

IV.—REPORT OF PRACTICAL AND SCIENTIFIC INVESTIGATIONS OF THE COD FISHERIES NEAR THE LOFFODEN ISLANDS, MADE DURING THE YEARS 1864-1869.*

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A.—REPORT FOR 1864.

As the subject of my investigations for this year, I selected the Loffoden fisheries as being the most extensive of all the cod fisheries on our coasts, and went to the Loffoden Islands during the first days of January, in order to be in time for the beginning of the fisheries. As regards the plan of my investigations, it was my intention above everything else to make myself familiar with all the circumstances and conditions of the fisheries, so as to gain a sure foundation on which further investigations might be built. I was therefore traveling nearly all the time, and during the winter I visited most of the fishing-stations. At every place I visited I paid close attention to the manner in which the fisheries are carried on, and to the natural conditions which might be supposed to have some influence on them; I likewise listened attentively to the accounts of experienced fishermen, and considered these of special importance for me, being entirely unacquainted with these fisheries. In this manner I have gained much important information, but I have also heard many erroneous and contradictory opinions expressed. In the following report I have therefore given only what I found to be true by my own observations, or what I at any rate considered highly probable. It will scarcely be necessary to explain why I have given to my report the character of a connected narrative. It was my object during the present fishing season to obtain as far as possible a general view of these fisheries, and I therefore give the information gained in this manner in the way which seems to me to agree best with nature's laws, reserving to myself the liberty of corroborating or correcting by further investigations whatever I dare not give in this report as absolutely certain.

A GENERAL VIEW OF THE LOFFODEN FISHERIES, AND SOME PHYSICAL CONDITIONS WHICH SHOULD BE TAKEN INTO SPECIAL CONSIDERATION.

The Loffoden fisheries are of very ancient date. They are spoken of at a very early age, and seem then to have been carried on chiefly by

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foreigners. That the Laplanders have also in former times been engaged in these fisheries, is proved by the remains of certain stone buildings erected by them, which are found in several places on the Loffoden Islands as near Svolveær. The time for these fisheries is generally the middle of winter, or the first four months of the year; therefore about the same time as our great spring herring-fisheries. It is the same instinct which urges the fish to approach the coast in large numbers, viz, the desire of propagating their species; in other words, the spawning process. To distinguish these fisheries, therefore, from those which, later in spring, are carried on on the coast of Finmarken, they are called "*gaat-fiske*," spawn-fisheries. This kind of fisheries, however, is not confined to the Loffoden Islands, but is, as is well known, carried on in many other parts of our coast; and there are many indications that the codfish approaches the coast along its whole extent, at least from Stadt, at the same time that it comes near the Loffoden Islands. The reason why the Loffoden fisheries have been so distinguished from olden times, seems not to be that the codfish approaches these islands in particularly large numbers, but rather that the locality offers so many natural advantages for the fisheries, and is at any rate better protected against the immediate influences of the ocean. It can, on the other hand, not be denied that this group of islands, by extending so far in a westerly direction, offers this advantage, that the schools of fish coming from the west can gather here easier, and, by going to their different spawning-places all along these islands, yield their tribute to man for a longer period of time than if this group of islands extended parallel with the coast.

The Loffoden fisheries proper, which are spoken of here, are carried on along the inner side, or that part of the islands looking toward the west fiord, from the farthest point of the island of Moskenas to Hindö, and sometimes still farther. Large schools of codfish approach these islands, likewise, on the outer coast every year; but as this coast is very rocky and almost inaccessible in many places, the fishing is attended with great difficulties, and would scarcely repay the trouble.

It seems to be a very important point to gain an accurate knowledge of the formation and nature of the bottom of the sea where fishing is going on; and it is very desirable that exact soundings be taken. This would not only save the loss of many implements, but would also contribute its share toward a more systematic way of carrying on the fisheries. My time did, of course, not suffice to make all these soundings. This would require the summer season, when the days are longer and the weather calmer. I shall, however, in the following, give all the information bearing on this point which I have obtained from personal observation, from fishermen, and from other persons* well acquainted with the fisheries.

* I am under special obligation to the superintendent of the fisheries, First Lieutenant Olsen, for much valuable information.

The deep sea in the west fiord, which seems to be a continuation of the deep sea of the ocean, seems to have an even, tolerably firm, clayey bottom, which, at any rate near the mouth, seems to approach much nearer to the eastern shore (the continent) than to the western (the Loffoden Islands), whilst farther up the fiord (near Skraaven) it again comes very near the Loffoden Islands. The fishermen say that the greatest depth is far up the fiord, exceeding 400 fathoms. It is probable, however, that near the continent a channel of just as great depth extends out to the western ocean. We do not, however, possess reliable information on this point, as the fishermen but rarely go out farther than a few miles from the shore.

On the Loffoden side we find this deep channel in most places bounded by an elevation rising almost perpendicularly and forming a rocky bottom. This elevation is called the "Egbakke;" nearer to the coast it slopes down again, and then rises again close to the hilly coast. If we follow this elevation in an outward direction we find it near the eastern Loffoden in the neighborhood of Skraaven and the Molla Islands at the distance of a rifle-shot from the coast, where the bottom suddenly falls 100-300 fathoms; farther west it gradually recedes from the coast till, near the western Loffoden, the distance between it and the coast is from 3-4 (Norwegian) miles. Near the outermost islands, Röst and Værö, soundings have been taken till far out at sea, and no greater depth than 60-80 fathoms has been found, so that the Egbakke is here probably still farther from the coast. This Egbakke, however, must not be imagined as an uninterrupted wall which at a certain distance from the coast shuts out the deep waters; for it is in many places broken by deep ravines which extend toward the coast, and which, as a general rule, seem to follow the narrow channels between the Loffoden Islands. From these ravines longer and shorter side branches go out in different directions, which in some places are interrupted by an intervening elevation, and continued on the other side. The bottom of these ravines seems in nearly all cases to be covered by a very thick layer of soft clay mixed with mud. The bottom formed by the elevations I have, as a general rule, found to be composed as follows: Nearest the coast it is invariably very uneven, forming steep terraces, often covered with a dense mass of algæ, or projecting peaks, which, when the tide is low, are more or less dry, and appear as dangerous reefs, against which the waves of the ocean dash with a roaring noise. Lower down the bottom consists more or less of sand or nullipores; and then at a depth of 50-60 fathoms we find a tolerably broad belt of a totally different character. This bottom, which is more or less sloping, is thickly covered with a layer of small, round stones, which continue to a depth of 80-90 fathoms, and is followed by a solid rock on the Egbakke, which, having risen somewhat and formed a more or less sharp ridge, often falls off perpendicularly toward the clayey bottoms below. It is natural that the sloping of the elevation will depend on the greater or less distance to the deep water. In

the East Loffoden it slopes more abruptly than in the West Loffoden, where for long distances scarcely any difference can be noticed.

Regarding the formation of the bottom farther out at sea but little can be said, as our information is very limited. Only this is known, that at a considerable distance from the coast (at least 8-12 [Norwegian] miles), it rises considerably, so that the depth of water, in many places, is not greater than on the elevated bottoms near the Loffoden Islands. This portion of the sea, which at no very distant future will undoubtedly become of great importance to our fisheries, is generally called the "ocean-bridge" (havbroen), and is said to extend at a certain distance along the whole western coast of Norway as far as the North Cape. Former investigations, however, have proved that this elevation does not form a continuous ridge, but consists of a number of irregularly-formed hills, separated by more or less broad valleys, in which, at any rate during a portion of the year (summer), some fish gather in large numbers.

Although the Loffoden Islands are considerably north of the Arctic Circle, the sea which laves them has by no means a complete Arctic character, a fact which may readily be recognized by its fauna. The cause of this is the same as that which gives to our whole country a climate which, compared with its northern latitude, must be called a mild one, viz, the Gulf Stream, whose influence in these islands is felt more directly than on most other portions of our widely-extended coast. A positive proof of this may be found in the fact that tropical shell-fruit have repeatedly been washed ashore on the Loffoden Islands, and I myself have gathered some. There is, however, another just as powerful stream, namely, the cold Polar stream coming from the Arctic Sea, which in a southwesterly direction goes along the coast of Finmarken, and which empties into the west fiord through the many narrow channels which separate the Loffoden Islands from each other. These two streams are, so to speak, engaged in a constant combat, at one time the one being more powerful and at another the other one. This must, however, not be understood in the sense that the one could either neutralize the other or hinder it in its course. Both streams possess their full power at all times, but their direction may be changed, so that at one time the Gulf Stream is stronger near the coast, while at another it is driven farther away from the coast by the Polar stream. The rule seems to be that the Gulf Stream runs at a considerable distance from the coast, where its influence may be felt far north, even as far as Spitzbergen, while the Polar stream seems in general to be nearer the coast. When the wind is northerly and easterly, or also when there is a calm, it will be found that (at any rate during winter), if we except the small changes produced by the coming in and going out of the tide, the stream has a southwesterly direction, or, as the saying is, "going out." When there are southwestern storms or so-called "sea weather," the stream generally goes in the opposite direction.

That this is really the Gulf Stream is seen not only by its producing a considerably higher temperature (in winter it sometimes rises in twenty-four hours from several degrees below zero to as many degrees above zero), but likewise by a very noticeable rise in the temperature of the water, at any rate near the surface. I have thus, after continued easterly wind with the atmosphere several degrees below zero, found the temperature of the water near the surface not much over $+1^{\circ}\text{C}$,* while after a southwesterly wind it rose within a short time to $+3^{\circ}\text{C}$. Farther down the difference is probably less marked, but it may be observed to a depth of 40-50 fathoms. In deeper water the temperature seems to keep more even, generally about $+4^{\circ}\text{C}$. It is probable, however, that the nature of the bottom has a considerable influence on the temperature of the deepest water. I have found that the soft clay mixed with mud, which forms the bottom of the ravines mentioned above, develops a remarkable degree of warmth, probably by a sort of chemical process (*e. g.*, fermentation.) When the thermometer was put in mud brought up from a depth of 100 fathoms, it quickly rose to $+10^{\circ}\text{C}$. The warmth of this mud was undoubtedly originally still greater, but decreased by being brought through the cold water.

I have purposely dwelt so long on these physical conditions of our northern coast, because probably we here meet with causes (currents of the sea and changing temperature occasioned by them, and nature of the bottom), which have a decided influence on the fisheries, and consequently ought to receive constant attention by continued investigations.

I now proceed to my subject proper, viz, the fisheries. We may here distinguish three principal phases, viz, the coming-in of the fish, their spawning, and their going out, all of which are of such importance as to deserve a separate chapter.

THE COMING IN.

Very early, according to information given me by fishermen, even before Christmas, there are signs of the codfish approaching the Loffoden Islands. About this time an unusual number of other small fish gather on the higher places of the bottom, among them some which generally are found only at a very considerable depth. Soon large codfish begin to make their appearance, and as their number increases, the other fish decrease gradually, until scarcely any other fish but codfish are found.

This early codfish is called the "announcing fish" by the fishermen, and differs according to all accounts from the real codfish, which does not make its appearance till the middle of January. Although I have had no opportunity to investigate this matter, it seems quite probable

* Degrees of the Centigrade scale can readily be reduced to Fahrenheit by means of the following formula: $x^{\circ}\text{Fahrenheit Centigrade} = 32 + \frac{9}{5}x^{\circ}$.—(TRANSLATOR.)

that these schools of codfish which come early belong to a distinct variety, which, differing in this respect from the codfish proper, stays far out at sea all the year round, and is by the approaching masses of codfish driven toward the coast. From what I could learn from the fishermen, it seems certain that some of these fish, by their peculiar color and thicker body, show a great similarity to the coast variety of the codfish found along the whole coast of Norway. But, on the other hand, it is certain that the fishermen, when speaking of this fish, also mean the codfish, and although it makes its appearance in the beginning of January, it does not differ from the codfish proper in any essential points. The only distinguishing mark of this codfish is said to be, that the skin covering the inside of the abdomen is white, while in the codfish proper it is dark. This mark seems, however, to be confined to individuals, for I have among the so-called announcing fish, which the fishermen called codfish, found some with a dark abdominal skin, and during the fishing season codfish proper with a white skin.

The coming in of the fish, which may be said to begin in January, generally lasts during all of February till the middle of March. The fishermen say that the codfish come in till the 12th of March, but it is of course impossible to fix an exact date. There are many circumstances which may either retard or accelerate the coming-in of the codfish, so that one year it may end sooner than another. The general experience has been, that after a southwesterly wind and mild weather following it, the fish come in quicker than after northerly or easterly wind and cold weather. The cause assigned for this is, that the sea has larger waves during a southwesterly wind, and the current going toward the coast drives the fish in the same direction. This theory, however, can only be accepted conditionally. To judge from what we know about other fish, the contrary might be expected, as it is well known that not only the salmon, but also several salt-water fish, as the mackerel, seem to take special delight in going against the current and wind. The real cause, I think, must rather be sought in the considerably higher temperature of the deep water, which in the above-mentioned kind of weather is communicated to the water near the surface.

The codfish do not come near the coast in one great mass, but always in schools, which, small in the beginning, gradually increase in size until they assume such large dimensions that they are called "fish-mountains." During good fishing seasons this expression does not seem an exaggeration. I have been assured that the codfish are often so closely packed, to a height of 20 to 30 fathoms above the bottom, that the fishermen who use lines can notice how the weight before it reaches the bottom is constantly knocking against the fish.

