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**On the Culture of
Salmonidae and the
Acclimatization of Fish**

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R. RATHBUN.

PAPERS OF THE CONFERENCES

Held in connection with

*The GREAT INTERNATIONAL
FISHERIES EXHIBITION*

ON THE
CULTURE OF SALMONIDAE

AND THE

ACCLIMATIZATION OF FISH

BY

SIR JAMES RAMSAY GIBSON MAITLAND, BART.

LONDON

WILLIAM CLOWES AND SONS, LIMITED
INTERNATIONAL FISHERIES EXHIBITION
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CONFERENCE ON THURSDAY, JUNE 21, 1883.

THE Chair was taken at 11 o'clock by the MARQUIS OF EXETER, who, after referring to the Inaugural Address by Professor Huxley, and the Paper by H.R.H. the Duke of Edinburgh, said the Conference would to-day be invited to give their attention to another branch of the great question of our fisheries, one which, though nearer home, and perhaps less exciting—for it involved no danger to either life or limb—was of great importance, and to many persons formed a most interesting pursuit. He alluded to the attempts which had been made to increase the value of our fisheries by artificial breeding and by importation; and they were much favoured in having the subject opened with a Paper by Sir James G. Maitland, Bart., who had devoted a great deal of time and energy to fish culture.

Sir James G. Maitland then read his paper as follows:

THE CULTURE OF SALMONIDAE AND
THE ACCLIMATIZATION OF FRESH-
WATER FISH.

The culture of Salmonidae properly understood embraces not only their artificial propagation, but also the production of their food; the regulation of their ascent to their spawning beds and of their descent to their feeding grounds; the manner of their capture and their rapid and economic con-

veyance to market ; just as much as the culture of corn is understood to mean not merely the sowing, but every step from the preparation of the seed bed to the marketing of the harvest.

The acclimatization of freshwater fish I will consider with special reference to the Salmonidae, and attempt to foreshadow the results of the importation of some of the best known foreign species.

ARTIFICIAL PROPAGATION.

The artificial propagation of the Salmonidae is still in its infancy, but the bearing it has on their cultivation in the future is so important, I propose to commence this paper with a short description of the process, and explanation of the principles which are involved in the selection of a site for, and in the erection of, a hatchery.

THE HATCHERY.

The most important requisite for the hatching house is pure water ; it is indeed to a hatchery what coal is to a steam-engine, all hatching apparatus of whatever kind being merely mechanical devices for extracting and transferring from it the greatest amount of energy to the ova.

WATER.

Water in its natural state is frequently unsuitable for the earlier processes in fish culture. It is subject to great variations of temperature ; it is rendered muddy by rain, and occasionally it is impregnated with lime or mineral to a fatal extent. Water in Great Britain, taken from a natural river even but a few miles from its source, is generally so contaminated with pollutions resulting from

civilization as to be unsuitable not only for the delicate ova and fry, but also for mature Salmonidae.

River water, however, if unpolluted and not overcharged with sediment, can generally by an expensive system of settling tanks be rendered safe for hatching purposes, and the alevins from ova incubated in river water in Scotland commencing to feed at a late period in the spring obtain much natural sustenance. Filtered water cannot be used with good results in a hatchery. The best filters deprive water of all animal life, while inferior filters cannot be run for six months continuously without great risk either of their fouling or passing an uncertain supply, especially where they have to contend with leaves and heavy frosts. Spring water is more equitable in temperature, generally free from sediment, and not liable to rapid fluctuation in the supply, but as the ova hatch out earlier the fry are entirely dependent for some months on artificial food. Taking everything into consideration, spring water should be used for the permanent supply to the hatching house, care being taken that it contains nothing in solution deleterious to the embryo, and of this, experience is the only safe guide; but it is very important that a supply of river water for summer use be also laid on, otherwise the fry must be removed from the trays four or five weeks after they commence feeding.

TEMPERATURE.

The average temperature of the water during the period of incubation fixes the length of that period, which varies in Scotland from 70 to 150 days. I formerly considered 41° Fah. as the best average temperature, Salmon eggs hatching in 97 days, while fungus does not grow readily, byssus taking from three to four days to generate to a

dangerous extent on the dead ovum, and the saprolegonei hardly appearing at all, at least on the charred surfaces of the hatching boxes; but I now find by using a larger flow of water through the trays, and by increasing the flow during the latter stages of incubation, that with a temperature of 45° Fah., fully 99 per cent. of Loch Leven Trout ova can be hatched into healthy well-formed alevins, and very nearly as good results with the eggs of the *Salmo Salar*, the difference being probably due to the difficulty of obtaining perfect impregnation in the case of ova taken from wild fish.

Spring water seldom varies more than a few degrees even in very cold weather, and where it is used the duration of the hatching period can be accurately approximated, which is often a great convenience.

At Howietoun in the winter of 1878-79, river water fell within a degree of freezing, and remained there for three months, so that Trout ova took 105 days from being spawned to the first appearance of red blood, which marks the middle of the period of incubation.

The quantity of water required in the process of incubation depends partly on the number of eggs, partly on the temperature of the water, and partly on the hatching apparatus used, but as I have hitherto only attained the very best results by the grille and tray system in the incubation of the eggs of Salmon and Trout, I will consider the water supply solely with reference to it, merely remarking that the quantity used in this system is greater than in any other; the result of eight seasons' experience has been in favour of the supply of not less than ten gallons a minute for every hundred thousand Lochleven Trout ova; about a third more for Salmon ova, and only a fourth of the quantity for the same number of *Fontinalis*

ova. A very much smaller supply will suffice during the earlier stages of incubation, but it is absolutely necessary to be able at any moment to command a sufficient supply in case of emergencies, such as are frequently occasioned by frost or by unusually warm weather.

