V.—REPORT OF PRACTICAL AND SCIENTIFIC INVESTIGATIONS OF THE COD FISHERIES NEAR THE LOFFODEN ISLANDS, MADE DURING THE YEARS 1870–1873.

By G. O. Sars.

A.—REPORT FOR 1870.*

It was my intention on this journey, if possible, to extend the observations of the development of the winter-codfish which I had made last year, and at the same time to renew my observations on certain points which I thought needed corroboration. By having made my observations at different seasons of the year, I had gradually succeeded in following the development of the winter-codfish from the egg to the age of one year; and among the rest I proved one important fact which will play a prominent part in all future investigations of the cod-fisheries, viz: That the small form of codfish, which, under different names (algæ-fish, bottom-fish, &c.), is found on our northern and western coasts all the year round, is not, as was formerly thought, a separate variety of the codfish, but the offspring of the winter-codfish; therefore winter-codfish which have not yet reached their full development. I had, likewise, in the course of my investigations, convinced myself that the many differences of color and shape occurring in these fish are, if not exclusively, at any rate to a great extent, due to the surroundings in which they live, especially the nature of the bottom, and the food which is dependent on this; and that if these surroundings are changed, the fish assume a different appearance in an astonishingly short time. It was my object this year to examine these fish during their further growth, and, if possible, to study and explain the various phases in their mode of living, as I had formerly done with regard to those young fish which had not yet reached the age of one year. I found, however, very soon, that the older the fish grew the more difficult such an investigation would be. Formerly I had been able to make my observations with the greatest ease from my boat, or even from the shore; and changes in the weather had never seriously interrupted my work. All was different now. The fish had long since left the coast, and gone out to the vast ocean; and I was thus obliged to use my fishing implements in order to get any idea at all regarding their place of sojourn and their

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mode of life. In the following, I intend to give all the facts I ascertained in this manner; and, as in my former reports, I shall first give a simple description of the course and the method I pursued in my investigations, and then give a brief *résumé* of the results.

On the 9th of May I left Christiania by steamer, and, traveling via Bergen and Trondhjem, I arrived at Svalvær on the Loffoden Islands on the 20th. From Svalvær, I immediately went to the fishing-station of Skraaven, which, in many respects, I had found the most convenient place for my investigations; and where, moreover, I had last year left a quantity of apparatus. The season was certainly farther advanced than when I left the Loffoden the last time; but I was pretty sure that I would not lose my thread this time, but could easily connect my investigations with those of last year.

My last method of fishing, which in the course of my investigations I had had to change quite frequently, had consisted in using short lines, with which last year I had caught a considerable number of fish, and I therefore intended to make use of them again; at any rate, in the beginning. There was one difficulty, however, connected with this, viz: the scarcity of bait. Formerly I had been fortunate enough to obtain fresh herring; but now I could not get a single herring; neither could I expect to obtain any shell-fish, as during the winter fisheries nearly all those near the fishing-stations had been used. The only bait which I hoped to obtain was a worm, the Fjæramak (*Arenicola piscatorum*), which are found here in large numbers, and which are successfully used as bait for small fish at different points along our coast. This worm, which lives deep in the sand of the shore, can only be obtained by being dug up with a spade; an operation requiring time and considerable skill, if it is not to be cut in pieces.

After I had spent several hours in procuring such worms I had my lines prepared, and set them in those places among the outer islands where the water has a depth of 20–30 fathoms, and where last year I had caught many fish. I was again successful; but what struck me as peculiar was the circumstance that nearly all the fish which I caught were so large that I could not well consider them as one-year-old fish, but rather as two-year-old fish; and as I must get the one-year-old fish, I could not be satisfied, but had to find out where these fish staid. By setting my lines nearer to the coast, and in shallower places, I succeeded in catching some one-year-old fish; but so few, that I became convinced that the great mass of these fish did not stay here. There was, therefore, no other chance left but to make investigations at random, with the hope of finding their place of sojourn. I had been obliged to do similar things so often during my previous investigations, that I was by no means worried by it; as I had not the slightest doubt that sooner or later I would find the one-year-old fish.

Instead of the heavy line I got myself a thinner hand-line with which I intended to fish at various points, and which would enable me to go

over a larger space of the bottom in a day than I could otherwise have done in a week. I was not particularly successful near the shore, but the pulling at the line by fish biting the bait was quite lively when I approached the hidden depths lying farther out toward the places where the bottom falls off abruptly toward the great deep. During winter when the weather is stormy these places are almost inaccessible, and then present one mass of seething foam. They are well known to the fishermen as good summer fishing-places, and are visited by them especially during the time when the pollack approach the shore. The pollack-fisheries are almost exclusively carried on in these places. At this time, however, the pollack had not yet arrived, and such localities were therefore exclusively held by their relatives, the cod.

The majority of the cod which I caught here (and I caught no other fish) were certainly one-year-old fish, having an average length of one foot; but occasionally I also caught larger fish which required considerable exertion in hauling up, and whose age was certainly three years at the very least. Of two-year-old cod I found but few. Most of the cod caught here were of the variety generally termed "algæ fish," as their color was more or less a reddish brown with a beautiful golden gloss on the sides, and their shape somewhat stouter than is generally the case. I knew, however, that this was only owing to their living among the red algæ; and during the course of my observation this opinion was fully confirmed.

