

14.—ATMOSPHERIC AND OTHER INFLUENCES ON THE MIGRATION OF FISHES.

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The subject now before us is one that plays a highly important part in the economic history of our food-fishes. During the last ten or fifteen years the migrations of birds have been extensively worked out by experts, and much light thrown upon the movements of these creatures. To put the matter in a practical way, what we want is a somewhat similar arrangement of forces, by which the migrations of fishes can be taken note of by any one who in any way comes in contact with them, and who is sufficiently interested, or can be sufficiently interested, in their existence to record the smallest facts concerning their movements and send in these records to some central station, where they may be made good use of and the results made known to science. The case in the matter of fishes is not so easy perhaps as in the case of birds, and yet what could be simpler than for a fisherman on some particular date to record such a series of facts as the following:

May 29, 1893; first large run of salmon, on flood tide, 17 feet 10 inches; wind light, WSW., showery.

On being received at headquarters probably other similar reports would arrive from various stations in the same district, and in case of any rivers not reporting, application should be made for information. In this way much valuable information might be collected, condensed, and published. Although an individual observer can do comparatively little, yet a number working together might do a great deal.

I have endeavored, as opportunity has offered, to make a few observations which I have recorded from time to time, and refer to them now in the hope that others may be interested and stimulated to similar effort. The more we work out the facts about the migration of fishes, the more complex very often does the question appear to become.

Primarily, there are two causes which lead to migration, (1) food supply and (2) reproduction of species. It has frequently been asserted that salmon do not feed, but every one who is acquainted with the life-history of that fish (*Salmo salar*) is well aware that they not only feed, but feed voraciously. It is not necessary to go to a fish-culturist to make sure of that fact. Salmon have been kept in fresh water from the time of their birth to maturity, and after the absorption of the umbilical sac have fed and continued to feed very much in the same way that other members of the family are known to do.

Every trout-angler who has fished in a salmon river knows how readily the yearling salmon or "parr" will take a bait. The fish at this stage has on its sides the "bars" or "finger marks," as they are often called, and bears a great resemblance to a trout, but presently puts on the livery of the smolt and goes to sea. This change means that it loses the peculiar "finger marks" on its sides, and also the general trout-like appearance, and becomes very silvery. It was formerly supposed that this silvery appearance was caused by a fresh growth of scales, but that has been found not to be the case. It is caused by a silvery pigment on the under sides of the scales, and on the opercles, which are scaleless.

Some years ago a rather interesting experiment was tried. A number of salmon parr were taken from the river and placed in an aquarium tank. In due course about half of them developed into the smolt stage. The others did not. Sea water was then turned on, the supply of fresh water having been previously cut off, and the water in the tank was gradually changed from fresh to salt. What was the consequence? Some people affirm that "parr" will not live as such in salt water. These not only lived, but very rapidly assumed the smolt stage after the salt water was added.

Now, we know that parrs feed. Anglers know, as I have already said, that they will take almost any bait. They have been found gorged with shellfish, crustaceans, and the larvæ of aquatic insects, etc. "Smolts" also feed voraciously; indeed, I have known them completely spoil the sport in a river.

Can it be supposed that the salmon in its early stages, during which it does not make any abnormally excessive growth, feeds voraciously, and after going to the sea takes either no food or very little, notwithstanding that the smolt, which has left the river perhaps less than a quarter of a pound in weight, returns in a few months as a grilse weighing 6 or 7 pounds. It seems unreasonable. It is found amongst domesticated fish, and this applies to the salmon, that at certain times of the year they feed very freely and at other times they take very little, but at all times more or less food is taken.

At Stormontfield on the Tay it was noticed on one occasion that the smolts which were to be let down to the sea were of a very much larger size than they had been in previous years. It was found on inquiry that the ponds had become charged with minute shellfish, and the liberal diet these afforded accounted for the extra growth of the smolts. Some smolts return from the sea as grilse in two or three months; others in fourteen or fifteen months. Those which return in three months have, taking a very low estimate, attained a weight of some 3 pounds; whereas those which have remained in the sea for the longer period, say from May of one year to July of the following year, do not attain a very much greater size than those which return in the shorter period. Exactly the same peculiarity has been noticed in the case of tame trout kept in ponds. Some grow very much more rapidly than others, and the period of a pondful of trout arriving at maturity will often vary a year and sometimes even two years.