Next only in importance to the water itself are the connections between the source and the hatchery. In making the connection with the spring it is safest to follow the spring a few feet below ground and fill in the hole with large stones. Where many small springs require to be tapped, a collecting well should be dug, lined with rough masonry, into which all the springs can be led; the connection to the hatchery from this well should be made by leading a glazed spigot and faucet pipe to the point nearest the hatchery, which will give sufficient pressure to feed the whole house by gravitation; here another small well, also lined with masonry, must be constructed, and from it a metal pipe (as fireclay will not stand much pressure) led into the hatchery, this arrangement keeps all the pipes underground, where they are safe.

The connection with the stream to bring in river water is not so simple, the greatest care must be exercised to secure a constant supply, and the difficulty of forming a permanent and perfectly safe connection is always very great. Leaves and débris are in some streams very troublesome, and ice at the beginning of a frost is a serious source of danger, floating against the screen or grating, and freezing to it. I once lost 300,000 Lochleven Trout ova from this cause. The winter had been unusually severe, the thermometer for several weeks never rose above 25° Fah., but at the beginning of February a thaw set in, and by the 1st of March every trace of ice had disappeared. The stream which fed the Fishery was in spate, and one of my hatching

houses is situated within the works, the water supply being obtained from a 20-ft. plank pond, used in winter as a settling tank, and whose feeder is supplied by a 10-in. pipe from the main inlet works. These in their turn are supplied by a sluice in a coffer-dam, and guarded by a screen placed nearly parallel to the surface, formed of perforated zinc in summer and of wooden slats $\frac{3}{4}$ inch apart in winter. The wooden frame had been removed on the 3rd of March, when the temperature fell suddenly to 12° Fah., and the thin ice floating down the surface of the stream clogged the perforated zinc screen, and froze into a solid mass, entirely stopping the supply of the works ; the water in the hatching trays unfortunately had been lowered two days before to increase the current so as to keep the eggs cleaner during the spate. The water fell in the boxes sufficiently to partially expose the eggs, these just showing the coloured globules which precede the formation of the red blood, and a thin film of ice formed on all the eggs. A few hours afterwards the screen was relieved, and the eggs thawed out by a gentle current of water. For a week no bad symptoms were visible, then several thousand turned white ; in a month it was evident that, although few more eggs had actually died, most of them had made no further progress, and the few which showed a distinctly formed embryo only proved how thorough had been the work of destruction : the ice had squeezed all vitality out of my baby Trout.

The stoppage of water by the screen being clogged with thin ice is frequently an invisible danger. It cannot occur when the stream is frozen entirely over, as the thin ice only travels on the surface, and when it comes against the screen is held there by the suction of the water in the same way in which a leaf is (this, of course, must not be confounded with

the screen freezing up from insufficiency of water, which only occurs at a more advanced period of the frost); the stoppage, moreover, is temporary, for as soon as the temperature rises, or the stream freezes entirely across, the cause is removed, and the water soon clears the passage for itself, but in this lies the very essence of the danger, namely, that the water may have been off the works for a few hours, and the eggs exposed to frost, and in the morning everything seems as usual, and the cause of the eggs dying, perhaps a week afterwards, entirely unsuspected. It is not advisable to place any hake or screen guarding the inlet perpendicular to the water, as leaves, &c., will collect in great quantities, and although fir branches laid in front generally prevent the water being entirely cut off, the amount of cleaning and watching is considerable, and a certain risk will always exist.

A leaf screen made of perforated zinc laid nearly parallel with the surface of the water is probably the safest way of making a connection with an open river; if properly placed, any débris collecting on the screen, so soon as it begins to reduce the flow, is washed off by the upper current, and the supply after having passed through the zinc screen can be led into a small collecting well, and thence piped to the Hatching-house.

The Hatchery itself should be substantially built on sound foundations, brick and concrete being probably the best materials to use; ventilation, light, and protection from frost are the principal objects in construction; and above all things the drains must be sufficient and rat-proof. Keeping these points in view, the situation of the Hatchery should be governed by the water supply. The house also should be as large as possible, as very much better work can be done in a few central establishments than in many

small ones. Eggs both fresh and eyed are so easily and safely transported that distance from the spawning streams is of far less consequence than proximity to a first-class railway station, from which the distribution of the fry can be readily effected.

The extreme importance of properly constructed and efficiently controlled Hatcheries must be my excuse for having dwelt so long on this portion in the paper, especially as a very prevalent and to many a very pleasant idea is that every watershed in the country should teem with small Hatching-houses, and that the water should be stocked with the improperly developed eccentricities so freely produced by dirt, ignorance, and overcrowding.

APPARATUS.

The apparatus employed in hatching Salmonidæ must necessarily vary with the species, temperature of water in hatching, and the character of the waters it is proposed to stock. The principal object is not to incubate the largest number of eggs in a given space, but to so incubate the ova that at some future period—for instance, twelve months after laying down the ova—the largest number of healthy fish may result; and I say this advisedly, for it is quite possible to hatch a very large percentage of the ova, and yet a very small percentage of the fry survive the first few weeks after they commence feeding. With a low temperature, and where the ova have to be sent away either as eyed ova, or the fry to be turned out before the conclusion of the yolk sac period, a very much larger number of Salmon and Trout eggs can be incubated per gallon of water per minute without any apparent loss than is possible in this country with a high temperature of water and with fry under constant observation for months after they commence feeding.

At Howietoun I use boxes, each of which will rear 15,000 Lochleven Trout fry for five or six months after hatching, and this without any appreciable loss, but I do not care to lay down more than 20,000 eggs on the grilles in each box, the size of the egg being 35,000 to the gallon. I find that if the eggs are laid down any thicker than this there is a decided difference in the vitality of the alevins and feeding powers of the fry.

I will now consider the Hatchery as a factor in the cultivation of migratory Salmonidæ, restricting myself for the present to those species placed by Dr. Günther in the group *Salmones* either with a wide geographical range, as *Salar*, *Trutta*, and *Cambracus*, or limited to Great Britain and Ireland, as *Brachypoma* and *Gallivensis*, merely pointing out that while touching on the general conditions common to the increase of the above named species, the extermination of the Bull Trout on the Tweed and the Sea Trout on the Forth forms a very serious point to discuss in treating of the culture of the Salmon, and that the best results can only be obtained by the careful protection and artificial production of the species best suited to each particular district. The objects here are to increase *Salmones* whose pastures are in the sea, and whose nurseries are in the rivers.

