Public Documents of Maine:

BEING THE

ANNUAL REPORTS

OF THE VARIOUS

PUBLIC OFFICERS AND INSTITUTIONS

FOR THE YEARS

1871-72.

AUGUSTA:
SPRAGUE, OWEN & NASH, PRINTERS TO THE STATE.
1872.

FIFTH REPORT

OF THE

COMMISSIONER OF FISHERIES

OF THE

STATE OF MAINE,

FOR THE YEAR

1871.

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

To the Governor and the Executive Council:

I have the honor to present the following report of my doings as Commissioner of Fisheries during the year ending December 31, 1871.

The most important business of the year has been the breeding of salmon from parent fish obtained in the Penobscot river, less attention having been paid to the construction of fishways than in former years, and nothing at all having been done in the cultivation of fresh water fishes.

Salmon Breeding.

In the report for 1870, the reasons for attempting the breeding of salmon directly from the stock in our own rivers were stated at length. They were, in brief, that great difficulty attends the getting of salmon eggs from Canada unless we purchase from the government establishment, and their prices have been so high as to render it out of the question for us to purchase more than a tithe of the quantity we need.

Early in the year I decided to try the experiment of breeding salmon near Bucksport, and the States of Massachusetts and Connecticut desiring to try also, whether they could not obtain salmon spawn for re-stocking their exhausted rivers on better terms than those offered in Canada, were allowed to share in the experiment by contributing to the expenses.

The plan was as follows: To buy live salmon of the fishermen in the vicinity of Bucksport, transport them to some convenient place where they could be confined within a small space in fresh water, and kept until the spawning season, when their eggs could be taken. All of the eggs were to be developed on the spot sufficiently to ensure their safe removal, and a portion of those belonging to Maine to be hatched out and turned into those waters to assist in increasing the number of salmon in the Penobscot, which would thereby become better able to afford us parent salmon in the future. Among the advantages which this plan would have over that of catching the parent fish on their spawning ground in the fall, three deserve mention. In the first place, we could beyond question obtain a large number of salmon from the owners of weirs, while it was a matter of great uncertainty how many could be caught on the upper waters, where they spawn. In the second place, we should be within easy reach of railway and steamboat transportation, while the spawning grounds lie in the wilderness. In the third place, the spawn that we should take away would not detract anything from the natural increase of the species in the river, since we should use for parent fish only those that would otherwise have gone to the markets, and the accustomed number of adult fish would still be left to deposit their eggs without molestation. There were, on the other hand, some serious objections to the plan. It is known that some wild animals become barren if imprisoned. Such might be the case with salmon. It might even be impossible to keep them alive during the long period intervening between their capture and the spawning season. A portion of the salmon caught about the mouth of the Penobscot, where the water is salt, might not really be on their way to the breeding grounds, and might not be ready to lay their eggs until the next year. Finally, who could tell the sexes apart? or how could we be certain of a due proportion of males and females among our purchases? Nevertheless, the locality selected on the whole was the most favorable.

After an examinination of the region, I selected Craig's Pond brook in Orland, as the site of operations. This is the outlet of Craig's pond, and is tributary to Allamoosook or Great pond, whose waters discharge through Eastern river into Penobscot bay. One of the motives for locating on Eastern river was the hope that by turning out a large number of young there, as we should do in case of a surplus, the river, which is a small one, might become stocked with salmon, and we might be able to catch the parent fish after the lapse of a few years, in closer proximity to the breeding works. During the first season, (and for several more, if operations were continued in the same locality,) we should be compelled to buy salmon caught about the mouth of the Penobscot, near the southern end of Verona, and the distance thence to the breeding works at Craig's Pond brook was about nine miles half through salt or blackish water and half through fresh. There were three dams on the way, to be surmounted by means of locks. The location was made so far from the fishing grounds, in order that in case of a surplus of eggs, the young salmon hatched from them might be turned loose directly from the hatching house into the fresh water, and yet be so far from the salt water that few or none of them would get down into it before they were old enough to breath it with impunity.*

The water of Craig's Pond brook was supposed to be peculiarly fitted to be the abode of salmon, old and young. It is so pure that a pin can be seen at the depth of six feet. Its sources are Craig's pond, the most transparent body of water I have ever seen in the State, and a number of large springs that enter the brook some thirty rods from its mouth. Just below these springs a pond, about forty rods in area and seven feet deep at the deepest point, was constructed by re-building an old dam which had been several years out of use. Here it was proposed to keep the parent salmon through the summer. The brook presented excellent facilities for the erection and maintenance of hatching works.

Arrangements for the supply of salmon were made with Avery H. Whitmore of Verona, who undertook to deliver them alive at Craig's Pond brook. The fish were placed in a dory that was pierced by auger holes to provide a circulation of water, ballasted and buoyed to keep it at the proper level, and covered with a net to prevent the fish leaping out. This was towed after another dory propelled by oars. The first attempt at transportation was made on the seventh day of June. Twelve salmon were put into the boat and eight of them died on the way, while the remaining four seemed nearly dead. The poor success in this trial appeared to be owing to lack of pure water, there being only a dozen holes for the change. A larger number of holes were bored, and on the next trip four fish out of seven were brought through in safety. The number of holes was then increased to a hundred, and the next three lots, of four, six and ten fish, respectively, were all brought through in safety. After this time there was very little loss in transportation, until hot days in July.

The number of salmon bought was smaller than at first intended owing to several causes. But little being known about the busi-

*Very young salmon, (called at that age "parr,") are unable to breathe salt water and die when put into it. There occurs, however, at the age of one or two years a remarkable change which fits them to breathe salt water as well as fresh, and when this occurs their instincts lead them to seek the ocean. They are then called "smolts."

ness of transporting salmon, we could get them delivered at the works only by special contract. The season proved a poor one for the salmon fishing, and the men who had undertaken to supply us did not catch as many as they anticipated. Finally the extraordinary mortality among those first received and the suspension of operations during the building of a new pound, as will be detailed below, seriously interfered with the collection of salmon.

The following table exhibits the receipts of salmon and their weights. Those received on the 26th and 28th were place in Dead brook. The others were received at Craig's Pond brook. In addition to the number here recorded, nine were placed in a pond near Bucksport village, making the whole number bought 111.

Record of Salmon received at Craig's Pond brook and Dead brook in 1871.

Date.	No. of salmon.	Aggregate weight.	Average weight.
June 8,	8	102 lbs.	12¾ lbs.
" 9,	4	52 "	13 "
" 10,	6	86½ "	14½ "
" 12,	10	113½ "	11⅓ "
" 14,	7	83 "	12 "
" 17,	6	80 "	13⅓ "
" 19,	11	114 "	10⅓ "
" 20,	7	75 "	10⅔ "
" 26,	7	76 "	11 "
" 28,	11	125 "	11⅓ "
July 1,	5	64 "	11 "
" 3,	9	102 "	11⅓ "
" 4,	5	61 "	12 "
" 6,	3	37 "	12⅓ "
" 10,	3	28 "	9⅓ "
Total,	102	1,199 lbs.	Gen. av.* 11 lbs., 12 oz.