During the following days I continued my observations in the many deep places which are near this fishing-station, and with the same result. There was no difficulty in obtaining as many one-year-old fish as I desired. These excursions were not without danger, and would have been still more so if I had not had experienced people with me. As soon as the heavy waves begin to come in from the sea, which cannot always be distinctly seen from a small boat, these places are not to be trusted. The weather may be perfectly calm, and the sea around these places be as smooth as a mirror, and still there is danger, unless great care is taken, of being suddenly ingulfed in the waves without the least chance of escape. It is, therefore, not advisable to go with the boat on these deep places, but rather to keep near the edge. It is astonishing to observe how the sea near to the boat suddenly rises in the shape of a broad pyramid, which slowly sinks down to the general surface. For a long time again the sea may look perfectly smooth, but as soon as the fishermen have noticed the above-described suspicious movement of the sea they cannot be induced to approach the place, for if the boat should be where the pyramid of water rises, it would surely be dashed to pieces. These dangerous places have caused many losses during the winter-fisheries, when boat-crews which were not well acquainted with these waters got within their reach. But by keeping at a certain distance one may, without any special danger, witness the grand and interesting sight of the great waves rising and falling. It may happen, however,

that one has to wait a long time before anything is to be seen. Every now and then the water is rising a little over the deep places but without disturbing the general calm, but suddenly the broad pyramid of water assumes larger proportions. At its top it has the appearance as if a fine smoke was rising from it, and at the same time it makes a sort of advancing movement, just as if some monster of the deep were pushing its snout out of the water; this is followed by a low rushing sound, as of a passing storm, and presently the sea rises to an enormous height, like a broad green and shining rampart, fringed at the top with seething foam, which falls forward with a terrible fury, beating everything around into a mass of whitish froth. While lost in admiration of this grand phenomenon one feels the boat suddenly raised up high and just as quickly flung down deep, and fear fills the heart that all is lost; but this feeling, which naturally overcomes a person who witnesses such scenes for the first time, soon passes away. In a short time everything is as calm as if nothing had happened, the large waves which have been occasioned by the breaking of the watery pyramid recede, and soon their distant roar as they break against the coast shows that the catastrophe is over. After the fury of the element is spent there generally follows a longer period of calm, as if the ocean were gathering new strength for another eruption, which is sure to take place sooner or later.

I have not given this description for my own or for the reader's amusement, but because (as will be seen from the following) this natural phenomenon had a good deal to do with my investigation of the fisheries. For the question arises why the fish show a decided tendency to keep near these deep places; and the most plausible explanation is found in the peculiar conditions produced by the heavy waves going over these places. The bottom is always rocky and has a peculiarly rich vegetation of algæ; the large algæ (*laminariæ*) flourish here as in all places which are exposed to the immediate influence of the waves. On and among these algæ there live a large number of lower marine animals from a size scarcely visible to the naked eye to those of considerable dimensions. Especially do the crustaceans live here which form the favorite food of the cod, as well as crabs, &c. It is not so easy, however, for the fish to catch these small animals, their instinct having taught them to avoid their greedy enemies by hiding among the algæ and by darting away with lightning-like rapidity. The cod would therefore not catch any more here than in other places where there is a similar algæ vegetation, if it were not that the above-mentioned violent agitation of the water afforded aid from time to time. As soon as the sea after a period of calm begins to rage in these deep places, a general confusion is, of course, produced among the small animals; they are whirled about and cast in every direction. This is the favorable moment for the cod, and as soon as the watery pyramid has broken, they come in large numbers from all parts and feast on the little marine animals which are momentarily powerless and stunned by the sudden

shock. The same is repeated every time the waves break, as during the interval of calm the marine animals will again gather among the algæ.

I thought that now I had found a place where all during summer I would be sure to find the necessary material for my investigations regarding the further changes of shape and color which the cod undergoes during its development. In this, however, I was mistaken. Toward the end of June the number of fish in these places decreased in a remarkable manner; and I likewise observed that I could never get a fish to bite the usual bait (*Arenicola piscatorum*), even when I dropped my line in places where I knew there must be small cod. Only every now and then I caught a few, and, strange to say, most of these in places where there was sandy bottom, while the algæ-bottoms seemed deserted by the fish. Most of the fish I caught also presented a different appearance. I very rarely caught any reddish-brown so-called "algæ-fish," with their peculiar golden gloss; and most of the fish I caught were of a pale greenish color and had a silvery gloss.

I soon found the cause of this change of the cod's place of sojourn and the consequent change of color. Several times when in calm weather my fishermen had rowed me along the sounds between the numerous little islands, distinguished by their shining white sandy bottom, there was frequently the appearance as of a dark cloud passing over the light bottom, which quickly disappeared when the oars were put in motion. I soon convinced myself that this phenomenon was occasioned by dense schools of small silvery-white fish, which appeared in large numbers in the shallow places near the shore. This little fish is well known under the name of sand-eel (*Ammodytes lancea*), and is considered an excellent bait for the pollack. But by examining the contents of the stomach of some cod, I found that the latter does not disdain it either, for it contained scarcely anything else but such fish. I also found the natural explanation of the above-mentioned changes in the one-year-old cod and of their fastidious taste. All the cod, both young and old, had left their former hunting-grounds and had gathered for the pursuit of the dense schools of sand-eels which were approaching the shore. On a beautiful calm day (the 28th of June) I was fortunate enough to observe this. While my fishermen were rowing me across one of those 6–10 fathom-deep inlets leading to the usual sand-eel places, I could see distinctly against the light sandy bottom enormous schools of large fish, all turning their heads in the same direction, viz, toward the shore. I immediately got out my line, thinking I would make a big haul in places where no fisher had ever dreamed of looking for large cod. But I was disappointed. The slow manner in which these fish moved showed that they were not very hungry, but had already taken a good breakfast. Although I put the daintiest pieces of shining sand-eel on my hook, I could not get a single fish to bite. As soon as the hook got near the fish they came swarming toward it from all sides, but

after having thoroughly examined and smelt the bait, they coolly turned their backs to it. By moving the line and causing the shining bait to dance about in the water, they could be made to repeat this maneuver, but none of them would bite. Only a fine line which I had brought from Christiania, and to which a pretty little fish of German silver was fastened, which certainly did not resemble any fish known to the cod, but whose shining gloss, similar to that of the sand-eel, seemed to have some attraction, and by drawing it slowly up through the water I succeeded in attracting a large cod nearly to the surface. It was evident that it had a great desire to swallow the little fish, but, on the other hand, it seemed to have an idea that everything was not all right, and therefore it refrained from satisfying its desire. Only when the bait was a few feet from the surface and threatened to leave the water altogether, the cod took courage and with a quick jerk snapped at it, but, as if frightened by its own boldness, it just as quickly shot away again and joined its comrades. In this, however, it would not have been successful if my hook had been stronger; but it was not calculated for such large fish; the cod consequently escaped with the fright and a slight scratch of the mouth. When I hauled in my line the hook was bent perfectly straight, and the metallic bait had been scratched in several places by the sharp teeth of the cod. This little description may serve to show some of the characteristics of the cod, which certainly is not so stupid as is generally made out, but whose greediness often runs away with its reasoning powers.