The size of the river has no fixed relation to the number and weight of fish caught in its estuary and contiguous seaboard, and if a very large number of smolts were annually turned in immediately above the tidal waters the stock of *Salmones* would be increased by a proportion of the number turned in, fixed only by the conditions of food and of natural enemies in the estuary and adjoining sea. I do not mean to say for an instant that all the fish reaching maturity would return or attempt to return to the mouth of the river in which they were liberated as smolts, but I think

that the evidence tends to show that most of them would do so. The question at this point resolves itself into a matter of pounds, shillings, and pence. Salmon smolts of two years old can now be raised at less than sixpence apiece, and Salmon in the estuary on their return are probably worth on an average five shillings each ; rent and the expense of nets, wages, and rates probably add another five shillings, of course if there was a much increased take the proportion to each fish would be less and all the fish that return to the estuary are not caught, but it will be sufficient for our purpose if we assume that a Salmon on his road to destruction is worth while still free five shillings two years after it has been liberated as a smolt ; if, therefore, 10 per cent. of the smolts turned in are caught two years afterwards no profit will result, for the increase would only equal the first cost, and the interest on the outlay would be nil.

The old idea in this country was to turn out young fish big enough (and big enough does not necessarily mean sufficiently educated) to take care of themselves. The results from the Stormontfield experiment at first, when everything was new and in working order, were sufficiently marked, but they have not been permanent, and if pisciculture had achieved no more, Salmon culture, in this country at least, would be an interesting exotic, with magnificent results in some cases, far oftener with none ; but fortunately it is not necessary to depend on two-year-old smolts for the future increase of our Salmon fisheries. Mr. Spencer Baird, who I am glad to see so ably represented at this Exhibition, in a letter to the Commission of Fisheries of the Dominion of Canada, refers to the magnificent increase of Salmon in California, an increase in five years from five to fifteen million pound weight in one river, an expenditure of merely two million Salmon fry per annum, which in this country

would entail less than a thousand a year after making a full allowance for all expenses. But stocking with fry or with smolts is but a small portion of the great question ; parts of some of our Salmon rivers are too fouled by pollution to rear fry after they are liberated ; it is only by adapting the means to the end that Salmon culture can reach the highest degree of success. In many parts of the country where the pollution is only moderate, we can meet it by taking advantage of the pure water above or by turning smolts in directly above the tidal waters, but I am certain the surest remedy for pollution is to make pure water pay. It is easier to shake an industry to its foundation than to put something better in its place, and if, through fish culture, pure streams and more plentiful food would displace the black sewers of our midlands without the intervention of harassing legislation, fish culturists will not have laboured in vain.

The next important point in Salmon culture is a consideration of the mode of stocking. The watershed must first be carefully surveyed, and the quantity of natural feeding for young fry, yearlings, and smolts estimated. Where clear spring water can be obtained close to gravelly shallows suitable for alevins, the most economical and efficacious manner of stocking is to cut narrow ditches just above flood water mark, fill in with gravel, and sew down eyed ova a few days from hatching, cover over with branches, and leave alone.

Where no springs exist young fry a few weeks after commencing to feed should be turned into the gravelly ripples, but where the stream is too sluggish or too large to be safe for fry, yearling fish can be turned in in spring as soon as the kelts are out of the water, but smolts should only be used immediately above the tidal water.

The temperature, hardness of water, earthy particles in

suspension, rainfall, &c., must be carefully studied in connection with turning in the young salmon, but with a little experience ultimate success is assured.

The Hatchery can supply eyed ova for the redds and fry for the shallows, and ponds should be constructed near the Hatching-house for yearlings, but where it is necessary to stock with smolts ponds for the purpose must be constructed near the head of the estuary, as the carriage of two-year-old samlets is neither easy nor economical. The time that intervenes between the smolt just entering the tidal water and its first return towards the river varies considerably on the east coast of Scotland ; two summers may sometimes intervene, and we must be careful not to assume that all fish return or attempt to return in the grilse stage, for I have found in the case of the Lochleven Trout only a small proportion spawn in the corresponding state.

But whatever the time is we know that his growth is most rapid, and his sea food must be studied before much further advance can be made in Salmon culture ; garvies and young herring probably form a great portion of his food, but whatever it be his paths in the sea are as well marked, and to some fishermen, alas, as well known, as in the river.

Trammels in the sea are successfully dropped by east coast fishing boats on their way out and lifted on their return. The food of Salmon at sea may possibly be influenced by the modes of fishing. Boats year by year go farther north and farther to sea for their Herrings ; the fishing grounds are slowly but surely receding from the shore. It is too early yet to foreshadow the results, it may be that food inshore grows more plentiful now that the Herrings are further out, or it may be that the Herrings are further out because the inshore food has decreased, it may be, and to a certain extent it must be, a matter of changing

currents and temperatures ; but what I wish to impress in this paper is that the sea food of the migratory Salmones forms a very necessary preliminary study to the great question of Salmon culture.

A diagram expressing the art of Salmon culture would contain no broad, hard, rectangular lines, no vivid colouring easy to be understood, but flowing curves traced by the ever varying intensity of the now few now many circumstances whose combination constitute the problem of the migratory Salmones. Temperature and food are here, as with the non-migratory species, the principal factors. The modes of capture and obstructions in rivers also weigh heavily against the increase of Salmon. But when one of our watersheds is sufficiently artificially stocked so that the advantages of the process are brought clearly and directly before the public an alteration in the modes of legal capture will assuredly follow.