The first salmon were placed in the pond prepared for them on the 8th of June. On the 12th two of them died; on the 13th two more, and by the 17th fourteen were dead out of forty-one received.

* It should be observed that this general average does not represent correctly the average weight of the salmon caught in the Penobscot fisheries, because after the first few trips Mr. Whitmore avoided bringing the largest salmon, the small ones enduring transportation better. I should say, therefore, that the average weight of the salmon caught in the Penobscot is as high as thirteen pounds.

On the 20th the mortality having increased to such a point that it became evident that not a single salmon would survive unless some change were made, the purchase of them was temporarily suspended and new modes of confining them were devised.

Nine salmon that were already diseased, were carried to Craig's pond and turned loose: there is good reason to believe that the most of them recovered. To contain the most of our fish, a a pound was built of stakes, brush and netting, after the manner of the fishing-weirs on the rivers, in the edge of Allamoosook pond, near the mouth of Craig's Pond brook. The area enclosed was twenty or twenty-five square rods, and the greatest depth was about seven feet and a half. The water was of the peaty color common in our ponds, and of the prevailing summer temperature. On the 27th this pond was completed and all the salmon remaining on hand, nineteen in number, were turned into it. Four of them died within ten days, and it is probable that few, if any of the remaining fifteen survived to the close of the season. By receipt of twenty-five in July the number was increased to forty-one. Twenty-one of these died in the pond, and two were turned loose. The last death was on the 13th of August and the eighteen remaining survived in good health until the close of the season.

To test other conditions for keeping salmon, an enclosure was made in Dead brook, a tributary of Eastern river, nearer its mouth, and accessible from tide water by passing through only one lock instead of three. The enclosure occupied the entire breadth of the stream for perhaps two hundred feet. In the deepest part the water was four or five feet deep, and its color was a trifle lighter than the average of brooks, but much darker than Craig's Pond brook. The bottom was muddy, and the current sluggish. On the 26th and 28th of June eighteen salmon were placed here. Two of them died, and so far as we know the others remained in good condition until October. Mr. Dresser was able to count fourteen of them at one time in September. On the 12th of October a heavy rain caused an unprecedented freshet, that swept away our barriers and turned the fish loose. Search was made for them but owing to the continued high state of the water none of them were found until their spawning was nearly completed. On the 4th of November several spawning ridds were discovered, and near one of them lay a pair of salmon. The female was captured on the 6th and carried to Craig's Pond brook. No others were caught.

Still another trial was made at Bucksport. Nine salmon were put in Spofford's pond, which lies about a mile from the Penobscot, and feeds the stream that runs through the village. This pond has very dark water, completely hiding the bottom at a depth of two feet. The bottom is, for the most part, muddy. Its tributaries are few and inconstant, and its outlet is small. It was supposed that the salmon might run down stream out of the pond when ready to spawn. This actually occurred the first week in November, but through some misarrangement of the gates or through a miscalculation as to the size of a hole necessary to admit the passage of salmon in the fall,* several made their escape and only one was caught in the enclosure prepared for them. This one, being a male, was useless, as there were males enough at Craig's Pond brook. Not all of the salmon, however, left the pond, for on two occasions, later in the season, a salmon was seen there. The one caught was in better condition than any others that I saw.

Nine salmon were put into Craig's pond, less with the expectation of catching them again than because they were diseased and could not be kept where they were first put. Still, efforts were made to catch them in November. If determined to find running water in which to spawn, they would leave the pond at its outlet since none of its tributaries were large enough. Gill nets were set in various places, but were unsuccessful until the spawning ridds were found, after which a net was set in their vicinity and took three males. None of the salmon entered the brook although their spawning was done within a dozen rods of the outlet, on a gravelly bottom, under two or three feet of water, near the shore. Salmon, then, will spawn in still water, if very pure, rather than enter a very small brook. Thus, all the salmon that yielded us any eggs, were the single one caught in Dead brook and those that were kept in the pound near the mouth of Craig's Pond brook. As it turned out, ten of the latter were females and eight males.

The first essay at taking spawn was made on the 2d of November. A sweep net was used, successfully, and the salmon were hauled out upon the sandy beach. Three of the females were found to be partially ripe, and yielded 12,500 eggs. The fish were all returned to the pound and the operation repeated the next day. From day to day the spawning continued until November 10th, when all of our female salmon, except one, had yielded a full

*A female salmon, after spawning, was seen to pass through an aperture less than two inches wide.

litter of eggs. The one exception was examined from time to time and gave no eggs until December 13th, and then only a few. We estimated the total number of eggs taken at 72,000, which, as will be seen, was a close approximation to the true number.

I will describe minutely the process of taking eggs that we pursued, since it differs essentially from that commonly pursued heretofore. One man takes a salmon by the tail, another puts her head under his arm, and thus the two hold her securely over a dry tin pan, ordinarily a foot above it. The fish is held right side up and with the head highest, to facilitate the flow of eggs toward the vent. A steady pressure upon the belly near the head will commonly cause the eggs, if ripe, to flow in a continued stream into the pan. When the litter is nearly exhaused it is necessary to stroke down the remainder of the eggs. If the fish be a very large one, or from any cause there is delay, she is not deprived of all her eggs at once, but allowed to rest. The eggs being taken, as soon as possible a male is brought over the pan and his milt expressed upon the eggs. Being of the consistence of cream, the milt does not immediately spread over all the eggs, but it is necessary to give them a motion over the bottom of the pan until the milt has come into contact with every egg. This is done by moving the pan rapidly in a horizontal circle, but perhaps brushing them with a feather would do as well. Now, and not sooner, water is added. Strange as it may seem, there is good reason to think that the secret of success in the fecundation of salmon eggs is in keeping water away. The pan is now allowed to stand still some fifteen or twenty minutes, until the eggs loose their temporary hold on the tin, when they are turned into the hatching boxes.

The arrangements for hatching at Craig's Pond brook, were a series of troughs in a room in the basement of a mill, fitted with glass trays, (or "grilles," as they are technically called, after the French,) and fed with water from the brook. There was no arrangement for filtering the water. More or less sediment was deposited on the eggs, but they were not injured by it; and it could not smother them on account of the form of the "grilles." These were made of frames of wood in which were set, vertically, strips of window glass, in two tiers, in such a way that the eggs arranged themselves in rows, each row resting on the edge of a glass strip and between two other strips. The grilles were raised from bottom of the trough and a current of water was constantly passing both under and over the eggs.

After the eggs had been thirteen days in the water they were carefully examined by samples of ten placed in a strong light, and the proportion of fecund and unfecund carefully noted. From two to eight samples were taken from each lot and part of lot. The following table exhibits the estimated number of eggs in each lot, the date when they were taken from the fish, the per centage fecundated, the loss by spoiling (mostly between Nov. 20 and Dec. 18,) and the number actually packed up on the 18th of December.