It often happens that although it is known that great masses of codfish, so-called "fish-mountains," fill the sea at certain places, none can be caught either with seines or lines. The fishermen say that the fish at such times keep entirely quiet, with their heads downward. Not-

ing but the arrival of a new school brings life into these masses of fish and drives them forward, and a great many are caught.

This "keeping quiet" of the codfish, regarding which the fishermen have very strange notions,* seems more particularly to take place during continuous cold weather with easterly or northerly wind, and is probably occasioned by the lower temperature which through the cold and the current flowing from the north to the south is communicated to the upper portion of the water which the fish must pass in order to reach the elevated bottom. It is a well-known fact that the salmon, before entering upon their regular journey up the rivers, stay for some time near the mouth, seemingly to get accustomed to the cold fresh water. It is very probable that the codfish does something similar. As the codfish come from a great depth where the temperature seems to be very even all the year round, they are probably very tender as regards a change of temperature. And, going towards the elevated bottom they must frequently pass portions of the sea which through the influence of the Polar Stream are quite cold. It seems natural to me that the fish do not enter these cold places as quickly as when the temperature has again become higher through the influence of the Gulf Stream. It is said, however, that there is a period when independently of the changes of temperature the codfish keeps very still, viz, immediately before spawning. It is likewise probable that the codfish have been outside the great elevation (the "Egbakke") for some time before this coming-in commences, or that they follow it for some distance until they find a suitable place for getting nearer to the coast. It is quite probable (although nothing definite is known regarding it) that they select places where the "Egbakke" is low or where it is intersected by clayey ravines. It is certain, however, that during their coming in they are guided by the formation of the bottom, and that coming from the deep they follow as far as possible the deep places, *i. e.*, the ravines. As a general rule they do not follow the middle of these ravines, but the edges, being guided by their many curves and turns.

Although the codfish is a genuine bottom fish, it does not keep near the bottom all the time, but keeps considerably above it, at any rate in certain localities, as the East Loffoden. The fishermen know this very well, and, where the current is not too strong, they like to use wooden or glass floats so as to keep the nets or lines some distance from the bottom. This is especially done with the lines, both ends being fastened to a float so that only the middle portion reaches near the bottom, while the remaining portion gradually approaches the surface. As the hooks baited with herrings are very close together, the fish will, at whatever distance from the bottom it may be swimming, meet some of them. I have thus noticed near Svolvev, where this method of fishing

* I have thus found the idea very generally prevailing among the fishermen, that the codfish seek certain places on the bottom where there are said to be springs of fresh water, which they drink in order to bring the roe to maturity.

is very common, that the codfish must have been at a considerable distance from the bottom, for a great number were invariably caught near both ends of the line, while toward the middle, which is of course nearer the bottom, other fish were caught. The codfish must, therefore, have kept at a distance of 20 to 30 fathoms from the bottom. They do, however, change their position, and seem in this to be guided by various circumstances, especially by the weather. If there be continuous cold with coast wind, the current going out, which, as has been said before, always occasions a considerable fall in the temperature of the sea-water, the codfish generally keep nearer the bottom than during southwesterly or so-called sea-winds. I have often had an opportunity for making this observation. When I made my observations near Svolveær, the weather was very changeable, there were frequent westerly storms, and the temperature of the sea-water was tolerably high, viz, near the surface between $+ 2^{\circ}$ and $+ 3^{\circ}$ C., and at the depth where the codfish were supposed to be it was $+ 3^{\circ}$ C. During my stay on the Raft Sound somewhat later in the season, when cold weather set in, the temperature of the water at the same depth was considerably lower, viz, only a little over $+ 2^{\circ}$ C., and the codfish were then much nearer the bottom. It is possible that a long-continued spell of cold weather will hinder the codfish from coming in, keeping them farther away from the coast than would be the case in warm weather.

Many other circumstances, however, may contribute to bring about this result. It is very important whether there is sufficient food in the sea, here chiefly small herring. This may be both beneficial and detrimental to the fisheries. It is detrimental if the herrings keep farther out, in which case the codfish are enticed away from their usual spawning-places hunting after the herring schools, in other words, not keeping steady on the elevated bottom; it is beneficial if the herrings are between the masses of codfish and the coast, especially where there are deep fiords. If a large school of herrings can be kept far up one of these fiords, a twofold advantage is gained: there is always fresh bait, and the codfish can be kept in a place farther removed from the immediate influence of the sea, where fishing may be carried on in nearly every kind of weather. Such a place is the East-Næs fiord which penetrates the eastern part of the island of East Vaagö from that bay of the West fiord, which on the inner side is bounded by Skraaven and the Molla Islands, and is known among the fishermen by the name of "Hölen." Here the fisheries have some years been very productive; especially near Fölstad on the eastern side of the fiord, whither large numbers of fishermen have been attracted during the last few years. That large fisheries cannot be counted on every year, has been sufficiently proved by this year's fisheries, although some schools of codfish come here every year. I am therefore inclined to consider the food of the codfish as the principal cause of the extraordinarily rich fisheries which occur here from time to time, as well as in some other places, the Raft

Sound, the Kanstad fiord, &c., although I do not mean to say that the codfish, if its coming in was not disturbed at all, could not find its way up these fiords without this food.

The circumstance that the codfish when approaching the coast follows the herring schools proves that it cannot deny its innate greediness, even during the time when the spawning instinct is all-powerful. This greediness is, however, not quite so great at this season, as I never, among the many fish which I examined at this time, found any whose stomach contained the usual food of the codfish, chiefly consisting of large crustaceans (principally decapods and amphipods). Even among those fish which were caught in the beginning of the fisheries, and of which I opened a large number, in order to obtain from the contents of the stomach some intimation as to the favorite dwelling-place of the codfish, I found in nearly all cases that the stomach was empty and had shrunk, which shows conclusively that they cannot have taken any food for a long time. Where anything was found in the stomach, it consisted chiefly of pieces of the bait torn from the lines.

The herring with a silvery shining color must certainly have a special attraction for the codfish, for they cannot refrain from snapping at the bait, which very often is nothing but old salt herring. It is of course understood that they will snap still more eagerly after fresh bait, so that it is very important for those fishermen who fish chiefly with lines, to procure fresh bait, even if they have to get it from a great distance. This will be particularly useful if the sea at those places where fishing is going on does not contain many herrings. Fresh bait will catch twice as many fish as salt herring.

I have said before that the codfish always come in in schools, and that the last are larger than the first. Each one of these schools seems to form a separate family consisting of spawners and milters. Even among the first schools the proportion between both sexes has been very even, while with other fish this is different, the milters always coming somewhat later than the spawners, in order to fructify the eggs laid by the latter. This has its reason in the peculiar circumstances of the spawning, of which I shall say more in another chapter. The generative organs are strongly developed both in the male and female of the first codfish coming in, but they have not by any means reached their full development, which is indicated by the roe and the milt being firm, and the former, moreover, being fine-grained. The fishermen, as a general rule, consider it as a good sign, when large masses of codfish approach the coast, if the roe is still firm and fine-grained, because this indicates that the fish will stay for a considerable time on the elevated bottom.

A question which comes up in connection with an investigation of our cod-fisheries, and on which I therefore desire to dwell before proceeding any further in my report, is this: "Where do the codfish come from? Where do these enormous masses of fish stay during the rest of the year, when no traces of them can be found?" There are many different

theories with regard to these questions. I have heard the opinion advanced that during the last years a great number of codfish had been observed near the coasts of Bear's Island and Spitzbergen, and that this was the cause why the Loffoden fisheries had been less successful of late years. Some people even suppose that there is a certain connection between the Loffoden and Newfoundland fisheries, a supposition which does not need any refutation. In both these theories it is presupposed that the codfish, as likewise the herring, undertakes long journeys from distant seas, which in former times seems to have been a favorite supposition, but which later researches have proved to be untenable. It seems much more probable that the codfish as well as the herring during the rest of the year stays not very far from the coast at a great depth, which it only leaves when the growing roe and milt and the consequent desire for spawning drives it in thick schools toward the nearest coast.

The circumstance that the codfish approach our entire long-stretched coast, at least from Stat, at about the same time, seems to point in this direction. If, as some suppose, the codfish came from near the North Pole, they would appear sooner near Finmarken than further south. This erroneous idea regarding the journeys of the codfish from the Polar Sea has also led the well-known scientist *Leopold von Buch* (*Reise durch Norwegen*, "Journey through Norway," Vol. I) to make the wrong statement, that the Loffoden codfish come from the north through the narrow sound which separates the islands from each other—a statement which any one who has had anything to do with the Loffoden fisheries knows to be erroneous. Neither is the explanation given by *G. P. Blom* (*Bemærkninger paa en Reise i Nordland*, "Remarks on a Journey to the North Country") correct, that the codfish come through the sound between Röst and Værö. It seems settled therefore that at any rate the chief mass of those codfish which make their appearance on the landward side of the Loffoden Islands, comes through the large fiord between Röst and the continent, and consequently as a general rule pursues a northeasterly course.

It must not be imagined that all the codfish schools follow exactly one and the same direction when approaching the coast. To describe it graphically the directions taken by the different schools must be imagined as numerous parallel lines all going in a northeasterly direction from the great deep along the middle of the west fiord, the most easterly and the most westerly of these lines being far distant from each other. For there are many circumstances which seem to indicate that those codfish which generally appear somewhat earlier near the West Loffoden are not the same which further east approach the coast of East Vaagö, nor the same which are found still further east near the east coast of Skraaven and the Molla Islands. This is proved by the fact that large masses of codfish often appear at exactly the same time at each of these places, and that there may be good fishing at the same

time near the West Loffoden and far east near Skraaven and the Molla Islands, while scarcely any fish are caught in all the intervening space. A considerable difference has also been noticed in the size and quality of the fish caught at the different fishing stations. Near the West Loffoden the fish are generally small, while further east, near East Vaagö, they are considerably larger, and the fish caught near the East Loffoden east of Skraaven and the Molla Islands in the Raft Sound and the Kanstad fiord have always been known for their great size and their fat flesh. Even in places not so far distant from each other a difference in the fish may be noticed. Thus it is said that those codfish which are caught near Balstad on the island of West Vaagö are considerably smaller than those caught at any other place in the Loffoden Islands. The fishermen even maintain that they could notice a certain difference in the different schools approaching one and the same fishing stations, so that they could tell immediately from the looks of the fish whether a new school had come in. It will be seen from this that even if at the beginning of the fishing season there is very good fishing near the West Loffoden, one cannot with certainty count on this being the case near the eastern islands, and even if but few fish have made their appearance near the western islands, there is no reason for supposing that the fishing near the eastern islands will be poor.

The codfish which come to the Loffoden Islands seem therefore to belong to many different tribes living independent of each other in the different ravines and basins of the bottom of the sea. And, as I said before, I consider it highly probable that these basins or ravines are not very far from the coast, but generally between the coast and the so-called "ocean-bridge" (hav broen), mentioned above. I have good reasons to suppose that at any rate a large portion of the Loffoden codfish, during the rest of the year, stay at a great depth in the West fiord itself. From some of the men who used to row me about on my journeys of investigation I heard the following which seems to point in the same direction: Some fishermen who were out fishing on the West fiord, at a distance of 3-4 (Norwegian) miles from the coast, near the end of May,—consequently, long after the time when the last codfish has left the Loffoden Islands,—noticed that as soon as the bait approached the bottom something commenced to pull at it. As they were anxious to see what sort of fish would come up, and as they happened to have a line of extraordinary length, they let it go down, and soon caught a fish, which certainly was a codfish, differing in nothing from the well-known Loffoden codfish. It is true that this is only a single instance, and other fishermen have made the same experiment without obtaining this result; but, on the other hand, it must be remembered that the codfish, when living at a great depth, must live more scattered in order to find their food, and that they cannot live together in such thick schools as when they come near the coast to spawn.

THE SPAWNING.

The end of March is generally considered the time when the majority of the codfish spawn. Physical conditions, however, exercise a great influence on the spawning process; thus, it may be retarded by long-continued cold weather and accelerated by unusually mild weather. It is, therefore, difficult to set any definite limits for this time, all the more as the different schools by no means all spawn at the same time. Some schools may be spawning while others are just coming in, and long after the time when the first begin to leave the coast, there are some schools which have not yet spawned. This may easily be observed in the fish which are caught, for it is not a rare occurrence that on one and the same day fish are caught with entirely loose roe and some whose roe is as firm as at the beginning of the coming-in season. The last-mentioned fish certainly belonged to a school which had but recently come in, while the former must have been near the coast for some time, as the schools coming in first always spawn before those coming in later.