Of obstructions in the river it is difficult to treat ; many upper proprietors prefer good Trout fishing to the pleasure of dragging about a few kelts in spring, and it cannot be too strongly impressed that Trout are most destructive to Salmon spawn, and that Salmon in their turn are after spawning most destructive to Trout.

I am aware it is very commonly held that Salmon do not feed in fresh water, probably because in common with all large-ovae Salmonidæ the ovaries for from two to eight weeks completely fill the cavity of the abdomen, and should the fish yield to hunger during this time the freshly swallowed food causes the immediate extrusion of the ova.

If Salmon never fed in fresh water a well-mended kelt would be a superfluous expression in the parlance of fishermen.

The deduction as to kelts in certain parts of the rivers is obvious.

Obstructions in the river will interfere little with young fish artificially bred descending to the sea, although they are often fatal to the ascent of spawning fish. Returning to the artificial propagation of salmon, the selection of breeders is very important, eggs from young fish being far smaller in size and the fry hatched from them more delicate than is the case with ova spawned from mature breeders. I think it therefore necessary that the Salmon should be caught and selected so soon as the rod fishing closes, as by selecting the best hen fish the future stock of the water will be much improved.

The non-migratory *Salmones* in this country are classed by Doctor Günther under the following species—*S. Fario* : *Ferox* : *Gilleroo Nigri-pinnis* ; *Orcadensis* and *Levenensis*, but probably with the exception of the *S. Levenensis*, which more nearly approaches a marine form, these are all more or less permanent varieties of *Fario* ; and their fry, at least those produced under artificial conditions, are more easily reared than the fry of the migratory species. Their cultivation may be said to consist in the selection of the oldest females for breeding purposes, in the artificial incubation of the ova and the rearing of the fry ; beyond this their culture resolves itself into a question of habitat and food, of habitat by choosing the species or variety best suited to the ends in view, and of food, for it is only by increasing the food supply in the water that the heaviest weight per acre and the most delicate quality of the flesh can be produced. The cultivation of the food supply in fresh water is effected by the reduction of coarse consumers of food who come in competition with the *Salmones*, by the cultivation, introduction, and acclimatization of fish whose value as food for *Salmones* is greater than the value of the sustenance they themselves derive from the water, as, for instance, the

Char of Loch Rannoch, who subsist almost entirely on the *daphnæ pulix*. The smelt, and some of the white fish also, may be the link in the chain which will bind the land-locked salmon to our northern lakes, and prove a very disturbing weight in the scales on the side of the upper proprietors on waters now tenanted by the migratory Salmonidae. I have only just commenced the construction of a botanical pond to enable me to study water plants as herbage for molluscæ, shelter for grammari, and the natural production of myriads of ontromostrica. On the sea-shore of the Western Highlands if the kelp be not regularly cut, or in other words rudely cultivated, for cutting is most assuredly a process in cultivation, the whelks and bukies decrease on account of the want of the young tender shoots of seaweed, and the fishing in the neighbourhood is sensibly diminished.

From this it is easy to understand what a great future may be opened out by the systematic culture of water plants in our inland waters.

Food limits the culture of non-migratory Salmonidae, therefore our study must be where to grow it, how to grow it, when to grow it, and what to grow. In lakes some shoal swimming fish is essential to the growth of the large species of non-migrating Salmonidae. Since the Char have disappeared from Lochleven in the first quarter of the present century, the ten pound Trout in that loch have passed into the realms of romance.

Acclimatization here steps in ; either the freshwater Smelt of America or our own *Osmerus eperlanus*, which I have successfully hatched and am now rearing in fresh water, if introduced into a Highland loch, for instance, Loch Tay, would enable it to carry a very heavy crop of some of the larger inland species, for instance, the landlocked Salmon of Loch Werner in Sweden, or the *S. Sebago* of America ;

but we must not conclude that the acclimatisation of every species is in all cases desirable, for if the Black Bass were introduced into the Tay, and the Pike Perch allowed to sport wherever he listed, even were the sport with the new comers at all commensurate with the highly-coloured descriptions which we have read, it will hardly compensate for a troutless river, and a salmonless estuary. There may be parts of the country where the Pike Perch would form a desirable addition to the local fauna, but I cannot conceive the Black Bass, who is only at his best in waters essentially fitted for Salmonidae, to be other than a most dangerous intruder. The Colorado beetle boasts, I believe, of a special Act of Parliament, and I do think the introduction of strange and dangerous species of fish should only be attempted under State control.

The *S. Sebago*, should he retain in this country his non-migratory instincts, would probably be a splendid fish for the Thames, and if used in the upper parts of the Severn would introduce a new and important element in the question of the respective rights of upper and lower proprietors. It is not for the public good that this should be done, for this fish would probably be able to hold the spawning grounds from all comers, and a rapid decrease of the migratory species would be the result, and if it be urged that a lake species would not localize itself to the upper portions of our larger rivers, still if crossed with a British variety, such as *S. Levenenses*, it in all probability would do so. The acclimatization of the *Corregoni*, of which there are many species, all of which can be easily transported as alevins in my opinion, only to be considered as a factor in the production of food for more valuable Salmonidae. If we had the great American lakes, no doubt the large white fish of Canada would, if introduced, form a valuable article

of popular food, but our space in this island is too confined to enable us to deal with other than the best we can have, and I doubt, except in a few solitary cases, if any of the *Corregoni* fall under this head.

The introduction of Golden Tench and the varieties of Carp are not considered in this paper, as the acclimatization of fishes has been treated merely in relation to *Salmonidae*.

DISCUSSION.