Lot.	When taken.	Estimated No. of eggs.	Percentage fecundated.	No. of eggs spoiled.	No. of eggs packed Dec. 18.
1	Nov. 2	12,500	[illegible]	93	12,500
2	" 3	11,500	94	127 }	20,650
4 pt. 1	" 6	9,500	92	297 }	
4 " 2	" 6	*3,000	85	510	0
3 " 1	" 4	300	†	4	0
3 " 2	" 4	2,500	95	17	1,700
3 " 3	" 4	16,000	96	131	21,400
5	" 7	5,000	100	144 }	
6	" 8	4,500	100	.10 }	
7	" 9	7,000	97½	134 }	14,250
8	" 10	85	100	0 }	
9	" 10	.50	100	2 }	
10	" 10	365	100	2 }	
		72,300	96	1,571‡	70,500

During the first few days of the incubation the water was as warm as common springs, and the eggs came forward rapidly; but as the winter's cold advanced, the temperature of the water fell several degrees. From 43° F., it receded to 41° and 38°, which latter figures may have been its average after Dec. 1. On some cold days it stood at 37°, and on the morning of Dec. 6th, at 34¼°, the temperature of the air at the same time being at zero.

As a necessary consequence of the cold, the development of the eggs was much retarded, and it was not until Dec. 18th that I thought it safe to move them. They were then so far advanced

* These were found to be so defective that we turned them into the stream instead of packing them up.

† Purposely kept from fecundation.

‡ These spoiled eggs were those that turned white, and were picked out from time to time.

that in all the fecundated eggs the circulation of the blood had begun. The mode of transportation adopted was in the main that in common use. The eggs were packed in tin boxes between layers of damp moss, and these tins were placed in large boxes of sawdust to keep them from freezing.

On packing up the eggs they were carefully measured and divided, as follows:

To Maine	21,750
" Massachusetts	21,750
" Connecticut	21,750
" Wm. Clift	5,250
Total	70,500

And of this total, I do not think more than three per cent. are unfecund.

Arrangements had been made with Messrs. Crockett and Holmes of Norway to hatch out a lot of salmon and turn them at the proper age into a tributary of the Androscoggin, and all the eggs belonging to Maine were sent to them. I was compelled to abandon the design I had entertained early in the season of hatching out a portion of the eggs for the benefit of Eastern river, to test the feasibility of stocking such a stream with salmon. The number of eggs obtained, although very encouraging, was not sufficient to warrant their division into two lots. The whole twenty thousand will, to say the least, be none too many to re-stock the Androscoggin. My preference would be for a number not less than a hundred thousand for a river of that size.

The results of the experiment are the eggs actually obtained and the important addition to our stock of knowledge on the subject of salmon breeding.

The eggs cost the subscribers to the fund $18.09 per thousand.* The price demanded and received at the Canadian governmental establishment at Newcastle when I purchased salmon eggs of them in 1870, was $40, gold; the eggs of a single fish costing several hundred dollars. The prevailing price of parties operating in New Brunswick has been $20 per thousand for eggs warranted to be fecundated. When the extraordinary mortality among the salmon we intended to use as breeders is considered, it is remarkable

*The cost to Maine was something more than this, since we own the apparatus, a great portion of which is good for future use.

that the eggs taken at Orland did not cost more. I have no doubt that with the advantage of this year's experience they can be obtained hereafter at an expense not exceeding $8 per thousand.

The experiment has decided in the affirmative the following questions, viz: 1st, whether salmon can be kept in confinement in a small enclosure from June to November; 2nd, whether they will, under such conditions, develop their spawn and milt to perfect maturity. It has also determined the conditions of safety in transportation, and to a sufficient extent for practical purposes, the conditions of safety in keeping them through the summer, and finally the best mode of manipulation to secure complete fecundation.

The development of the sexual functions was apparently complete and normal, with the single exception of one of the females mentioned above, and the abnormal condition of her ovaries was not owing, I think, to imprisonment. In all other cases the eggs were ripe at the ordinary season, (Nov. 1st to 10th)—they flowed freely from the fish, and so far as we can judge there was no imperfection about them. The males yielded an abundance of milt. The sexual instincts were strong. The males sought the society of the other sex, as we could observe in the case of several pairs that were placed, after partially stripping them, in a small pond in the brook. Even after we had taken, as we supposed, all their eggs, the females would burrow in the gravel like the wild fish, as though that was a job they had undertaken, and would not be prevented from completing.

As to the conditions of keeping salmon in safety through the summer, my conclusions may be briefly stated thus: Salmon will live in perfect health in common river, pond or brook water, provided that there be sufficient change to prevent stagnation, that the depth be not less than four feet, that they be not too much crowded, that the bottom be not newly submerged, that the water be not too transparent, and in the case of a brook, that there be not a large per centage of the water from springs in the immediate vicinity. It is necessary, of course, that the salmon should be in good condition when placed in the enclosure. I have no doubt that some of the salmon that died in the pound died from injuries received in capture and transportation, although Mr. Whitmore was very careful in handling them. Of those in Dead brook two or three had received injuries that destroyed their eyes. But the causes that resulted in the death of so many of our salmon in

Craig's Pond brook were mainly of a different character. The symptoms were these: sluggishness and heedlessness; an inclination to swim near the surface of the water; a white, filmy appearance of the eyes, which seemed to be accompanied or followed in many cases by blindness; a white fungoid growth on the abraded tips of the fins and wherever the scales had been rubbed off; white blotches breaking out on all parts of the body, even where there had been no mark of injury, particularly on the head, proving on examination to be patches of white fungus growing beneath the scales and pushing them from place; finally, death. The cause is to be sought for among the following peculiar conditions to which these fish were subject: first the greater part of the water was from springs in the edge of the pond where the salmon were confined; second, the temperature was consequently very low, ranging (June 9th to 20th) from 47° to 54° F., while the common temperature of rivers and ponds at that date is from 60° to 70°; third, the extreme transparency of the water may have exposed them to too great an amount of light; fourth, the bottom of the pond had not been covered with water for several years, and there was more or less vegetation on it. I am inclined to think the latter circumstance the principal source of difficulty. Yet trout remained in the same pond in good condition throughout.

The pound in the Allamoosook pond was so near the mouth of the brook that the water from the latter may have had an unfavorable influence upon the salmon in the pound, and be chargeable with the death of seven out of twenty-five salmon brought in July. In Dead brook the conditions seemed to be just what were desired, (freshets excepted) and although the volume of water became very small in August and September, there were no deaths from that cause, nor from the high summer temperature. In the pond near Bucksport village, too, I think the conditions are very favorable. The only serious difficulty there is that the salmon do not all leave the pond at the outlet when spawning time comes. This can probably be remedied by enclosing a portion of the pond around the outlet and placing the salmon within the enclosure. A barrier 410 feet long would enclose, such is the shape of the shore line, nearly five acres, with an extreme depth of about 13 feet, perhaps not more than 8 or 10 in the drouth. This would be ample room for hundreds of salmon, and they could certainly be caught in the fall. Cartage for one mile, which would be necessary here, does not appear to be so objectionable as five miles of towage.

