fry made their appearance. The difficulties attending the incubation and after care of the white fish are somewhat greater than with the salmon, on account of the minuteness both of the egg and the young fish after emerging from the shell. The egg of the white fish when first laid, is a little over one thirty-second part of an inch in diameter, but in a short time increases to nearly one-eighth of an inch. The little fish when first hatched out is about three-eighths of an inch, almost transparent, and having a small umbilical sac attached to its body

filled with a transparent oily fluid, upon which it almost wholly subsists for about three weeks; at which time it becomes absorbed.

The salmon lies prone upon his side during absorption of the sac, while the young white fish, on the contrary, immediately after emerging from the shell, begins swimming about rapidly, and apparently rests neither night nor day.

Every effort was made to find out the proper description of food for these little creatures, but without success; the consequence was, they dwindled away and died. I therefore felt much discouraged and disappointed at this unfortunate result of my first experiment. An accident, however, gave me the information that all my investigations had failed to elicit. It happened that a few of these minute creatures had managed to escape through the fine wire gauze screen, and passed down through some pump logs into a small pond, in which they evidently found food which suited their nature, as they grew rapidly and soon became beautifully developed young fish. In the pond into which the young fry had escaped, I had, about three years before, placed some roots of an aquatic plant, which grew vigorously, spreading itself all over the bottom of the pond. The fibrous parts of this plant were covered with a small crustaceous insect, upon which I frequently noticed the young fish feeding.

I placed some of these little fish on exhibition, at the Provincial show at London, in September last, where they attracted much attention. They were then about five inches in length. Others, in December, had attained the length of seven inches, and were beautifully formed.

I may be permitted to add, that I believe this to be the first successful experiment on record anywhere, of the artificial production and after-growth of this highly prized and delicious fish. To the science of pisciculture, as applied to the artificial breeding of fish, must be attributed the valuable knowledge I have thus been enabled to obtain.

Increase of Salmon and Grilse in Wilmot's Creek, in the Fall of 1869.

The number of Salmon and Grilse that entered this creek during the fall of 1869 were far greater than the most sanguine in their expectations had anticipated. As previously stated, the remnant of salmon that had escaped extermination in this creek in the fall of 1866, did not exceed *half a dozen* in number, and formed the

slender stock from which the present system of artificial fish breeding has been successfully introduced into the Dominion.

In the fall of 1869, the number had increased to such an extent that upwards of *three hundred salmon and grilse* could be seen at one view in the reception house, (a building 15 by 36,) upon that stream. It was filled literally to overflowing. Over and above the fish in the building, it was estimated by many that there were a still greater number in the stream below, (that is, between the reception house and the lake, a distance of about two miles).

The salmon that were entrapped in the reception house, or at least as many of them as were fitted for manipulation by the artificial process, were operated upon and then returned to the stream. The ova taken from them were laid down in the hatching troughs in the adjoining breeding house.

I shall, if no unforseen accidents occur, be enabled to turn out in April and May next some hundreds of thousands of salmon fry for distribution in the several streams of the country.

Disposal of Ova and Fry to Native and Foreign Applicants.

Besides the channels now suggested for disposing of the ova and fry, a new and profitable one might be opened up, by disposing of the surplus to native and foreign applicants. Many of the latter class, will, no doubt, be found in the several States of the neighboring Republic.

Efforts have already been made by the fishery commissioners of some of these States to procure salmon ova to re-stock their exhausted rivers. Dr. Fletcher and Rev. Livingston Stone were engaged in obtaining the ova of salmon, from New Brunswick, under the direction of State officials, in New Hampshire.

Now that a fish-breeding establishment is being carried on by the government of this country, it would be impolitic to allow foreigners to procure fish ova from our rivers and streams. Should they desire a supply, either of ova or fry, the proper channel through which to obtain them will be the Piscicultural establishment under your department.

As you are already aware, Mr. Atkins, Fishery Commissioner for the State of Maine, has applied for a supply of impregnated salmon ova from the establishment under my charge. Numerous applications have also been received by me from private individuals in the United States, asking for supplies of ova of different kinds of fish,

and residents of our own country have frequently made similar applications.

The introduction and maintenance by the Government of a fish-breeding establishment in this country, although it has for its primary object the re-stocking of exhausted waters within the Dominion, may nevertheless be used as a means to open up a remunerative traffic, the profits of which would materially aid in defraying the necessary expenses involved in the undertaking.

In conclusion, I beg to crave your earnest consideration of the views which I have endeavored to embody in this hurriedly written and somewhat imperfect report; trusting, however, that it may in some slight degree be the means of assisting you in urging upon the Parliament of Canada the claims for support to which the science of fish-culture is so justly entitled in this Dominion.

SAMUEL WILMOT, *Fishery Officer.*

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