Mr. WILMOT (Commissioner for Canada) said he rose with great pleasure to move a vote of thanks to Sir James Maitland for the very lucid and instructive Paper he had read, for he felt satisfied that much benefit would be derived from it. He was a deep lover of the science of fish culture, believing it to be one of the means by which the population of the earth hereafter would derive much benefit in the way of food and wealth. It was well known that the waters of almost every country which had been largely inhabited had become very scarce of fish, but this result was brought about by the greed and avarice of mankind almost entirely, not in consequence of the predatory habits of other fish which frequented the same waters. In any new country an abundance of fish was to be found in the rivers and waters, showing that the balance of nature was evidently correct; that though fish fed on fish, they did not exterminate one another; but the moment man stepped in with his engines of destruction, the fish were reduced to such an extent that this great International Exhibition had been established for the purpose of devising means whereby this description of food could be increased. He regretted to find that, to some extent,

there was a difference of opinion with regard to the means to be adopted to this end, but, for his part, he advocated the protection of fish in every possible way, as well as of assistance to those engaged in artificial production. In Canada this subject was of very great importance. It was now some years ago since artificial culture was introduced by himself, with the recognition of the Government, and now they stood second to no other country with regard to it. The number of Salmon they turned out annually was not exceeded by any other country in the world. During the last two years from thirty-five to forty millions of Salmonidae had been turned into the waters of Canada through the artificial process, and, though there were no doubt sceptics and others who were inimical to the science of fish culture, he thought that could only arise from ignorance of the benefits to be derived from it. At first sight it seemed extraordinary that fish could be produced by artificial means; but it was a most simple process when understood. Fish were so prolific, that man with a little ingenuity could produce from them far more than nature could herself, because it was a well-known fact that large quantities of the eggs of the fish family were destroyed by other species. This was the ordained law; it was intended that fish should live on fish, because if all the eggs of fish were permitted to hatch out, there would be no room in the waters for them. Consequently, nature had provided wisely that fish should live on one another, and this being the case, large numbers of ova must be consumed. Under artificial culture, however, where the egg was protected from its enemies, a larger percentage could be brought to maturity than by the natural process. Hence, if it could be shown that 75 per cent. of the eggs could produce living fish, the system ought to be encouraged by all intelligent

people. Sir James Maitland had gone into the matter in a most lucid and instructive manner, and there was no doubt that when the Paper was disseminated it would do a vast amount of good. The only difficulty that he saw was, that it did not appear to go hand in hand with the ideas of some scientific gentlemen, who maintained that protection was not necessary to some of our fish. He contended, however, that if an intelligent country considered fish culture of service at all, it should also adopt every possible mode of protecting the fish. It would be no use for a pisciculturist to trouble himself to reproduce fish in great numbers if the intelligence and legislation of the country did not protect that which had been produced, and if every one were allowed to fish without any control. It seemed to him, therefore, that it behoved all who were interested in this matter to join in every possible measure to enhance the production of fish, either by natural or artificial means, and also to protect the fish afterwards. Nearly every civilized country possessed laws for the purpose of protecting fish; and when some gentlemen came forward and said that fish could not be exterminated, the consequence must be that all these protective laws were a mistake, and that every one should be allowed to kill and eat as he pleased. He maintained, on the other hand, that it was the duty of the legislature of every intelligent country to suppress intemperance of all kinds, not only in the matter of liquors, but in killing fish; and to pass judicious laws for the benefit of mankind. If any law were more judicious than another, it was that the waters should be protected from the inordinate destruction of man, in order that fish might be produced in larger numbers, both as a luxury for the rich and for the benefit of the poor. He felt that he was treading on somewhat

delicate ground in giving expression to these sentiments ; but as this was the first opportunity he had had, he felt it his duty to express publicly the strong conviction which he entertained on this subject.

Professor HUXLEY begged leave to second the vote of thanks which had been so well moved by his friend Mr. Wilmot. Unfortunately, he had not had an opportunity of seeing Sir James Maitland's establishment at Howietown, but he had frequently been favoured by reading and hearing what he had done, and thus had the means of knowing not only the nature of his operations, but what was to his mind the singularly precise and accurate scientific spirit which he had brought to his work, and it was the secret of the very remarkable success he has obtained. In this matter, as in all biological questions, the secret of success lay in attention to minute details, and that was really the moral of the Paper. You must, in the first place, be able to comprehend precisely—which very few people did—the exceeding complexity of natural conditions, and then you must know how to carry into practice all the precautions necessary to meet the variation in those conditions. He could not recommend anyone who was endeavouring to acquaint himself with natural history to take up a more useful and valuable study than that of the manner in which Sir James Maitland had carried out his operations with regard to fish culture. He dwelt upon this point the more because, since the time—some forty years ago—when M. Coste first popularised the notion of fish culture, the idea became prevalent that you only had to carry out artificial impregnation, or the collection of spat in the case of Oysters, and the thing was done. He need not say what disappointment those who first experimented in the matter of Oyster culture were destined to

undergo ; that was a matter recorded not only in the minds but the pockets of a large number of persons. The same considerations applied to all forms of fish culture, and unless those who undertook it were prepared to work at it with that happy combination of science and practice which was exemplified in the case of Sir James Maitland, disappointment would await their efforts, as it had those of many persons who had attempted the same process. For himself, he did not take very rosy views of the value of protection pure and simple for sea fisheries, but perhaps he was all the more inclined to attach especial value to thoroughly well considered and scientific fish culture. He was inclined to think that it was in this direction we must look, and not to measures of inefficient protection, for the ultimate preservation of our fisheries. This was not the time to discuss the point, but he gathered from Mr. Wilmot's remarks that there was some extremely wicked person who had been saying that protection was of no use in Salmon fisheries ; that people should be allowed to destroy anything and everything they liked ; but anybody who heard the remarks he had ventured to offer at the first Conference would be aware that he, at any rate, was not one of those wicked persons. No one had insisted more strenuously than he had done on the absolute necessity for the most careful protection for those sea fisheries in which protection could be shown to be efficient, and if any one were prepared to show that measures of protection as efficient as those which were adopted in the Salmon fisheries, and which must be enforced unless the Salmon fishes were to be destroyed, would be equally efficient in the case of any of the sea fisheries, by all means let them be adopted, and no one would be a stronger advocate for protection than he should be ; but, until it was made clear

that the regulations were efficient, that you were really doing something for the fishery, and not burdening the fishermen with useless and vexatious regulations, it would be better to leave the question of protecting sea fisheries alone.