I knew now that the only bait with which for the time being I could hope to catch cod would be its own food at this period, viz, sand-eels. This little fish, which is but little esteemed farther south, plays quite an important part in these regions, as it occurs in enormous numbers. Since it exercises no little influence on the movements of the cod, I shall report what I learned regarding its occurrence and mode of life. During winter it seems to live at a great depth, for it is never found near the shore, and only occasionally in the stomachs of fish caught in deep waters. Toward the beginning of summer they commence to make their appearance by coming in large and dense schools to the sandy bays and sounds near the fishing-stations. In spite of its small size (it measures scarcely a span in length), it is a very greedy fish and devours various small pelagian animals, which are often heaped together by the current in the sandy bays in enormous numbers, and these bays are the favorite resort of these fish and their spawning-place during summer. The comparatively large grains of roe, having a beautiful reddish-yellow color, do not float about like the roe of the cod, but are laid on the loose sand on the bottom, where they go through their development. This fish has the peculiar custom of digging in the sand, so that when the tide is out it may be taken with spades from the dry sand at quite a distance from the water, and this is really the only way in which the fishermen, at any-rate near this fishing-station, procure this bait. It cannot be caught

with common nets, for it is so small and nimble that it can slip through the smallest opening. Even if the net was so fine that they could not get through, it would nevertheless, if applied in the usual manner, be of no avail, as every individual fish would have managed to escape before reaching land, and would have dug itself deep down among the loose sand. In some places, however, these fish are caught in enormous numbers with the so-called sand-eel net, an implement which can only be used for catching these fish. It consists of a large square piece of closely-woven stuff, which has to be manipulated by several boat-crews. During the spawning season of the sand-eel, this net is sometimes, with considerable trouble, got under the schools; by a quick movement the four corners are then raised, and the contents emptied into large boats. The fish are then taken to the shore, and without any special preparation they are simply piled up in great heaps, from which they are gradually taken in the course of the summer and autumn, just as occasion demands, and used as food for men and cattle.

This fish possesses the remarkable peculiarity that, piled up in this manner, it will keep for a long time without entirely decomposing, and although it is not probable that this half-putrefied food is very wholesome if partaken of for any length of time, it is nevertheless eaten a great deal in many districts and actually considered a delicacy.

The cod and the pollack are, however, more fastidious in their taste, and there is absolutely no use in offering them anything but quite fresh sand-eel. As soon as it is a day old it becomes unsuitable for bait. Whenever the sand-eel only is used for bait the above-mentioned net is not used, but whenever bait is needed, they are dug from the sand with spades. They cannot, however, be caught in this way at all times. In clear, sunny weather the sand-eel does not like to go on the sand. One may therefore often hunt for it in vain for a whole day, while the following day hundreds may be caught. Nor can one count on catching it in this manner in every place. The so-called sand-eel places known from time immemorial are but few in number, and are often limited to a very small space. Near the fishing-station of Skraaven there is only one such spot, covering scarcely more than 40–50 square yards. It consists of a reef covered with loose sand, stretching across a narrow sound. When the tide is high this reef is completely hidden by the water, while at low tide the sound may be crossed at this place without any danger of wetting one's feet. From this very limited place all the fishermen of this station get their bait, and it is sometimes crowded with people, each one digging in the sand. It is a comical sight to see this crowd of fishermen engaged in this manner, and to observe with what rapidity and precision they perform their difficult task. As soon as by removing a quantity of sand some of the small, shining fish have been brought to light, one must either by a quick movement of the spade throw them up higher on the dry sand or kill them. If not, they will immediately dig further down into the moist sand, and if one were

to attempt to catch the live fish with the hands they would, like eels, slip between the fingers. I have more than once witnessed this peculiar fishing process, as I had to get all my bait in exactly this manner.

Since I had learned to know the taste and place of sojourn of the cod at this period, I no longer looked for it in those places where it had formerly been found in such large numbers, but I cast my lines where I supposed any sand-eels to be, viz, along the edges of the deep ravines rising from the depth of the ocean toward the sandy bays. My fishing in these places was successful beyond all expectation, and I returned nearly every time with my boat heavy laden with fish. I not only caught one-year-old cod in this manner, although the greater number were certainly such, but also two and three year old fish; occasionally I even caught unusually large fish of exactly the same size as the common winter-cod. Nearly all, both the one-year-old and the older fish had a very light grayish-green color with a silvery gloss on the sides and the usual dark spots; they possessed in other words all the characteristics of the so-called "sand-eel cod," well known in the Lofoden. One of the largest fish, measuring 1½ (Norwegian) yards in length, I took home to examine more closely and had its picture taken and colored exactly, in order to compare it with the winter fish which was well known to me. It was then seen that even down to the most minute details it was the exact image of the common winter-cod or skrei, and neither I nor the fishermen to whom I showed it could point out a single difference in either shape, color, or size. The only thing which distinguished these large sand-eel cod from the winter-fish was, that the generative organs were not yet fully developed, although in the larger ones both the roe and the milt could be plainly discerned, and so far developed that they certainly during the coming winter would have come to the fishing stations as real skrei with fully matured roe and milt.

While I continued my investigation of the mode of life and place of sojourn of the so-called sand-eel cod, the pollack began to make its appearance. All the fishermen were now busy getting ready for pollack-fishing, and left the cod entirely undisturbed for the present. The food of the pollack at this time consisted likewise for the greater part of sand-eels. This could be seen by opening the stomach of some that had been caught, but likewise by direct observation. When my fishermen rowed me about among the outer islands I often noticed on the rocky ledges turning toward the Westfiord an unusually large number of birds (gulls) collected in a small space. There was nothing specially striking in this; but the way in which these birds acted was peculiar in the highest degree. With their snow-white plumage forming a very striking contrast with the dark background of the rock, they sat frequently in regular rows like soldiers, all turning their heads in one and the same direction. Not a movement could be noticed, not a sound was to be heard; they looked as if they had become petrified and had firmly grown to the rock.

