SOME RESULTS

OF THE

INTERNATIONAL OCEAN RESEARCHES

BY

DR JOHAN HJORT
DIRECTOR OF FISHERIES
BERGEN

PUBLISHED BY
THE SCOTTISH OCEANOGRAPHICAL LABORATORY
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INTERNATIONAL Ocean Research has now been in existence for five years, during which period more cruises and more scientific investigations have been carried out than in perhaps any other kindred branch of Science. In these operations no less than ten steamers—viz., a Belgian, Danish, Dutch, English, Finnish, German, Norse, Russian, Scottish, and Swedish — have been independently engaged, during a longer or shorter portion of the year; and a large staff of scientists, both young and old, have devoted their labours to the solution of the problems of the sea.

The aim that the originators have had in view from the very start has been to obtain, during a period of five years, the first complete general survey of all the most noteworthy features—such as ocean-currents, minute organisms, and the life-history of fishes, for these had never previously been thoroughly investigated—in the vast North-European seas which stretch from the Baltic to the North Sea, and thence to Iceland in the West, and Spitsbergen and the Murman Coast in the North. This immense task has demanded hundreds of observation stations, entailed cruises many thousands of miles in length, and taxed to the utmost the powers of all on board and in the laboratory. Through their exertions, immense numbers of temperature-readings, chemical analyses, and measurements of currents have been obtained; while specimens beyond number of sea plants and animal forms have been collected and subjected to the nicest scrutiny. Hundreds of thousands of fish and millions of fish-eggs have also been secured, to enable their occurrence and wanderings to be delineated.

In any large organisation we find that it is by first comparing small particulars with one another that big results are afterwards obtained, and it will therefore be impossible for me to name each individual, or render to everyone the praise to which he is entitled. I will content myself with mentioning that the results obtained are due to the keen interest in the work shown by the scientists from different countries, and to the true seamanship with which our stout sailors in their small steamers faced hardships at all seasons of the year.

It is clear too that, before we have finally treated and compared the

* Translated from SÆRTRYK AF AARSBERETNING VEDK. NORGES FISKERIER, 2 Hefte 1907.

enormous amount of material in our possession, it will be out of the question for either our critics or myself to properly estimate the importance of the work performed. I will therefore select merely a single problem, and endeavour to throw light on it out of the experience we have now at our disposal,[1] and I will deal accordingly with the question that has most occupied my attention during the past few years, viz., *Of what practical use have the investigations carried on been to the fisheries of the lands taking part in them?*

Undoubtedly it has been a much disputed point, both with professional fishermen and with the scientists themselves, what reasonable or even possible claims could be urged for the expediency of scientific research. This is, in my opinion, largely to be ascribed to the fact that the practical needs, and with them the scientific tasks, of the different countries are so widely divergent. Now it is common knowledge that in the history of agriculture in every country there has existed a period when all progress consisted in breaking up fresh land, a time when there was far more unutilised soil than there were human beings to till it. This is the period of expansive cultivation. But we also know that, with increasing population, there came in most of the old civilized lands a time when the question was, how to get the fullest advantage out of the fields in use—how to obtain from high farming the most beneficial and economical results. So, too, we find in the fishing industry times when new fishing-grounds are discovered, while again another generation may be occupied with the problem of how to deal most profitably with the old grounds that are known so well,

When practical workers ask for practical results they generally mean new fields for operation and new possibilities of expansion, so that a special glamour rests both in agriculture and in fishing over the period when expansive industry is taking place. However, it is precisely during this particular period of expansion that scientific investigation both in agriculture and fishing plays a subordinate role. This is especially the case with powerful communities abundantly supplied with capital, where we may safely say that most of the progress made and knowledge acquired, with regard to new fishing grounds or gear, may be ascribed to the genius, perseverance, and courage of hard-working, self-taught men. And anyone who has seen the fleets of first-class fishing steamers, and has made the acquaintance of their intelligent, energetic fishermen, must have become aware that a few small scientific-research steamers must, of necessity, have a relatively

[1] In what follows I base my views mainly on results obtained from the investigations carried out by International Commission A, which is principally concerned with the study of the natural history of the cod and herring groups. Want of space prevents me from expatiating on other extremely valuable discoveries made, more especially concerning the plaice; and I shall confine myself to remarking that, largely owing to Danish, Dutch, English, and German investigations, discoveries have been made with regard to the plaice of a similar nature to what I shall describe in the course of my lecture.

limited capacity to discover new fishing-grounds, fresh signs of fish and more serviceable appliances.

In Norway, no doubt it has been, and still is, possible to make some advance in this direction, but this is due to special circumstances which are likely to disappear more and more every day. When the Norse Fishery Board got their own ship and commenced scientific observations, they soon discovered that an immense work lay before them, nothing less, in fact, than to examine the great banks, hundreds of square miles in extent, where fishing had never taken place before. And numerous experiments were afterwards carried out by the State, and results published,[1] which, it is hoped, have materially assisted the Norse fishermen in their difficult task of changing from the old coast-fishing in open boats to deep-sea fishing in suitable, decked vessels. I may mention here that these experiments had actually an additional interest in that they showed it was possible during investigations of this nature to make discoveries of an expansive kind also. For new industries have undoubtedly sprung up as the result of our examination of large portions of the banks off the Norse coast, in the Arctic Ocean, and of the banks between the Faröe Islands and Iceland. These experiments were made at all seasons of the year; in winter during the cod-fishing, and in the summer when the boats were out catching ling, brosme, and halibut. Attention has also been paid to the herring fishery, and to an examination of the coasts, and fresh fields for enterprise in coastal waters have been revealed.

However, the Norse fishing industry also has undergone great changes in the last few years. Instead of open boats, the fishermen have acquired decked vessels of various sizes, and are now in possession of no less than 4,500 such craft. So that in Norway, too, the industry will itself by their means become gradually more and more capable of undertaking all practical experiments.

Thus, as far as the North European lands, and consequently their international investigations are concerned, the practical use and importance of scientific research will nowhere consist in its capacity to extend the fishing-grounds and to find new appliances. Sooner or later there will come a time when we shall look to the geographical examination of sea-banks, only as a means to increase our general knowledge of fish-life at various depths, and in various regions. But both National and International Fishery Research will then, in my opinion, have a great and constant task to perform, in dealing with the vast amount of information and facts that can be brought to light for our guidance towards a proper understanding of the conditions under which the fishing industry is prosecuted, and of its future possibilities.

[1] See my book, "Norse Sea-fishes" in "The Fisheries of Norway" I, Bergen 1905, and also the various reports on fishing experiments published in the Annual Report on the Fisheries of Norway.

To make this clear I will recall to you two important points, which, as far as we can trace, have always occupied a leading place in the history of the industry. One is the great fluctuation to which the yield of our fisheries is subject from year to year, or from one group of years to another; the other is the old question, whether the fish-supply has fallen off as a consequence of overfishing.

Fluctuations in their fisheries have from time immemorial played an important role in the economy of States. In the Middle Ages, for instance, the appearance of the herring shoals was the deciding factor in the economy of whole provinces; and towns sprang up and vanished with equal rapidity, according as the herring shoals came or stayed away. In later years also statistics show considerable variations, and that not merely in such coast-fisheries as those of Norway and Sweden, but actually in Britain's drift-net fishing too. In Norway the great periodic cod-fisheries, as far as records go, have been subject to such surprising fluctuations that the population's "good or bad years" have been very largely dependent on them. As typical examples we may mention the Lofoten and Finmark fisheries, in the latter of which the numbers have ranged between three and twenty-three million cod within the short space of three years.

We can show great variations even in the North Sea fisheries, although it is naturally very much easier for large steamers to follow and search for the shoals, than it has been for shore fishermen along the coasts of Norway to do so. The English and Scotch statistics point to striking variations in the catches of haddocks taken by the trawl. I will merely allude to Prof. D'Arcy Thomson's statistics of the catch by Montrose trawlers during the years 1896-1903. From these it appears that the average catch of haddock per vessel varied between such extremes as 1,300 and 3,250 cwt. in the different years. In the English statistics for 1905 a very comprehensive diagram is shown of the considerable variations in the catches of different sizes of haddock during the years 1903, 1904, and 1905. In 1903 there were quantities of small haddock, in 1904 and 1905, on the other hand, very few.

Closely connected with fluctuation is the important question whether or not the fisheries are constantly deteriorating. Complaints have been made unceasingly since the Middle Ages in all the lands bordering on the North Sea, that the fish supply has been falling off, and the outcry has always been greatest in bad years. But with the enormous increase in the fishing industry during the last decades, the problem has assumed proportions hitherto unknown. In the North Sea, Skagerack, and Cattegat especially, fears have arisen lest the fish supply has been affected by reckless methods; and for some time past the problems, over-fishing, close-time, and size-limit, have been busily discussed by scientists no less than by the fishermen themselves.

Before I attempt to show what light our investigations can cast upon these old burning questions regarding the life-history of fish, I will deal in a few words with the methods and means that we adopt. Our main object is to describe the haunts and wanderings of the fishes, as well as their growth and structure during their whole existence, from the time when they are born, scarcely a millimetre in size, to when they, once or oftener, reproduce their kind. But to be able to follow the life of the fish thus, from the egg to the mature state, demands an almost incredible amount of knowledge and hard work.

1. It requires, in the first place, knowledge of the species at every stage of its development, to be able to tell an egg, a larva, or a fry of any one kind from all the others. This has only become possible, so far as most of our more important sorts of fish are concerned, by means of the large collections made, and the studies carried on under the auspices of the International Federation. We are now in a position to tell nearly all the more important species of fish from one another during the whole or greater portions of their career[1]; and this result is due to the fact, so interesting from an ordinary biological point of view, that these species present special characteristic differences, sometimes in size and sometimes in their structure, during the whole course of their existence. A careful examination of their structure has even revealed differences between various varieties of the same species. Thus, the German Heincke pointed out a difference in the number of vertebræ and other bodily dissimilarities between the Spring Herring and the Dogger-Bank Herring, a discovery that enables us to discriminate between the two kinds.

   That the eggs of most food-fishes float in the sea, the herring alone being an exception, is now a fact generally known. The little eggs, about a millimetre in size, develop in a few days or weeks into larvæ only slightly larger; and these too remain floating, some near the surface and some at considerable depths, till they gradually, after a few weeks, acquire more and more the structure and appearance of the future fish. A month or so they continue suspended in the waste of waters, and then, if possible, seek the bottom, where they by degrees attain to maturity.

2. It is of the utmost consequence for our investigations to find out how fast fish grow, and how old they are at their relative sizes. Here, too, the operations of the International Federation have enabled valuable progress to be made.

[1] The systematic advance made during recent years in our knowledge of the cod family, with which we are chiefly concerned here, is pre-eminently due to Danish researches; and I would refer the student to the published works of the Danish scientist, Dr. Joh. Schmidt.