It has been found, in some instances at least, that "parrs" become "smolts" and go to sea, some of them the first year; the great majority the second year; and some not till the third year. This, too, is found to be very much the case amongst domesticated trout. It is found necessary at the end of the first year to take them out of the pond and sort them. If this be not done the larger fish will eat many of the smaller

ones, and at the end of two or three years their sizes would be altogether disproportioned, some weighing only 2 or 3 ounces, others as many pounds. I have known cases of trout (*S. fario* and *S. levenensis*) reaching the weight of 4 pounds in two years, whereas it usually takes three years for a trout to reach a pound.

A smolt weighing a few ounces let off at Stormontfield on the Tay in the month of May returned in July of the same year weighing 3 pounds. On the other hand, a smolt which His Grace the Duke of Roxburghe let off on May 14 did not return until July of the year following, and it had then attained a weight of only 6½ pounds, having, in fourteen months, only just doubled the weight gained by the other fish in less than three months.

These and many other observations tend to prove that fish spending a long time in the sea do not continue to grow at the same rate as during the first few months. There is little doubt but food supply is the great incentive which drives salmon to the sea. They feed, and feed voraciously, in our rivers at times. But sometimes they take but little food—as, for instance, when spawning, when the temperature is very low, and when on migration. It is quite possible, for these reasons, to get plenty of salmon with nothing in their stomachs; and, as their digestion is very rapid, even after a good meal little trace of it might be found in a few hours.

The idea seems to exist in many minds that the huge bodies of the salmon are developed by a very indefinite something which the fish manage somehow or other to obtain by a process which they call suction; and this, as a recent writer very aptly remarked, points to something rather like microscopic supplies.

There is, however, no doubt that the food of the salmon, when in the sea, consists largely of herrings, young and old, sand eels, crustacea, etc. They follow the young herrings in shoals closely, and in many cases are found gorged with these fish. So much is this the case that when, a few years ago, the herrings failed to visit a part of the Scotch coast at the accustomed time, the salmon also failed to turn up in anything approaching their usual numbers; indeed, hardly any salmon were to be got at all, although they were usually very plentiful during the herring season. In the summer there are a good many young herrings in the Solway Firth, as I have frequently found when dredging, etc. It is a curious fact that the herring, which formerly was excessively abundant as a mature fish in the Solway, should have left it entirely, although immense quantities are still found in the sea just outside the Firth.

A great many reasons have been given for the desertion of the Solway by the herring. It took place about thirty years ago, and people blamed steamboats, trawling, railways, and many other things, but no really satisfactory reason could be given, and I am not aware that anyone has ever yet explained the mystery. But knowing as we do now what a great influence temperature has on the movements of fishes, and putting other facts together, I dare say if we could put the question to the herrings and get an answer from them it would be that we had rendered the water of our Firth unsuitable, and therefore they prefer keeping out of it. About the time the fish left, or just before it, there was a great rage for hill drainage, and the result of this hill drainage was that an amount of rainfall that formerly took several weeks to run off came down in about three days, during which time the rivers draining the watershed were in a state of high flood. Now when we take into consideration that the watershed of the Solway Firth is about ten times as big as the Solway itself, it will be seen that the effect of this hill drainage on the water of the Firth must be very

great, especially taking into account the shallowness of the estuary in question. The same has been noticed elsewhere where conditions are somewhat similar. But in some of our deeper lochs, where the water would not be affected so easily, the herrings still remain.

The migration of the herring is not to and from the Arctic regions, as was once supposed and as was reported by all the older naturalists, but simply from deep to shallow water, and I am convinced that they really remain comparatively near our islands all the time. Their migration, it has been found, depends largely on temperature. The study of the movements of these fishes is a very interesting one, and well worthy of a considerable amount of time, labor, and money being spent on it. No one who has not seen a herring shoal can form a conception of what it is like or of the enormous numbers of fish it contains. If we allow a herring for every cubic foot and assume a shoal to be a square mile in extent and 18 feet deep, it would contain 500,000,000 of fish; and there are a great many shoals of vastly larger dimensions. Such, indeed, is the enormous rate of increase that the whole quantity caught by man does not appreciably affect their numbers, and they would literally choke up the sea if they were not largely destroyed by other fishes as well as by birds. One of the fishes most destructive to the herring is the cod, which follows the shoals as well as the salmon, to which I have already referred.