The earliest spawning which I observed during the last Loffoden fisheries was toward the end of February far up the Eastnæs fiord. By fishing with a fine net on the surface of the sea I caught some small, completely transparent globules floating on the water, which I at first took for some very low species of aquatic animals, as I was entirely ignorant of the peculiar spawning process of the codfish, to which I shall now refer. I had in former times heard fishermen say that the roe of the codfish could be seen floating in the water, and that at certain seasons it filled the sea to such an extent as to make the water appear quite thick; but as this was in such direct opposition to anything I had hitherto known of the spawning of fish, I could not but suppose that what had been taken for spawn was in reality nothing but those lower aquatic animals which (as is well known) often fill the sea. The roe of codfish I never looked for, unless brought up from the bottom. The microscopic examination of the above-mentioned globules showed beyond dispute that they were eggs, although they were too little developed to decide whether they were fish-eggs. Gradually these eggs, floating about freely, became more numerous, until, about the end of March, they filled the sea, so I could get as many as I wanted. I now succeeded in following their development step by step until the tender little fish slipped out of the shell and swam about in the water.

It is certain that these eggs were really the spawn of the codfish, and of no other fish, to judge in the first place from their enormous number, and in the second place from comparisons which I made between them and roe, which about this time could, by a gentle pressure, be extracted from spawners.

This roe did not sink to the bottom, but floated on the water like that which I had first observed. This peculiarity of the roe of the codfish, to which no parallel is found in any other fish, must be caused partly by

the absence of the gluey matter which in nearly all other fish holds the eggs together, partly by an unusually large quantity of fine oil contained in the egg, which makes the specific weight of the roe a little less than that of the water. Only when the fœtus is dead, and the egg shrinks in consequence, does the roe sink to the bottom; unless this is the case, it continues to float in the water during the whole period of its development; and even the young fish recently hatched floats about in a similar manner, with its heavy umbilical bag attached to it, which for some time supplies it with food.

This phenomenon is of great interest, from a scientific point of view, and likewise deserves special attention from practical considerations. Much which hitherto seemed entirely inexplicable in the habits of the codfish when near the coast, the great irregularity with which in different years it makes its appearance near the various fishing-stations, the long so-called "fishing-periods," when for many years it stays away from certain fishing-stations and goes to others which in former years were not considered good, the periodical increase and decrease in the total mass of fish coming to the Loffoden, and possibly many other hitherto unexplained phenomena, must be ascribed to the peculiar conditions under which the codfish spawn. It is well known that the salmon invariably seeks the river and even the exact spot where it has been hatched; and this peculiarity is not confined to the salmon, but to many other fresh-water fish.

The same instinct is undoubtedly possessed by salt-water fish also, such as the codfish, and many important data all point in this direction. One might thus expect that the codfish would, after a number of years (so far it is not yet known how long it takes the codfish to reach maturity, *i. e.*, the capacity to spawn, but, to judge from other fish, it would scarcely be more than four to five years), return to those places where they have spawned in large numbers, and that good fishing might again be looked for; but experience shows that this is by no means the case, and the cause will easily be found from what I said above. The eggs of other fish, especially those which, like the eggs of the herring, are pasted to objects on the bottom of the sea, must, during their whole development, stay in the place where they were laid, while those of the codfish become a prey to wind and weather, and are carried hither and thither by the current.

It thus happens not unfrequently, as was the case during the last Loffoden fisheries, that the greater portion of the roe is driven out into the sea by the wind blowing from the land and by the current having an outward direction, so that but little of it is seen near the fishing-stations, while at other times, when the wind blows toward the land, and the current goes in the same direction, it fills the water near the fishing-stations, and, when there is a strong wind from the south, is thrown on shore in such enormous masses as to form, so fishermen have assured me, a layer several inches in thickness. A great many young fish are

undoubtedly destroyed in this way, but this does not signify much if we consider the enormous masses which are probably lost in other ways. It seems that not only other aquatic animals but likewise the codfish themselves, when going out, destroy a great deal of the roe which fills the sea.

The latter case must therefore be considered more favorable for the future Loffoden fisheries than if the roe is driven out to sea. Although this will not directly hinder the development of the young fish, it is a great question whether the roe, when the wind again blows toward the coast, will be driven to the same place from which it came; and it may happen that it is driven to coasts which are unfavorable for fishing, so that probably the greater portion of the young fish of that year will be lost to the Loffoden. It is likewise very fortunate if the cod, before spawning, comes as near to the coast as possible, especially if the spawning go on in deep fiords sheltered from wind and current, of which there are not a few in the Loffoden Islands. The question might even be raised, if nature might not be assisted in this respect, so as to prevent the occurrence of unfavorable years, which exercise such a depressing influence not only on those specially engaged in the fisheries, but on the whole country. I here refer to the artificial hatching of fish. It is not a new idea to apply this successful discovery also to salt-water fish, for it has been mentioned and discussed more than once, although the difficulties in the way of carrying out the idea have been many and seemingly insurmountable, difficulties chiefly occasioned by the manner in which the spawning process takes place, and the great depth of water which seems requisite for the development of the eggs. Nothing of the kind seems to be in the way here of carrying out this idea, so that it would be the proper locality for taking a step in this direction. The trouble would be very small, as nothing would have to be done but to place the artificially-impregnated eggs in suitable and sheltered places (I know many such in the Loffoden Islands), and then leave them to themselves.

There would be no difficulty in getting together a considerable number of eggs in a comparatively short time, considering the enormous quantity contained in one spawner. Leuwenh ock estimates that a medium-sized codfish contains no less than $9\frac{1}{2}$ million eggs. A single codfish may thus produce a number of fish almost as large as that of a whole Loffoden fishing-season. During the investigations which I intend to make next year, I expect to give special attention to this matter.

Regarding the way in which the codfish acts during the spawning process, I have learned the following: After having kept remarkably quiet just previous to it, the codfish becomes restless as soon as the roe has reached its maturity. In dense schools, male and female mixed together, they will now rapidly swim hither and thither on the elevated bottoms, the females dropping the eggs and the males the milt. This spawning process of the codfish is as a general rule not going on at the

bottom, but at a greater or less distance from it, which can easily be inferred from the manner in which the fish are caught in the nets.

Reddish spots, looking like inflamed places, which are always found on the belly of the spawner after spawning, indicate, however, that the fish occasionally go to the bottom, probably to rub against stones so as to aid the roe in coming out. That the spawning does not go on all at once, but that it takes some time, may be seen from the fact that the eggs toward the inner end of the roe-bags are far less developed than those near the outlet. How long a time it takes I have not yet been able to find out, but probably several days.

During the time which elapses from its first approach to the coast till the spawning is finished, the codfish gets very lean, partly in consequence of its taking but little food, partly in consequence of the spawning itself, which always weakens fish. Its greediness after the spawning is over is therefore very remarkable. I have been told that the codfish about this time not only swallow medium-sized fish, but also the entrails of fish thrown into the sea by the fishermen with the heads of the fish yet hanging to them. In some cases the heads have been so large that it could not swallow them, and they stuck fast in its jaws. In connection with this I will mention the idea quite prevalent among the fishermen, that the codfish before it goes out to sea fills its stomach with stones, or, as they say, "takes in ballast, because by losing so much roe, or milt, it has become too light for undertaking its long journey to the deep waters." Improbable as this sounds, there may after all be some cause for it. It is quite possible that the famished codfish in its greediness has occasionally swallowed stones along with aquatic animals sticking to them.

After the spawning is over, the codfish do not stay very long on the elevated bottoms, but hasten to get to their usual places of sojourn, there to find the food which they require after the long period of fasting.

THE GOING OUT.

This phase of the Loffoden fisheries is likewise of great importance, and it has often been said that the best fishing has been had during the going out of the codfish. This applies as a general rule more to the western islands, where the elevated bottoms are more extensive than in the east, where they often form comparatively speaking only a narrow ridge along the coast. Two circumstances, however, must be taken into consideration, which have a great influence on the fisheries at this particular period. It has been observed that the codfish when leaving the coast either go in a straight line to the nearest deep, and this is unfavorable to the fisheries, or that they go along the western elevated bottoms. In the latter case the fisheries near the western islands may be very productive, as the schools may be followed from one fishing-station to the other, and large numbers be caught before they reach the deep.

The weather has likewise a great influence on the conduct of the codfish during its going out. With steady coast-wind, accompanied by cold weather, the codfish chooses the shortest way to the deep; and if the contrary is the case, it likes to follow the westerly elevations of the bottom. It is highly probable that the temperature of the sea-water, which is naturally dependent on the weather, has a good deal to do with this.

Although the codfish have been observed to keep much higher in the water while going out than while coming in, it is probable that they nevertheless go very much according to the formation of the bottom, even if they do not follow exactly the same way they came. It has thus been observed that where they have gone up very deep fiords, they followed one side of the fiord in coming in, and the other in going out. On this circumstance, together with the peculiar formation of the bottom, the very rich fisheries depend, which in certain years occur during the going out near the fishing-station of Fölstad on the eastern shore of the Ostnasfiord.

The clayey ravine, 100 fathoms wide, which at the mouth of the fiord occupies nearly its whole breadth, is divided into two branches almost opposite Fölstad; these two branch ravines surround an extensive stony bottom lying in the middle of the fiord, and run very near the eastern and western shores, which they follow for a considerable distance, till farther up the fiord they are interrupted by a shallow ravine (only 6 to 8 fathoms deep) stretching obliquely across the fiord at its narrowest place. The inner portion of the fiord forms an isolated basin, which in its eastern part, near the fishing-station of Liland, is 60 to 78 fathoms deep. This part, called Lilandspollen, is known as an excellent fishing place, and is one of the principal spawning places of the codfish.

When the spawning is over, the codfish go again across the oblique ravine, but nearer to the eastern shore, following the deep east ravine in a southerly direction, and gather in large masses near the peninsula of Fölstadland, which stretches far out into the fiord. When going out, the codfish seem to be in a much greater hurry than when coming in, and there has never been an instance of their keeping perfectly still for any length of time during their going out, while this is a common occurrence during their coming in. This period of going out is the very time when there is the best fishing, and in a few days as many fish are caught as during the rest of the fishing-season.

Nets have proved particularly useful at this season, and might even be used more extensively, as not the least injury to the future fisheries may be apprehended from them, while the case is very different during the period of coming in.

Regarding the further fate of the tender fry, I have not been able to learn much. After the young fish have left the eggs, they have no control over themselves, but are driven hither and thither by wind and waves. Only after the umbilical bag has disappeared, and the fins have

become more developed, do they make voluntary motions. It is not known what becomes of the large number of young fish which are hatched here every year. It can scarcely be supposed that they keep near the land, as the fishermen have never seen any during the spring and summer. It is possible they keep at a considerable distance from the coast, and perhaps they follow their parents to the great deep as soon as they are able to use their fins.

B—REPORT FOR 1865.

As the Department of the Interior has requested me to report as soon as possible on the practical and scientific investigations of our cod-fisheries made by me during the present year, so that my report might be laid before the "Storting" (Norwegian Parliament), I will endeavor to give a brief account of my activity during the last Loffoden fisheries, as well as the short time which I have at my disposal will permit, before I meet the commission at Trondhjem.

Already during my last sojourn in the Loffoden Islands, I soon became convinced of the difficulty of my task, and likewise of the vast extent of the field for thorough investigations which was opening out before me, and as the whole question had aroused my deepest interest, even the greatest difficulties have not deterred me, but have on the contrary urged me to do everything in my power to have light thrown into the darkness which is still resting on many portions of the life and nature of the codfish during its sojourn near our coasts. It is my firm conviction that a great deal can be done in this direction, although the practical results which should form the ultimate object of all these investigations can in the very nature of the case not be obtained immediately. Although the first results will principally benefit science, we must not give up the hope of obtaining practical results. It is certain that most of our modern discoveries have only reached their great importance for practical life by a series of scientific researches; and it is just as certain that the practical results which we confidently hope to reach with regard to the question of the cod fisheries will only be fully appreciated when they are based on a firm scientific foundation.

The first thing to be done is, undoubtedly, to gain a most accurate knowledge of the nature and mode of life of the codfish. Only after this knowledge has been gained much of that darkness will disappear which is still resting on the migrations of the codfish; and their seemingly irregular appearance now in one place and then in another, their disappearance, their return, &c., will be found to be dependent on certain fixed laws of nature, which to know beforehand will be of the highest practical interest.

I have already, during my last sojourn in the Loffoden Islands, given some attention to this matter, endeavoring to get some light, but so far I have not yet obtained that knowledge which is necessary for leading

to really important results. My object, then, was merely to get as far as possible a general idea of the fisheries as a starting point for future investigations, and I have endeavored in my last report to give all the information which I gained in a connected form. I soon became convinced that in order to successfully carry on these investigations a systematic plan had to be followed, so as not to scatter attention over too many points and make the investigation superficial.

This year I selected the latter part of the fishing-season for my investigations, intending to give special attention to the spawning in all its relations, because this phase ought naturally to be the first object of an investigation, and because already, during my last stay in the Loffoden Islands, I had become convinced that it presented many peculiar features which deserved a more thorough examination. This is the season when the young fish come into existence, the same which in a few years will return to the same place as full-grown codfish. An opportunity is thus offered of observing the codfish during the earliest stages of its existence; and although a considerable period elapses between the time when the young fish leave the coast and the time when they return to give birth to myriads of fish, I consider it possible that if we only get a correct knowledge of this fish during the earliest and last stage of its existence, we shall be better able to draw conclusions regarding its place of sojourn and mode of life during that period when it entirely eludes our observation.