For the method first adopted to ascertain the age of fish we have to thank the Danish scientist, Dr C. G. Joh. Petersen. He

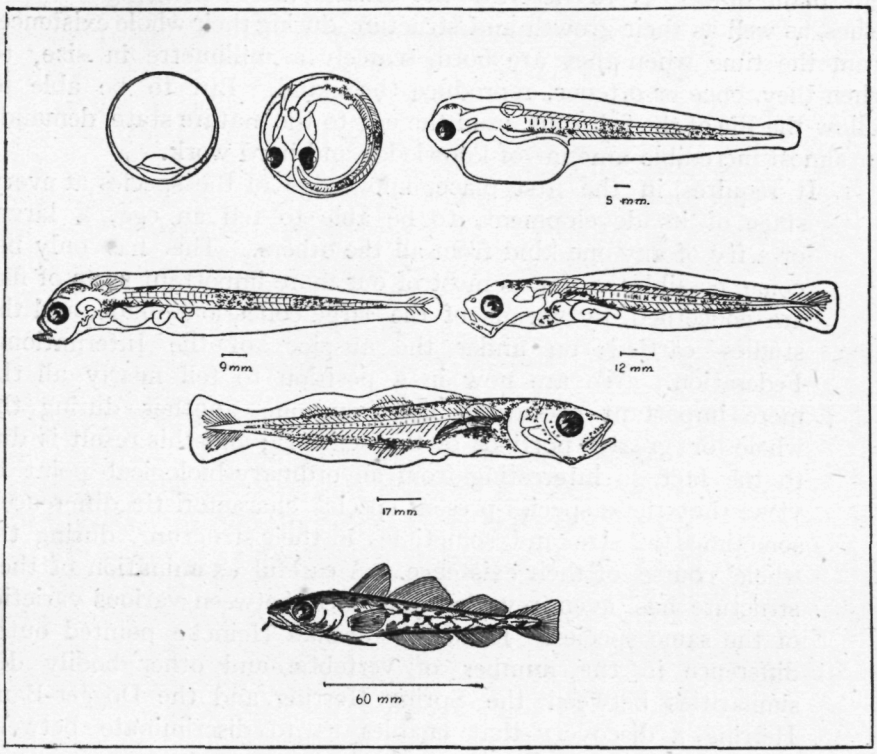
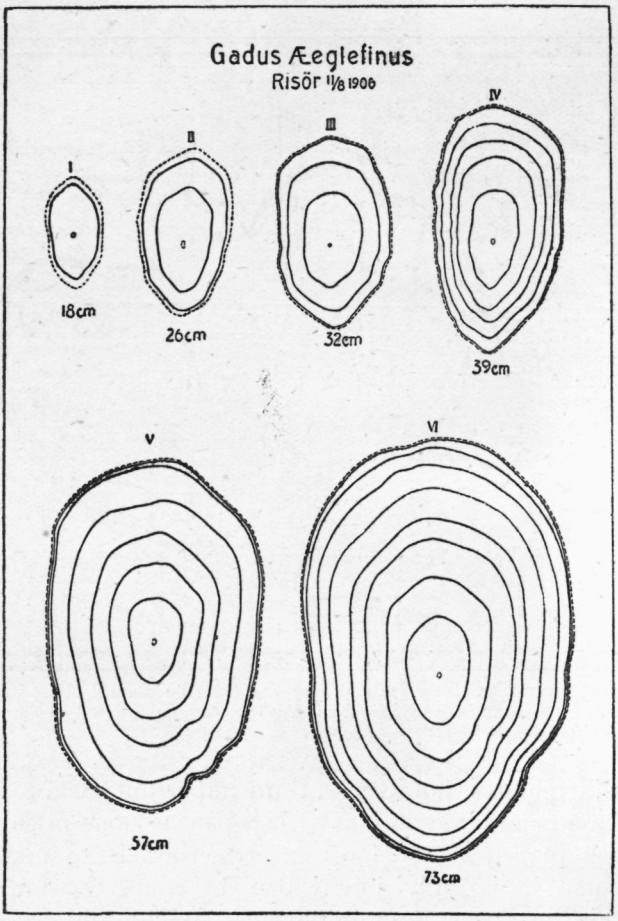


Fig. 1. A cod's development from the egg into fry 6 cm. long. From drawings by G. O. Sars.

found that when he measured a large number of specimens and arranged the results in a scale according to size, the measurements resolved themselves into certain groups, which he considered coincided in many cases with the age-classes. Accordingly, he called the ones born that same year the *nought-group*, the ones born a year before the *one-group*, and so on. But this method, though a great advance at the time, proved more and more unsatisfactory as increasingly difficult problems presented themselves.

It was, for instance, extremely hard, if not impracticable, to tell by this method the ages of the older groups, and at all the different stages there was very often great uncertainity as to the particular group to which an individual belonged. Another difficulty was that the same species was found to vary in growth considerably in different localities.

It was therefore a great step forward when the German Reibisch discovered that the otoliths of plaice showed age-rings



[1] Fig. 2. Scales of haddock at various ages.

similar to what are found on the stems of trees or the horns of cattle. Henceforward it became possible to tell correctly the age of each individual plaice. Later on, it was clearly demonstrated that not merely the otoliths, but many of the bones and, what is more, the scales showed age-rings—a fact which now enables us, with certainty and precision, to tell the age of every cod, haddock, saithe, herring, or sprat, as well as of many other species of fish.

Owing to these two great advances, that we have learnt to

[1] For this and most of the following figures we have to thank Messrs K. Dahl, D. Damas, and B. Helland-Hansen, reports of whose investigations will shortly be published.

recognise each species of fish throughout its whole career, and that we can ascertain the ages of all the most important kinds, we are now well equipped for tracing their life-history.

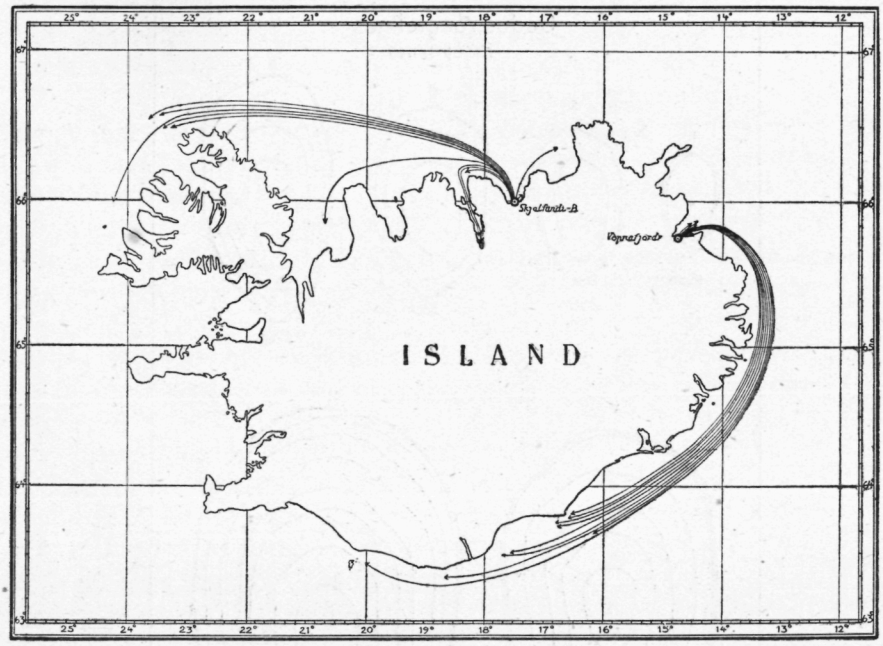


Fig. 3. Marking experiments from Iceland, showing that the mature plaice wander from colder waters (Vopnafiord and Skjalfandi Bay) to the southern and western shores to spawn. (From Dr. Schmidt's researches).

3. There still remains, however, a third important task, to investigate their haunts and wanderings. This can be done in several ways, of which the safest and most exact method is to mark the fish. Of course it is only practicable to mark larger specimens, and this has been done to a great extent and with excellent results Large plaice, for instance, have been found to travel long distances in the North Sea and to wander from the northern to the southern side of Iceland.

Still it is impossible to use marks for the younger classes, or even for the larger fish of certain species, so that the only method left is to fish for and examine eggs, larvæ, fry, younger and older growths at their different stages, and to study all experience thus acquired and therefrom deduce conclusions.

In accordance with this method the spawning grounds of the cod in northern Norway were in 1901 carefully examined. A number of tow-net hauls were made in all directions among the banks off

the coast, and large quantities of floating eggs were obtained. On counting these eggs after each haul, it was found that a haul of five minutes duration, with a little silk tow-net one metre in diameter, showed thousands of eggs floating over those banks thirty to forty fathoms deep, where the fish spawned and the fishermen took spawning cod. None, or scarcely any, were to be found, on the other hand, in the deep channels between the banks.

Thus our investigations into the distribution of the spawn enabled the spawning-grounds to be accurately defined. Nay, we even succeeded in finding masses of eggs upon one bank that had hitherto been unfished, and which yielded afterwards, in the same season, no less than one and a half million cod: thus showing that our system could have a practical as well as a scientific side.

By carrying out hundreds of experimental trawls for young fish over the whole North Sea and large parts of the Atlantic, the Danish scientists ascertained that the larvæ of the eel were only to be found in the deep portion of the Atlantic, and far-reaching conclusions could accordingly be deduced as to the wanderings of the full-grown eel and its young.

We can similarly determine their wanderings by noting the variety of sizes of fish on any one bank. When we find a far greater number of large cod in the southern part of the North Sea during the winter than in the summer, we naturally infer that these large cod have wandered there. Doubtless it stands to reason, that the fishermen get their observations and opinions in just this way; and most of them can tell from such observations at what season to expect the various sorts of fish which wander over the regions of the sea.

But science works under far more favourable conditions. The fisherman must trust his memory for his knowledge. The scientist notes each age and size exactly, and perceives differences that would quite escape a fisher's eye. Of this I shall have more to say later on.

4. A fourth group of methods indispensable to proper investigation into the life-history of fish consists in chemical and physical determination of the properties of sea-water. By these methods we get to know the conditions of temperature amidst which fish live, the chemical composition of the different layers of water (such as their salinity), as well as their currents and other important movements. This study will explain many of the wanderings, and especially the wanderings of the younger classes, which as fry are swept helplessly along; and it will further widen our knowledge, by showing us the bounds—imperceptible to the eye—between the

different layers of water, which in many cases explain the behaviour of different species and varieties of fish.[1]

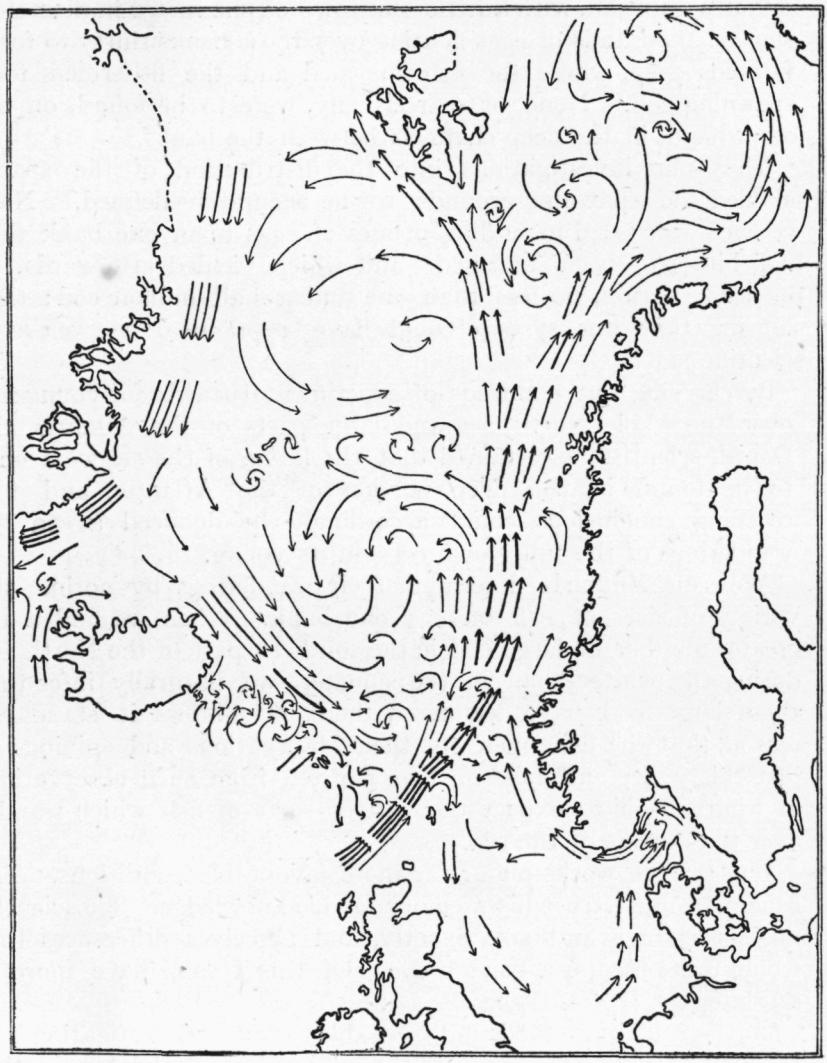


Fig. 4. The currents in the North Sea and Northern Sea (from Helland-Hansen and Nansen's observations). The thick arrows along the West Coast of Norway show the Gulf Stream. Off Greenland and East Iceland the Polar Stream can be seen going south.