Suddenly they became animated; as on a given signal the whole flock raise their long wings at exactly the same moment; with deafening screams they rise and wing their flight over the sea; like a thick white cloud they may be seen to descend at some distant point of the ocean which resembles a foaming whirlpool. This is occasioned by the pollack which have surrounded a school of sand-eels and forced them toward the surface of the water where they can easily catch them. The poor little fish are at the same time attacked by the birds from above. This lasts but a short time; soon the school of sand-eels is scattered in all directions, the pollack have gone into deeper waters to renew the chase, while the birds, nearly every one with a glittering sand-eel in its beak, are slowly flying toward the rocks which they left a short time ago, to watch their chance for catching more fish. The fishermen also watch this opportunity when the pollack are near the surface, and, if they are in time, generally catch a few. But what interested me specially was the fact that quite frequently large and small cod were caught instead of the pollack. This happened oftenest in the beginning of the pollack-fisheries, showing that the cod, which generally keeps near the bottom, occasionally imitates its more lively half-brother's mode of life.

For a time the fishermen's pollack-fishing and my cod-fishing were quite successful. But suddenly a change took place. The fishermen came home discouraged with almost empty boats; the pollack and the birds had been there as always, but none of the fish would bite. My cod-fishing was not so successful either, and half a day often passed without a single bite. I soon found the cause of this. Both the pollack and the cod now used another kind of food, which they seemed to prefer to the sand-eel. Some days previous the many pillars of smoke-like spray seen on the western horizon indicated that a considerable number of whales were approaching the Westfiord; and on a fine, calm day, when I was out in my boat, about the middle of the Westfiord, I was suddenly surrounded on all sides by blowing and snorting monsters of the sea. Gigantic whales showed their broad, black backs over the surface, often in dangerous proximity to my boat, and with a hollow noise squirted the watery spray high up into the air, while nimble dolphins leaped high above the water, their sides glittering in the rays of the sun. Occasionally a sudden foaming motion could be noticed in the water; just as if the waves were breaking against some hidden rock, two high pointed fins rose above the surface and quickly disappeared again. This was the gigantic fish well known in these latitudes by the collective name of störje, while farther south it is with greater accuracy called "makrel-störje," and which belongs to the same species as the tunny, so highly prized in the Mediterranean. By looking down into the clear water I could often see large and small schools of scared little fish swim underneath my boat with lightning-like rapidity, and when hard pressed by their pursuing enemies, leap high over the surface, showing their shining silvery sides. Although I did not succeed

in catching any of them, I had not the least doubt that these were young herring, and that they formed the food not only of the above-mentioned large marine animals, but also of the pollack and the cod, and that this was the reason why they would no longer take the bait offered to them.

By examining the stomachs of some of the fish caught at this time (both pollack and cod), I found them crammed full, no longer with sand-eels, but with young herring. The herring is a more uncertain fish than the sand-eel, and it was purely accidental if any of them approached the coast. The great mass of them generally kept far out on the Westfiord, and I have reason to suppose that both the pollack and the cod followed them; and that the entire failure of the pollack-fisheries at this period, as well as the unusual scarcity of other fish near the coast, could be ascribed to this cause.

Before I left the Loffoden I wished to make observations in some other localities, and for several reasons I selected the two stations of Risvær and Brettesnæs, lying east of Skraaven. I staid longest at the first-mentioned place, which I had not yet visited, because it seemed to afford special interest in my investigations. It is one of those fishing-stations east of the Raft Sound, which have long since been deserted, but which were much frequented in olden times. About 30–40 years ago rich winter-fisheries were carried on here every year. At present only one family lives here, but traces may still be seen of the many fishers' huts which served as places of shelter to the numerous fishermen who came here. The place must have offered many special advantages for fishing. The fishermen had not to go out very far; and from the windows of the houses they could distinctly be seen hauling in their nets. Numerous outer islands afforded ample protection against the sea, more so than in most other fishing-stations. It might seem premature to give any definite opinion as to the cause of the decline of the fisheries. I shall, however, at the end of my report refer to it, and give my view of the matter, as well as some facts which might be of weight. For the present I shall simply report the course of my observations in this place.

My first object was of course to ascertain whether the young of the winter-cod were found here in as large numbers and under the same conditions as in those places where the winter-fisheries proper are carried on. By conversing with the people of the place I got all the information I desired. The young of the winter-cod is well known here. It is found all through summer in large numbers, and this very year the fishing for this fish had been quite successful. The fish that were caught measured, on an average, one foot in length, and were, therefore, one-year-old fish. They were caught so readily that even two men going out with their lines would in a comparatively short time have their boat quite full. During the first days of my sojourn I likewise caught many fish, both on the algæ bottoms and everywhere among the islands. As

long as one had bait (for which sand-eels were used) there was no difficulty in procuring in a very short time a tempting dish of delicious small fish. Regarding the looks of the fish, it had as at Skraaven sometimes the characteristics of the algæ cod and sometimes those of the sand-eel cod, which latter gradually became more common, as the coming in of the sand-eels took place at this time.