The return of this latter fish to the rivers is an exceedingly important economic question. During autumn, when they run up the river to spawn, they take, perhaps, less food than at any other time, but the abundance amongst which they have been living previously has caused such a development of fat that the fish are really provided by nature to a great extent with the food which they require at this particular time. Very much the same has been observed with regard to domesticated fish. On a trout farm, for instance, it is observed that as soon as we reach October the fish which are in the habit of spawning at that time almost cease to feed, whereas the occupants of other ponds which do not spawn until January go on feeding until hard frost sets in and the water becomes very low in temperature.

Fish being cold-blooded animals pass into a more or less torpid condition during cold weather. The influence of an approaching thunder storm in preventing fish from rising is well known. Fish also often do not rise when the barometer is falling, whereas when we have a steady rise in the barometer from the west a good run of salmon is often noticed in the west coast rivers. But when the barometer reaches 29.50° the run ceases. It has also been observed that they run better in west coast rivers when the barometer is lower on the west coast than it is on the east coast. When it is rising and reaches 29° the best run occurs; and from 29.50° seems to be the most favorable point.

Temperature is also an important factor in connection with the migration of fishes of probably all kinds. It must generally happen that the temperature of a river differs from that of the sea or the estuary. Many writers have remarked that the low temperature of the sea induces the salmon to leave it and seek the higher temperature of our rivers. This has been particularly remarked about our North Sea and east coast rivers, which are earlier than those on the west coast. Fish-culture has taught us a good deal here. It was found that in cold weather fish were later in spawning than in mild weather; that during a hard frost they spawn very tardily; and when there is a mild rain and rapid thaw they spawn more freely than under any other

circumstances. If an apparently ripe fish, from which it is found impossible to obtain ova, be taken from ice-cold water and placed in a tank, the inflowing stream of which is gradually raised from 32° to 50° Fahrenheit, it will be found under such conditions to yield its eggs freely.

Some time ago, when trying to obtain ripe salmon in the river Nith, I found it quite impossible, though a large number of the fish were taken. I found, however, that fish were spawning freely in the river Cluden, which is a fork of the Nith. I had thermometers placed in the two streams, and the result bore out the opinion I had previously formed, namely, that the water of the Cluden was warmer than that of the Nith.

On a stream of my own I have noticed repeatedly that during a mild spawning season trout avoid one of the tributaries. The reason is that the temperature of this tributary is so much lower than that of the main stream. It is very little affected by the weather, being mostly spring water. But let the weather be reversed and hard frost set in, the fish then take this tributary freely because the water is several degrees warmer. I have remarked other instances in which the same thing occurs.

It has been said that the temperature of the sea being colder than that of the rivers the fish leave it, seeking a higher temperature. I have not noticed this so much myself, but I have seen it mentioned as the experience of some writers, and have also seen it recorded in the Government fishery reports and elsewhere. But this I have noticed, that the temperature of the sea, in some places at least, during the late spring months is often a great deal higher than that of the rivers, very often varying 10° F. or more. It has often puzzled naturalists why salmon run up the rivers in spring and summer, and many reasons have been put forth, such as change of food, to get rid of parasites, to escape from seals, etc. But none of the reasons brought forward will bear much scrutiny.

The following, however, has occurred to me: Knowing how important it is on a trout farm so to feed and care for the fish in the spring as to build up the ova, which are then developing in the ovaries, and knowing that the proper or improper treatment of the fish at this time means a lot of good or bad ova the following season; knowing also what a great effect temperature has on the spawning of fish, one would infer that the high temperature of the sea water has such an effect on the reproductive organs that it may compel the fish to leave the warmer waters of the sea and take refuge in the rivers. These early fish, too, are the best fish, and very naturally so, clean-run fish as we call them.

When the water of the sea is of a low temperature, as in early spring, we do not get in our Solway rivers such a large run of fish as we get later on. In the month of March, for instance, when the east winds are blowing, the fish do not run nearly so well as in April, and they do not run so well in April as in May. From 1880 to 1884 I took up my residence at a place on the coast called Douglas Hall, where a considerable salmon fishery existed, there being four stake nets fishing over a dozen pockets or pounds. So regular was this spring run that, although the fishing legally commenced in February, the nets were not put on before the end of March, and some of them in April, because it was not remunerative to put them on earlier on account of the scarcity of salmon. But later on, as the sea became warmer, a good many fish were found running. If the weather remained cold and the temperature of the sea remained at a low point the fish did not run; but as soon as the state of things was reversed, no matter what the day of the month, in came the fish.