In Norway, in particular, the exhaustive researches made in the

[1] The Swedish scientist, Mr O. Pettersson, especially merits our praise for the way in which he has succeeded in developing hydrographical methods; while, since the institution of joint operations between the different countries, the Central International Laboratory, under the guidance of Dr Nansen, has also introduced many improvements. Mr Ekman's velocimeter, for instance, which measures the velocity and direction of currents, is particularly worthy of mention.

Northern Sea have been of the utmost value, and we shall in a short time make public an interesting report by Dr Nansen and Mr Helland-Hansen. The latter gentleman has also made important measurements of the velocities of currents over the great edges and banks, as well as in the fiords and the North Sea; and, thanks to his exertions, we are now in possession of facts that were previously quite unknown. The same work has also been carried out by Swedish scientists in the Skagerack, and by Dutch scientists in the North Sea.

Even within the confines of these methods we have acquired no small amount of fresh experience. Ideas formerly held about the direction and strength of currents have been much modified within the last five years, and have in certain cases been quite revised or put on a surer foundation.

Having thus glanced at the more important methods of work by means of which science endeavours to unravel the whole life-history of fishes, I will now discuss a few observations which these methods have placed beyond doubt, confining myself to some out of our many discoveries.

I am going to take only such examples as are best calculated to throw light on general questions, which I will finally endeavour to elucidate. And I must here observe that I am merely selecting the most important kinds—viz., the herring, saithe, cod, haddock, and with this last, to some extent, the plaice.

We will commence by considering a few noteworthy points in the natural history of

THE HERRING

ROUND all the coasts of the North Sea, Skagerack, Cattegat, and Baltic, herring-fisheries are carried on, and along all these coasts the herring is one of the most important industrial fishes. Its natural history therefore, and more especially its capricious appearance near the land, has always been a matter of great importance. Another momentous question which has attracted much attention has been that very different shoals of herring have been found to make their appearance along the various shores. The practical fisher has for long discriminated between herring from the Dogger Bank, from Shetland, from Skagerack, and from the coast of Norway; and in this last case again, he has learnt to distinguish between spring herring, large herring, fat herring, and so on.

Preliminary investigations threw no light upon all this. It was merely possible to declare, like the practical fisher, that the various shoals showed

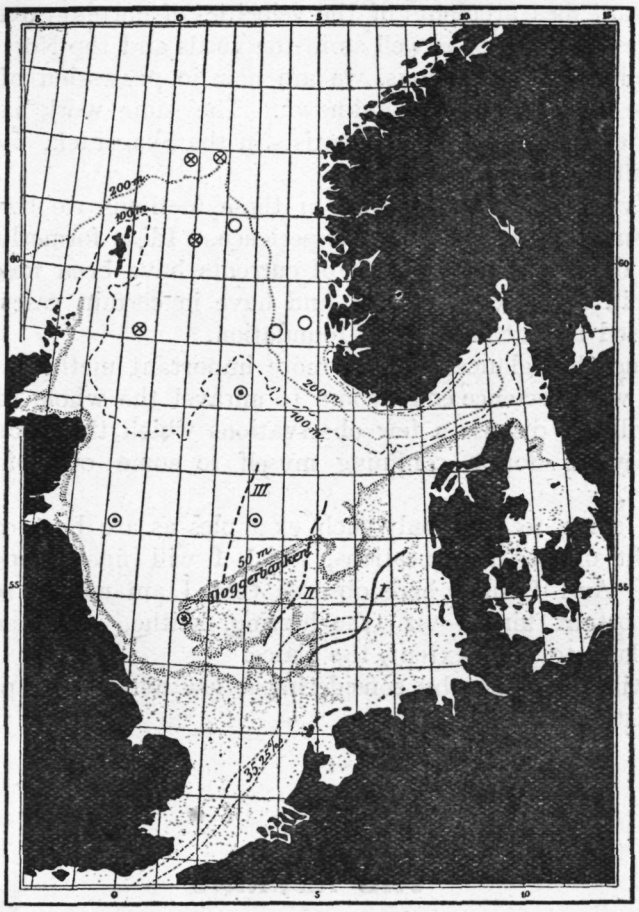


Fig. 5. Distribution of different shoals of herring in the North Sea. A ring denotes Norse Herring. A ring with a dot denotes Dogger Bank Herring. A ring with a cross denotes Shetland Herring.

certain characteristic differences ; as, for instance, that the Shetland and Dogger Bank herring spawned in the summer and autumn, while the Norse Coast herring spawned in the spring, and that the fat herring were never found with mature roe or milt.

It was a great advance when the German Heincke published a long series of results obtained from a study of the different shoals of herrings.

After the most painstaking and laborious study he succeeded in

showing that there really were considerable distinctions in the structure of the different sorts. He found, for instance, that the Dogger Bank

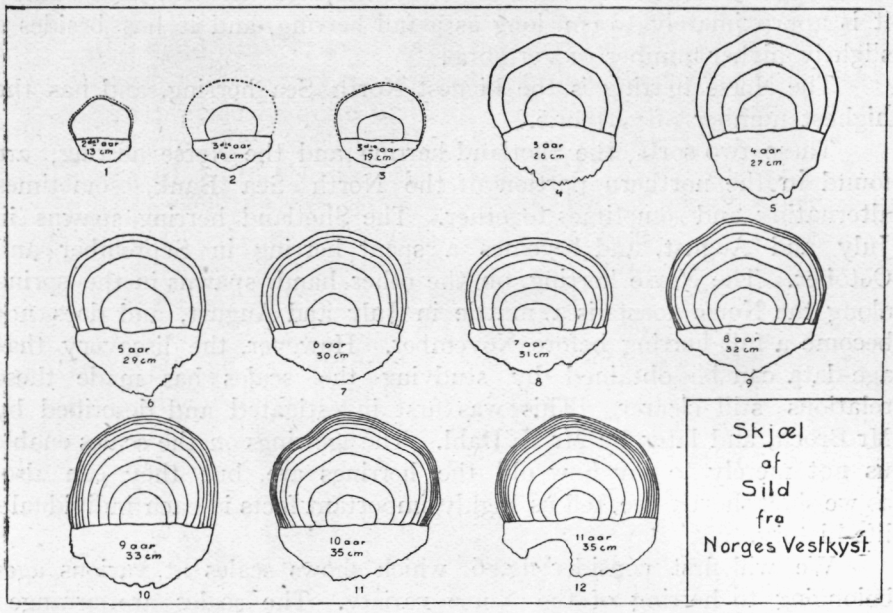


Fig. 6. Scales of herring from two to eleven years old.

herring (which he called the Northern Bank herring) had a smaller number of vertebræ than the Norse spring herring. His studies were, however, more directed towards establishing a definite method than towards trying to depict the distribution of herring shoals in the sea. Large quantities of specimens were sent us from the different countries, and these were examined by Mr Broch in the Norse Fishery Board's laboratory.

To achieve this latter task became obviously the aim of the International Research Federation, and herrings were accordingly captured throughout the length and breadth of the North Sea, with a view to show what kinds were in existence.

I show a chart (Fig. 5), to give an idea of what was effected in this manner, from which it will be seen that on the Dogger Bank, off the east coast of England, on the Great Fisher Bank, and I may add, in the southern portion of the Skagerack, there is a sort of herring—or perhaps I should say a group of shoals—which is essentially different from the others. These herrings are comparatively small—about 24-25 cm. long; and, as is well known, they are full herrings in August, and have a low number of vertebræ (56).

In the northern portion of the North Sea, on the west side towards

Scotland and the Shetlands, there is a variety of herring called the Shetland herring, which in many characteristics comes midway between the Dogger Bank herring and the Norse herring. In size, for instance, it is approximately 30 cm. long as a full herring, and it has besides a slightly higher number of vertebræ.

The Norse herring is the biggest North Sea herring, and has the highest number of vertebræ.

These two sorts, the Shetland herring and the Norse herring, are found in the northern portion of the North Sea Bank, sometimes alternating and sometimes together. The Shetland herring spawns in July and August, and becomes a spent herring in September and October. The Norse herring, on the other hand, spawns in the spring along the Norse coast, is a mattie in July and August, and does not become a full herring before November. However, the discovery that age-data can be obtained by studying the scales has made these relations still clearer, This was first investigated and described by Mr Broch, and later by Mr K. Dahl. The age-rings on the scales enable us not merely to say how old the herrings are, but they can also, as we shall shortly see, tell us highly important facts in each individual's life-history.

We will first consider fig. 6, which shows scales at various ages belonging to herring of the Norse variety. The scales are arranged according to age, and each scale is drawn to a size corresponding to the size of the fish. From the figures we see that the growth is regular till the fish is about four or five years old, when a very much weaker growth begins. The rings become closer and closer in the advanced age-classes (8-11 years). The different scales no doubt do not present an uniformly homogeneous appearance ; and the growth in one scale may be perhaps somewhat greater than in another, still, taking everything into account, the scales depicted—like many thousands of others that we have examined—invariably exhibit the same type.

This becomes even more obvious, if we examine the scales of other kinds. Another set of figures (Fig. 7) shows three scales of each of four kinds of herring—viz., the Norse Fiord herring, the Norse spring herring, the Skagerack herring, and the Shetland herring. In the case of each of these four kinds we have taken the scale of a five year-old, a six-year old, and a nine-year old specimen.

Now if we compare these three groups of contemporary scales, which have all been drawn proportionately to the size of the fish, we observe first of all that their size varies noticeably, and on closer inspection we find that this is due to a distinctive difference in the conditions of growth. While the growth of the spring herring, as previously mentioned, was strong and regular up to the fifth or sixth year, the growth of the Fiord herring is on the whole far less and is sooner checked.