Mr. BRADY (Inspector of Irish Fisheries) said he might say a word on the question of the protection of Salmon fisheries, as compared with the protection of sea fisheries. He belonged to the sister country, and they had had a great deal of experience with regard to the protection of both sea fisheries and Salmon fisheries. There were very valuable fisheries in Ireland, and a series of Acts of Parliament had been passed for their protection, though previously to 1848 there was no machinery for putting them in force. The Act of 1848, however, gave the machinery, and imposed licence duties on all engines used for the capture of Salmon; the amount of revenue thus derived being over £10,000 per annum, and the effect had been that within his own official experience the Salmon fisheries had increased from about £2,000 a year to nearly £6,000. With regard to sea fisheries, although he was as great an advocate as Mr. Wilmot could be for the protection of any industry where it was required, he quite agreed with Professor Huxley that if there was any doubt whatever about the effectiveness of legislation, he should not hamper fishermen by restrictions which might be perfectly useless. The Act of 1842 gave power to the Commissioners in Ireland to impose restrictions on sea fisheries as well as Salmon fisheries, and certain restrictions were placed in certain bays on certain modes of fishing, particularly trawling. In one bay the restrictions were introduced in 1843, and were continued till 1862. At that time a change in the Government took place, new ideas came in, and an

inquiry was held as to the advantages derived from these restrictive bye-laws in this particular bay, the result of which was that the late Sir Richard Griffith, as Chairman of the Commission, resolved to put an end to these restrictions, and this was done much against the wish of those who opposed trawling. The effect had been that all classes of fishing in that bay had greatly improved. There was another bay where the same restrictions against trawling were imposed in the same year, and had remained to this day, and at the present time the fisheries there were more deteriorated than they were fifty years ago, when trawling was first interfered with. It would no doubt be asked, Why did he not repeal that bye-law? Well, he certainly was inclined to repeal it, and invited the trawlers to give evidence on the point; but they did not come forward, and therefore there was no power for the Commissioners to act.

Dr. DAY said he did not think the remarks of Mr. Brady had anything to do with the subject in hand, but he could not help thinking he had given opinions in the place of reasons, and statements in the place of facts. He could not help thinking that there might be trawling going on and fisheries might improve, but who that knew anything about fishing would admit that because you got a number of fish you must be improving fisheries? Acting on that principle, if you killed all the fish you would be improving the fisheries. He could not see that trawling could by any possibility improve fisheries in a bay, unless it killed certain carnivorous fish; however, this question would come forward at another time, when it could be more fully discussed. With regard to the Paper of Sir James Maitland, he would remark that that gentleman had taken up a position which was taken up by the Government in most foreign

countries; he had, at his own expense, kept hatcheries, and fisheries, which in almost every civilized country were carried on by Government officials. If they were told that a person who drew a fish out of the water was entitled to the thanks of the community for adding to the food of the people, how much more was he entitled to gratitude who spent his time and money in increasing the number of young fish, and so augmenting the food supply of the population at large? Another question of some importance was this, Whom had they to thank for the present condition of fisheries, those who made such large profits by destroying the Salmon and polluting the rivers? If the legislature permitted these things, surely it was bound to give some assistance to fisheries by adding to the supply of young fish, to make up for those that were destroyed. Sir James Maitland was carrying out experiments which no doubt would be of great benefit to fisheries; he was trying experiments on hybridisation of fish. With regard to land-locked Salmon, it might or might not remain in the upper waters of the river if there was no large lake to which it could have access; but the question arose, if you crossed the Trout and the Salmon, whether the young would be sterile, and if they could not breed, would they develop the propensity of going down to the sea. If the fish remained in the upper waters of upper riparian proprietors, would they have the means of getting a breed of fish which they could keep to some extent to themselves? At present the lower riparian proprietors on some rivers were catching a larger proportion of the Salmon, whilst the upper riparian proprietors were like clucking hens who were hatching eggs and letting the fish down to construction. With reference to the acclimatization of fish, Sir James Maitland had given a warning which ought to be taken to heart.

There were many who would introduce new kinds of fish to our waters, for three reasons ; one, that they were good for sport to our anglers ; secondly, that, like the Gold Tench, they were pretty ; and thirdly, that they were useful. Now he must confess he thought the Black Bass was a rapacious fish to be introduced. They heard the other day of a wonderful collection of fish in the sea, and if science would only point out any enormous piece of water in which this Black Bass could prey on shoals of fish as large in quantity as the Cod off Lofoden Island, where there were twenty million in one mile, then the Black Bass might be introduced, but until these localities were found it would be as well to be cautious.

Mr. WILLIS BUND said he knew a gentleman on the Severn who had for some years, at great expense, hatched a large number of fish and turned them into the water. This year, owing to some local jealousies, as soon as ever the fish were turned out, a considerable quantity of lime was put into the water, and the fish were killed. Of course that was an offence which could be dealt with and punished, but there was another kind of offence, glanced at in the Paper, which they were wholly powerless to prevent, and of which they had an instance only lately. A gentleman had spent a large sum in artificially breeding and in bringing a Trout stream to a very high state of efficiency, when a neighbour of his placed in the stream a bucketful of young Pike. Of course he could not more effectually have destroyed the work of years, but he was guilty of no legal offence whatever. He therefore considered the hint given in the Paper was very valuable, that some provision should be made to prevent rapacious fish being introduced into water not suited for them. Every water should be made to produce the best fish it could, and if Salmonidae were

the best fish those waters could produce, they ought to be confined to them ; at any rate, if large sums of money were spent, either by private individuals or the public, in introducing new fish and in improving the fisheries of the water, there ought to be some means by which ill-natured persons could be prevented turning in rapacious fish, and thus in a short time undoing the work of years. Either the Local Fisheries Board or the Home Office should have some authority or power to say what fish should be turned into the waters, and he hoped that some regulation of this sort would be one of the useful results which would follow from the Conference.