In order to be on the spot early enough to witness the spawning process from beginning to end, I left Christiania near the end of February and arrived in the Loffoden Islands in the beginning of March, therefore before the period when the spawning generally commences. I had thus an opportunity of witnessing the coming in of some of the fish, and found several of my last year's observations corroborated. From information obtained immediately after my arrival regarding the former and the present condition of the fisheries, I could see that this year they were of a very peculiar character. While in other years the coming in may be said to have come to an end about this time, it had this year scarcely begun in full earnest, as the chief mass of fish had not yet assembled on the elevated bottoms. I soon found that the cause of this delay was the unusually cold and calm weather which had prevailed in these regions for a considerable time. During the continued coast-wind the temperature of the sea-water had become unusually low, even down to a very great depth. Immediately after my arrival at the fishing-station of Henningsveer, I made observations, and found that the temperature of the water near the surface in the Gimsö current was only $+1.2^{\circ}$ C., and that even as far down as 100 fathoms it was but little higher.

In consequence of the coldness of the water the fish kept at an unusual depth and far from the coast, and very few of them had crossed the ridge (the "Egbackke"). That there was a large number of them on

the other side only waiting for a change of temperature to cross the ridge was sufficiently proved by the rich hauls which some fishermen made whose lines or nets extended exceptionally far beyond the ridge. I had thus a complete corroboration of the opinion expressed by me in my last report, that the temperature of the sea-water has a great influence on the fisheries.

As soon as the weather changed, the fish came upon the elevated bottoms in enormous masses, and everywhere rich hauls were made with all sorts of fishing-inplements. The so-called "fish-mountain" which entered the portion of the sea between Skraaven and Svolvær seems to have been enormously large, to judge from the endless quantity of spawn.

Some time after this, I found, on a calm day, that whole part of the sea covered with a thick layer of floating spawn in various stages of development, so that with a large gauze net I could have taken tons of it. I obtained a quantity of eggs for the purpose of making further observations, and, in a few days, I saw, to my great joy, that my glass jars were full of codfish-fry. By changing the water, I kept them alive for more than two weeks, during which time they had completely lost their large umbilical bags. After this time, however, one after the other of the little fish died, probably from want of the necessary food. But as it was my intention this year to study the development of the codfish from its earliest stages, this being the first step toward obtaining a thorough knowledge of the natural history of this fish, I could not rest satisfied with this first experiment. The earliest stages of the development of the egg I would only be able to observe by artificial impregnation. I therefore obtained some mature eggs of recently-caught fish, placed them in a glass vessel containing sea-water and mixed with it a small quantity of milt. Microscopic observations proved unmistakably, after only one hour had elapsed, that nearly all the eggs had become impregnated.

I continued my observations from hour to hour, and could thus observe the minutest details of the many remarkable changes which the egg undergoes until the fœtus begins to show itself. After eight days, the outline of the fœtus could be seen distinctly in the eggs, and after eighteen days, I had the pleasure to see the tender little codfish come out of the eggs which I had impregnated. I have accurately studied this whole development, and have laid my observations before the Association of Science, accompanied by drawings giving every stage of the development on a magnified scale. By request, I have also exhibited some of the principal drawings at the fishery exposition in Bergen.

My careful observations of the development of the codfish-eggs have been made not exclusively with a scientific object. These practical and scientific investigations of our fisheries, which have been made through the liberality of our Storting, have brought to light a very important fact regarding the propagation of the codfish, which is not only of

great scientific interest, but which may also lead to highly important practical results. I here refer to the remarkable fact mentioned already in my last report, viz, that the eggs of the codfish are not laid at the bottom of the sea, but that during the whole period of their development they float about near the surface of the water. As an unavoidable consequence of this circumstance, enormous masses of eggs are either destroyed by the waves, or washed ashore, or driven to distant places by the current and the wind. If it were possible to assist nature by directing large masses of eggs to places where they could be safe from the hurtful influences of wind and waves, a just hope might be entertained that this would prove a decided benefit to the future of the fisheries. The main object would be not so much to increase the number of fish as to confine the fish to certain localities specially adapted to the fisheries.

The well-known Swedish naturalist, Nilsson, has already spoken of the possibility of successfully applying pisciculture on our sea-coasts, and as he is certainly an undoubted authority in all such matters, I shall quote his words. In the introduction to his "*Skandinavick Fauna*," vol. IV, part 3, he says, on page 32, after having mentioned the various methods of artificially hatching fresh-water fish :

"If any one were to ask me whether artificial hatching could with advantage be applied on our sea-coasts, *e. g.*, to the herring, I would unhesitatingly answer in the affirmative. Since artificial hatching has been so successful in fresh water, it should certainly also be tried on the sea-coast, Lund's method being probably the best for the purpose. Since it has been proved that, following its instinct, every fish goes to spawn to the place where it was born, no fear need be entertained that this artificial hatching would only prove a benefit to some other coast."

The reason why, so far, no experiments have been made in this direction, must be found in the prejudices which are always opposed to anything new ; but it must be said that there have also been other difficulties in the way of carrying out this idea, chiefly the way in which the eggs are generally laid, and the very considerable depth which often seems to be an essential condition of their successful development. These difficulties, however, are not met with in the hatching of the codfish-eggs. The experiments made by me this year have proved that codfish-eggs may be artificially impregnated and hatched even under the most unfavorable circumstances (I used, *e. g.*, common glass vessels containing sea-water) ; it is, moreover, very easy to obtain in a very short time enormous quantities of codfish-eggs impregnated in a natural manner, as they float freely in the water.

During my observations of the development of the codfish I have learned the following, which, in connection with what has been said before, may deserve attention from a practical point of view :

1. Only those eggs are fit for impregnation which, by a gentle pressure, may be squeezed out of the belly of the codfish ; by pressing hard it often happens that eggs come out which outwardly look as if they

were mature, but which, seen under the microscope, appear to be surrounded by a thin covering, which contains the blood-vessels necessary for the life of the egg, and which would prevent the fructifying parts of the milt from entering the egg.

2. Eggs, taken not only from live fish but likewise from such as have been dead for a short time, will retain life and may be successfully hatched.

3. When the egg has reached a certain stage of its development it is not so tender, and can stand a good deal of outside influence. I have thus seen eggs successfully hatched which were entirely mouldy on the outside.

4. The above-mentioned principle also applies to the young fish which have just come out of the eggs. As long as they have the umbilical bag they can live a remarkably long time in impure water; but as soon as this bag has disappeared they become more tender, and as soon as the gills have developed they will very soon die when placed in impure water.

5. The whole development of the egg does not occupy half the time required for the salmon-egg. Even when the temperature is very low it does not take more than eighteen days, and when the temperature is higher it even takes less.

6. Experiments have proved that by artificial impregnation nearly all the eggs have become fit for hatching. When we remember that every individual female codfish can on an average produce 9,000,000 eggs, it will be seen what an enormous number of productive eggs can be procured in a short time and without any great trouble. From what has been said before, it will also be seen that the impregnated eggs of the codfish can be conveyed to a considerable distance without losing their capacity of developing.

Although I am of opinion that this matter is important enough to deserve our full attention, I consider it premature as yet to make direct propositions for carrying out the principles above mentioned on a large scale. Most people will laugh at the "foolish" idea of artificially increasing the number of fish in the vast ocean. But then people in the beginning laughed at the idea of artificially raising fish in our lakes and rivers. The results obtained are, however, already so great and palpable that even the greatest scoffers and skeptics have to give in to the irresistible force of facts. For the present I can do nothing but point to the above-quoted words of the famous Swedish naturalist, and in what I said I only endeavored to show that none of the difficulties which are in the way of artificial hatching are met with on our coasts, as far as the codfish is concerned, and that, on the contrary, the idea seems quite practicable.

In my investigations concerning the development of the egg, I likewise learned to understand certain phases of the spawning process, which formerly seemed to me quite inexplicable. It has thus been

proved by the experience of many years, and as far as I am concerned by my own personal observations, that during the spawning process the spawners are nearer the surface than the milters, and these latter never come to the elevated bottoms after the spawners, but frequently before them. With other fish the reverse is the case. The cause of it is the strange circumstance that both the roe and the milt of the codfish always float towards the surface of the water. The heaviest part of the egg, which is the very point where the fœtus begins to develop, and where the small opening is found through which impregnation takes place, consequently always is turned downward. In order that impregnation may take place, and the tender sperm contained in the milt may enter the opening in the egg, it is necessary that the sperm should approach the egg from below and not from above; and it is likewise necessary, if impregnation is to take place, that the milt should be secreted at the same time as the roe or before. With other fish whose spawning process has been made the subject of investigations, both roe and milt sink to the bottom, and that part of the egg which in the codfish is turned downward is here turned upward, and the male fish must therefore wait until the female fish have laid their eggs, when they take their place and pour their milt over the eggs. The observations made by me this year have, however, convinced me that the codfish is not the only exception to this general rule; for, as far as I could observe, the spawning process of the haddock (*Gadus æglefinus*) is very similar to that of the codfish, and in the Loffoden Islands takes place about the same time; and later I obtained, by means of a fine gauze net, roe of three different kinds of fish, which was floating about near the surface.

During a zoölogical excursion which I took this summer along our Southern coast, I was fortunate enough to witness the mackerel fisheries, which were going on at this time. I here met with similar facts. The mackerel, which about this time approach the coast in dense schools in order to spawn, do not lay their eggs on the bottom. Their eggs, which have a beautiful clear oil-bladder at their upper end, are easily recognized, and float about near the surface of the water exactly like the eggs of the codfish, driven hither and thither by wind and waves. I also here found eggs of different other fish floating about, and I succeeded in hatching some of these, without, however, being able to ascertain to what kinds of fish they belonged. From all these observations it seems to be clear that these peculiar features of the spawning process, at least as far as sea-fish are concerned, are rather the rule than the exception.

I had intended to make further investigations of the spawning of the codfish, but was unfortunately prevented by the fearful and continuous gales which soon after my arrival visited our Northern coasts, and which, with scarcely an interruption, lasted all during the following month, doing great damage to the fisheries, as the fishermen were prevented from reaping the rich harvest which under favorable circumstances would certainly have come to them. I felt sure, however, and expressed

this conviction immediately after my arrival to several persons, that the fishing-season this year would extend much further into spring than usual. Nearly all the fishermen, however, left the Loffoden Islands at the usual time, viz, the middle of April, although the sea was still full of fish. As late as the middle of May, when my stay in these islands came to an end, some people living near Skraaven caught a goodly number of fish with lines at a very short distance from the coast, and among the female fish caught by them there were some which had not yet begun to lay their eggs, which had not happened within the memory of any living man so late in the season.

I considered it of the greatest importance to follow up the development of the young fish as far as possible, and I greatly desired to make the necessary investigations. Even during the last days of my sojourn in the Loffoden Islands the sea was full of young fish, and wherever I cast out my fine net I was sure to catch some. But on account of the spawning process being retarded this year, these little fish were not much more developed than when I left the Loffoden Islands last year, which was a month earlier.

It was not possible for me to extend my stay, as the sum of money placed at my disposal by the government is not very large, and would not allow me to finish my investigation this year. But as the whole matter is of great importance, I hope to be able to continue my investigations next year at the point where I left off this year, and thus follow the young fish through all the phases of its development, until it leaves its birth-place.

As regards the prospects of future fishing-seasons, I consider them as exceedingly favorable. The steady south and west winds which prevailed all during the spawning-season have probably driven a great portion of the eggs far up the west fiord, where we hope that they will develop undisturbedly; and thus after a number of years there would again be good fishing near the old but now mostly-deserted fishing-stations east of Skraaven and the Molla Islands. This would prove a great advantage to the Loffoden fisheries, as the sea near these stations is much better suited for fishing than farther west.

C.—REPORT FOR 1866 AND 1867.

It was my intention in these two years to follow up as far as possible the development of the young codfish and observe its mode of life during its stay in its birthplace. This, in connection with my former investigations of the development of the eggs, I considered as the most natural beginning toward obtaining an exact knowledge of the natural history of the codfish, on which future practical investigations could then be based. My observations were made at the two fishing-stations of Skraaven and Brettesnæs, lying near to each other in the East Loffoden, as I thought it best to stick to one locality in order not to lose the thread of my observations.

In the following I shall endeavor to give a brief review of all the information I gained in these two years regarding the fate of the young codfish after it has left its embryonic state and entered upon a more independent kind of life. I shall dwell as little as possible on the purely scientific aspect of the question, as I perhaps shall have another occasion to enter upon it more fully. I shall, therefore, only mention what I consider of general interest.

In order to connect my observations direct with those made last year, I left Christiania on the 25th April, and could already on Monday, the 7th May, begin my work at Skraaven. I had chosen this place as the one most convenient for my observations, as I was still under the impression that the young codfish staid but a very short time near the coast and gradually went out into the deep. Skraaven is one of those places where the great deep of the west fiord approaches nearest to the coast, as toward the south and the east the distance to the ridge is only one-half (Norwegian) mile.

The first days after my arrival I took with my fine net a considerable quantity of floating codfish-roe from the surface of the water, all in the very last stages of development, showing that the spawning, although it had lasted till the time of my arrival, was now completely finished. Wherever I cast out my net I also caught a number of codfish fry, both such as had recently left the eggs and were still provided with the large shapeless umbilical bag, and some whose bag had been completely absorbed, and which, therefore, had already commenced to lead an independent life. It was an unfortunate circumstance that, even when I tried to isolate them very carefully, I found them dead after a short absence from home, often in such a state of decomposition as to make any examination impossible.