The facilities for hatching are best at Craig's Pond brook, and were it not so far from the fishing ground, it would be best to continue operations at that point. A large pound could be constructed in Allamoosook pond, in which to keep the salmon, and by the use of wire instead of twine the danger of losing the fish by breakage of the walls would be lessened.

I have no hesitation in advising that the operations with salmon be continued in the same vicinity. They should be conducted on a larger scale, which, with our present knowledge on the subject, is quite feasible. I think two or three hundred salmon might be bought at Bucksport next season, and with such success in keeping them as might reasonably be anticipated, more than half a million of eggs might be obtained. The necessity of having salmon eggs from some source to restock exhausted rivers is imperative. But that should not be the only aim of these efforts. There is ground for believing that an application of the artificial system to the breeding of the salmon in any of our rivers, even to the Penobscot, where that species is now most abundant, would be a feasible mode of increasing their numbers. But this subject has been sufficiently discussed in former reports,* and need not be pursued further here.

The mode of manipulation is of sufficient importance to deserve further mention. It has been the common practice to express eggs and milt into a dish of water, and secure contact by straining the water. It was supposed that since fishes lay their eggs in water, such an important process in their economy as fecundation could not be safely performed out of water. It has however been found that the less water there is with the eggs the more effectual is the application of the milt, and the nearest approach to perfect success is in the entire absence of water. The reason is this: the milt loses all potency within two minutes at the longest after it is put into water. Probably the greater part of it is dead much sooner than this. Unless it touches the egg before it is dead, of course the egg is not fecundated. When not mingled with water the milt can remain a longer time without losing its force, and has even been kept in a bottle for days and still retained its power to fecundate the egg. The eggs, too, after they have been a few minutes in water begin to absorb it,† and soon lose the capacity to

*Third Rept. p 24: Fourth Rept. p. 26.

†In about four minutes, according to my own observation, and the absorption continued fifteen or twenty minutes.

be fecundated. Though scientific observers had known that the milt dies so soon after being put into water, and that the egg within half an hour ceases to absorb water, I am not aware that any one thought of dispensing with water in the operation of fecundation, until a Russian gentleman, Mr. Vrasski, dissatisfied with his success when following the instructions of English and French writers, made a trial of the dry method with remarkable success. His method* was not exactly that which we employed at Orland, but it gave me the clue to success. The importance of the new method may be judged when it is stated that by the old method only sixty-five per cent. of the eggs were ordinarily fecundated, while by the new we attained at Orland, an average of ninety-six per cent. Such success was altogether unprecedent in my own experience, and, so far as I know, in the experience of any manipulator of salmon and trout, except Vrasski. There have been some lamentable failures with salmon eggs which were doubtless owing to the use of water with the eggs.†

Shad Hatching.

Nothing has yet been done at this branch of fish culture except the experiments on the Kennebec in 1868. The condition of the shad-fishery on the Connecticut river still indicates that the efforts at artificial breeding by the States of Massachusetts and Connecticut, in 1867 and 1868, have caused a remarkable increase of shad.‡ So well established does the feasibility of the thing now appear to be that I think another season should not be allowed to pass without a beginning at shad-hatching on some of our rivers. I think a suitable location could be found in the Kennebec or Androscoggin near Merrymeeting bay. From an establishment there, not only might those two rivers be replenished, but others where shad are nearly or quite extinct might be re-stocked.

Fishways.

But little progress has been made in the construction of fishways during the past year. On rivers where the principal migra-

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*See Appendix.

†Nevertheless, when an abundance of milt is used, and there is no delay, the old method may be very successful, as we proved in the case of lot 3 pt. 2, fecundating 95 per cent. of the eggs, but with an expenditure of milt that circumstances would not generally admit.

‡See Appendix.

tory fishes are extinct, I have been the less desirous to hasten their erection because of the present lack of means to re-stock them. The Presumscot, for instance, is naturally a salmon river, but that species is now extinct there. It will be necessary, in order to its restoration, that a large number of young salmon be introduced to the river, and it is very desirable that it be done as soon, at least, as the fishways are completed. It has hitherto been impossible with the means at my disposal to buy salmon in sufficient quantity to stock a single river yearly. It is to be hoped that the operations at Orland have solved the problem how to get the eggs.

There is nothing of importance to report in relation to the fishways already in operation in various parts of the State, further than that they are generally satisfactory.

During the past year a substantial stone fishway has been completed over the dam owned by the Cabot Manufacturing Company at Brunswick. The height of the falls is about eighteen feet, and the known impetuous character of the freshets in this river seemed at first to present very serious obstacles to the construction and maintenance of a fishway. The idea at last occurred of cutting through a projecting point of ledge at the northwest end of the dam, on the Topsham side of the river, and building the fishway of stone on the lower side of the point, which would serve to shield it from the floods. It was necessary to make the first fifty feet of the fishway level in order to avoid a very expensive piece of rock cutting, which a descent directly from the dam would have necessitated; and the long level passage, being provided with low walls, allows a ready overflow to the surplus water in high stages of the river, so that neither ice nor logs nor an unmanageable volume of water can ever enter the main part of the fishway. The descent was accomplished in a section of the fishway, about one hundred and forty feet long, ten feet wide inside and three feet deep, built on the plan of the successful fishways in Ireland illustrated in the report of 1870. The walls where they were not formed by the solid ledge, were of heavy stone laid in cement, and the whole work was of the most substantial kind. The cost did not much exceed one thousand dollars.

The lower dam at Brunswick is still unprovided with a fishway. It is owned by a large number of individuals who are divided in sentiment on the question of complying with the orders of the commissioner, and have thus failed to come to any agreement.

While some of the owners are desirous of doing their share toward the discharge of the common obligation, others demur; and no one is willing to assume the responsibility and cost of the fishway unless the others will bear their share of the burden. Meanwhile the powers of the Commissioner are exhausted in prescribing the fishway. The only remaining step is a suit against some one of the proprietors, and this the Commissioner is not authorized to bring.

I submit whether here is not a case showing the need of further legislation,—whether, since each owner is individually liable for the penalty in case of failure to meet the requirements of the commissioner, there should not be an express provision of law that any owner may call a meeting of owners, as provided in chapter fifty-seven of the revised statutes, in the case of repairing a dam, and whether, in case the majority refuse to build the fishway, it should not be made lawful for any owner to build it and recover from the others their shares of the expense.

The fishway in question would be easily built, not costing probably more than two or three hundred dollars. The location decided upon was on the north side of the island, and there it would be comparatively safe.

Expenditures.

The following is a brief summary of the expenditures for the year:

Share of season's expenses at Orland	$392 44
Labor of sundry parties	174 84
Apparatus and materials for fish culture	254 24
Drawing, engraving and printing	99 40
Pay of Commissioner	344 00
Travelling expenses and miscellaneous	274 70
Total	$1,539 62

Respectfully submitted.