Professor G. BROWN GOODE (U.S. Commissioner) said he should be pleased to give a few figures illustrating what fish culture could do. Professor Baird (U.S. Commissioner) informed him that the Sacramento River, California, was, owing to the large number of canneries there, to a large extent depleted of its Salmon ; but by the establishment of a hatchery there he had turned out something like sixty-seven millions of eggs or young fry of the Californian Salmon in the past eight or nine years, one-fourth of which were put into the Sacramento River, and it was now much more productive than ever before. On the Clacamass, in Oregon, a similar experiment was tried some years ago with a like result. These experiments had clearly shown that the Salmon industry of the Pacific Coast, which was now producing fish to the value of something like three million dollars a day, was thoroughly under the control of fish culture. He might also take the case of the Connecticut, in the last century, which was one of the most productive rivers ; but by the construction of a great dam, 60 miles above its mouth, the Salmon were cut off from the spawning ground, and for very nearly ninety

years not a Salmon was seen. In 1866, or thereabouts, the Commissioners of Connecticut began to plant Salmon in this river, and four years afterwards they began to appear. In the first year 500 fine Salmon, of 15 lbs. to 20 lbs. each, were taken ; in the following year almost an equal number. Since that the Commissioners of the States have discontinued Salmon culture in that river, the supply has again fallen off, and the river might now be considered practically deprived of its Salmon again. He simply wished to add a word in confirmation of what Sir James Maitland and Dr. Day had said concerning American Bass. Although he did not like to say anything against a fish which was a countryman of his own, he thought it was a fish which interested only the private individuals who were able and willing to feed him, and were willing to pay any sum for the gratification they found in angling. So far as fish with which public fish culturists should deal, the Black Bass had no claims whatever, unless they put him into the same stream with Pike, and let them fight it out together.

Mr. W. OLDHAM CHAMBERS, seeing Professor Brown Goode on the platform, thought perhaps he would have given the Conference the benefit of his experience with the *Salmo sebago*. A few months ago Professor Baird sent him over fifteen thousand eggs of the land-locked Salmon, in the hope that they would form an important feature in fish breeding in this country, but he said nothing or little about the *Salmo sebago*. He thought there were many rivers in England which were completely cut off from the sea, and if the land-locked Salmon could be introduced into them, or into the Broads of Norfolk, it would be very advantageous.

Professor G. BROWN GOODE remarked that his colleague Mr. Earle might be able to give more definite information

concerning the land-locked Salmon than he could, but at the same time he should like to make up for his detractions of the Black Bass by saying a word or two in favour of the former fish. It was held in high esteem by his countrymen, as might be judged by the fact that the United States Commissioners had for some years carried on a hatching establishment on Grand Lake Stream and the subordinate streams on other lakes in Maine for the propagation of the eggs of this fish. The young fry had been introduced into many smaller streams and lakes in the Northern States. The experiment had not been worked out to the utmost extent yet, but there was every reason to believe that the land-locked Salmon was going to be extremely valuable in the northern lakes, and he saw no reason why it should not be equally valuable in the lakes of Scotland. Mr. Wilmot was equally familiar with this fish, for it might be said to be more abundant in British North America than in the States. It was undoubtedly the same race as the *Salmo salar*. In some instances it had become land-locked by the erection of dams within the memory of man, in other instances it had become land-locked by natural causes before or soon after the settlement of the country, whilst in other instances, again, it was not land-locked by any artificial obstructions, but remained without any obstacle to its visiting the sea save the great distance it would have to traverse. It lived in the head-waters of some of the large rivers. The same might be said, to some extent, of the red-spotted Trout, or Char (*Salmo fontinalis*), which in the northern parts of Canada and Nova Scotia descended to the sea, where it lived during a large part of the year, and was known as the Sea Trout, and was a great favourite of anglers. It inhabited the lower stretches of rivers and streams, and frequently descended into the sea; those

which did get into the sea were considered to be very fine. After passing the limit of Long Island, which was the limit of the distribution of Salmon, the same barrier of warm temperature which seemed to keep the Salmon from going up the large rivers, prevented the red-spotted Trout from descending from the mountains to the sea; and it had really become land-locked by reason of temperature barriers in the southern part of its range, though it extended into the southern spur of the Alleghanies six or eight degrees of latitude farther south than the point at which it was able to descend to the sea. The land-locked Salmon is a most delicious fish, though not quite so large as the *Salmo salar*; it was rarely more than eight or ten pounds in weight, and, on account of its long detention in fresh water and diminution in size, its eggs were considerably smaller than those of sea-running Salmon.

Mr. WILMOT said there was a celebrated American showman who once came to England and took away an animal called Jumbo. The same gentleman in former years exhibited a certain animal at his museum in New York which he advertised as the "What is it?" It seemed to him the same term might be applied to the land-locked Salmon. His impression was that there was no such thing in existence as land-locked Salmon, scientifically or naturally. It was the true *Salmo salar*, which had a different coat and a different shape from the water it lived in, in the same way that the showman he referred to put a coat on the animal he exhibited.