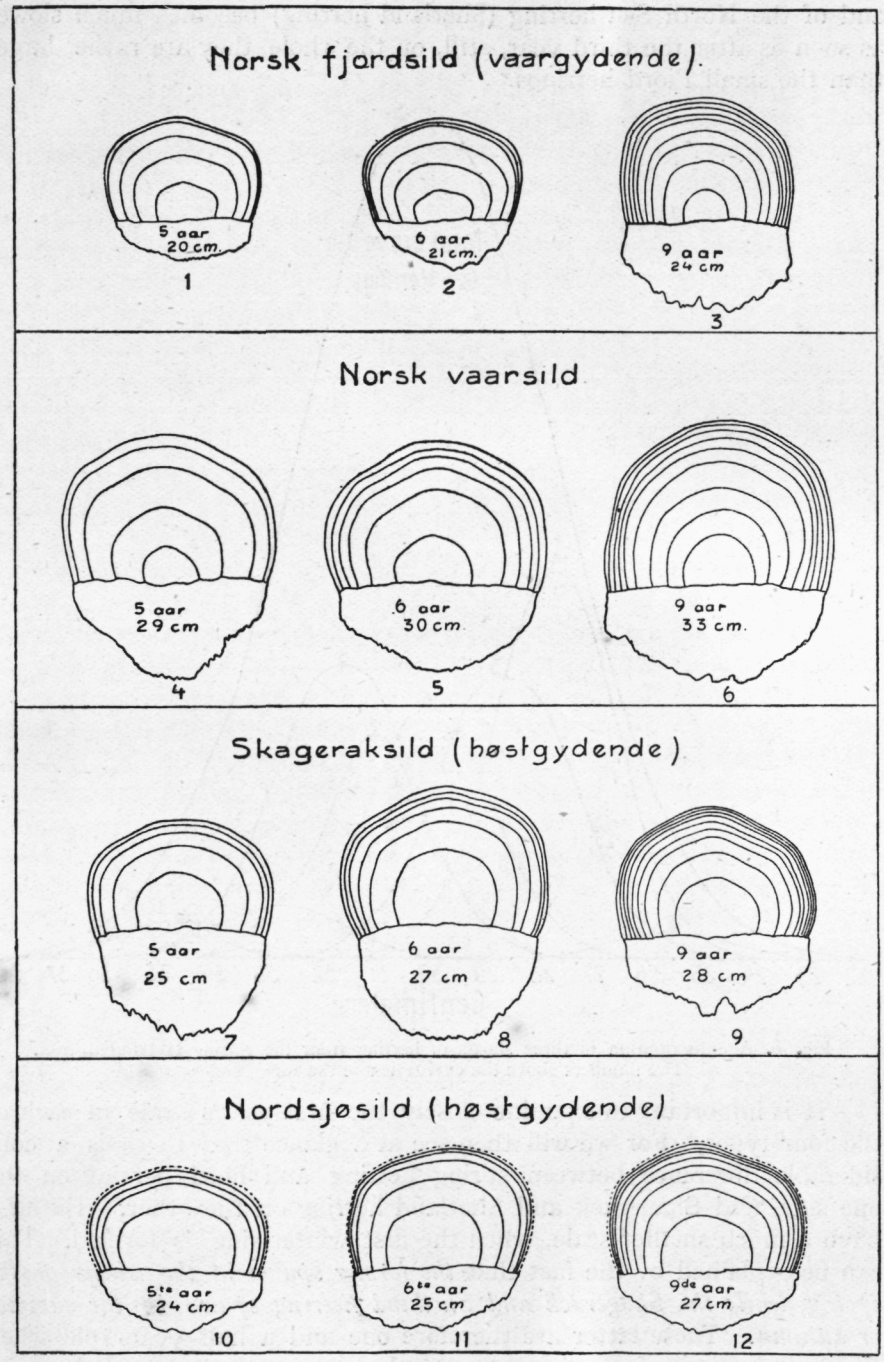


Fig. 7. Scales of various types of herring.

See, for instance, the six-year old scale. The growth of the Skagerack and of the North Sea herring (Shetland herring) becomes much slower as soon as after the third year, still, on the whole, they are rather larger than the small Fiord herrings.

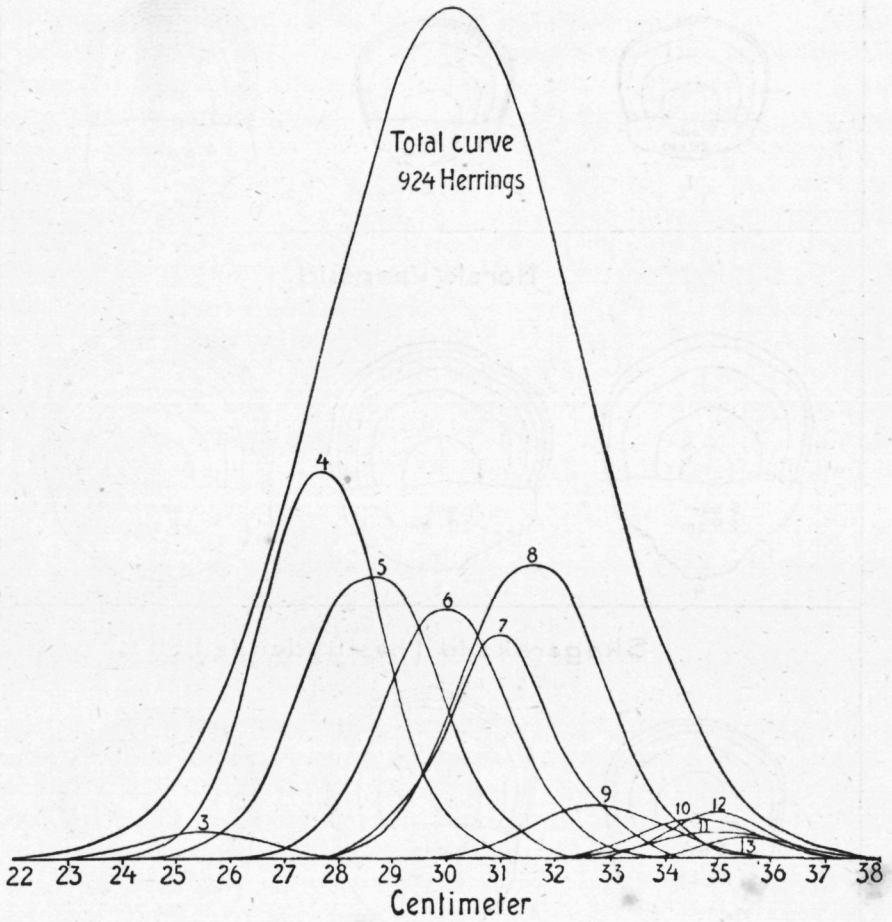


Fig. 8. Age-distribution in three shoals of herring from the Spring-Herring district. The numbers above the curves denote the various ages.

It is important to examine closely the first year's scale in each of the four types. For we will then see at a glance that there is a considerable difference between spring herring and fiord herring on the one side, and Skagerack and Shetland herring on the other. The first have a much smaller scale, when the first winter-ring is formed. This can be explained by the fact that *the former spawn in the winter or the spring, while the Skagerack and Shetland herring spawn in the summer or autumn.* These latter are therefore one and a half years old when the scale forms its first winter-ring, and consequently are much larger.

We can thus distinguish a winter or spring spawning herring from one that spawns in the summer or autumn, a point of the utmost value, since we are enabled, in localities like the Skagerack and North Sea, to sort out each single herring of the two varieties, and obtain accordingly a much surer method than the old body-measurements for tracing the wanderings of the different shoals. We could even tell out of a catch made in the Skagerack, and out of another at the Viking Bank, which herrings had been born on the Norse coast. And by this method, after repeated experiments with the drift-net, we will be in a far better position to demarcate the distribution of the various shoals than I should have thought was possible, at any rate as far as the North Sea was concerned.

The same holds good for the southern part of the North Sea, where both spring and autumn spawning herring are to be found. For instance, there is a small variety of herring near the coast off Lowestoft that spawns when three or four years old, and attains a size of 20-26 cm. This variety has quite a little scale in the first year of its existence, a very big one in the second year, and then the growth begins steadily to decrease. It can therefore be easily distinguished from the Dogger-Bank herring.

But by these studies of the scales we decide not merely the age of the herring and its variety, we can also attack a venerable and much debated problem, the so-called *age-distribution in a shoal.*

Let us go back once more to the spring herring, and look at a haul of 924 specimens, taken this year in three casts at distances of a few miles from one another. If we denote the measurements of all these herrings by a curved line, we get a large connected group, while our graph shows at the same time the herrings in the mass. But by defining the ages, we find the herring to consist of no less than eleven age-groups—viz., fish from three up to thirteen years. As you see, there are extremely few in the 3-groups, but many between four and eight years. And it is of more than ordinary interest that in all the three casts, which were made at considerable distances from each other, the proportion between the different age-groups was practically the same. In all, for instance, the 8-group was far more numerously represented than the 6 or 7-groups,

Accordingly, we venture to conclude that, at anyrate in its main features and up to a certain degree, this haul represented the age-distribution of such herring as were being caught at the same time, for they were not taken in gill-nets, but in seine-nets, which retain fish of every size and kind.

I shall deal later on with some valuable lessons that may be derived from these observations. Suffice it to say here that, whereas the spring herring is thus a spawning fish from 3 to at least 14 years old, we have found the mattie to be a young herring from $1\frac{1}{2}$ to 4

years old, and that therefore this question is definitely settled once for all.

I now come to :—

THE SAITHE[1]

THANKS to the work at many hundreds of observation-stations where fishing experiments have been carried out with pelagic tow-nets,

Fig. 9. The dotted portions indicate the localities where saithe eggs are to be found. The shaded parts of the coasts show where young saithe are met with.

[1] Many of the investigations to which we shall allude in what follows will be more fully described in a treatise by Dr Damas, on the researches carried out during recent years by the "Michael Sars." Dr Damas has himself examined the greater part of the material that has been collected.

we can now quite safely assume what has been long known to fishermen, that the saithe only spawns in the early months of the year at depths of 80 fathoms, or let us say in water 150 metres deep. This means that the fresh spawn is not to be found except in the northernmost part of the North Sea Bank, and along the Edge, or over the deeper portions of the Romsdal Bank. A little north of Romsdal all spawning ceases, and in the whole of northernmost Norway, in the fiords, and in the Skagerack, we find only a few scattered eggs. The

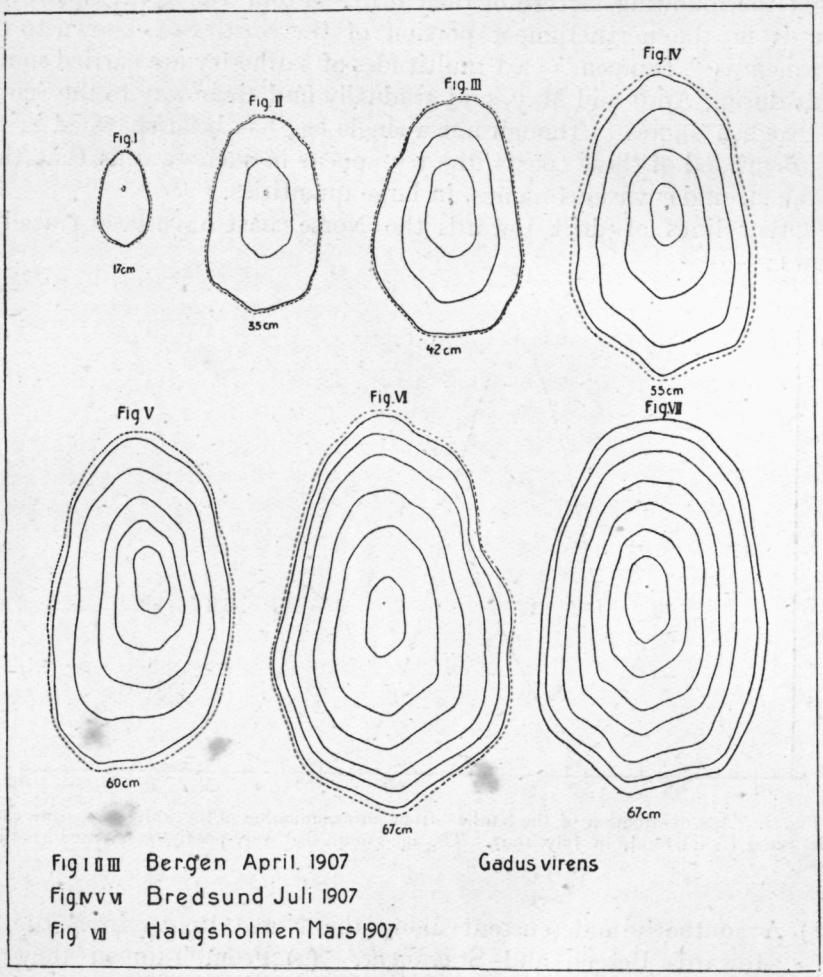


Fig. 10. Scales of saithe at various ages.

distribution of saithe eggs coincides accordingly with the 150 metre curve of depth, and even then is dependent on the water having the high salinity of 35 per mille.

From this spawning-line the larvæ and tiny fry are swept by the currents towards land; and such eggs as are spawned off the Norse coast—for instance, near the Rent—being nearest land, reach the shores of Norway as early as the month of May. Others, however, may be carried many hundreds of miles, and continue their development as they go; and saithe-fry have been taken in the month of September (1900) over the great deeps between Bear Island and Norway.