One day I devoted to fishing at a great depth (about 100 fathoms). The bottom was everywhere composed of clay, occasionally mixed with gravel and small pebbles, and the fish which I caught here were, as a general rule, larger than those caught in shallow water. While in shallow water one might always be sure that any fish that bit would be cod (just as the fly-fisher on our small streams is sure that any fish which snaps at the fly is trout, *Trutta fario*) very different kinds of fish were caught here, which could already be noticed by the way in which the fish bit. Sometimes the line suddenly felt heavy without any previous jerk at it having been noticed, and, after a troublesome hauling, a large slimy brosme or cusk (*Brosmius vulgaris*) came up, its eyes sticking far out of its head on account of the diminished pressure of the water. Another time there were some gentle, scarcely perceptible, pulls at the line; but in beginning to haul it in one could notice that no small fish was coming. The higher the line came the lighter it got, so that toward the end it felt as if both fish and hook had been lost, and before it had been hauled in entirely a beautiful pink-colored ner (red fish) or Norway haddock (*Sebastes norwegicus*), with eyes protruding and mouth wide open, leaped out of the water, the hook firmly fixed in its mouth. Again, there would be a powerful pull at the line, so that for a time one could scarcely move it, and presently it would get so light as to induce the belief that the fish had been lost; then again it began to feel heavy; this time it would be a halibut (*Hippoglossus maximus*) which had thus to suffer for its greediness, and which had to be hauled in very carefully and knocked a few times on the head before it could be taken into the boat. Often a large cod would bite, and, corresponding to the nature of the bottom, it would have a very pale grayish-green color. Some very large but very lean cod which were caught here, covered all over with parasites (fish-lice), were, by my fishermen, called winter-cod which had been left over from the last winter fisheries, and which, from some reason or other, had not found their way to the great deep where the great mass of the winter-cod always goes after they have done spawning. Such specters are every now and then caught all the year round, and their miserable starved appearance is in a very plausible manner explained by the fishermen, who say that they do not find sufficient food to which they had been accustomed while farther out at sea.

For some time yet I was quite successful in my fishing, but soon there was a change, and the same complaints were heard from the fishermen, that fish were scarce. The numerous pillars of smoke-like spray which, on certain days, could be seen far up the Westfiord, resembling the chim-

ney-smoke of a large manufacturing city, indicated that dense schools of young herring had now also reached east, and that not only the whales but also the cod were feeding on them. The same I found to be the case at Brettesnæs, where I staid a few days. At Skraaven the cod had not yet come near the shore, although it had begun to make its appearance at the usual fishing-places, the algæ bottoms.

At the same time that I made these investigations of the one and two-year old cod I had also occasionally devoted my attention to the tender young ones from last winter, but had found that this summer was particularly unfavorable to these investigations. On account of the unusually calm and steady weather, which lasted all summer, with scarcely an interruption, the current, as is usual in such weather, was generally going out of the Westfiord and carried everything which could not resist its power out to the ocean. The water near the fishing-stations where I staid was, therefore, generally quite clear and transparent without ever showing that rich life of different pelagian animals which on a former visit I had noticed in these parts, and which certainly was closely connected with the occurrence of the young cod. I had in the beginning of my stay at Skraaven occasionally noticed, especially after a short storm from the southwest, that these diminutive fish, measuring scarcely a few lines in length, were playing about near the surface of the water in the same places where I had observed them on former occasions; but never again did I see such enormous numbers as in 1866. I often found that what I had taken for the young of the cod were the young of other fish. A young fish distinguished by a considerably shorter and plumper shape than the young of the cod appeared on certain days in very large numbers in the places which had formerly been frequented by the young cod. On other days the sea would be so void of all life that one could row long distances without even seeing a medusa.

The period in the development of the young cod which this year I desired to investigate was the transition from the roving life near the surface of the water to the more stationary mode of life near the shore; in other words, their change from pelagian to littoral animals. The above-mentioned natural causes unfortunately prevented me from making any exhaustive observations. I several times observed the peculiar transition period when the young cod go under the medusæ. But these, as well as later observations, were by far too isolated to get any reliable corroborations of facts which I had ascertained by former observations. Even toward the end of my stay, when the young cod had begun to show themselves near the shore, their number was so small that I had no hope of getting at any new facts. The only additional fact was this, that their passage to the deep begins much earlier than I had formerly thought. In order to ascertain this I had a sort of fish-trap constructed, which I set in different places, varying in depth, and baited it with refuse of fish. In this trap I caught, as early as the beginning of

August, at a depth of 20–30 fathoms, unusually large young cod, which certainly belonged to this and not to the preceding year, and which, therefore, must have come near the shore very early.

My experiments with the fish-trap were, however, interrupted in a very unexpected and peculiar manner by a marine animal which is well known in these latitudes, and much abhorred by the fishermen on account of the injuries it inflicts on the fisheries. This is the so-called hag-fish (*Myxine glutinosa*), a very low form of fish, with a soft, boneless, slimy body, without eyes, and even without a clearly-developed head, resembling a worm rather than a fish. During the winter-fisheries the fishermen, to their disgust, are often made aware of the existence of this animal, especially on soft, clayey bottom. When, as often happens, the fishing implements have to remain in the water for several days on account of storms, the majority of the fish caught on the hooks or in the nets are often entirely destroyed by the hag-fish, which penetrates the skin of the fish and in an incredibly short time devours all the soft parts, leaving nothing but skin and bones. I had no idea, however, of the enormous abundance in which this hurtful animal occurs. Wherever I set my trap in deep water, either on hard or soft bottom, they always found their way to it, attracted by the bait, and destroyed everything in the trap by the incredible quantity of slime which this animal secretes, and with which it covers everything it comes in contact with. Once, when I had left my trap for a day on soft, clayey bottom, at a depth of about one hundred fathoms, I found it completely filled with thousands of these disgusting creatures, which had changed the contents of the trap to a compact mass of tough slime which could only be removed with the greatest trouble, and which made my trap useless for quite a number of days.

Toward the end of August I left the Loffoden for the south. But as I wished before my return to examine a point which lay beyond the limits of the fish district proper, I went to the island of Bodö, where I intended to stay for a while, in order to ascertain whether the young of the winter-cod were found here under the same conditions as on the Loffoden. The time selected by me was unfortunately not a favorable one, as large schools of young herring had just made their appearance, so that the fish were enticed away from their usual places of sojourn and together with pollacks, whales, and other marine animals were chasing the delicate little herring. Although I was therefore not very successful in my fishing, and could not by direct observation get a complete idea regarding the occurrence and mode of life of the cod in these regions, I nevertheless, from fishermen and other people well acquainted with the fisheries, obtained some very interesting information, which, in the following, I shall briefly report, reserving for the end of my report the conclusions which may be drawn from it.