During this stage of their development these little fish are so tender that they cannot exist out of the water, and that even the least touch affects them so much that they die in a very short time. This is certainly the most dangerous period in the life of the young codfish. Millions of them are undoubtedly destroyed by unfavorable circumstances, *e. g.*, storms and high waves, by getting into the breakers or being in other ways exposed to hurtful influences. It seems, however, that even at this early period they instinctively seek sheltered places. I observed on a calm, pleasant day, somewhat later in the season (the 20th May), large numbers of them near the surface of the water in the shallow sound and inlets on the east side of Skraaven, where there is a light sandy bottom. This was the first time I observed them while at liberty, for hitherto I had only been able to observe them in my glass vessels. They generally measured only 7-8 millimeters in length, and they were so transparent that I could easily distinguish them against the sandy bottom. All that could be seen distinctly with the naked eye was the disproportionately large and broad head, the eyes protruding on each side, while the rest of the body only appeared like a small fine thread vibrating continually.

As they were all swimming about on the surface of the water, I could take them up with a flat porcelain saucer and thus transfer them to my glass vessels without touching them or taking them out of the water. In this manner I succeeded in keeping them alive for some time and could subject them to a thorough examination. During the following days I repeatedly visited the same places, in order to observe their further development, and when the weather was tolerably calm I was generally successful. I noticed, however, that their number was not equally large every day; and some days I could, even when the sea was very calm, watch a whole forenoon and only catch a few. I soon found the cause of this. Whenever the fish could be seen in large numbers the sea was swarming with microscopic animals, especially those small crustaceans which are commonly called "herring food" (*Calanidæ*). In these little animals the tender young codfish found an easily digested and nutritious food, and seemed to enjoy them with great relish. By examining the contents of their stomachs under the microscope, I found this to consist exclusively of small crustaceans, chiefly belonging to two species, *Calanus finmarchicus* and *Temora longicornis*.

The warm and calm weather which continued during the following days, and the gentle easterly current, brought constantly-increasing masses of these crustaceans near the shore, and on the 12th June the sea presented a scene of animal life of which only he who has spent a summer on our western coast can form an idea. Everywhere in the sounds and inlets the water seemed thick with myriads of these microscopic crustaceans, and by taking up a little sea-water in the hollow of the hand one caught hundreds of these diminutive animals. Among them floated different kinds of medusæ, stretching out their thread-like feelers, and quickly drawing them in when a sufficient number of these small crustaceans had settled on them. But of special interest to me was the almost incredible number of young codfish which at the same time filled the sea. They might be seen everywhere from the surface of the water down to a considerable depth, appearing like dark vibrating threads eagerly engaged in snapping after the different species of *Calanus*. They had grown considerably, the largest measuring about 24 millimeters in length, and had gradually lost their embryonic appearance by which in the beginning they distinguished themselves so much from the grown codfish. The clear and undivided embryonic fin surrounding the whole body had already in part dissolved into the first and second dorsal fins peculiar to the grown fish, and even the characteristic thread-like appendage under the chin had, in the larger specimens, begun to show itself as a little projection on the lower jaw.

Up to this time I had been able to observe them uninterruptedly from day to day, and had taken note of the slightest changes which they had undergone. But now unfortunately there was a change in the weather, strong east wind and westerly current, which for a number of days made it impossible for me to get on the water. I nevertheless hoped that as soon

as the weather would get calm I would find the young codfish again in their usual places, and that consequently there would be no gap in the series of my observations; but in this I was mistaken. When at length I again visited my usual fishing places, I found the sea-water quite clear and transparent. Of the "herring-food" which formerly had filled the sea, not the least trace could be found, and with it the young codfish had likewise disappeared entirely. In vain did I examine all the neighboring sounds and inlets; not a single young codfish could I find. I began to fear that they had left the coast for good, and their appearance in great masses on the day mentioned before had been a premonitory sign of their departure, analogous to the assembling of the birds of passage before their departure for southern latitudes.

Hoping to meet with a few stragglers, I made use of the first fine day (the 23d June) for an excursion far out on the Westford to a distance of more than one (Norwegian) mile from Skraaven, and, after a long search, I discovered a few swimming near the surface seemingly lost from their comrades. These were the only ones I could discover, although I was on the lookout the whole day. Everything seemed to indicate that their stay near the shore was actually over, and after having searched for a few days longer I began to think of my return, convinced that I had extended my observations as far as possible. But before returning I resolved to make a last attempt and institute a search near some other fishing-station.

Several reasons induced me to select Brottesnæs, which is about a (Norwegian) mile farther north. The first few days I was just as unsuccessful as at Skraaven, and I therefore began to lose all hope of finding them again, when, on a beautiful calm day (the 5th July), I accidentally, while roving about on one of the deep inlets, discovered a young fish which was almost entirely concealed under a large medusa (*Cyanea capillata*) so that only its tail could be seen peeping forth. By means of a dipper of fine gauze I succeeded in catching the medusa and the young fish with it, and to my joy I found it really was a young codfish. You may imagine that I now scanned all the medusæ, which are very common here, very closely, and I found the same phenomenon repeated. Under most of them I found one or more young fish. These were not all codfish, however, for among them I also found another kind of young fish, easily distinguished by their shorter and stouter shape, and, on closer examination, I discovered that they were the young of the *Gadus æglefinus*, or the haddock. Only these two kinds of young fish and none else I found under these peculiar circumstances. I did not find a single young pollack under any medusa, although the sea was full of them at this time.

What can be the cause of this very peculiar relation between two such different animals? This was naturally the first question I asked. That these very tender young fish at this stage of their development should seek the medusæ, these jelly-like aquatic animals whose numberless

poisonous threads extending in all directions make them objects of terror to all smaller animals, and cause even human beings to avoid them carefully, seemed so utterly inexplicable that I thought in the beginning these fish must against their will have gotten into the power of the medusæ. This animal did, perhaps, exercise a magic power over the poor young fish similar to that of certain tropical snakes, which make little birds fly right into their open jaws. But on closer observation I abandoned this idea. These little fish were swimming about fearlessly between the numberless threads of the medusæ; they were scared away by the least noise, returning again after some time. There must consequently be something which attracted the fish toward the medusæ. Possibly they sought shelter under their large disk against other fish. This explanation seemed plausible, but was not entirely satisfactory. Careful observations have now convinced me that the young fish approach the medusæ chiefly for the purpose of catching the many small animals which constitute the food of the medusæ, and which it stupefies by its numerous poisonous threads stretched out in all directions, finally towing them up close to its disk.

Although the young fish thus deprive the medusa of part of its legitimate food, they at the same time render it a very important service which fully compensates for the loss of food. The medusa is much troubled by a parasite, a small crustacean (*Hyperia*), belonging to the tribe of the amphipods, which—often in very large numbers—cling firmly to the medusa by means of their sharp claws, and eat their way deep into its jelly-like body. I invariably found some of these crustaceans in the stomachs of the young codfish.

This remarkable relation between the medusa and the young codfish is not, however, entirely free from danger to the latter, although in many cases it affords a safe place of refuge from the persecutions of other fish. By coming too near to the disk of the medusa the small fish may easily get entangled in its poisonous threads and thus lose their life. I have found a tolerably large young codfish which had met its death in this manner.

The following days I paid frequent visits to these inlets in order to make further observations of the young codfish, and I found the locality exceedingly favorable for my purpose. Whenever the tide comes in the current brings large masses of medusæ floating on the surface of the water; and when the water is very high they are often so closely piled together that one cannot see the bottom, and I was always sure of finding some young codfish under them. These, however, were now so quick in their movements that I had to be very skillful in managing my purse-net in order to catch them. In most cases they disappeared with lightning-like rapidity as soon as they saw my purse-net, and I only succeeded in catching them when they were so hidden under the medusæ that they could not notice the first movement of the purse-net. The largest young codfish which I caught in this manner measured about 40 milli-

meters, or $1\frac{1}{2}$ inches, in length, and showed already distinct colors, 5-6, more or less, dark streaks running all round the body, while on the sides a silvery or golden gloss could be seen. Some days when the weather was very fine and calm I took excursions far out on the Westfiord, and likewise found, even at a distance of one-half a (Norwegian) mile from the coast, young codfish under the medusæ floating on the surface of the water, not only under the variety having long threads (*Cyanea capillata*), but also under the harmless disk-shaped *Medusa aurita*. Sometimes I even found them keeping quite still under other objects floating in the sea, e. g., pieces of algæ, &c.

This was the extent of my observations for this year. The season was now so far advanced that I had to think of my return and defer any further observations of the young codfish till next year. I was still of opinion that the (comparatively speaking) few codfish which I had found near the medusæ were only stragglers, and that the great mass of them had gone out to the deep, not to return to the coast till they were fully matured and ready to spawn. I was very anxious, however, to reach absolute certainty regarding this matter, and even if I should fail in this, it would be very interesting to follow the further fate of these young codfish which remained near the coast, as far as possible.

The following year (1867) I left Christiania about the middle of July, and arrived near the Lofföden Islands about the time when last year I had to close my investigations. It will easily be understood that I hastened to get out to sea, as fast as possible, so that I could connect my observations directly with those of last year. I also succeeded, the very first day, when from Skraaven I was making an excursion far out on the Westfiord, in observing a few young codfish which kept under the medusæ floating about near the surface of the water. I did not succeed in catching any of them, but I became convinced that this year's fry could be observed under the same conditions as last year's, and that they were not so far developed as to leave any gap in my observations. Later, I became convinced that their number near the coast must be very large, by examining the stomachs of a number of large fish, especially the large pollack, which, about this time, were caught in large numbers.

Every one of these pollacks was crammed with young fish, often it is true in such a state of decomposition that it was impossible to decide to what species of fish they belonged, but just as often I could ascertain these to be young codfish, the only strange circumstance being that they were all considerably larger than any of those I had observed near the medusæ. This seemed to prove that the young codfish, when they abandoned their roaming life near the surface, kept nearer the bottom of the sea in order to find their food, which the medusæ did no longer supply. But as it was my object not only to study the mode of life and further fate of the codfish, but also to make them the subject of as complete and thorough a scientific investigation as was possible, observing the

least changes in their shape, color, and different organs which they still had to undergo before reaching maturity, this was not enough for me. I had therefore to find some way of subjecting them to a closer examination. But how was this to be done? The places where the pollack are generally found are all on that side of the ridge looking toward the ocean, and are consequently exposed to its immediate influence; only in perfectly calm weather I could entertain the hope of meeting with success in my investigations. The depth in these places is moreover quite considerable (at least 10-20 fathoms), so that even in the most favorable weather it would be a great question whether I would be able to catch any young codfish with the apparatus which I had at my disposal.

Resolving not to lose courage, I visited the places where the pollack are found as often as the weather permitted. I had frequent occasion to witness the playful gambols of the pollack, which the favorite poet of these northern people, Peter Dass,* has described in so simple and true a manner in his "Nordlandske Trompet" (Northern Trumpet):

Thou gaudy pollack! I had nearly forgotten
To sing of thy gambols and cheerful sport!
How happy thou dancest at midsummer's time,
When the sun shines warm, and the weather is calm,
And nature gladdens the hearts of men.
How often I saw thy sportive schools
Change the shining surface to seething foam,
And romp about in the waters!
But alas, when thy joy has reached its height,
The fisherman's net is approaching
To take thee away in its gloomy folds
And end thy sports with thy life!

I was told that the pollack found its food in these places, and from former observations I knew that this food, to a great extent, consisted of young codfish. I was much interested to see how the pollack caught the young codfish. It looked like a systematic chase, and it certainly looked as if the pollack were acting with a common and well-defined purpose. As far as I could observe, the schools of pollack surrounded the little codfish on all sides, making the circle constantly narrower, till all the codfish were gathered in one lump, which they then by a quick movement chased up to the surface of the water. The poor little fish now found themselves attacked on two sides: below, the voracious pollack, which in their eagerness often leaped high above the water; and above, hundreds of screeching sea-gulls, which, with wonderful rapidity and precision, pounced down upon those places where the pollack showed themselves, to share the spoils with them. I, of course, did not fail to make use of this chase in order to catch some of the scared young codfish; I was, however, unsuccessful in my endeavors, although I repeatedly had my boat rowed to those places where pollack could be seen, and could see how the sea-gulls caught one fish after the other at the distance of only two or three yards.

* Peter Dass died 1708.—TRANSLATOR'S NOTE.

This whole chase is carried on so rapidly, and the young fish stay only so short a time near the surface of the water, before they are again scattered in all directions with lightning-like rapidity, that it was not even possible for me to see any, much less catch them with my insufficient implements.

The next time I went out I took a couple of good fishing-lines, hoping to catch a pollack whose stomach might contain some young codfish in a good state of preservation, and I actually succeeded in this manner in obtaining a few well-preserved specimens, and once I even found in the stomach of a pollack, which I opened immediately after it had been caught, a live young codfish measuring eighty millimeters in length, which, when placed in a glass containing fresh sea-water, recovered rapidly and swam about in the water, so that on my return I could subject it to a thorough examination and could draw its picture.