Summing up all that we have learnt through catching fry and larvæ, we get the following picture of their drift. From the great spawning-grounds in the northernmost portion of the North Sea, known to the fishermen as "Tampen," vast multitudes of saithe-fry are carried southwards during April and May, and gradually find their way to the Scotch and English shores. Though not a single egg has been spawned in the neighbourhood of these coasts, the fry appear in such swarms that they are taken, under various names, in large quantities.

Other lines of drift towards the Norse coast have been traced as follows:—

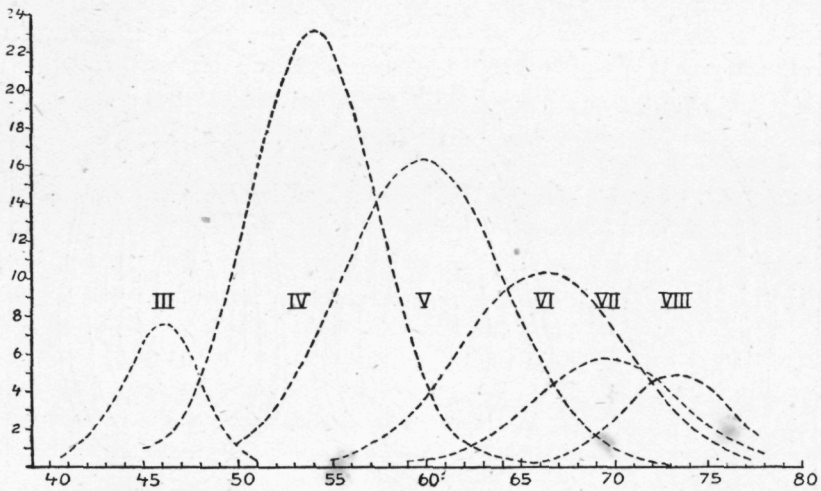


Fig. 11. Age-distribution of the Saithe—from an examination of the scales of 654 fish caught at Bredsund (Sondmore), in July 1907. The age-groups that were poorly represented have been left out.

(1) A southerly undercurrent along the Norse Rent carries the fry towards Bergen and Stavanger. (2) From Tampen they are borne towards the land to the north of Stat; and it has been even possible to trace an uninterrupted floating mass the whole way. (3) Investigations north of Shetland make it extremely probable that they are carried from the Atlantic into the North Sea, and that the fry taken outside the Great Edge, which

have drifted passively towards Norway, come right from the Atlantic and Britain's western coasts.

The result of this drift is, therefore, that vast masses are carried to places where they were never spawned—to Scotland, to England, to Norway, from Lindesness to Finmark in the North, and into all her fiords. In these latter they appear in such incredible quantities, that a few casts with a little seine in the Borgund fiord near Aalesund, resulted in a catch of no less than 25,000 fry.

One result of the direction of the currents is that in the southern portion of the North Sea, there is a complete absence of fry, that the Skagerack is only poorly supplied, and that in the Christiania Fiord they are not to be found. Hydrographical circumstances explain this; for the salt ocean-water in which the saithe spawn, only comes into the Skagerack along the bottom. That the saithe can thrive in the Skagerack has been proved by the fact that such specimens as are found there, grow far better than saithe-fry in localities where they most abound.

So then we see in the life-history of the saithe a striking example of the power of ocean-currents to carry fry from the Atlantic or North Sea to the Arctic Ocean; and we also make the highly important discovery that stretches of coast, hundreds of miles in extent, are dependent for their fish-supply upon spawning in distant waters.

Owing to the different conditions of its growth, the fry that now develop along the Norse coast, and as far north as the Murman coast, afford us much matter of interest. We find that in the more southern regions fry grow with far greater rapidity than in higher latitudes. We may state, as an example, that saithe in the second year (1½ years old) from the Skagerack coast, can be already as much as 36 cm. long, while saithe in the third year (2½ years old) from Finmark and the Murman coast are found to be only 28 cm. long. This will explain at once why the youngest year-group, "the small saithe," is only fished for off the west coasts of Norway as far as Romsdal but no farther. Beyond that the small saithe in the autumn are too small to be worth the catching; but south of Romsdal the fishermen catch and salt many barrels of small saithe, the O-group, in the fall of the year.

Just as we can tell the age of the herring, so we can ascertain by the scales the age of the saithe, or, at any rate, can safely do so up to fifteen years. Over fourteen or fifteen the additional growth is so small that is difficult to define the age accurately to a year. The scales then give the impression that the fish has finally reached old age. It can be seen further from the figure that the growth of a saithe is fast and regular, and the curve of growth accordingly shows an uniform ascent and descent.

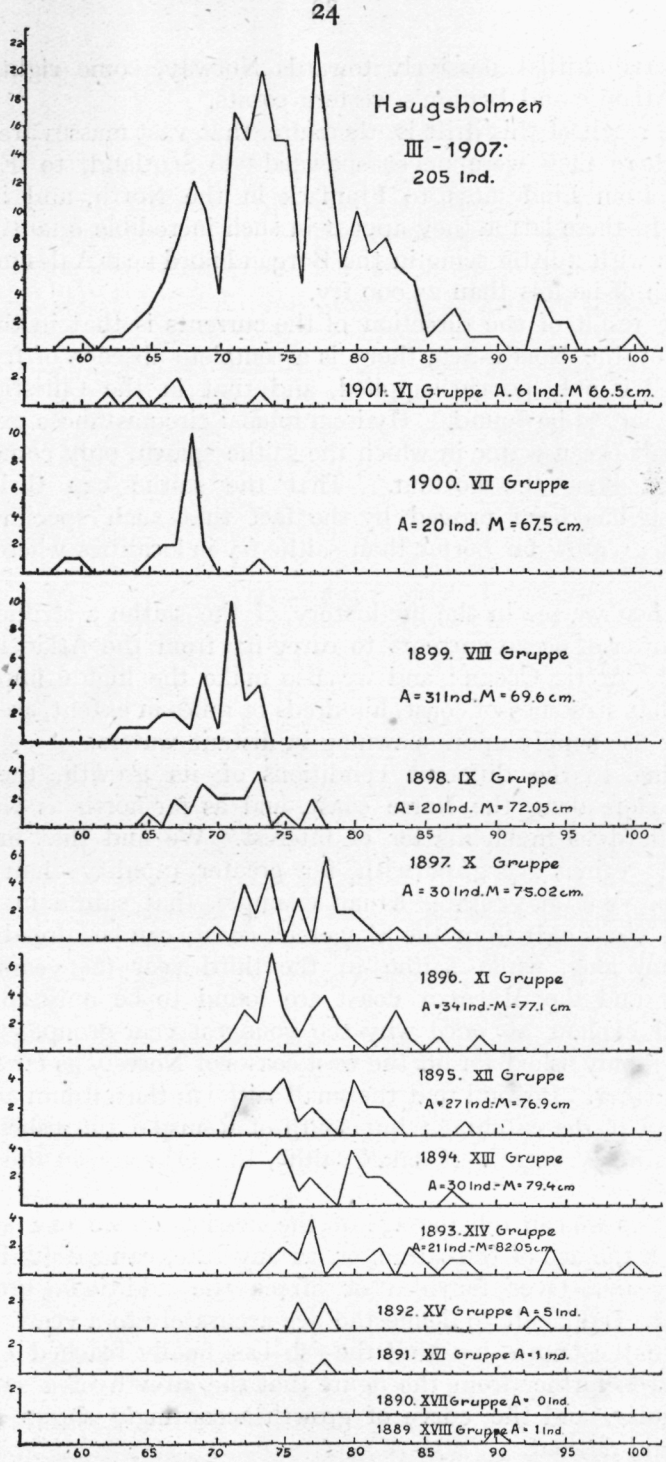


Fig. 12. Age-distribution in a catch of saithe at Haugsholm (Sondmore) in March 1907. The top curve gives the whole catch (205 fish), and each of the other curves deals with a definite year-group (the year of birth being also shown). *A* denotes the number of individuals, and *M* denotes the average length.

I shall exhibit two figures to illustrate the age-distribution in a haul of saithe.

One is from a catch with a sink-net in the summer, which consequently consisted of non-spawning fish; though previous experience leads me to believe that it represents the younger spawning year-classes, or the groups from three to ten years. It will be seen that there are comparatively few specimens of the first group, probably because all saithe do not become mature at the same age.

The other haul was made at Haugsholm, near Aalesund, in the winter. It represents the largest spawning fish, and even shows saithe up to eighteen years old—that is to say, fish that may be assumed to have spawned fifteen times. The oldest specimens showed clear signs of old age, as, for instance, in the structure of the scales.

THE COD

HARD painstaking work has shown that the floating cod eggs are spawned over far wider tracts and at more varying seasons than the saithe eggs. In the southern parts of the North Sea, along the English coast, in the Skagerack, in the Belts, in the Norse fiords, on the banks of the Norse coast right up to Finmark, in the Faröe Islands, and along the southern side of Iceland, large quantities of cod eggs have been discovered. German and Danish researches in particular have considerably enlightened us as to the locality of cod eggs in the North Sea. Danish researches in Iceland have shown that the eggs are found only along the south side, and Norse researches along the coasts of Norway have made it absolutely clear where the spawning of cod-eggs takes place there.

The spawning of the cod differs from that of the saithe in that it takes place in much shallower water, and therefore much nearer the coast. It even occurs within the fiords, though there are far larger masses spawned outside them. Seeing that it takes place nearer the coast, the fry have less difficulty than the saithe fry in reaching tidal waters. So we find cod fry in shallows along every coast, both round the whole North Sea, the Skagerack, the Norse fiords, and in the Arctic Ocean. However, a great drift takes place also, and masses are carried for great lengths of time and for long distances in the sea, while some are even borne along by the deeper layers of water.

This has been made clear by experiments carried on in northern Norway. The newly-spawned eggs were found in March and April strictly limited to the adjacent banks, while the small fry were found by the month of June scattered far outside these banks, and in August

and September, fry, several inches long, were found floating over the greatest deeps of the Northern Sea, more than one hundred nautical miles from the nearest land. Owing to the direction of the ocean-currents these fry were thought to have come from far south, perhaps even from the Romsdal Bank or the North Sea.

Those which are carried thus over great deeps seek the bottom in deeper water. In Skagerack, for instance, small one-year-old cod have been found at 30-40 fathoms, and in the Arctic Ocean young cod have been found at a depth of 150 fathoms.

The rate at which the young cod grow varies according to the surroundings in which they find themselves. In the southern portion of the North Sea and in the Belts they grow with great rapidity, and attain a length of 20 cm. even in the first year; while cod fry have been found a year old and only 4-5 cm. long in Skagerack, and in many places along the Norse coast the average size is between 7 and 8 cm. The same difference in growth is also found in the later years.