Land-locked Salmon, which he called *Salmo salar*, was a fish which could be obtained by any pisciculturist at his pleasure; all he had to do was to hatch from the egg of the *Salmo salar* a number of little fish, put them into a large body of water from whence they could not reach the

sea, and if they found food congenial to their wants, they would grow and develop into a large fish, slightly changed in colour and scarcely perceptibly in form. Such had been his experience in America and Canada. Lake Ontario was filled with this fish. When he was a youth he had known thousands killed in one night, and the farmers caught them in such numbers as they entered the streams to deposit their ova, that some of them got enough to buy their farms with. In the stream which ran within a few yards from where he was born and brought up he had killed hundreds and thousands of them on their migration up from their sea, Lake Ontario, into the smaller streams and rivers to deposit their ova, in the same way as the *Salmo salar* left the ocean and ascended rivers. For want of proper precautions, proper protection and good legislation, this Salmon had almost disappeared from Lake Ontario. At first there were no laws in the country, and consequently every man killed as he pleased, and as the poor creatures came up, they were destroyed right and left. The Indians killed them, and the white Indians killed them still more. To prove that the *Salmo sebago* was the true *Salmo salar*, he might say that he had taken eggs of *Salmo salar*, impregnated them, hatched them, and taken them up into the rivers running into Lake Huron; and to-day nothing but the true *Salmo salar* were found in Lake Huron, though smaller than were found along the coast. That was evidence to show that you might make land-locked Salmon in any water you chose where the fish could find congenial food, and where they could not get to the sea. It might be said, How could the Salmon in Lake Ontario be said to be land-locked when the St. Lawrence emptied that lake into the sea? Salmon were feeders in the sea and breeders in fresh water; they migrated annually to the

rivers to reproduce. When they were abundant in the waters of the gulf, they passed up the St. Lawrence, entering every stream on either side up into Lake Ontario; and were it not for the great barrier of Niagara Falls the Salmon would be found in the upper springs of Lake Superior. It was their instinct to go onward and onward until they found a suitable spot for spawning, and they would have passed into Lake Erie and Lake Superior, the same as Lake Ontario, were it not for the Falls; the consequence was they entered into the smaller streams which fed the lake and went back into Lake Ontario instead of into the sea, where they had remained up to the present time, as the true sea Salmon only acclimatized to fresh water. Any gentleman in England who was desirous of having land-locked Salmon, if he had a lake with a great depth in the middle and small streams running into it, into which the fish could go to breed, might produce land-locked Salmon from the eggs of the Salmon of the sea.

Mr. BIRKBECK, M.P., on behalf of the Executive Committee, desired to thank Sir James Maitland for his excellent Paper, and also to thank Mr. Wilmot for his remarks on the question of State aid to Fisheries. He thought the advice he had given was most excellent, and only regretted that the House of Commons was not more largely represented. He could only hope that through the press the members of the Legislature would be able to read, mark, learn, and inwardly digest what had passed, and would persuade the Government of the day to recognise the importance of giving assistance to our fisheries. He could not specify any one particular direction in which that aid should be given, but he went on the principle that inasmuch as State aid was given in foreign countries and in our own colonies, the same assistance ought to be given in England.

The resolution was then put and carried unanimously.

Sir JAMES G. MAITLAND, in reply, said that he was very glad that his Paper had elicited remarks from the representatives of America and Canada, both of which countries were pre-eminently known for fish culture. He could not say that he agreed with all the remarks that had been made. Fishing was a very old art; fish had been caught ever since man went out in a coracle, but fish culture was still very young, and it would be expecting a great deal to expect Parliament to change legislation in a moment before this art had had time to approve itself to the nation. He quite agreed with the opinion expressed by Mr. Brady that so long as there was any doubt, they should not legislate. With regard to his hybrid experiments, they were yet too young to say exactly what might come of them, but they showed peculiar forms in scaling, and perhaps might help towards connecting different species of Salmonidæ and reducing them down to one or two species, the others being merely varieties. He was much obliged to Mr. Wilmot for his remarks on land-locked Salmon; but having had some experience on lakes in Scotland where Salmon had been bred and had not gone into the sea, he had found invariably that where there were no Char in the lake the Salmon had become very large in the head, and seldom exceeded four or five pounds in weight. On the other hand, some nine years ago he got a few eggs of the Leuvi Trout from the late Mr. Buckland, and turned about one hundred and fifty into a small piece of water a little over one hundred acres, which contained nothing but small Perch. Last Friday a gentleman brought him one of these fish, which he had found washed ashore, which must have been just nine years old; it measured $33\frac{1}{4}$ inches, but was in very bad condition. The Trout when put under con-

ditions of having shallow swimming fish beside it had obtained this enormous size, and he had no doubt it was absolutely necessary to land-locked Salmon to have shallow-swimming fish to feed upon. If they were not present in the water, they should be introduced first, and the *Salmo sebago* afterwards ; this would make the experiment more successful. He concluded by proposing a vote of thanks to the Chairman, who had taken a great interest in the operations of the Fish Culture Association, of which he was President.

The Marquis of HAMILTON had much pleasure in seconding the vote of thanks to the Chairman. He could not but think that the speeches which had been delivered that morning would have the most practical effect on all those interested in fisheries. He hoped the observations made by Mr. Wilmot with reference to State aid being given to the fisheries of this country, would be earnestly taken up by the public at large, and that before many months had elapsed they would take a practical form, and be brought forcibly under the notice of Government.

The vote of thanks having been passed unanimously,

The CHAIRMAN assured Congress it had given him the greatest pleasure to be of any use by occupying the chair. He had seldom presided at so interesting a meeting, or gained so much knowledge in so short a time. He must say he did not believe in land-locked Salmon as a distinct species. He believed you could produce a land-locked Salmon from the ordinary fish. He recollected when his uncle, the late Lord Spencer, had the fishing on the Tweed, he collected a quantity of par and put them into a small tarn high up on the hills, where they remained for seven years. When they went to fish this lake it was full of silver fish of about 3 to 5 lbs. in weight, jumping just like

Trout would do. He believed those fish were the par which were put in seven years before, which had turned silver, like Salmon. It was hoped they would continue to increase, but they became thinner, and gradually dwindled away. Before sitting down he must say a word in defence of the poor Black Bass, which had been so hardly used. He fully agreed with the remark that they should not be put into Trout streams, where they would be as destructive as Pike, but in many parts of England, particularly in his own country, there were neither Salmon nor Trout in the streams, only Pike, Perch, and the most abominable of all fish, coarse Bream. In those waters the Black Bass would be a useful addition, he would rise to a fly; he would take any bait; he would live with the Pike, and he was exceedingly good eating. They contained very few bones, and he thought the flesh was decidedly more like fresh Whiting than any other fish.

The Congress then adjourned until 2 o'clock.

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