After I had staid several days near Skraaven, I went on the 31st July to Brettesnæs, where, during the preceding year, I had noticed young codfish; I expected to find in the deep inlets large numbers of medusæ and possibly near them some young codfish, but I was disappointed in my expectations. The unusually cold and raw weather which had prevailed during the early part of the summer seemed to have exercised a retarding influence on the development of the medusæ, or at any rate to have kept them at a greater distance from the shore and at a greater depth. It was a rare occurrence to find a medusa near the surface of the water. In vain did I repeatedly and at different times of the day search all the sounds and inlets in the neighborhood; I had invariably to come back empty-handed. But I observed the same phenomena as at Skraaven; not only the pollack but likewise all the other large fish which I examined had their stomachs full of young fish, among which the codfish preponderated.

I considered it both a loss of time and an objectless waste of strength to fish for pollack in order to get young codfish, for only in very rare cases could I hope to obtain specimens in a state of preservation which would permit of scientific examination. I therefore resolved to take excursions in various directions, hoping that some chance would turn up of observing young codfish. And sooner than I had expected, such an opportunity presented itself. It was a beautiful calm day (the 3d August), and I had my fishermen take me out to the deep east of Brettesnæs, when I noticed that in a certain place the sea was filled with pieces of algæ and other objects which doubtless must have come from the shore and been driven hither by the current.

On closer examination I found that these objects floating in the sea formed as it were a continuous broad road extending parallel with the coast from the mouth of the Raft Sound in the north and following all its turns as far south as the eye could reach. A slight breeze which sprang up about this time and produced a gentle ripple on the water, let this road appear more distinctly, as the water within its limits remained perfectly

smooth on account of the fatty substances which with the algæ had collected near the surface of the water.

This phenomenon is well known to the inhabitants of this coast, and is by them called "*Strömblak*"; it chiefly occurs where there are sounds with a strong current, and it was nothing new to me. I nevertheless resolved to give more attention to it, as I thought it probable that the current might here have brought together a considerable number of medusæ and possibly in their company some young fish; and I was not mistaken.

Among the algæ I found numerous medusæ, many of which showed unmistakable signs of having lain in dry places for some time, and were consequently more or less in a state of decomposition. Nevertheless I found among them some few that were strong and healthy, and I soon discovered under them several young codfish, of which I caught two. They were both very small, scarcely larger than the largest which I had last year found under the medusæ, so that they did not aid me much in continuing my study of the changes of form and color which the young codfish undergo. All those which I caught in this place seemed to be very young, and probably belonged to those which had been hatched last.

But when our boat gently approached the above-mentioned smooth streak I discovered large and small schools of young fish swimming about freely; they seemed to be considerably larger than the young fish I had observed this year, and disappeared quickly as soon as the boat approached them. After several futile attempts I at last succeeded in catching some in my purse-net, and, to my great joy, found that they were actually young codfish, measuring 50 to 60 millimeters in length. I could now examine them while still in a live condition, and thus supplement the observations which I had formerly made on those which had been taken from the stomachs of pollack, but which had all, more or less, been in a state of decomposition.

Now first I got a correct idea of the peculiarly beautiful coloring of these fish during this stage of their development. It is quite different from that of the full-grown codfish, and these young fish are certainly some of the prettiest-looking I have ever seen. The dark cross-streaks which had already showed themselves on the larger of those young codfish which I had caught last year, had now dissolved into 3-4 parallel lines of square spots of a more or less bright reddish-brown color, which contrasted beautifully with the light color of the body, resembling a chess-board in the regularity of their arrangement. The sides and the head showed an alternating silvery or golden gloss. The characteristic thread-like protuberance under the chin had now become fully developed, as also the fins; in fact, aside from the color, these fish could immediately be recognized as codfish.

I knew now where I had to look for them in the future, and supplied myself with the necessary fishing implements. The only drawback

was that I could only pursue these investigations in very calm weather, and the following days were unfortunately anything but calm, a strong east wind prevailing all the time. But sooner than I had expected under the circumstances, another and more convenient opportunity presented itself for continuing my observations under far more favorable conditions.

One day when my fishermen rowed me along the shore in the sheltered inlets, where in lieu of something better I intended to observe the young pollack of which there were a great number, I suddenly discovered close to the bottom some young fish of about the same size, which, however, by their brighter color and their peculiar marks differed from the pollack, and in which, to my great joy, I soon recognized young codfish. I did not succeed in catching any that day, but I had now found the lost track and determined to follow it up.

The first fine day (the 23d August) I went to the place where I had seen the young codfish, of course well supplied with all the necessary implements; and I had not to search long, for all along the shore they were found in as large numbers as the young pollack. They were now so large that I could catch them with bait; and I even succeeded in catching several with a fine hook. I caught quite a number that day, and could now subject some of them to a thorough anatomical examination. On examining their stomachs I found that small as they were they could not deny the well known voracity of their species. The contents of the stomach consisted of a great variety of marine animals. Some were completely filled with young snails; one had swallowed a full-grown *Gammarus locusta*, which filled the stomach and was well preserved with all its feet and claws; another one had swallowed a tolerably large worm (*Annelide*), one-half of which had been completely digested, while the other half had scarcely entered the stomach; and it even happened once that a large young codfish which I had placed with others in a tub filled with sea-water, snapped after a smaller codfish evidently with the intention of swallowing it, in which, however, it did not succeed as the fish was too large.

The following days I visited various places in the neighborhood so as to obtain a more correct knowledge regarding the number of young codfish in these waters. In nearly all the bays and inlets which I visited I found them in very large numbers together with young pollack. They had doubtless come near the coast quite recently, for previously I had not seen a single one. In a certain sense we may, therefore, count an important period in the development of the young codfish from this time; for they have now changed their roaming sort of life to a more stationary one, or, to speak scientifically, they have from pelagic become littoral fish.

As an intermediate stage between the pelagic and littoral periods, we may consider the time when they seek the company of the medusae. As these by wind and current are driven on the shore in very large

numbers, it may be said that they, in a manner, show the young codfish the way to the nearest coast. When measuring about 40 to 50 millimeters in length, they leave the protecting company of the medusæ to seek their food elsewhere; about this time they seem to gather in larger and smaller schools, which in the beginning, as if loath to renounce their roaming life, roam about for some time near the coast.

This appears to be one of the most dangerous periods in the life of the young codfish. They are eagerly sought after by various fish-of-prey, especially by the pollack, which arrive about this time, and which certainly destroy millions. These small defenseless young fish would therefore have but a very poor chance of reaching maturity if their instinct did not teach them to seek the quiet bays and inlets, where, among the algæ grazing near the shore, they find sufficient food and shelter from their persecutors.

After having continued my investigations for some time, I returned to Skraaven in the beginning of September. Here I likewise found young codfish all along the shore, the largest number close to the landing-places, so that by going a few steps into the water I could catch as many as I wanted. What struck me very much, however, was the circumstance that during all this time they did not seem to have grown much, although a considerable time had elapsed since I had first observed them near the shore. Only every now and then I caught some larger ones, but this was, comparatively speaking, a rare occurrence, the overwhelming majority measuring about 60 to 70 millimeters in length. I observed them day after day far into September, but strange to say their average size remained the same. They seemed to have stopped growing entirely, although one might have thought that just at this very time they would grow more rapidly, as they had plenty of food in the numberless small animals living among the algæ.

It was evident that here was a curious problem which must be solved, and after I had begun to study the question thoroughly, I soon found its solution. The fish which day after day might be seen near the coast were not, as I had thought in the beginning, the same individuals, but there seemed to be a constant emigration and immigration. If we remember that not all the codfish spawn at one and the same time, but that there may be a difference of one and even two months, it is evident that there must likewise be a great difference in the development of the young fish. It is quite probable that some young codfish which had not yet given up their roaming life, were found near the Loffoden till the very end of my stay there, *i. e.*, the beginning of October. In all probability those young codfish which I saw swarming near the landing-places must be counted under this category.

But what became of the larger and older fish? The answer to this question was easily found and its correctness could be corroborated by direct investigation. As is the case with other fish of greater size, the smaller ones are generally found near the coast, while the larger ones seek

the deep water. In order to catch larger young codfish, I must therefore seek a more suitable locality and supply myself with the proper fishing implements. By means of a tolerably large purse-net which could be let down to the depth of several fathoms, and herring as bait, I succeeded during the following days in catching some of the older codfish. When the weather was sufficiently calm and the water clear, I could easily observe them. The larger they were, the deeper did they keep themselves swimming about with their belly pressing against the bottom. Only with great difficulty I could by means of bait entice them higher up, while the young pollack both large and small were swimming about near the surface.

Thus these two kinds of fish show their different nature even at this early period. The codfish distinguishes itself from the pollack by being a genuine bottom-fish. We may also see in this circumstance the first indication of the "going out" of the young codfish. As they grow older and larger they probably gradually seek a greater depth of water, until they meet their progenitors in the great deep outside the coast. The larger young codfish which I caught in the above-mentioned manner a few days before my departure, *i. e.*, in the beginning of October, measured 120-130 millimeters, or upwards of four inches in length, and could at most be scarcely considered more than seven months old. From this time on they probably grow more rapidly, and I therefore presume that it scarcely takes more than three or at most four years till they return to their native place as full grown codfish, to give birth in their turn to millions of young fish.

In the above I have simply given a report on the history and the results of my observations during the last two years, and I shall add a few remarks. There are probably many who, after having read the above, will say, "All this may be quite interesting to read, but of what practical use is it? Does the government for those sums which are spent on these practical and scientific investigations get the value of its money?" It will be useless to argue the question with those who expected important practical results from the first year's investigations, just as if such results were ready made and only waited to be brought to light. I hope, however, that there are some persons who, from the very beginning, have looked at the matter in the right light, and who have become familiarized with the thought that practical results can only be reached by a thorough scientific investigation, and can only be considered as actual results when they rest on a firm scientific foundation. These persons will understand me when I explain to them my views of the whole matter. I consider it necessary in every extensive investigation, especially when, as in the present case, a new field has to be entered, that, first of all, the object of the investigation is fully and clearly understood; and that, secondly, a well-defined plan is followed.

To plunge at once *in medias res*, and enter upon suppositions before any firm basis has been gained, may look well enough to the casual ob-

server, and may gain fame for the one who starts some such brilliant suppositions, but this way of proceeding is, in my opinion, by no means a safe one. It is better to proceed slowly but surely even if every foot of ground has to be gained by overcoming difficulties. The knowledge obtained in this manner may truly be called a safe capital which will yield rich interest. My first object was to gain as complete a knowledge as possible of the natural history of the codfish, and I have sought to gain it all the more eagerly, as I consider such a knowledge as an important result in itself.

True to my above-mentioned determination to follow a well-defined plan in my investigations, I have, in the full sense of the word, begun *ab ovo*, with the development of the egg, and have, step by step, followed the further development and fate of the young fish during their stay in their native place. Any one who knows how incomplete our knowledge of the propagation and development of salt-water fish has been will grant that a connected series of observations of one of the most common and most important species of fish will always possess great scientific interest; and I do not hesitate for a moment to declare it as my sincere conviction that such observations are also of great practical importance, if in no other respect, at any rate because they must be considered as a necessary link in the chain of our knowledge of the natural history of this fish.

It will easily be understood that the knowledge of the development of the young codfish gained by a single series of observation cannot be complete and exhaustive. I have, to the best of my ability, endeavored to get from them as much information as possible, but I must confess that there are certain points which require a closer examination and a fuller corroboration. I therefore consider it necessary to follow the development of the young fish once more, and likewise to ascertain whether they are found under the same conditions on other points of our extensive coast. It would, finally, be a matter of great interest to follow the development of the young codfish farther into the winter, which doubtless could be done if one had the necessary apparatus.

D—REPORT FOR 1868 AND 1869.

In accordance with the plan mentioned in my last report, I started for the Loffoden in the first days of November, 1868, in order to continue my observations of the young codfish. I did not expect, however, that my observations would extend very far into the winter, as shortly before I left the Loffoden Islands last season I thought I had noticed signs that the young codfish were beginning to go out to the great deep. I considered it of great importance to follow them as far as possible, and with this object in view, I was not frightened by the prospect of having to spend the darkest and most stormy part of winter in these arctic regions.

After a long and difficult journey, I reached the Loffoden Islands toward the middle of November, and immediately commenced my investigations near Skraaven, endeavoring to make the best possible use of the short days. I found the young codfish under the same conditions as when I left, all along the shore, even near the landing places, but, although the season was much farther advanced than when I left last time, their size was about the same.