CHARLES G. ATKINS,
Commissioner.

AUGUSTA, December 31, 1871.

APPENDIX.

I.

Shad Hatching in the Connecticut.

[From Report Conn. Commissioners on Fisheries, May, 1871.]

In the month of July, 1867, Mr. Seth Green, of Mumford, N. Y., under the joint patronage of the Massachusetts and Connecticut Commissioners, made the first experiments in the artificial propagation of shad in the Connecticut River, a short distance below Holyoke dam. Mr. Green's skill and large experience in the culture of fish especially fitted him for the work. His first attempt resulted in hatching about two per cent. of the ova. His second attempt, with improved arrangements, brought out seventy per cent. His third effort secured ninety-nine per cent.; and in three weeks he put into the Connecticut River about forty millions of young shad. At this time nothing was really known about the growth of the shad; there was a great difference of opinion among fishermen and naturalists; some asserted that it reached maturity, or marketable size, in one year; others, that it took from two to five years. The better opinion seemed to be not less than three nor more than five years; and this was partially corroborated by the investigations of Mr. U. S. Treat, of Eastport, which showed that alewives, which are closely allied to shad, take four years to mature. It was also corroborated by the time of the disappearance of shad, after the building of dams. In the fall of 1867, more young shad were observed at various places along the river from Glastonbury to its mouth, on their way to the sound, than had been noticed for several years. The ferry boats on the river repeatedly scooped them up on their aprons, while many were caught by the fishermen in their fine meshed nets.

In the following summer, June 20, 1868, Mr. Green repeated his experiments in the hatching of shad at Holyoke, under the direction of the Massachusetts Commissioners, and for about twenty days had complete success. He turned out "several millions" of young fry daily. On the 12th of July, the weather became so extremely hot that the temperature of the water ranged from 84° to 88°, and the spawn was spoiled in the hatching boxes. It is estimated that sixty millions of young shad were put into the Connecticut that year.

During the same year attempts were made by the Connecticut Commissioners to hatch shad at Brockway's Point, but it was the 8th of July before the ova were placed in the boxes, and the extreme heat of the weather destroyed them.

No attempts were made to hatch shad in 1869, the Commissioners deeming it prudent to await the results of the experiments of 1867 and 1868, before incurring further expense. The great increase of young shad, seen in 1869, as in 1868, confirmed the belief that they would mature in due time and an abundance of merchantable shad would appear by the year 1871 at the farthest.

To the surprise and delight of our people, however, they appeared in unusually great numbers in 1870. Such a run of shad had not been seen in twenty years. On Sunday, the 22d of May, they appeared in the Sound in vast numbers; captains of vessels sailing through the Sound, reported immense shoals of them near the surface of the water, all making for the mouth of the Connecticut River. On Monday morning, the 23d, over twenty-eight thousand shad, of good size, were taken from the pounds at and near Saybrook. The same day, at Lewis' pound, beyond Nuncatesick Point, *three thousand five hundred and sixty were taken at one time*, being seven times the usual catch. At Haddam Island, seven hundred were taken at one haul of the seine. At Wethersfield, nine hundred were taken during the day. At Holyoke dam, four hundred and fifty were taken between 4 and 5 o'clock in the afternoon. At all the other fishing places on the river, so far as heard from, the catches were unusually large, and the fishing continued uncommonly good throughout the season. The average quality and size of the fish were also good.

Now the largest hauls of shad in or near the Connecticut River, of which we have any authentic record, were in 1811, when *twenty-two hundred and eighty* shad were caught at a single draft at Rutty's Fish Place. Prior to that time, the largest single draft had been made in 1802, at Haddam Pier, and it numbered about *twenty-three hundred.* Comparing these figures with those given above, from Nuncatesick Pound, it will be seen that the single catch last year at that place was larger by nearly 60 per cent. than the largest single draft ever before recorded.

It cannot be positively asserted that this great run of shad was the result of the hatching of 1867. Your Commissioners entertain the belief that it was; and there are certainly plausible reasons for such belief. It is a remarkable coincidence that such a sudden increase should appear just at the time many had predicted it and looked for it. It is a pertinent fact, too, that no other river shared in this abundance: the supply elsewhere was as scanty as in former years. Indeed it is only because this is the *first* attempt ever made to cultivate *shad*, that any doubt about these results would be entertained.

With salmon the experiments have been repeatedly tried, under a variety of conditions, in France, England, Scotland, Ireland and Canada, and with uniform success. Salmon is a far more difficult fish to cultivate than the shad; but when hatched artificially and put into the river to go to the sea, it is sure to return. Why, then, should not the artificially hatched shad return? Indeed, why was not this a return of the fry of 1867? Your Commissioners *repeat* that they believe it was; and acting upon this belief, they deemed it their duty to continue the work of hatching at Holyoke. They employed Mr. James Rankin to attend the hatching boxes, and during the short period of seventeen days, from June 20 to July 7, there were hatched and put into the Connecticut over fifty-four millions of young fry. Acknowledgments are due to the Massachusetts Fish Commissioners for their kind permission to catch shad within their State, out of season, and for the free use of their State hatching boxes. Like consent having been given for the coming summer, the hatching will be repeated by your Commissioners. It is their design, too, to make attempts to increase the shad in other rivers, by hatching ova in their waters or transporting the fry from the Connecticut. Many persons, however, have expressed a desire to make such experiments at their own expense, and as inquiries have been made about the methods to be observed, the following explanations will, it is believed, prove useful as well as interesting.

The hatching ground at Holyoke is on the east side of the river, about three-fourths of a mile below the dam, near an old fishing place. The seine was usually hauled three times a night—at half past nine, half past ten, and half past eleven o'clock. Only a few fish were hauled at a time. There was about one female to four males. Immediately upon being taken from the net, the fish were placed in a tub (of water dipped fresh from the river), and held carefully in the water while the operator passed his hand, with gentle pressure, along the abdomen towards the tail, forcing the spawn into the water. If it does not come with gentle pressure the fish is not ripe, and another is put in its place. When all the females have been thus stripped, the males are taken and served in the same way; the largest and most vigorous being selected for the purpose. One male will suffice for ten females; but where there is an abundance of males, as is usually the case, it is best not to be sparing of the milt. By this process the ova are all fecundated. They are then removed to the hatching boxes in the river. These boxes are made of inch pine boards; they are two feet long, eighteen inches wide, and twelve inches deep, with wire gauze bottoms, twelve meshes to the inch. An inch pine strip two inches thick, three inches wide, and three feet four inches long, is fastened on each long side, about midway between the top and bottom, at a slight angle with the line of the bottom, to float the box at the right depth and to give it a slight inclination down stream. So that the current striking the bottom will be turned up into the box. The boxes are placed a short distance from the shore in water about three feet deep, where the flow is constant and pure. They are strung together in a line, and held in place about eighteen inches apart by means of cords running along and fastened to the strips on each side. The current gives the boxes a gentle rocking motion which keeps the eggs in constant agitation. In about twenty-four hours, if the egg has been impregnated, life, or movement, is seen in the egg, with the aid of an ordinary magnifying glass. If the egg has not been impregnated it changes color and should be immediately removed. So rapidly does the process of incubation proceed that in the short period of from forty-eight to sixty hours, varying with the temperature of the water and atmosphere, the little fellow, with a few spasmodic jerks thrusts his tail and head through the shell and ceases not to wriggle until he finds himself entirely divested of its fragments and swimming free in his native element. They have so small an umbilical sac that they can be kept in the hatching box only a day or two, according to the temperature of the water and air. They are let out at midnight, when they immediately make for deep water, where other kinds of fish of their size dare not go and where larger fish cannot see them.