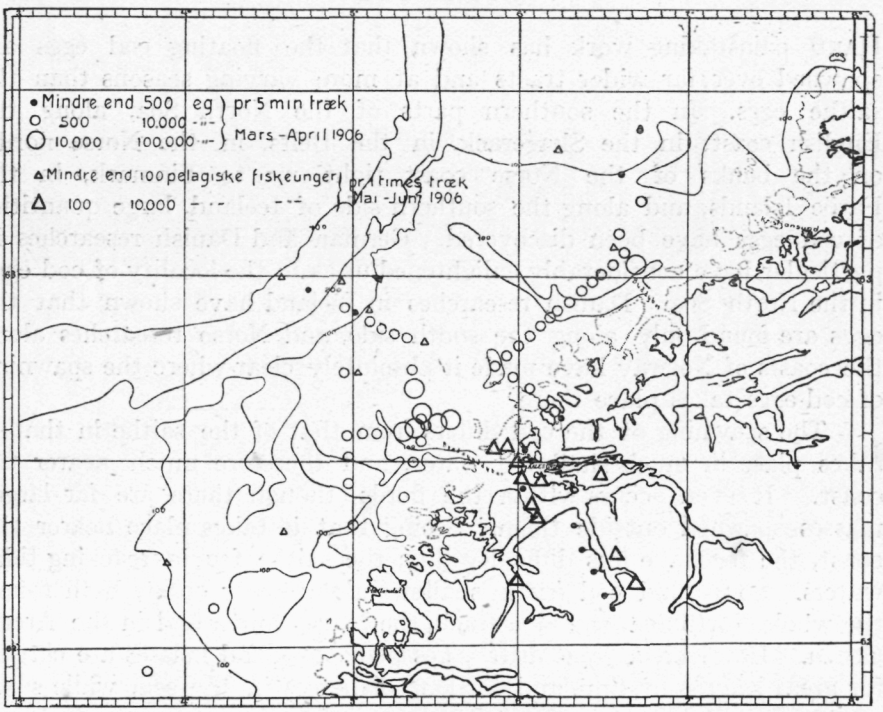


Fig. 13. Distribution of eggs and fry of the cod species off Sondmore and Romsdal.

Although it is not so easy to tell by the scales in this instance as it is with saithe, it is yet possible to ascertain the age in many cases; and at all events the following is an indisputable fact. In the second and third

years the cod continue to grow rapidly, but from the fifth year they show considerable differences in summer and winter. In the Norse fiords cod have been found nine years old; but the bulk are only from 3-5 years old.

Cod spawn exceptionally after the second year, but as a rule do not commence till the fourth year. This holds good also with cod in the Danish Belts, where mature fish 30 cm. long are found which spawn in the third year. In the North Sea, on the other hand, the spawning fish are much larger, and most of them do not mature till they have attained a size of 70-80 cm.

Quantities of material have recently been collected from the Skagerack and from Finmark, so that we are now perfectly well aware how old the "Skrei" or Finmark cod is in different localities. It has not, however, been possible yet to treat the whole of this material, and I will merely mention that the smallest spawning cod from the Lofoten fishing this year were about 70 cm. long and were 6-7 years old; and that some of the largest of our specimens were about 117 cm. long, and proved to be 16-17 years old. Hence we see that many cod may be assumed to spawn 11-12 times in their lives.

We have a vast amount of material also throwing light on the wanderings of the cod, partly statistical studies of the catches of the fishermen, and partly marking experiments. We know from German statistics that large cod appear in the North Sea during the winter on the shallow south banks, and that they disappear again in the summer. We know from Norse statistics that large cod are caught in Finmark in the summer, and on the Skrei Banks in the winter. We know further that the most extreme fluctuations occur from year to year from as far north as Spitsbergen down to the spring-herring districts. We know from Danish researches in Iceland that the large spawning cod collect to spawn along the south shore in the winter, and that they are caught off the north shore in the summer. Marking experiments have also shown that they pass in and out of the fiords, and move along great stretches of our coasts.

THE HADDOCK.

THE haddock spawns in the northern portion of the North Sea in deepish water. This fact is attested by all the Research steamers that have worked there. The Germans have actually published a map showing the connection between the cods' spawning near land and the haddocks' spawning upon the deeper more northerly banks.

The young of the haddock grow rapidly, and remain pelagic during May, June, and July. During all this period, especially in the month

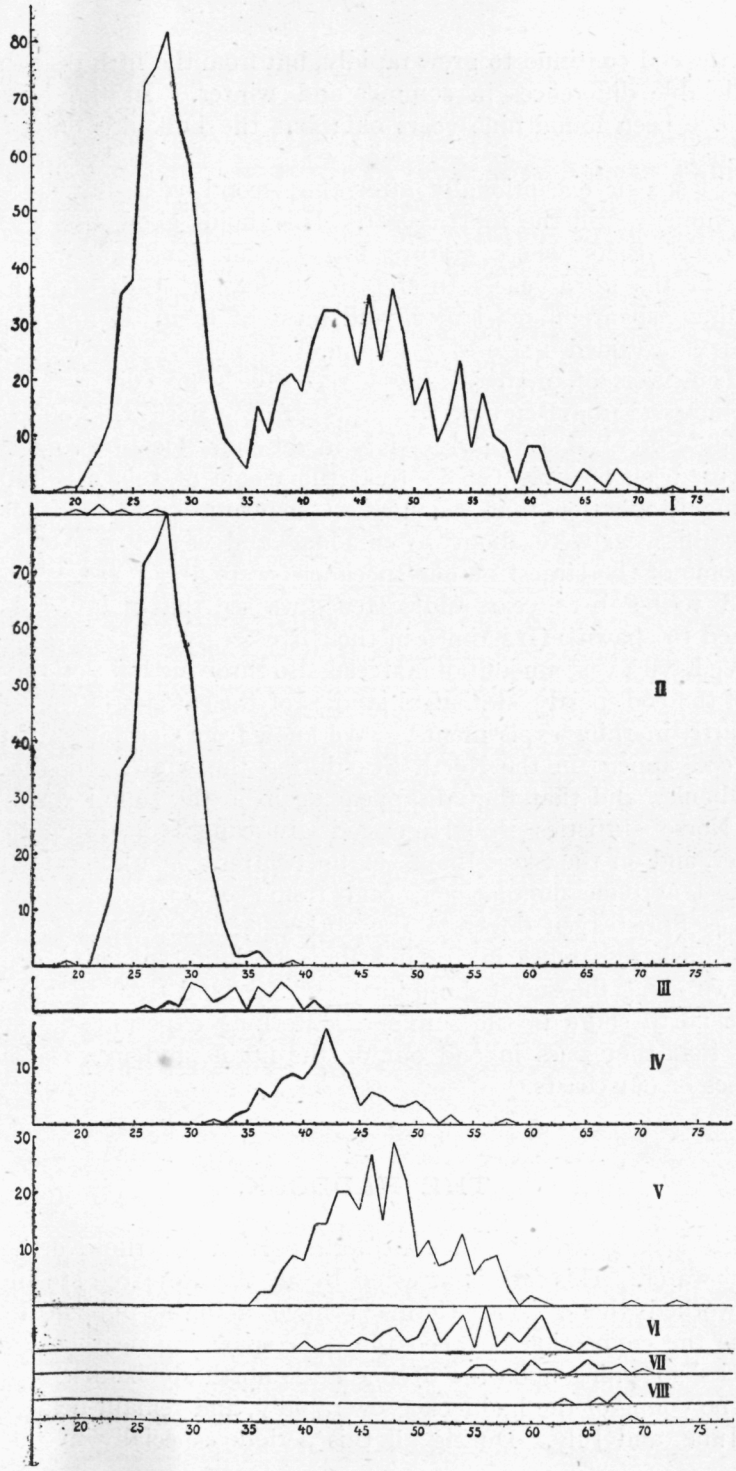


Fig. 14. Haddock from the Skagerack (July-October 1906). The first curve shows collectively all the individuals examined. Each of the other curves shows a year-group, which is indicated by Roman numbers. I denotes fish born in 1905; II fish born in 1904; III fish born in 1903; and IV fish born in 1902; and so on.

of July, they are carried out of the North Sea in myriads, and are driven, some towards the Norse coast, some into the Skagerack, and some northwards to the Northern Sea. Here we have repeatedly, during our cruises, found drifting fry. As can be seen from one of our maps, where only the first year's stations are put down, we have taken numerous observations in the Northern Sea of drifting haddocks, which may come either from the North Sea or from the Atlantic.

This drifting takes place even more in the case of whiting, which, it is certain, only spawn in small quantities along the Norse coast north of Strat. Much the larger portion of the swarms of little whiting which are found there have indisputably been produced in far more southern waters. By simultaneously observing the fry and measuring the currents, we have been able to settle this point beyond all doubt.

The age of a haddock can easily be told by its scales, so that we have therefore been able to compare its growth at the various ages in different waters and at all seasons. I will now proceed to give a few examples.

Sufficient material has been collected from Norway to put us in possession of the whole life-history of the haddock. Experiments with the trawl at Aalesund in 1906 showed that in the winter, when its growth is arrested, the year-old fry is 13-14 cm. long ; the 1-group is 21-22 cm. ; and the 2-group 30 cm., or a little over. The 3-group was 36 cm. last autumn. These small haddocks are fished for, and side by side with them are found also older individuals, which run up to 76 cm. long. So that altogether there are groups from two to eleven years old, which are all systematically fished for, both in the fiords and out on the coast banks.

The growth of these fish has been found to be about 10 cm. a year for the first year or so, but it afterwards decreases as they approach the higher ages (11 years). However, they grow irregularly, and some year-classes may have a greater or lesser increase than the average.

The largest fish among our material were obtained last year at Hull, out of a catch from a trawler that had returned from the White Sea. They were 55-80 cm. long, and their age was from 9-14 years. The scales of these haddocks, as far as the older year-classes were concerned, showed very slight growth and a poor structure—the characteristics of old age. In the material from the Skagerack the growth appears fully as large as in the case of those taken from the Norse coast.

What interests us most is the division of the different age-classes that we find in a large number of specimens collected by line-fishing last year off the Norse coast in the Skagerack. We discover here that two of the year-classes—the years 1902 and 1903—are much more scantily represented than either the years before or after. Nor is this due to mere chance, seeing that our trawling over at the Jylland Bank in the Skagerack gave the same results.

In a similar manner Swedish trawling has shown that in different years the fry vary considerably in the Skagerack, and the same was found to be the case in the years 1903-1905,[1] when researches were made along the coast of the Skagerack and in the Norse fiords leading into it.

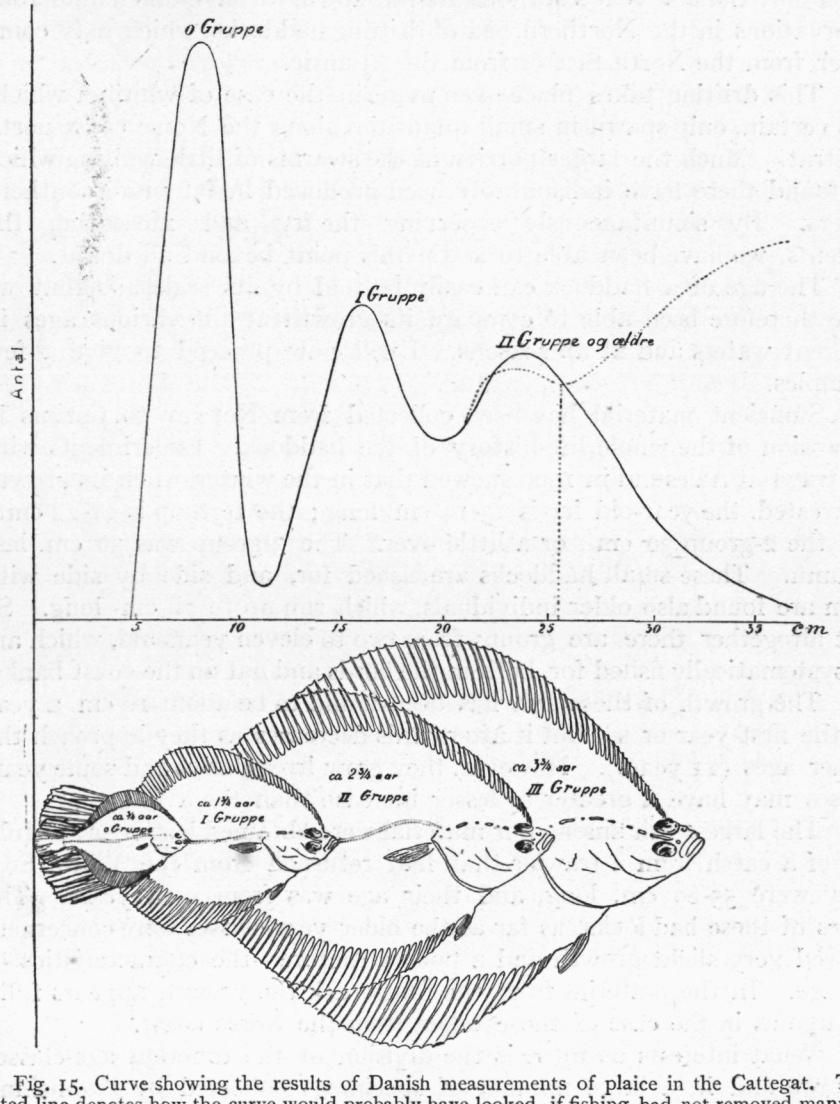


Fig. 15. Curve showing the results of Danish measurements of plaice in the Cattegat. The dotted line denotes how the curve would probably have looked, if fishing had not removed many of the larger sizes. (From the Danish scientist Dr A. C. Johansen's report).