At the same time that the Loffoden fisheries are going on, it may happen here (at Bodö), especially during south or west winds, that the whole

sea right up to the harbor of Bodö is thick with floating roe. There can be no doubt that this is the roe of the cod; but the question is, where does this enormous mass of roe come from? The general opinion seems to be that it comes from the Loffoden, and is consequently brought here by the current from the northwest. But, in the first place, it must be borne in mind that the distance from Bodö to the nearest fishing-station in the Loffoden is quite considerable, and secondly, that during the above-mentioned winds the current will always be in such a direction that it could not possibly bring anything from the Loffoden. During south and west winds the current generally goes from southwest to northeast, or follows the coast in a northerly direction, coming in through the different sounds between the outer islands. The roe can therefore not come from the Loffoden, but must simply have come in from the sea outside of the outer islands, where, consequently, large schools of winter-cod must spawn every year. I also heard that during the preceding summer enormous masses of cod "*mort*"* (½–½ year old cod) had been observed here all along the shore, even close to the harbor of Bodö. This has probably not only been the case that year, but is undoubtedly the general rule here, as well as in Loffoden. Only as long as no scientific observations had been made or published, people did not make any distinction between the young of the cod and the young of the pollack, and comprehended all the young fish found along the shore under the collective name "*mort*," meaning by this, principally, the young of the pollack. Even this year, which had been unfavorable to the coming in of the young cod, I had often occasion to observe them among the young pollack, measuring about a finger in length, and often occurring in considerable numbers. As far as the one-year-old or rather the 1½-year-old young of the winter-cod are concerned, they are found here all summer through in large numbers, together with the large cod, and under exactly the same conditions as in the Loffoden. I have no doubt that the same may be observed on many other points of the coast, and I have likewise obtained some corroborative information regarding this matter from several men who are intimately acquainted with the fisheries.

This is, in short, the result of many observations at Bodö. As I herewith closed my observations for this year, and as I have in the above already given a simple report of my investigations, I can add nothing but a brief *résumé* of the more important results gained by this year's observations, and the conclusions which may be drawn from them regarding the occurrence, mode of life, &c., of the winter-cod.

Among the more important results I must, as I have already said above, count the certain proof that the so-called "*smaagjed*"† is nothing

* "*Mort*" or "*mórt*," a purely provincial term, signifying cod or pollack, younger than one year.—TRANSLATOR'S NOTE.

† "*Smaagjed*" means "small pike," and is a provincial term applied to young cod of a certain age; no one, of course, supposing that they are real pike.—TRANSLATOR'S NOTE.

else but the offspring of the winter-cod. The name "*smaagjed*" is only applied to such cod which have attained to such a size that they can be caught with a line, which can scarcely be done before they are a year old. Younger "*smaagjed*" were, therefore, formerly not known here, as, strange to say, the enormous number of fish in younger stages found all along the coast had been entirely overlooked, and always mentioned together with the young of the pollack, under the collective name of "*mort*." Just as during the preceding year it has been the chief aim of my observations to find the connecting link between these so-called "*smaagjed*" and the tender young ones of the winter-cod, I considered it my chief object to follow up this link by continued observations, and, if possible, to ascertain the connection with its final development—the full-grown winter-cod. Although the outlines of the circle representing the life of the cod have by no means been as yet drawn equally clear at all points, I believe, nevertheless, that so many and essential portions of it are so distinct that the remaining portions can easily be supplied. The connection of the so-called "*smaagjed*" with the larger "bottom-fish" or "algæ-fish," as a younger representative of the same fish, is quite evident; and as the connecting link between the latter and the winter-fish or skrei we have the so-called siil-torsk or sand-eel cod, which, in all essentials, shows the most complete agreement with the genuine winter-cod, from which it is only distinguished by not having its generative organs fully developed.

As far as the so-called "*smaagjed*" or the 1–2 year-old offspring of the winter-cod is concerned, it shows in its mode of life a series of phases or periods which are mainly dependent on mere outward circumstances, especially the different food which is thrown in its way; but as the occurrence of this food is by no means accidental, but with very slight variations of time and place is repeated in exactly the same manner every year, these periods in the mode of life of the "*smaagjed*" must be considered just as invariable as the former periods of the fish before it has reached the age of one year. We find, on the whole, that the cod is a very stationary fish, and that from the very beginning, when it appears near the coast, measuring about a finger in length and called "skrei-mort," it is constantly wandering from shallow to deeper waters. If other circumstances did not occur, this wandering would be continued without interruption; so that the cod, the older it got, would get farther and farther out into the deep. With a large number of the cod this regular development goes on undisturbedly, so that already in the second year a great many of the offspring of the winter-cod have reached the deep, or rather the edge of the great ridge rising from the deep, which they follow until they reach the ocean. Others of the offspring of the winter-cod which, during their wanderings, have got to one of the many algæ-bottoms, take so much delight in the food they find here that they stay on these bottoms for shorter or longer periods, and are soon followed by some of the "*smaagjed*" on their gradual journey from

the coast to the deep. Experience teaches them now to prefer the many hidden raised bottoms where the heavy waves break; and some of them assume here a completely stationary mode of life, which soon shows itself in their shape and color. The large and fat algæ-fish, with a very distinct reddish color and an unusually short and compressed shape, are such stationary fish. But even these may, in a comparatively short time, assume a different appearance, viz, when the coming in of the sand-eels entices them away from their old hunting-grounds. But the schools of sand-eels do not only entice away the cod living on the algæ-bottoms, but likewise a large number of those cod which have already reached the ridge (the "*eg-bakke*"), and these fish, which often are the exact counterparts of the winter-cod, may, on their return to the deep, remain on the algæ-bottoms and become genuine algæ-fish.