Of the shad taken last summer about nine-tenths of the females were not ripe. The second haul of the evening generally afforded the most ripe fish. At times the hatching boxes were exposed to violent storms—the waves breaking over them and tossing their contents about; but no injury was done to the ova. It was found that the spawn taken from the female an hour after its death would hatch. The percentage of loss of ova in process of hatching, was so small as to be inappreciable. In the line of boxes that were ranged nearest the shore (there were three lines), the spawn hatched six hours sooner than those in the line ranged farthest from the shore, where the water was three degrees colder. As the weather grew warmer, it was found that the process of hatching was hastened. Increased motion of the boxes seemed to produce a like result. The coarser the mesh of wire on the bottom of the box the better, so long as it will retain the ova. During the period of hatching there were several violent thunder storms, but no harm followed. Success depends mainly upon three things: perfect impregnation, constant motion of the ova, and freedom from mud and sediment. The ova from half spent shad are always small, and they take longer time to hatch than do the ova from unspent fish. Where the current is not rapid, a strip about two inches wide and an inch thick, with bevelled edge, may be nailed across the bottom of the box about midway from the end; this will serve to catch more water and turn it up into the box.

II.

Vrasski's Experiments.

[Translated from the Bulletin of the Paris Acclimatization Society.*]

In his early experiments Vrasski followed the directions given in the works of French and German pisciculturists; but the results obtained were far from brilliant. He never succeeded in hatching out more than an insignificant number of fish. From several thousand eggs, as he said in one of his letters, he got only a few dozen fry. The rest of the eggs spoiled and were lost for want of fecundation. Meanwhile all the prescriptions of the books in respect to fecundation had been followed with scrupulous exactness.

In the autumn of 1856, Vrasski engaged in the microscopic

*A translation of the entire article has been published in the New York Citizen.

study of the eggs and the milt, and kept a journal in which he recorded the minutest circumstances and incidents relative to each attempt at fecundation. Two months of persistent effort brought the desired result. The journal and the microscope proved to him that his poor success was the direct result of following the advice of the foreign manuals. In order to fecundate, it is necessary that the spermatozoïds of the milt of the male penetrate the eggs of the female. To this end the manuals recommended to take the eggs in a dish of water, and to take in another dish of water the milt from the male, and finally to turn the diluted milt upon the eggs. According to his diary, kept with perfect exactness, Vrasski was convinced that the fecundation was the less complete in proportion as the mixing of the milt and eggs had been delayed. Ten minutes interval between taking the milt and applying it to the eggs was enough to cause almost a complete failure of the fecundation. His observation and microscopic study of the eggs and the milt demonstrated that: (1st,) if the eggs are received into water as soon as they come from the fish, they absorb it, and preserve the the capacity of fecundation only whilst this absorption is unfinished, that is to say for half an hour or more. Once filled with water the eggs no longer take in the spermatozoïds. If on the other hand received in dry dishes when they come from the fish, the eggs remain for quite a long time in a neutral state and do not lose the faculty, when put into water, of receiving the spermatozoïds; (2nd) the spermatozoïds of the milt, on falling into the water immediately begin a series of rapid and vigorous movements, that continue only for a minute and a half or two at most; after that nothing is to be seen except, in here and there a spermatozoïd, disconnected, spasmodic movements. When the milt is taken from the male directly into a dry dish it does not change for several hours, and during this time the spermatozoïds retain the faculty of setting themselves in motion whenever they find themselves in contact with water. Enclosed in a dry tube and well corked, the milt preserves its fertilizing properties for six days.

Taking into consideration these observations, and the fact that both eggs and milt are slowly obtained, their entire mass not coming at once, Vrasski reached the conclusion that, when taken in water, the greater part of the eggs filled themselves with water and the spermatozoïds ceased to move, before it was possible for for the pisciculturist to mingle the eggs with the diluted milt.

He therefore adopted the system of dry dishes, and turned the milt upon the eggs as soon as he had put water with it. His success was complete; the eggs were fecundated without a single exception.

III.

Notes on the Development of Salmon Eggs.

All the eggs from a single salmon are in general of the same size and color, though different individuals may yield eggs that differ in both these particulars. In color the egg varies from pink, which is most common, to salmon color. Sometimes the salmon color approaches scarlet and sometimes orange. The color resides in the yolk, and largely, (I am not now prepared to say wholly,) in the oil globules that are distributed over the inner surface of the investing membrane, the outer shell being quite colorless, though not perfectly transparent.

On first issuing from the mother fish the outer shell and the yolk membrane lie in close contact. The size of the egg is now about three-sixteenths of an inch in diameter. In shape it is nearly spherical. After the egg has been several minutes in water,* the shell membrane suddenly begins to expand, and the growing space between it and the yolk is filled with water that penetrates from without. This water space lies above the yolk, which sinks to the bottom of the hollow sphere in which it is enclosed. The process of absorption continues fifteen minutes,† more or less, and at its close the egg is about one-sixth larger than at first, now measuring seven thirty-seconds of an inch in diameter, and its color, (as seen from above at least,) is modified by reason of the intervention of the water-space between the shell membrane and the yolk.‡

No trace can yet be seen, by ordinary instruments, of the germ. Before the expiration of the first day, however, a semi-transparent body, the germ, is seen to rise from among the oil globules that have clustered on the upper side of the yolk. The portion of the germ that projects above the surface of the

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*Four minutes in the cases that I observed.

†It is a question my observations did not determine whether there is any connection, or any close correspondence in time between the absorption of water and the adherence of the egg to external objects. According to my observation the egg does not adhere until it has been a short time in the water.