Among other things it seems to be a general impression that a heavy spate causes a good run of fish up a river. I believe that in many instances this is so, but I find that there are exceptions to this rule, and nature seems to have an unerring code of laws governing these migrations. Sometimes a heavy spate occurs without any fish running. I believe I am right in saying that the bulk of the salmon entering our rivers only run on spring tides, and on those tides preceding the highest spring more than the two or three tides after the highest spring. And if the inflow of the spring tide be accompanied by a strong westerly wind on our west coast rivers, more fish come up than if there be no wind at all; and should the wind happen to be from the eastward, a very much smaller number would come up. Now, what effect has the wind on the tide? A strong westerly wind causes the tide in our rivers to rise higher, to flow longer, and to remain high longer; and if the fish run, as they appear to do, on the top or head of the tide, as it were, a westerly wind, causing the tide to flow even half an hour longer, would give a chance for far more fish to get up than if it had stopped at the ordinary time.

It is supposed, generally, that salmon only run with the flood; that if they find the tide ebbing they turn back to the sea and run up with the next tide. The larger run of fish is therefore accounted for by the longer time they have to run. More fish come up from neap to spring than when the tides are falling off from spring to neap, and during that period of time the only tides upon which fish will run to any extent are those just after the highest spring. Should a land spate occur at the same time a very good run of fish may be looked for, especially if it be accompanied by a west or southwest wind. In many instances I am exceedingly sorry to say a land spate is almost a necessity in many of the rivers to enable the fish to get through the pollutions and over the numerous obstacles which they meet with in their ascent.

It has been said sometimes that fish can smell the rain, and certainly they often appear to know beforehand when it is coming. I have reason to believe that fish sometimes run into a river, anticipating a spate. So trout in a pond will sometimes become very restless, and run up the raceways and then, in an hour or two, down comes the rain. It is most important to get reports from streams which are in a state of nature, unpolluted and unmolested, as far as possible. Such is the stream which passes near my own hatchery, and on which I am a riparian owner. It is a small stream and only frequented by a few salmon; fewer, I believe, than in former years. During one spawning season I personally devoted a considerable amount of time to studying the habits of the salmon in this stream. I believe I made the acquaintance of every salmon that passed up that stream for about a month. As a rule, I found that they did not run by day, but by night. Only during a heavy spate would they run by day. During some nights they did not run at all, on other nights several went up. The early fish were nearly all males; indeed it was quite exceptional to get a female early in the season. Later on I found both sexes coming up. I found, also, that they almost invariably ran on spring tides, and that they did so whether there was a spate or not. A westerly gale during spring tides was followed, as I expected, by a good run of fish. I noticed one pair of fish particularly, that came towards the end of the season; they had evidently, from some cause, been prevented ascending the stream before. They went upstream until they came to a place that suited their ideas, and there they stopped and constructed a redd and deposited their ova. The operation took about a week. I then took away the female and confined her in a tank, and waited

to see what the other fish would do. I thought it extremely probable he would go upstream and try to find another female. But instead of that he dropped down into the next pool further downstream, and remained there two days and two nights; on the third night he dropped down three pools further, then into another pool further downstream, and from there he journeyed seawards.

Fish having spawned evidently have a desire to get away to sea again, and I believe it is owing to their often not being able to get away with sufficient rapidity that they are attacked by the horrible fungous (*Saprolegnia*) disease which abounds in our rivers during some seasons.

One remarkable occurrence which I observed was the sudden appearance in the stream of four spent female fish, which, I was perfectly satisfied, had not been in the stream before. I concluded that they were fish from the main river, which had descended that river after spawning and, for some reason or other, took a run up this tributary for about three miles.

When observations of this kind are made on most of our streams, and reports sent in to some central committee, to be investigated and classified, as has already been done in the case of birds—when all those who are personally interested in our fisheries bestir themselves and investigate the facts in connection therewith, or place facilities in the way of others who can do it for them, then we can expect to unravel the mysteries of nature.

That salmon often return year after year, not only to the same stream, but to the same spawning bed, is a well-ascertained fact. The case has a striking parallel amongst birds, as, for instance, in that of the swallow. But there is a very large field for inquiry into these interesting matters, and I hope the foregoing remarks may be the means of stimulating others to the good work, which the scientist or the tyro will alike find productive of much enjoyment, whilst they will have the satisfaction of knowing that the result of their researches may be of much value to those who have to deal with our fisheries and the important questions concerning them.