In order to find larger and older codfish I had to choose locations where the bottom declined very abruptly. The last time already I had chosen such a place and had found it very convenient for my observations. From the south a very deep inlet called "Galtvaagen" extends far inland; it is well protected from the sea and wind, and its bottom falls off abruptly on both sides; the inner portion has a flat sandy bottom, which near the coast has a rich vegetation of algae. Here I found, both at the time of my departure last year and now, a large number of small young codfish; I therefore hoped that in the deeper places of this inlet I would find the larger young codfish on their gradual journey toward the great deep. I soon discovered in the deeper places some young codfish of considerable size, which, with their heads pressed against the bottom, were swimming around among the stones where the bottom began to rise toward the shore. These fish were, however, much more cautious than the smaller ones, and could only with difficulty be enticed to snap after the bait attached to my purse-net. As this way of fishing is rather awkward except in places where the water is shallow, I soon abandoned it, and got a fine line with two hooks baited with herring, and a few days later caught some of these young codfish. The largest measured 150 millimeters, or almost 6 inches, and were therefore considerably larger than the largest I had caught just prior to my departure last year. The young fish, scarcely half the size of the above-mentioned ones, which kept near the shore seemed meanwhile to decrease in number day by day, and it finally became a rare occurrence to see them in those places where formerly they had made their appearance in enormous numbers. These young codfish were therefore evidently going out; and as I did not catch any more of the larger ones in the deep places, I began to think that they were preparing to leave the coast for good to undertake their long journey to the unknown places far out at sea where the grown codfish live when not near the Loffoden Islands. When thinking more about it, however, I found that this could not be the case. For they would go almost direct into the jaws of the large schools of codfish which probably about this very time were approaching the Loffoden Islands for the purpose of spawning; and, judging from the greedy nature of these fish, there could be no doubt that they would not spare their own offspring, but swallow unmercifully every young fish which came in their way. I knew, however, that nature takes better care of the preservation of the species than to permit such an occurrence, and I therefore felt sure beforehand that they must still

stay near the coast for some time, and that I in some way or other would meet them once more before my departure.

After several resultless investigations made in different places, I one day (the 10th December) cast my line near a high rock called "Skarvbjerg," which rises perpendicularly from the sea, which is sheltered from the wind, and where close to the shore there is a depth of 8 to 12 fathoms. The line had scarcely touched the bottom when there was a vigorous pull at it, and on each hook I brought up a struggling young codfish. I now continued to haul them up as fast as I could go. Sometimes I caught one, sometimes two, and in a very short time I had about twenty. All of these were considerably larger than those I had formerly found near the coast, all measuring from 150 to 200 millimeters. I had now found a convenient place where in the future I could always procure young codfish, and was well contented with this day's result. But as I had set myself the aim not only to examine from a zoological point of view the changes of shape and color which the young codfish undergo during their development, but also to obtain a general idea of their mode of life during the various stages, I could not rest satisfied with this result. I must also find out whether they were likewise found in other places under similar conditions; in other words, whether these conditions applied to *all* young codfish of this size.

The investigations made by me during the following days seemed to confirm my belief that such was the case. In most places where I cast my line near the coast, at a depth of 6 to 10 fathoms I caught several young codfish of a similar size. Nowhere, however, I found them in such large numbers as near the Skarvbjerg.

On a particularly calm and fine day I therefore examined this locality more closely, if possible to find the cause of these fish appearing in such extraordinarily large numbers in this place. The water is remarkably clear and transparent at this season of the year, and in calm weather one can see the bottom at a very great depth, and I could consequently examine the place very easily on a fine day. From the Skarvbjerg the coast falls off almost perpendicularly toward the bottom, at a depth of 6 to 8 fathoms. As in nearly all the sounds near the Loffoden Islands, the bottom consists of coarse sand. At this place, however, it was for a considerable distance covered with algæ, which gave it a spotted appearance, light and dark places alternating. I soon noticed young codfish, and my observations convinced me that they must live here in very large numbers. As often as they crossed from one grove of algæ to another, their bodies were, even at this great depth, brought out in distinct outline against the light sandy bottom; and by watching one of these bright spots for some time I could see one codfish after the other, and often many at a time, cross in every direction. It was evident that here they must find plenty of food, and by examining several young codfish which I had caught here, I found this fully corroborated. Their stomachs were invariably filled to their utmost capacity with different marine

animals, especially small crustaceans, many so large that one of them filled the stomach and was lying there in a good state of preservation, with all its feet and claws. The enormous number of crustaceans was easily accounted for by the nature of the bottom and the general character of the location.

Right opposite the Skarvbjerg there are two islands separated by a narrow sound, the current coming from the ocean passing through it from three different points. These three different currents meet at the Skarvbjerg, and all the small animals brought in with the current gather here. Even later in the season the place is well known to the fishermen as a good fishing place for other fish, which, during the summer, like to come near this steep mountain.

The great variety of color in the young codfish was quite remarkable, although most of them had not yet assumed their final dark-spotted appearance, but showed on their sides on a dark background three rows of bright spots (almost as white as chalk); the color of this background varied very much, so that no two fish were alike in this respect. All the different shades of color could be observed, from bright red and yellow to a bright green or gray. A great difference could likewise be observed in the shape, some (always those having a bright red and yellow color) being thick-set, the outline of their back being strongly curved; others again having a more slender and elegant shape. I found that all these variations of shape and color were chiefly occasioned by the difference of food. The thick-set, reddish-yellow fish had chiefly lived among the algæ and had swallowed large numbers of the reddish crustaceans which are found here, while those of a light green or gray color had chiefly lived on the sandy bottom, where they had not found so much food; they were consequently much thinner. In their stomachs I found, besides a few small crustaceans, several species of worms living on the sandy bottom; in some, a few young fish, *e. g.* young *Cottus scorpio*.

During the following days I was quite busy examining these different varieties and making drawings of them, and only occasionally I took a short trip to my usual fishing-station near the Skarvbjerg, in order to procure fresh material for continuing my observations. In the course of the winter the number of fish decreased gradually, so that toward the end I could fish for hours without catching anything. The few young codfish which I caught were not much larger than the first time I found them here, although a considerable time had elapsed. The phenomenon observed by me at a previous visit thus repeated itself. It seemed as if their growth had been stopped, although the rich and plentiful food found here would rather lead to the opposite result. I knew, however, from experience that it only seemed so, and that the simple explanation was this, that the few young codfish which were still found near the Skarvbjerg were not the same as those seen here some time ago, but younger ones, which up to this time had lived some distance from the coast.

Those young fish which I had the first time found here in such enormous numbers must, therefore, have gone to other places, probably to the great deep. In order not to lose the thread of my investigation, I had therefore again to go after them. As none were to be seen in the sound between the islands, I had to make my observation farther out at sea, which at this season of the year could not be done every day. The stormy weather which set in at the beginning of the month (February) and which continued for a number of days, seemed to place an insurmountable obstacle in my way. All I could do was to wait patiently until the weather got fine again.

On the first tolerably calm day I went out, fully supplied with fishing-lines and fresh herring for bait. But I soon found that fishing here was not so easy as nearer the coast. The strong current, which, in consequence of the long-continued stormy weather was coming in from the great deep, made it impossible for me to keep the lines steadily near the bottom. Every time my boat was raised by a wave the lines were likewise raised a considerable distance from the bottom, and every time the boat sank lower the lines got entangled among the algæ, and when the boat rose again the hooks and bait were torn off.

After several futile attempts, during which I had lost quite a number of hooks, I abandoned my purpose, and returned to my usual fishing-station near the Skarvbjerg; but not a single fish did I catch here, nor could I discover any among the algæ, which, formerly had been their favorite place of sojourn, and where I had often observed hundreds of them.

The same was the case in some other places which I visited in the course of the day. The young codfish seemed to have disappeared entirely. It was evident that the only place where there would be some hope of finding them would be those very places outside of the islands, and covered with algæ, where I had been so unsuccessful. But I was convinced that, in order to succeed, I must change my method of fishing, and use implements more suited to the circumstances. I had, in the course of my investigations, so often to make similar changes, that I had become accustomed to them. I had begun to take the newly-hatched young fish from the surface of the water with a porcelain saucer; then I had used a small purse-net made of fine gauze; then a small hook tied to a thin thread; then a large purse-net; and finally a regular fishing-line. I now determined to use a stationary line, which I could set in a convenient place in the evening and haul it in in the morning, believing that I would save much time which I had formerly lost in catching young fish. I had such a line prepared and furnished with about 100 of the smallest hooks I could find.

As soon as I could procure enough fresh herring for bait, I set my line at a depth of 20 to 30 fathoms in one of the sandy bottoms, bounded on both sides by dense groves of algæ. The following day the weather was not very favorable, but for hauling in a line you need not be so particu-

lar about the weather. I therefore went out anxious to see the result of my new method of fishing. I soon noticed that there must be fish on the hooks, but I was not prepared for as large a haul as it turned out to be. On nearly every other hook there was a young codfish, and when the end of the line had come up, I was almost surrounded by fish. They were all considerably larger than those I had formerly observed in this place, their average length being about one foot. In the beginning I thought that these must be two-year-old fish, but when I afterward set my line in a shallower place I also caught smaller fish, so that I soon had all the different grades of size. The "going out" of the young codfish to the algæ bottoms had probably begun much sooner than I had expected, and some of the older fish had, perhaps, already gone out while I was still pursuing my investigations in the shallow places along the shore.

That these fish, which later in spring are well known to the fishermen by the name of "algæ-fish," are really young codfish, and not, as the fishermen generally believe, a separate species of torsk, which lives all the time on the algæ bottoms, has been placed beyond a doubt by my former investigations. These fish were, both as regards color and shape, so exactly like the full-grown codfish, that by placing them side by side there could not be the least doubt that they were the same fish at different stages of their development. Some of them, which chiefly seemed to live among the algæ, differed at first sight somewhat from the others by their plump shape and their brown and even red color, and by a larger number of the characteristic dark spots. But there was no doubt in my mind that these differences were only caused by their having chosen locations which yielded more and better food, and that, under less favorable circumstances, they would in a comparatively short time again assume their usual color and shape; for I found fish in every imaginable intermediate stage, and as regards the younger fish, former observations had proved this conclusively.

Occasionally I also caught a considerably larger fish, not much smaller than the small winter-codfish, only that the organs of generation were not yet fully developed. All these larger cod I considered to be stragglers from the generation immediately preceding this one, therefore two-year-old fish. The chief mass of the small codfish living on the algæ bottoms during spring and summer belong, in my opinion, to one and the same generation, and the very considerable difference in size is easily explained by the circumstance that they are hatched at different times (the spawning-season of the codfish lasts from the middle of February till some time in May), by the difference in the quantity and quality of their food, and likewise by purely individual causes.

Having now again found the young codfish in a new phase of their development, and having thus found the thread of my investigations, which I had almost considered as lost, the next thing for me to do was to corroborate more fully the results of my observations, and to get some idea regarding the occurrence of the small codfish in the different local-

ities. I therefore continued my line-fishing for some time in different places, and whenever the conditions were the same as when I first commenced this kind of fishing, I invariably caught large numbers of fish.

I delayed my departure until I had obtained some of the eggs, which at this time (beginning of March) were floating about everywhere, eggs which had been laid by the large schools of spawning codfish which had now come near the coast; and until I had artificially hatched some of the small, almost microscopic young fish, which during a former year had formed the starting-point of my investigations. I had thus, step by step, followed the young fish for a whole year during the different phases of its development and had thus finished one of the first and most important, and at any rate least known, chapters in the natural history of the winter-codfish. Further investigations of the growing codfish I had to defer till another year, as I had staid long beyond the time I had set myself.

During the time when I made the observations which I have briefly described in the foregoing, viz, during winter, the grown winter-codfish had come near the Loffoden Islands at the usual time, and had given plenty of employment to all the fishermen. The largest fisheries were going on at the very place where I had stationed myself, viz, Skraaven, so that for some time people almost waded in fish, liver, and roe.

Although a study of the cod fisheries themselves was not included in my plan for this year, as my time was too much occupied with the investigation of the development of the young fish, I nevertheless resolved not to miss the chance entirely of making some observations on matters which I thought might in some way be connected with my present investigation, and which formerly I had no chance of making, on account of other questions which required my undivided attention.

The first point was to examine those winter-codfish which came in first, if possible from the contents of their stomachs, to reach some conclusion as to the places where these fish staid. Of the many winter-codfish which I examined only very few had some inconsiderable remnants of food in the lower portion of their stomach. From what I found I concluded that their food consisted almost exclusively of herrings, and even in the greenish homogeneous mass contained in the lower part of the entrails I discovered portions of the gills of the same fish. In one stomach I found the whole backbone of a herring, which, by its extraordinary length, proved it to have belonged to the large sea-herring, which during the last years has during winter come near the outer coast of the Loffoden Islands and Westeraalen in enormous numbers. Many reasons led me to the conclusion that the sameness in the character of the food was not merely accidental during this year; and it is my firm conviction that the principal food of the full-grown codfish really consists of herrings and similar small fish. Its unusually bright and shining color and its strongly-developed teeth indicate a genuine fish of prey. I consider it, therefore, highly probable that the codfish

live in the same places as the herrings and similar small fish. But if we ask where these places are, no definite answer can be returned, since we do not know where the sea-herring stay during the time that they are not near the coast for the purpose of spawning. I shall have occasion to refer to this matter again, and give that opinion which I consider as the most probable.

The second point was, to examine the so-called "coming-in" fish, which in the opinion of the fishermen is different from the codfish, and which, especially in the beginning of the fishing-season, is frequently caught together with the common winter-codfish. I had already during my first stay in the Loffoden Islands cursorily examined this fish, and found that the only distinguishing mark which was mentioned, namely, that the skin of its belly was light, while with the codfish it was darker, was wanting in most instances. But as at that time I was not so well acquainted with the normal appearance of the codfish as I am now, I resolved to institute a careful comparison between the two fish, in order to arrive at some certainty in this matter. In order to do this, I had first to make myself acquainted with a number of individual codfish, and therefore selected from among the fish brought to land the most characteristic specimens, which I examined carefully, measuring them and making accurate drawings of them.