‡I believe this to be the true explanation of the change of color which some observers have described and attributed to the influence of fecundation.

yolk is nearly hemispherical in shape. (See Plate, fig. 8.) In a few hours after its appearance, a deep fissure sinks through it, dividing it into two nearly equal parts. These parts are sub-divided in the same way by a fissure at right angles with the first, and the process continues until the subdivisions are too small to be distinguished. This process is termed segmentation, and after it has proceeded a couple of days the germ presents nearly the same appearance as before its commencement.* A few days later still, it is found that the germ is increasing in width and decreasing in height, until, about the tenth day, the pellucid body is no longer to be seen projecting above the mass of the yolk. At this period I have not been able to distinguish fecund from unfecund eggs with the means at my command.† The germ has formed, has risen, and has subsided again, in the one as well as in the other, and figure 9, which is drawn to represent the unfecund, may also be taken to represent the fecund egg on the tenth day. With a side view the germ cannot be seen, but when viewed from above it is very distinct, a nearly circular pellucid body (fig. 9*a*, u. c.) bounded by the group of oil globules, and containing near its center, a faint dot. This dot is present whether the egg be fecund or not.

About the thirteenth day the fecundated egg enters upon a new phase of development, whither the unfecund egg does not follow. This is the spreading of the germ until it envelopes the whole yolk. The transparency of the expanding portion is such that it would be extremely difficult, if not impossible, to trace its progress, were it not for a constriction made by its margin on the upper surface of the yolk, and for the presence of a large number of colored oil globules which accompany its advancing margin. By the position of these globules the process can be traced by the naked eye, in a very favorable light. On the fourteenth day the spreading of the germ is plainly begun, (figs. 10 and 10*a*.) The colored globules occupy about twice the space on the surface of the yolk that they did on the tenth day, and show a tendency to arrange themselves in concentric circles. The ring which before appeared to mark the limits of the germ is still apparent, but the area within

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*Having made no drawings illustrating the process of segmentation in the egg of salmon, I must refer to the drawings in the plate, figs. 3, 3*a*, 4 and 4*a*, 5 and 5*a*, that represent different steps of the process as it was observed in the eggs of trout. The process in the eggs of salmon is very similar.

†I have not yet studied the unfecund egg sufficiently to warrant me in saying whether segmentation ever takes place in it or not. If not, then at 24 hrs. from the fish it will be easy to distinguish whether an egg has been fecundated.

it is not so clear as before. The unfecund egg meanwhile remains as in figures 9 and *9a*:—and in fact, its only change after that seems to be a very slow one toward disorganization. The germinal area varies more and more from a circular form, and in many cases it becomes a little broader, but it is still pellucid, and there is no change at all like that which we see proceeding in the fertilized egg on the fourteenth day. For many days it maintains a deceptive brightness, appearing sometimes to resist disease and the effects of handling during the first three weeks, better than the fertilized egg, and it will generally happen that after all the good eggs in a mixed lot are hatched, there will remain a number of these fair-looking failures.

But to return to the fecundated egg. On the sixteenth day it presents appearance of figures 11 and 11*a*. The germ now covers about one-third of the surface of the yolk. The central ring is no longer well defined, the globules that compose it being partially dispersed, but the outer ring, marking the advanced margin of the germ is clearly drawn and there is another (sometimes two) inside it. The constriction of the yolk by the germ is seen in the profile (fig. 11) and just above it, (F,) the trunk of the embryo salmon can be seen by the aid of a hand microscope. Figures 12 and 12*a* show the process two days further advanced. Figures 13, 13*a* and 13*b* exhibit the egg on the twentieth day. Here it will be seen that the marginal ring is still well defined, but the others are reduced to mere vestiges, straggling out like limbs from the general mass of colored globules, which are arranged under the trunk of the fish. The latter is now easily seen in profile, in figure 13, its head being toward the left; 13*b* is a rear view of the egg; in the center is that portion (*D*) of the yolk not yet covered by the germ; above is the trunk of the embryo. On the twenty-second day, (fig. 14) the uncovered portion of the yolk, (*D*,) is very small and the globules have an arrangement that presents the appearance of an insect sprawling out on the surface. On the twenty-fourth day, (figs. 15 and 15*a*,) the margin of the germ has closed up, and the yolk is, so far as we can see, completely enveloped. In place of the clear open space at *D*, (fig. 14) we have only a group of oil globules, over which lies the tail of the fish, whose trunk, (*F*) can now for the first time be easily discerned while looking down from above.

From this point for many days the process of development presents few salient features. The trunk of the embryo increases in size, and various organs appear in their primitive forms. Already the lobes of the brain are distinguishable. The ocular nerves and the disks at their extremities which are destined to become the eyes of the fish, are the most forward in their development. Soon after the vertebral column with the transverse striæ that mark its divisions into vertebræ can be seen.

About the thirtieth day or soon after,* the first indication of the circulation appears. Under the anterior part of the body is a colorless organ whose presence is made known by a regular pulsation. This is the heart. Up over the left anterior region of the yolk-sack a column of oval bodies can be seen moving toward the heart by regular steps, in time with its pulsations. These bodies are the blood-disks, and they are floating in a colorless blood through a vein that traverses the whole left side of the yolk-sack. At first this circulation is faint in movement and the disks are few, but in a few days the heart increases the vigor of its beating and the vein becomes a broad, well-defined line across the side of the yolk-sack, and along its course a good many oil globules have arrayed themselves, lending to the vein a color which it does not of itself possess. The embryo is now sensitive, and is often seen wriggling and swinging its tail from side to side, sometimes almost doubling itself up. These movements are perhaps generally owing to some irritation, that of light or heat, for instance, but they are evidently voluntary, and by them we may know that the embryo, yet many weeks from hatching, is already a sentient creature. This stage of development is illustrated by figures 16 and 16*a*.

The growth of the embryo from the establishment of sensation to the time of hatching, I have not studied very closely. A phenomenon that occurs early in this period is the development of color in the eye. This happens about the thirty-fifth or fortieth day, or earlier or later, according to temperature, and is the criterion by which the fecundity of the egg has generally been judged. It is safe enough, for the two black dots are prominent objects, but it is in most cases quite desirable to know the character of a lot of eggs some weeks earlier.

The time elapsing between the appearance of black eyes and hatching is in spring water about thirty-five days, making seventy days for the whole process of incubation. But in cold stream water the period is often 175 days.

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*The thirty-fifth day in the most tardy of my specimens.

On first emerging from the egg the young salmon is almost helpless. The yolk-sack is larger than is the case with any other fish that I have observed. A comparison between figures 6 and 17 will show the difference in form between trout and salmon immediately after hatching. The latter drawing is of natural size while the former is twice natural size. In the course of six or eight weeks, the sack is all absorbed, going to build up the rest of the embryo, and at the end of that time the young salmon is ready to begin his roving predatory life.

Salmon eggs of the same age develop with remarkable equality so far as time is concerned, always provided, of course, that they receive the same treatment. There is no such irregularity, for instance, as will warrant the expectation of development in an egg that has remained in water of a temperature of 43° F. for fourteen days or more and still presents the appearance of figs. 9 and 9*a*. During the various stages from the 14th to the 24th day, the likeness is remarkable. C. G. A.

IV.

Explanation of Plate.

[The same parts are lettered uniformly throughout.]

C—Germinative area in an unfecund egg.
D—Yolk.
E—Germ.
F—Trunk of the embryo.
G—Eye.
H—Position of the heart.
I—Vein, conveying blood to the heart.
K—Yolk-sack.