What particularly attracted our attention was the fact that the year-class born in 1903 was always the least in evidence.

[1] *See* Mr K. Dahl's pamphlet: "On the value of artificial cod-hatcheries in the eastland fiords." —Annual Report on the Fisheries of Norway, 1906.

We have plenty of material also from the North Sea. Not only are there the copious statistics showing catches made by regular trawlers, but the Research steamers carried out many hundreds of experiments with the trawl, and most of the fish taken by these means were measured. Over six hundred of these trials were made with trawls of the same dimensions, and the material collected was placed at the disposition of the English and German scientists.[1] The Norse Research steamer, too, collected material from every quarter of the North Sea with a view to solving the age question.

Our examination of this wealth of material has at last been concluded, and the following are some of our principal discoveries.

1. The growth varies considerably in different parts of the North Sea. Thus, in the same month, Dogger Bank haddocks will be larger than those caught on the deeper banks in the northern portion of the North Sea. Different years, again, seem to show a different growth. Haddocks, for instance, in the years 1902 and 1903, were smaller than haddocks of the same age in the years 1905 and 1906.

2. It would appear to be the general conclusion arrived at, as a result of these six hundred trials in every quarter of the North Sea—no less than from the Norse experiments—that there is a preponderating quantity of younger fish of the ages $1\frac{1}{2}$ and $2\frac{1}{2}$ years; and we ourselves are decidedly of opinion that the older year-classes are much less abundant.

   One cannot but feel convinced that this material is more representative of the North Sea's fish-supply than statistics of the fish brought to bank. For the fishermen endeavour to catch certain sizes, and those always the largest sizes; and further, they make chiefly for those places where they expect they will catch large fish.

   In the material brought in by the Research steamers we found, in the majority of cases, a large number of younger fish, and only comparatively few specimens of the older haddocks.

   Here I may say that the picture showing the catches of haddock in the North Sea, recalls the picture, due to Danish research, of the catches of plaice in the Kattegat. In both cases the youngest year-groups are numerously represented, while in the older year-classes the numbers are but scanty. The spawning fish are, therefore, disproportionately fewer than the fish of the younger year-classes; and we may almost venture on the general assertion that in any considerable aggregate of haddocks there will be only one or two of the spawning year-classes represented.

[1] The statistics are being compiled by Mr Helland-Hansen.

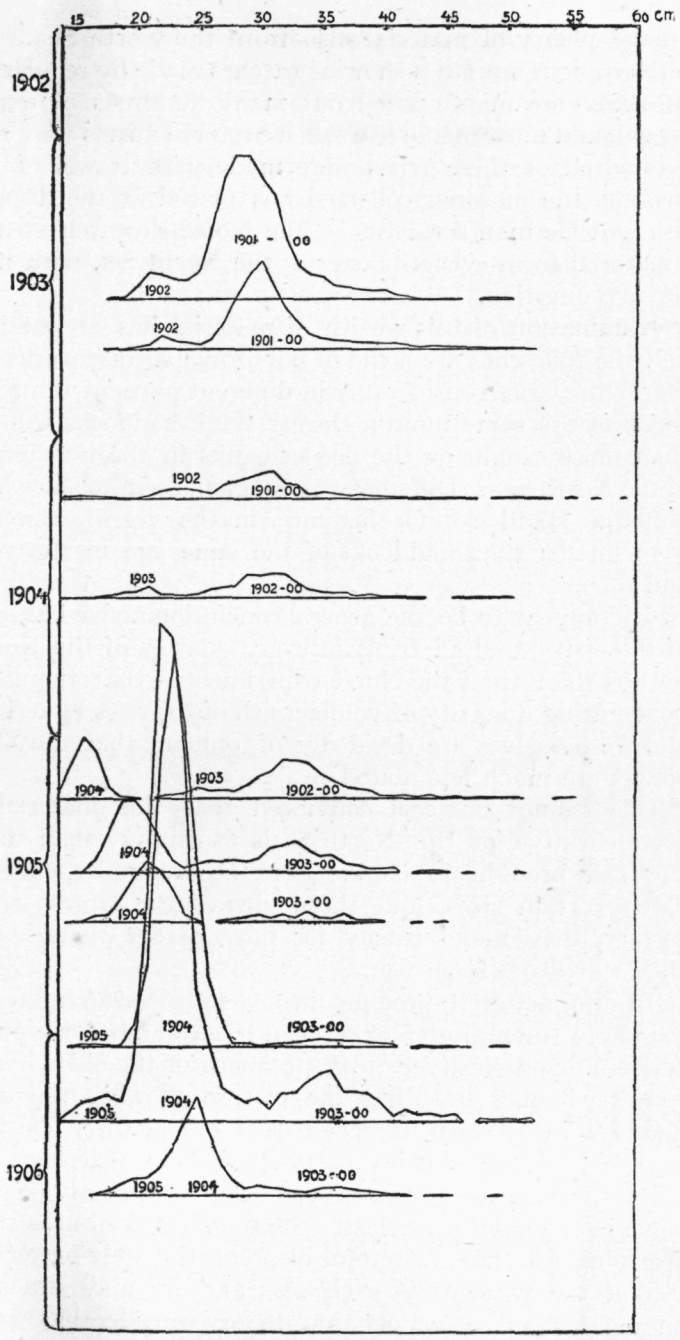


Fig. 16. Measurements of haddock from the central portion of the North Sea, made at different seasons of the year during the period 1903-1906. Each curve represents the number of individuals of various sizes (14-60 cm.) caught during a given season. The curves show the various groups. The year of birth is also given with each of these goups.

3. Of the utmost importance too is the really significant fact that our material, from other banks in the North Sea, clearly points towards the same numerical relations between the different year-classes. Thus, on all the banks, individual fish born in the years 1902 and 1903 were in much scantier numbers than those born in 1904. This will appear from a series of curves showing the number of individuals of the various sizes from the different banks that were from time to time subjected to investigation;

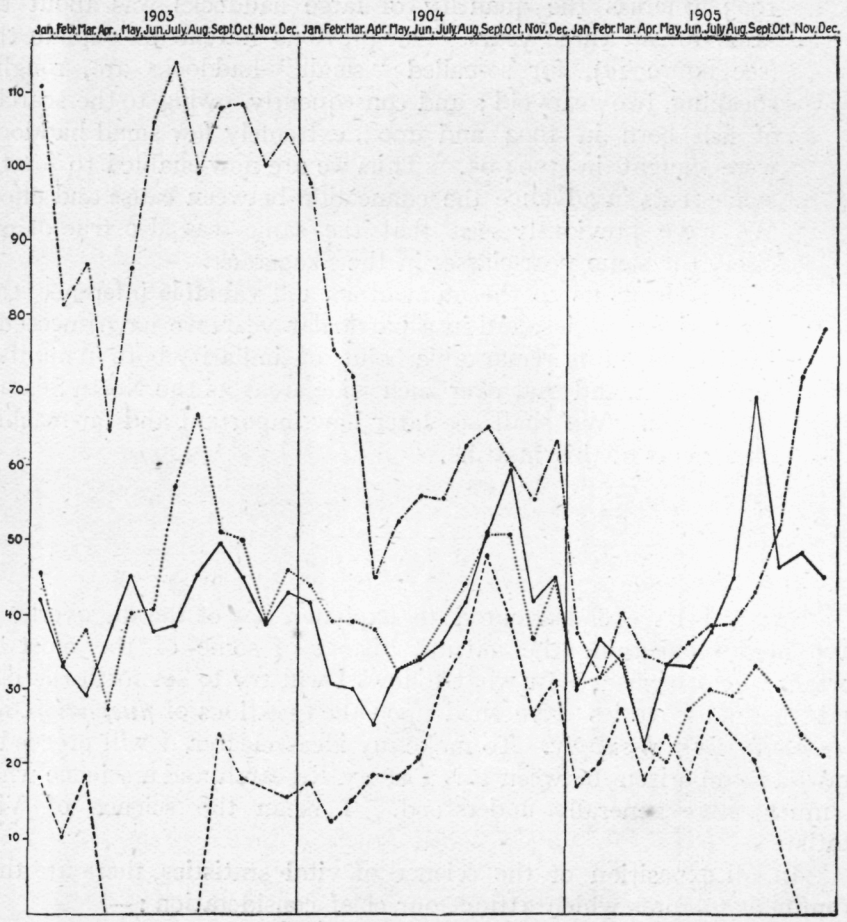


Fig. 17. From the English official statistics, quantities of haddocks landed at English ports (in hundredweights):—

large haddocks
medium ,,
small ,,
size not indicated.

such as the Dogger Bank, the Great Fisher Bank, the Coast Banks, and the banks in the northern portion of the North

Sea. Compare figure 16 and the accompanying explanation, where it will be seen that in 1904 small haddocks, which would then be representative of the year-classes 1902 and 1903, were only caught in very small quantities; while, on the other hand, in 1906, numbers of haddocks born in 1904 were brought to bank.

From the copious English fishery statistics, it appears that, in 1904 and 1905, fewer small haddocks were landed than in 1903, whereas the quantity of large haddocks was about the same for all three years. Our previous statements explain this (see figure 17), for so-called "small" haddocks are, roughly speaking, two years old; and consequently, owing to the scarcity of fish born in 1902 and 1903, extremely few small haddocks were caught in 1904-05. Thus we are now enabled to foretell some years in advance the connection between cause and effect. We have previously seen that the same was also true of precisely the same year-classes in the Skagerack.

This leads us to the momentous and valuable inference, that for a given species, and in a particular year, we have succeeded in demonstrating remarkable points of similarity both in numbers and growth, and that over such wide areas as the North Sea and Skagerack. We shall see later how important and far-reaching the effects of this may be.

So far I have endeavoured to explain a few of the discoveries we have made concerning the natural history of some of the most important sorts of fish. In what follows I will try to set forth the light that these discoveries have shed upon the questions of *fluctuation*, and *decrease in the fish-supply*. To make my ideas clearer, I will proceed to draw a comparison between this Fishery Research and a science which is much more generally understood. I mean the science of Vital Statistics.

In all exposition of the science of vital statistics, there are three prominent features which attract our chief consideration :—

1. Birth-rate. 2. Age-distribution. 3. Migration.

It is customary to study these questions by the help of what are called representative statistics. A certain number of individuals are selected, who are supposed to stand for the mass of people, and attention is directed to them. We ascertain from this source their average

length of life, their wanderings, their increase or decrease, and whether sickness, war, disaster, or emigration plays any appreciable part in reducing the population.

It seems at first sight a bold suggestion to propose studying the fish-supply on lines like these. A population can be counted; but who knows how many fishes are in the sea? And yet it appears to me a project, big with possibility, to regard the discoveries of fishery research from a similar standpoint to what has been adopted in the science of vital statistics. As a matter of fact these two biological sciences have much in common. Both are engaged in studying living organisms with their probabilities of life and death. And by comparing fishery research with the older and surer science, its shortcomings and discoveries will be even more clearly brought to view.

Let me ask you then, in the spirit indicated, to consider the results which you have just been listening to.