A new interruption in the normal development is occasioned by the appearance of the schools of small herrings. Following the old rule that everything new possesses a peculiar charm, the cod now prefer the herring to the sand-eel, although one should think that both would taste very much alike. Where (as it sometimes happens) the schools of herring come close to the shore, the same cod may have made the trip from the shore to the deep, and again from the deep to the shore, two to three times. As a general rule, however, the schools of herring keep farther out, and rather entice the fish away *from* the shore than *toward* it. These schools of herring consist either of large, fat summer-herring or of very small, young herring, probably that year's young ones of the so-called ocean-herring; and these are the ones which are specially enticing to the young cod. The same schools of young herrings also show themselves at other times of the year in different stages of development. For a long number of years small and large schools of half-grown (one-year-old) herring have during the winter Loffoden fisheries steadily made their appearance in the Westfiord, and stragglers have every now and then come near the shore, where they are eagerly caught and used as bait for the cod fisheries. I consider it extremely probable that both this half-grown herring and the very small herring roaming about the Westfiord during summer are the offspring of the ocean-herring.

I desire to draw special attention to this circumstance, as it is my opinion that the occurrence of these schools of small herrings in the Westfiord exercises a decided influence on the cod-fisheries. In olden times neither the ocean-herring nor the schools of small herrings which come to the Westfiord regularly every winter were known in these latitudes. The ocean-herring seems to have kept further north, near the coast of Finmarken, where it took the place of the capelin (*Mallotus arcticus*) found there now. We have seen what a disturbing influence the schools of young herring, roaming about during summer, exercise on the normal migrations of the young cod, and the supposition lies very near, that the schools of larger herring entering the Westfiord in winter likewise influence the coming in of the winter-cod. As these schools of

herrings, just like those coming in summer, generally keep inside, *i. e.*, on that side of the ridge (egbakke) looking toward the Westfiord, and as this ridge all through the West-Loffoden is at a considerable (2–3 Norwegian miles) distance from the coast, they would here have but little or no influence on the coming-in of the cod, while in the East Loffoden this would be entirely different, because there the ridge is very near the coast. Especially south of the fishing-station of Skraaven does the ridge come close up to the shore, and this station, which in connection with the Molla Islands forms a long wedge stretching out into the Westfiord, likewise forms the natural boundary between the two great divisions of the Westfiord—the outer and the inner basin.

In the outer basin the fisheries have been successful at all times, only with this difference, that the fish have not always in the same number entered the limited sheet of water between Skraaven and Vaagen, called "Hóla." But in the division lying east of Skraaven, or the inner basin of the Westfiord, the fisheries have been exceedingly irregular. In olden times rich cod-fisheries were regularly carried on every year at the now deserted fishing-stations of Risvær, Swellingerne, Kanstadfiord, &c., but during the last few years only scattered schools have been observed at the fishing-stations immediately east of Skraaven, the Guldbrands Islands, Brettesnæs, and the Raft Sound, while the fishing-stations farther east, formerly so rich in fish, are now entirely deserted. I think the main cause of this is the schools of herring entering the Westfiord during the winter-fisheries. The chief mass of those fish which in former times made their appearance at the above-mentioned eastern fishery-station had then, as now, by following the ridge, been obliged to go round the south side of Skraaven in order to enter the inner basin of the fiord; and as in those times neither herring nor any other food was to be found here, these schools had, according to their custom, gone further, always following the ridge rising toward the coast.

Circumstances are different now. As soon as the schools during their coming-in get to the above-mentioned point of the ridge stretching far out into the Westfiord, they will as a general rule fall in with one or the other of the passing schools of herring, and thus by pursuing the herring, which always keep the middle of the fiord, get farther away from the coast. It is my conviction that the winter-cod goes as far east in the Westfiord now as in olden times, only with this difference, that while near the eastern fishing-stations it does not stay on the fishing-banks as formerly but keeps in deep water or inside the ridge. Every winter while the cod-fisheries are going on at the western fishing-stations, real winter-cod are occasionally caught with deep-water lines even at the most easterly fishing-station, viz, Kanstadfiord; and it is very improbable that these should be scattered forerunners of the great mass of fish coming from the west, which all by themselves should have undertaken the long journey from the western fishing-stations. It seems much more natural to suppose that these scattered fish belong to large

schools which are not so far away, which, however, are not reached by the fishermen, because these schools keep in the very deep water inside the ridge, where the usual fishing implements, nets and lines, cannot be used. It would, nevertheless, be worth while to make experiments here with very long lines during the winter-fisheries. It seems to me, as I mentioned before, very probable that large masses of cod also enter the inner portion of the Westfiord every winter, do not, however, approach the coast, but spawn in the deep water; in accordance with the peculiar spawning method of this fish there would be nothing to hinder this. Old fishermen have assured me that a long ridge slanting on both sides also runs along the middle of the Westfiord, and that these sides are much frequented by fish. This ridge is also in part given on the new fishing-map of the Westfiord, and the observations made by me this year fully corroborate its existence, only its extent, especially in the inner fiord, seems to be much larger than is marked on the map. In the middle, between Skraaven and the inland (Stegen), I found this ridge rising 120–150 fathoms from the bottom; and the bottom was not as in the other deep places of the Westfiord a soft clay, but mixed with gravel and small stones, the very bottom which fish like (so called "fish-bottoms").

I am extremely anxious not to be misunderstood with regard to the above. Whatever I have said regarding the relation of the winter-cod to the schools of herring is by no means to be considered as fully proved facts, but only as suppositions, which, however, have a great deal in their favor. It would be very desirable if accurate scientific investigations of the occurrence of the herring in these latitudes could be made, and especially if more light could be thrown on the so-called ocean-herring, whose young in all probability are those very schools of herring which enter the Westfiord during the winter fisheries. I consider it as beyond all doubt that there is a mutual relation between these two fish, the cod and the herring; and I have already, in my former report, expressed it as my opinion that the normal food of the winter-cod consists chiefly of herring, and that only during its younger stages, as "smaagjed" or algæ-fish, it lives on the various small marine animals which live in shallow water among algæ near the coast. This opinion seems to gain strength by the above-mentioned circumstance that the winter-cod which occasionally approach the Lofloden fishing-stations all during summer have invariably a miserable and haggard appearance.