Fig. 1. Natural size of egg of Brook Trout, *(Salmo fontinalis.)*

Figs. 2, 2 a, 3, 3 a, 4, 4 a, 5, 5 a. Trout's egg, twice natural size, showing successive stages of development. Figs. 2 and 2 a, show the appearance at fifteen hours, the germ having made its appearance. Figs. 3 and 3 a, first step in segmentation, at nineteen hours. Figs. 4 and 4 a, segmentation further advanced. Figs. 5 and 5 a, about forty-eight hours, segmentation far advanced.

Fig. 6. Trout *(S. fontinalis)* just hatched; twice natural size.

Fig. 7. Natural size of egg of Salmon *(Salmo salar.)*

Figs. 8 to 15 a. Eggs of Salmon; twice natural size.

FIGS. 8 and 8 a. At three days from fish, (fecundated,) the process of segmentation having proceeded so far that we can no longer distinguish the divisions of the germ. E, the germ, is surrounded by a mass of colored globules, so small that they are not represented separately, but in the mass. The appearance of the unfecund egg is very similar.

FIGS. 9 and 9 a. Unfecund egg, thirteen days from fish. This is also a good representation of either a fecund or unfecund egg at ten days. There should be a dot in the center, like 10a.

FIGS. 10 and 10 a. Fecund egg, thirteen days from fish. The germ, E, is expanding and pushing before it groups of oil globules, which compose all the color represented. Compare with 9 and 9 a, which are unfecund.

FIGS. 11 and 11 a, represent the fecund egg at fifteen days. 11 is a side view; 11 a, a view from above. The germ now covers a third of the surface of the yolk, and the trunk of the embryo (slightly exaggerated in size) can be seen at F.

FIGS. 12, 12 a, 13, 13 a, and 13 b, represent further stages of development of the fecund egg. 13 b is a rear view of the egg at nineteen days from the fish. D is a part of the yolk not yet covered by the germ.

FIG. 14. At twenty-one days, the yolk nearly covered.

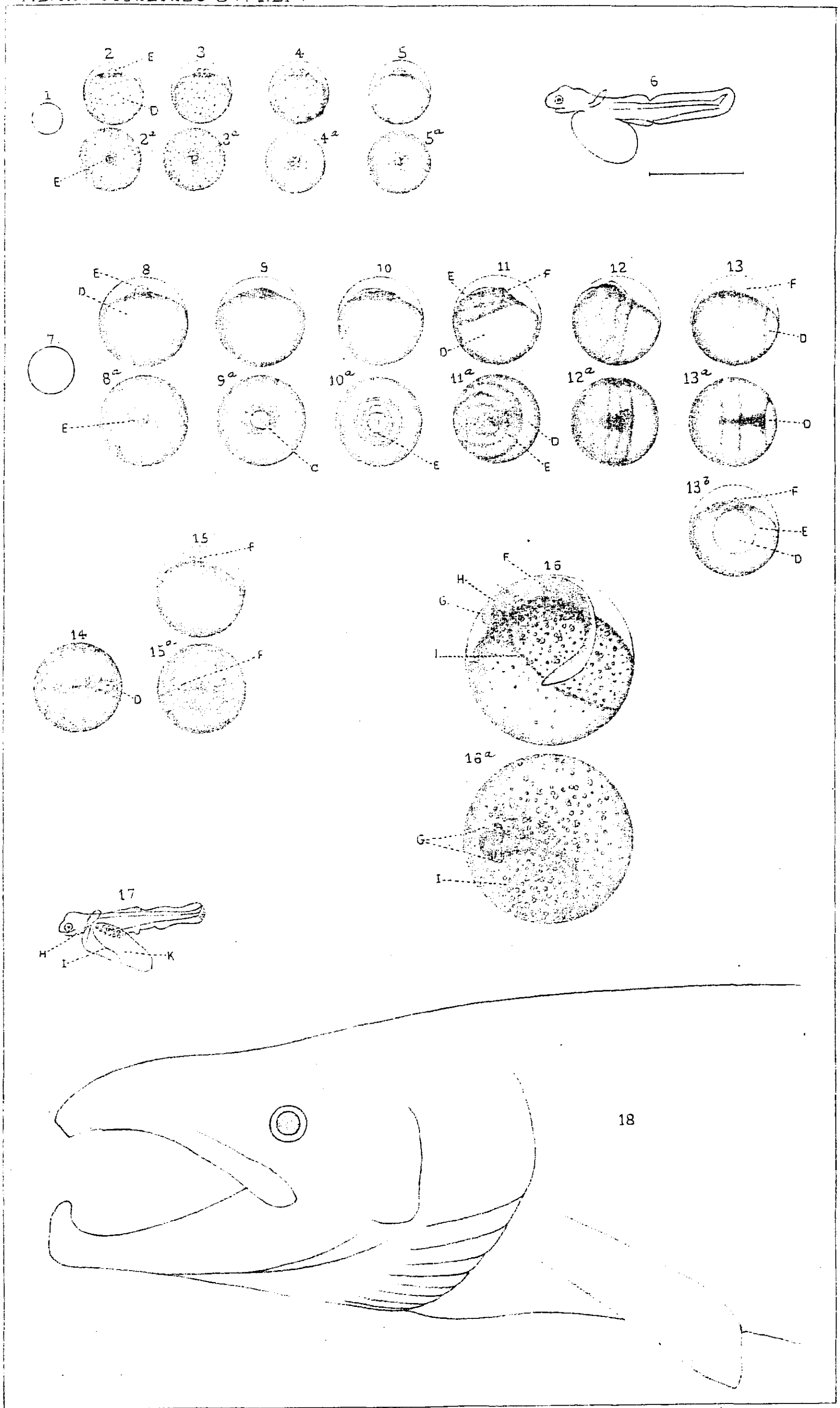
FIGS. 15 and 15 a. At twenty-three days, the yolk entirely enclosed; the trunk of the embryo plainly seen, its head lying toward the left.

FIGS. 16 and 16 a. Fecund salmon egg, four times natural size, at about thirty-five days from deposition. The embryo fish is now active, and circulation established; the line, I, crossing the yolk-sack obliquely, is a vein conveying blood toward the heart, which is situated at H.

FIG. 17. Young Schoodic salmon just hatched. The young of true salmon is so closely like this that it cannot be distinguished from it. Natural size.

FIG. 18. Head of male salmon at the spawning season. Both jaws are studded with small teeth that are not represented in the drawing. The hook at the extremity of the lower jaw is only seen near the spawning season, gradually disappearing after spawning is completed.

NOTE.—Fig. 6 is after a drawing from nature, by Prof. E. S. Morse. Fig. 18 is reduced from a photograph of a salmon caught at Bucksport, in November. All the other figures are from nature.



Drawn by C.G Atkins

J.H. Bufford's Lith. Boston.

EMBRYOLOGY OF SALMONIDAE.

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