1. After long and careful examination of the spawning of fish, and of the drifting or passive wanderings of the eggs and larvæ, the first fact that becomes patent is that the fortunes of the fish-supply do not depend on local conditions alone. If we wish, for instance, to study the life-history of the saithe or its movements, it will not be sufficient to confine our observations to the Norse fiords or to the coasts of Britain. The saithe in these waters have arrived there, and are not in either case locally produced. On the other hand, although there are millions of newly-spawned eggs and swarms of spawning saithe on the northernmost extremity of the North Sea Bank, it would be absurd to fancy that one could study there the whole life-history in every stage of development, exactly as we study a stationary population. As a matter of fact, both eggs and full grown saithe have entirely disappeared from Tampen a little while after spawning has taken place. Nothing proves more clearly the necessity for complete organisation, and the advantage of international co-operation in these researches, than this very fact that the fish from their earliest commencement are denizens of the open seas.

   This knowledge, moreover, is not without its value when we consider the relations between the fish-supply and mankind. For it shows that a species of fish, whose life-history reveals such astonishing wanderings, can *never be seriously affected by mere local contrivances*. Hansen propounded the interesting theory that it might be possible, by counting the eggs, to calculate the number of fish in the sea. The experience we have acquired as to the characteristic localities of the spawning, and as to the

great emigration and immigration which takes place even before the eggs are hatched, is, in my opinion, sufficient proof of the impracticability of this proposal.

For the same reason it seems utterly impossible to get a clear impression of the numerical relations between the fresh accessions of young individuals and the older year-classes. It seems hopeless to attempt so stupendous a task.

Thus, fishery research cannot accomplish one great achievement of vital statistics. It cannot ascertain the number of births and their proportion to the whole living population. But this deficiency gives us less concern when we remember that all our researches appear to make us more and more assured—at anyrate, as regards the most important kinds of fish in the sea—that even those sorts which are most sought after by man, are always receiving enormous accessions of young individuals. Especially does this seem to be the case with plaice and haddock, and this too in waters where only one or two mature year-classes are to be found. It follows, therefore, that in all proposals for preserving the fish-supply, attention must be directed towards the protection of the older rather than the younger year-classes. This has been previously maintained and demonstrated by the Danish scientist, Mr C. G. Joh. Petersen.

2. What most convinces us of *these enormous accessions of the young year-classes* is *the fluctuation in their numbers*, and the circumstance that, as said before, *this fluctuation can be detected over wide stretches of sea.* I mentioned previously that the growth of the haddocks over the whole North Sea and Skagerack in the years 1902 and 1903 was slower, and the accession of young individuals far smaller than in the years either before or after. But other researches have shown that the phenomena were even more remarkable. Various disturbances took place that year in other fisheries as well. The large cod fisheries in Northern Norway sank to a minimum, and the French official statistics for 1903 noticed similar conditions in the Iceland fishery.

In Norway, it was not merely a want of cod that so impressed the people. There was a universal want of fish of every kind; and when the cod did finally arrive, the appearance they presented was truly a miserable one. I personally wrote about this in the year 1903, although I had at that time no knowledge of the state of affairs in Skagerack and the North Sea. "Besides the exceptionally poor quality of liver, which sank in sea-water, the scarcely-developed sexual organs struck me as exceptionally remarkable. Not only were the ovaries imperfectly developed, but the extremely small size of the eggs in March showed a develop-

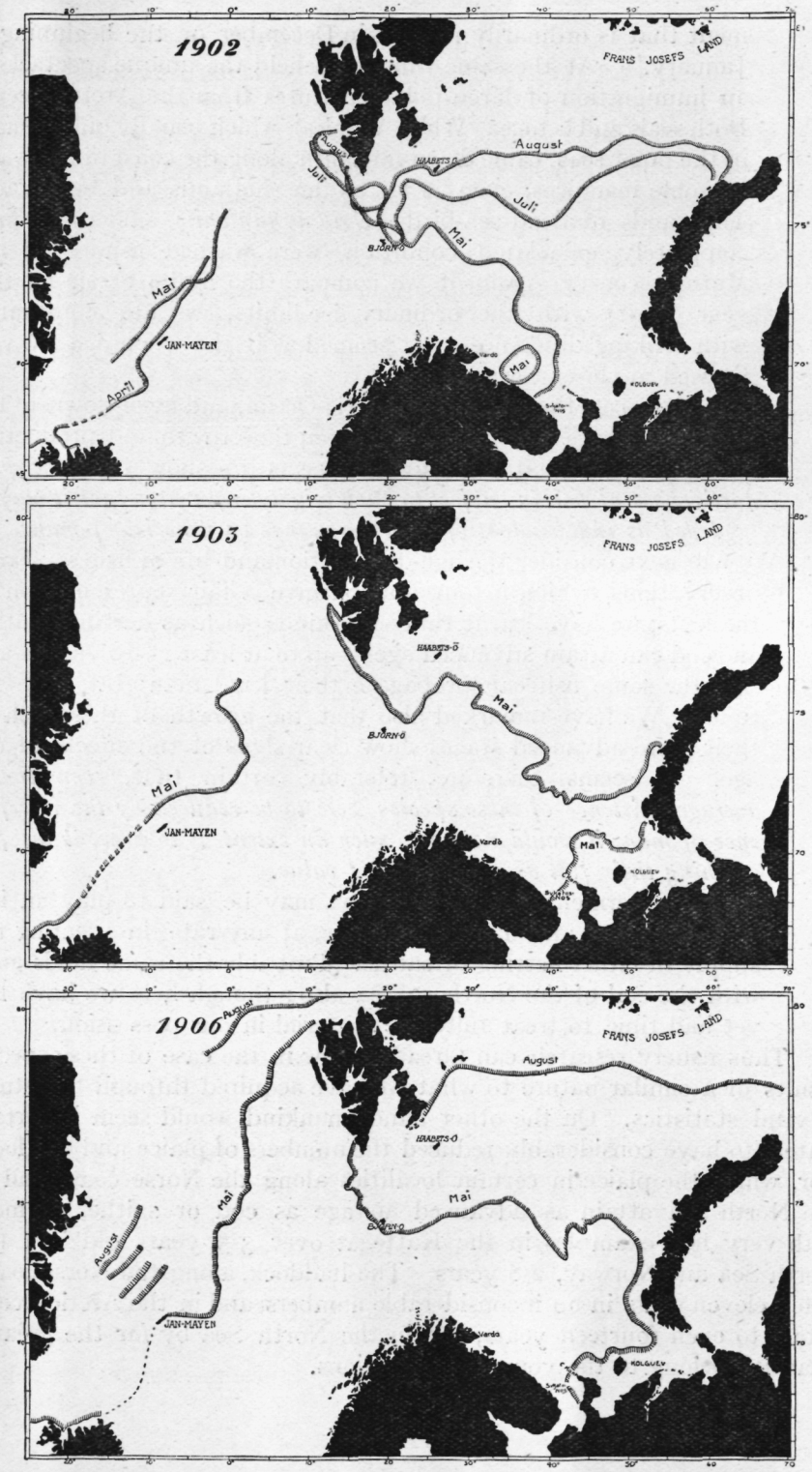


Fig. 18. Ice limits in 1902, 1903, and 1906.

ment that is ordinarily present in December or the beginning of January." At the same time we beheld the unique spectacle of an immigration of large polar creatures from the Arctic Ocean. Both seals and cetacea (White Whales), which usually only remain in the polar seas, came down far south along the coast of Norway; in some instances, even as far as the Shetlands and Skagerack. Thousands of dead sea-birds (*Uria brünnichii*), said to be in a completely emaciated condition, were washed ashore on the Murman coast. Again, if we compare the limits of ice for this year (1901) with the ordinary ice-limits, we are confronted with striking differences. It seemed as if the whole ice-sea was pressed n closer towards us.

That we can thus from the Arctic Ocean, and even down to the North Sea, trace a connection between the growth and production of fishes and climatic conditions, seems to show that *the productiveness of fish is subject to such mighty influences that it may be regarded as independent of the interference or fisheries of man.*

3. We will next consider the age-distribution and life of fishes. From observations, which in our opinion give a fair representation of the facts, we have learnt that some kinds, such as herring, saithe, and cod can attain advanced ages—up to at least 15-18 years—and that the same fish can propagate their kind many (at least 15) times. We have remarked also that the growth of these fish in their more advanced stages show clear signs of the effects of old age. It seems, therefore, tolerably certain that, *even if the average existence of these species were to be reduced by the interference of man, it would not be to such an extent as to prevent the fish reaching their full developmeut and value.*

The fishermen, on the contrary, may be said to play an immaterial part; and have little share, at any rate, in affecting the supply of either herring or saithe. Probably the same holds good with the cod of the Northern Sea also; though here we have not yet had time to treat fully the material in our possession.

Thus fishery research can already show in the case of these species results of a similar nature to what we have acquired through the study of vital statistics. On the other hand, mankind would seem in certain waters to have considerably reduced the numbers of plaice and haddock. For, whilst the plaice in certain localities along the Norse coast and in the North Sea attain as advanced an age as cod or saithe, we meet with very few examples in the Kattegat over 3-5 years old; in the North Sea and Norway, 2-8 years. The haddock, along the Norse coast, reach eleven years in no inconsiderable numbers, and in the Arctic Ocean attain to even fourteen years, but in the North Sea by far the greater quantity belong to the younger generations.

As final evidence, however, that decrease is here the cause, it is imperative that we should regard those haddocks submitted to us for examination as fairly representing synchronous conditions in the North Sea; and further, that we should show proof indisputable that North Sea haddocks in former times enjoyed a longer existence.

It is clear that this latter point, in any case, cannot be proved with sufficient certainty for us to come to any definite conclusions. Our chief result is then that, through these age-assessments, we have *a method by means of which we can confidently define, with regard to considerable lengths of futurity, to what extent the existence of the fish will be affected by proposed or actually existing fisheries*. Still, I do not think that a happier result could be expected or desired than this—to have it in our power to trace and determine the variations, whether increase or decrease, occurring in the ages of the fish.

A task of this nature would be for the fishing industry what statistics of population are for insurance. From vague conjecture and undefined impressions our knowledge of the subject will pass to certainty and thorough comprehension. For it is clearly evident that neither the views of practical men, nor ordinary statistics, can yield so sound a knowledge as statistics founded upon scientific assessment of age. If we look at a catch of fish on the deck, or even measure all of them, and set the results in curves, we shall not get that particular enlightenment that is of so much importance, I mean a knowledge of the composition of the various age-classes. It was only by exhaustive analysis, for instance, that we succeeded in establishing the fact that 1903 was inferior numerically to the other years.

Only by exact age-assessment can we hope to really solve that problem to which forestry devotes so much attention—at what age does the individual (tree or fish), reach its best selling value? Fishery research, like forestry and insurance, deals with questions of the widest range. No doubt, these two latter sciences are far ahead in the matter of results obtained. Still we too may now claim to be well under way, seeing that we have the means to know what we wish to know, and that it is merely a question of carrying out the necessary work; and this is, in my eyes, the greatest achievement of the first five years of International Fishery Research.

In my opinion this result is of so great value that the work will be energetically and systematically continued on similar lines. And one of the principal tasks which we must some day contend with, and which is likely, I fancy, to obtrude itself upon us before long, will be placing under continuous observation those kinds of fish that seem to be endangered by fishing, such as the plaice and haddock. We shall have to gather large collections of material for study from all the waters where the fisherman capture these fish, and we must endeavour to

point out and carefully explain the influence such fishing is likely to have in the future.

Especially interesting will it be to compare such different waters as those of the Skagerack, North Sea, White Sea, and the vast Atlantic, as well as those that wash the Norse and Iceland coasts. Undoubtedly we shall derive therefrom splendid discoveries of both practical and theoretic interest, and these discoveries await the attention of International Fishery Research.

THE END

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