Having thus become thoroughly acquainted with the looks of the codfish, I endeavored to get specimens of the so-called "coming-in" fish, in order to institute comparisons between this and the former. The first specimen I obtained appeared to have certain distinguishing peculiarities of shape and color. The shape of the body was thicker and plumper than in the codfish proper, the head was not so pointed, and rather broader across the neck; the color likewise differed from that of the codfish proper, the main color being a distinct brownish-yellow, the number of dark spots was larger and extended farther down the sides. But what had still greater weight, in my opinion, was the circumstance that the teeth were smaller and fewer in number than in the codfish proper. The specimen which I examined had just come out of the water, and was quite fresh and in an excellent state of preservation. On opening it I found it to be an unusually fat female, with a remarkably large liver and large fully-matured roe-bags. As regards the number of rays in the fins and its general anatomy this fish was an exact counterpart of the common codfish.

With a view of still further examining this so-called "coming-in" fish, I went to a place on the east side of Skraaven, where the elevated bottom is somewhat narrower, and where "coming-in" fish were said to be found quite frequently among the common codfish.

When I arrived, the fishermen were just hauling in a net, and I therefore resolved to see what fish were in this net. The fishermen pointed out several fish, which in their opinion were not real codfish, but "coming-in" fish. Some of them were, as far as their shape and color was

regarded, exactly like the specimen I had examined; but there were some where the differences noticed by me were by no means so distinctly marked, and with many fish neither I nor the fishermen could tell to which class they belonged. Every imaginable shade of difference between the two was found, and not one of the distinguishing marks mentioned by the fishermen seemed sufficient to draw a sharp dividing line in all cases. I therefore arrived at the conclusion that the "coming-in" fish and the codfish proper were really one and the same fish, and that the peculiarities occasionally found in some of the former were owing to purely accidental circumstances, *e. g.*, food and location; in other words, I felt convinced that the young of the "coming-in" fish may become codfish proper and *vice versa*.

During these fisheries I also occasionally had an opportunity to make some other observations, which all went to corroborate some points in the spawning process of the codfish mentioned in my first report. I had thus several times an opportunity of convincing myself that the male fish, contrary to the general rule, while spawning are nearer the bottom than the female fish. Those boats which employed drag-nets almost exclusively caught male fish, while those using floating-nets caught female fish.

That the male fish must be nearer the bottom I would have declared as a necessity, even before I had found it corroborated by tangible proofs, from the nature of the matured eggs; for these are always found in such a position that the side containing the micropyle turns downward. Even when (as frequently happens in experiments made with artificial hatching) some eggs are squeezed out of a codfish which have not yet been fully matured, and are still covered with the thin skin containing the blood-vessels, they will nevertheless turn the side with the micropyle downward. It will therefore be easily understood that during the natural spawning process the male fish must be lower than the female, so the milt which is rapidly rising towards the surface may hit the only place in the egg where impregnation can take place. The build of the eggs, on the other hand, necessitates their floating near the surface. The many experiments with fish-eggs which I had made during former seasons, and likewise this winter, had proved this peculiar phenomenon beyond a doubt. If, therefore, any one in making such experiments, should find that the eggs placed in some vessel do not float toward the surface, this is either a sign that the water does not contain sufficient salt, or that the eggs are not mature, or that they have begun to decompose. Wherever this is the case, they can never be hatched.*

I must yet mention another point, which I consider of great interest, and which I found corroborated by my investigations. For several seasons I had observed, toward the end of my stay in Skraaven, that the water in the sounds formerly so clear and transparent had become thick

* I have mentioned this because I have been told that experiments with the artificial hatching of codfish eggs, made in Christiania this spring, had proved my statement that codfish eggs were always developed while floating near the surface to be incorrect.

even up to the very landing-places, and that this was occasioned by enormous masses of floating roe in every imaginable stage of development. In the beginning I thought that this roe had been brought in from the sea by the current, as the codfish farther out had commenced to spawn; but, to my astonishment, I found that the quantity of roe farther out was not large enough to warrant such a supposition. I soon found out the real state of affairs. This was the time when the fisheries were in full blast, and one large boat-load of fish after the other was brought ashore by the fishermen. It was, therefore, an every-day occurrence to see the fishermen on their return from the sea everywhere busy at work cutting and cleaning fish, taking out the entrails, the liver, and roe, finally cutting off the head, and throwing the fish on the shore or on the many boats for the purpose of drying or salting. All this was, by dint of long practice, done with an amazing rapidity and precision.

These fishermen, however, had not the least idea that by thus tending their wonted business they were, at the same time, acting as "artificial hatchers of fish." But this was really the case. By the one cut which opens the belly of the fish, a slit is invariably made in the roe-bag or in the milt, a considerable portion of the mature eggs and the loose milt flow out and mingle in the water. When the cleaning of the fish, as often happens, is going on on the strand, a good deal of the roe coming out of the fish during this process is undoubtedly lost by lying in the warm sun too long; but often it will develop, even here, if it falls into one of the numerous puddles of fresh sea-water which the going-out tide has left. These puddles then take the place of the intermediate hatching-vessels, where mature eggs will certainly be hatched and be taken by the tide into fresh sea-water, where they can develop.

I one day watched a fisherman who was cleaning fish, and, for this purpose, had selected a convenient place close to a small puddle. I remembered the place and let the man get through with his work. When he had gone I went and examined the puddle. Its formerly clear waters had disappeared, and it resembled a pool of blood, filled with roe to such an extent that the water had a jelly-like consistency. Although the conditions in this case were not very favorable, as the puddle was too small for the enormous mass of roe, and as the man, utterly ignorant, of course, of his having acted as an artificial hatcher of fish, had, besides roe and milt, thrown in blood and different parts of the fish, I nevertheless determined to see whether some of the roe could possibly be hatched. I therefore put some of it in a glass vessel containing fresh sea-water. I soon had the satisfaction to see that nearly all the eggs floated toward the surface, a sure sign that they were not yet spoiled. After awhile I examined these eggs microscopically and became convinced that they were not only sound but that they had also become impregnated. The peculiar preliminary process termed "the separation of the yolk" commenced simultaneously in all the eggs, and during this and the following days I could witness all the different phases of development which I had formerly observed in eggs artificially impregnated by me. I have, therefore,

not the least doubt that most of the roe collected in the above-mentioned puddles when taken out by the tide would develop, and all this in spite of the circumstances being rather unfavorable in this case, especially as the fish from which this roe had come had been dead for quite awhile.

I have given a full account of these occasional observations made by me during the fishing-season, because I thought they might be of general interest. My chief object this winter was, however, to observe the phases in the life of the growing young codfish during their stay in their native place. As I had thus by this winter's observations only supplemented former investigations by extending them over a full year, and had as far as was possible under the circumstances thrown light on the first period in the natural history of the codfish, I will, before I close, give a brief review of the results and the probable conclusions which may be drawn from them regarding the place of sojourn and mode of life of the growing codfish.

During the first days after the young codfish have been hatched, they are the most helpless beings which can be imagined. The large umbilical bag keeps them always floating near the surface of the water, where they are tossed about by waves and wind without being able to offer any resistance. As soon as this bag has been absorbed, they begin to lead a more independent life, although they are not yet strong enough to resist the current. A natural instinct leads them deeper into the water, where they are not so much exposed to its influences. Their food during this period and later, as long as they lead a roaming (pelagian) life, consists of different small pelagian animals, especially the small, transparent crustaceans known as "herring-food," because they form the principal food of the herring during the summer. Toward the end of summer, when they have reached the length of about an inch, they begin to come near the shore and lead a more stationary sort of life. This change is effected gradually, and begins with their seeking the company of the medusæ, which about this time are by the current driven toward the shore in enormous numbers, and thus actually show them the way. Thus the fish become more accustomed to the shallow places near the shore, and to the food found in these places, but as yet they are by no means fully prepared to assume their stationary mode of life near the shore.

After having left the medusæ they for some time roam about near the coast, and are often found in large schools near the so-called "Strömblak," where the current has gathered near the surface of the sea a large number of floating objects, *e. g.*, live, dead, and half dead medusæ, pieces of algæ, &c., or they keep near the outer coast, where they are numerically persecuted by the voracious pollack and other fish of prey, as well as by sea-gulls and other birds. Love of life, however, makes them gradually leave these dangerous places and go to the more sheltered sounds and inlets, where they finally adopt the stationary mode of life near the coast, which the young pollack have adopted some time before them, and gradually accustom themselves to the food which here is found

in abundance, consisting of different littoral animals, especially crustaceans.

The young codfish may soon, however, be distinguished from the young pollack by their different habits. The young pollack are generally found near the surface, while the young codfish keep nearer the bottom, the deeper the larger they grow, and their favorite places seem to be those where the coast falls off abruptly.

It will be noticed that on the whole the similarity in the stationary mode of life between the young codfish and the young pollack is only a seeming one, but that the former are in reality migrating all the time, which circumstance only escaped my observation because they do it so gradually and at different times according to their different age. Those young fish which in the beginning come close to the shore migrate in proportion as they grow larger into deeper water, and their place is taken by smaller and younger fish which hitherto have kept near the medusæ, or have been in that state of transition when in large schools they roam about near the outer coast. These again, as they grow up, very gradually seek the deeper places, which have been left by the other young fish, which migrate to still deeper water, &c., until at last at the age of one year the young fish, well known to the fishermen by the name of "algæ-fish," make their appearance at a depth of 20 to 30 fathoms on the sandy bottoms between the groves of algæ near the outer coast.

I believe that, by my former remarks, I have proved satisfactorily that these fish are not different from the codfish proper, but that they are the young fish from the preceding year. It is true that on certain parts of our coast, especially in the deep fiords, small codfish are found, which always keep in shallow water and never grow as large as the large codfish; but this is only caused by the natural conditions being less favorable to the development of the codfish than near the outer coast. In the fish-market in Christiania I have seen codfish which only measured one foot in length, and which, nevertheless, had mature roe and milt. Such instances never occur near the Loffoden Islands, where the smallest codfish having completely developed sexual organs never measure less than a yard. Even in the largest algæ-codfish found near these islands I, in most cases, only discovered very insignificant beginnings of roe or milt, which show that all these fish occurring on the algæ bottoms are by no means fully grown, and are only temporarily sojourning there, and finally go out to sea, where probably in a short time they assume the distinct characteristic features of the codfish. As yet I cannot say from personal observations at what time of the year or at what age they leave the coast, but hope that future investigations will throw more light on this matter. I consider it very probable, however, that their "going out" is as gradual and scarcely noticeable as their previous migrations to a shorter distance from the coast.

From the fishermen I learned that the one-year-old codfish occur most numerous a short time after the close of the winter fisheries and far into the summer, for those persons who stay at home are in the habit

of catching them with small lines; but toward autumn their number decreases very perceptibly, although even then "algæ-fish" of different sizes are occasionally caught. From this it appears as if the "going out" took place, to some extent at least, in the course of the second year after the hatching. It is possible, however, that later in the year they only barely go out to the deep water, where there is no fishing at that time, and that they stay near the outer side of the great ridge (Egbakke). I consider it highly probable that some, although, comparatively speaking, a small number, remain somewhat longer, until they are fully grown and their roe and milt is fully developed, and these are probably the fish which are known to the fishermen under the name of "coming-in fish," "ridge-fish," and "bottom-fish," and which are by them considered as the fore-runners of the schools of codfish which come in at the beginning of winter. It is quite natural, however, that there is not room enough for all the masses of fish which gradually migrate from the algæ bottoms toward the deep. The greater number of them must, therefore, go farther in order to find sufficient food. Gradually, therefore, they reach the outermost bottoms, from which they again migrate farther.

The actual place of sojourn of the codfish is, as I said before, not known with absolute certainty. I shall, however, venture to make a supposition; all the more, as from several reasons I have felt constrained to abandon the supposition expressed in my first report, that they staid in the great deep between the ridge and the coast. Later investigations have made it seem probable that their place of sojourn is not the deep between the coast and the ridge, but this ridge itself. Early observations have shown that this ridge, which, though interrupted in several places, forms a continuous series of shallow places, extends along the greater part of our coast at a considerable distance from the land, and that it has always abounded in fish of various kinds, among the rest large codfish. People formerly believed that these codfish, distinguished from other codfish by the name "bank-fish," always lived here, and must consequently also spawn and develop here. But my observations on the propagation and development of the codfish have convinced me that this cannot be the case. According to these observations *all* the codfish, without exception, must spawn near the coast, in order that the eggs may be properly impregnated and hatched, and that the young fish may find the food which they need at the various stages of their development. Nothing therefore seems more natural than to suppose that the "bank-fish" and the codfish are one and the same fish, and that this ridge stretching out far at sea is the proper place of sojourn not only of the codfish, but possibly of other fish which, like them, only appear near the coast at certain seasons, of the year, *e. g.*, the herring. In this locality, therefore, the full grown codfish live all during summer and autumn, and only when their sexual organs have been fully developed, which probably takes place the third year after the hatching, do they gather here in large schools in order to come nearer to the coast for the purpose of spawning.