Regarding the general occurrence of the winter-cod, I have already in my former report expressed the opinion that it does not only approach certain points of the coast for the purpose of spawning, but that it probably approaches the coast along the whole long-stretched northern and western coast of our country at one and the same time, and that the great reputation which the Loffoden fisheries have enjoyed from time immemorial has been caused more by the peculiar orographic formation of this group of islands—their stretching out into the ocean like a long

wedge—than by any greater abundance of fish. Wherever observations have been made during the season when the Loffoden fisheries are going on winter-cod have been observed, and of late many places which were formerly unknown have been observed, and promise excellent winter-fisheries. The information gained by me at Bodö likewise seems to point to the fact that enormous masses of fish spawn every year near the outer islands. On the whole, it may be safe to conclude that wherever large numbers of the "smaagjed" are found near the coast during summer, its parents, viz, the winter cod, will come regularly, at any rate as far as the outer raised bottoms, in order to spawn. I feel convinced that many places where excellent cod-fisheries could be carried on are at present left alone, which to a great extent is caused by the characteristic cleaving of northern people to old customs. The Loffoden have the reputation of being the only place where winter fisheries can be carried on to any advantage; and when the time for these fisheries is near, young and old everywhere prepare themselves for the long and difficult voyage to the Loffoden, there to undergo terrible hardships and return not only without having earned anything, but even with loss, while often quite near, almost at their very door, they might have the richest winter-fisheries. The large gathering of fishermen at the Loffoden fishing-stations makes it very difficult, and at times impossible, to keep proper order; and there are constant complaints of quarrels and fights among the fishermen, causing great loss of fish and fishing implements. The new fishing-law has not served to remove the cause of these troubles, which have increased from year to year, inflicting incalculable damage on the fisheries. This has been particularly the case where fishing was confined to a comparatively small space, *e. g.*, in the East Loffoden. All the more reason is there to inquire whether there are not other points on the coast where remunerative winter-fisheries might be carried on, so that the fishermen could be more evenly distributed along the coast. It would seem most natural to leave this to the fishermen themselves, but the force of the old routine is so powerful with most of them that no improvement can be looked for unless the government takes the matter in hand.

B.—REPORT FOR 1871.

As in former years, I shall later give a full account of the course and results of my practical and scientific investigations of the fisheries, and shall for the present only speak briefly of my labors during the summer, my chief object being a proposition to the department regarding a somewhat different arrangement for the next year.

My principal aim this year was to examine the so-called "bank-fisheries," which are carried on on the so-called "Hav-bro" ("sea-bridge") out in the open sea, 12–14 Norwegian miles from Söndmöre and Romsdalen; and I likewise intended to get all the information attainable regarding the other fisheries which are carried on here, especially the

winter-fisheries. For the last-mentioned investigations, which would chiefly consist in an examination of the formation of the bottom, and of the other natural conditions of the places where fishing was going on, I needed no special outfit, but could manage as in former years with a common boat and three men. The case would, however, be different with regard to my intended examination of the banks of the sea. Before I started I drew the attention of the department to the fact that an open boat would be entirely useless, and with such a boat I could not hope for any results. I had an idea that I could carry on my investigations much better if I had a small covered vessel, and I therefore resolved if possible to hire one. I soon found, however, that there was considerable difficulty in hiring such a vessel at this time when every vessel was in use; and when I at last secured an old vessel, which fortunately was not engaged, I could only hire it for a certain time, regardless of the condition of the weather. On this anything but comfortable vessel, manned by four sailors, I made altogether four trips during the summer, two from Aalesund and two from Christianssund, each trip occupying about a week. Unfortunately, the weather was very unfavorable. On my first trip I met with a great calm, so that after having floated about for several days in constant danger of running against one of the many hidden reefs which extend for many miles beyond the outer islands, I did not even get half way to Storeggen, and had finally to return without having accomplished anything, chiefly because I was not prepared for a long voyage and had but a scanty supply of provisions on board.

On my second trip I was more successful. Not only did I reach Storeggen, but I even proceeded 3–4 Norwegian miles beyond this point, or about 20 miles out in the open sea; and although the weather was not particularly favorable, I made several important observations of the full-grown bank-cod, which in no essentials differs from the common winter-cod, and of the young fish of that year. Besides the weather there were a number of circumstances which hindered my observations, circumstances which I had not counted on, and which undoubtedly prevented me from obtaining those important results which under more favorable conditions I might have looked for with certainty. Among these hinderances I must mention the unusually strong current which prevails at Storeggen, at the best fishing-places, and which made it very difficult for me to examine the bottom, or to set and haul in my fishing implements; moreover, I was often in an incredibly short time driven away from the very points where I desired to make observations. It might be said that one way was left open, viz, to cast anchor as the fishermen do while engaged in fishing out here. This I would certainly have done if my boat had, like the fishing-vessels, had a crew of 10–20 men, sufficient to raise the anchor from the great deep (about 100 fathoms). But to do this with only four men could not be thought of for a moment.

Later in the season, when, after long and weary negotiations, I had succeeded in hiring a yacht at Christianssund, with a view of making observations on the outer banks, which had never yet been examined, I was hindered a great deal by the very stormy weather. I deplored this all the more as I had looked for great results from these very observations. I had to hire the yacht for a certain time and pay so much per day whether I used it or not. The weather about this time happened to be extremely changeable. It might be quite calm and suddenly a storm would come up, and this would be repeated several times a day. Although I clearly saw that the weather could not be relied on, it seemed a great disappointment, after having hired the yacht and prepared everything, to lie still on shore; and I therefore resolved to go to sea in spite of the weather, hoping that possibly there might be a change. But the storms continued, there was a high sea and a strong current, so the time which I could actually devote to observations was very limited indeed; and after having braved a terrible storm off Hustadvigen I was compelled to seek the small harbor of Smörholmen, near the Kvitholm light-house. The most provoking circumstance was that the following day the weather was perfectly calm and beautiful, but that I could not make use of it as there was not wind enough to take my vessel out to sea. The next day it was raining and storming again, and I was forced to return to Christianssund. After having rested a day I resolved to make one more attempt during the few days that the yacht was still at my disposal; but I was unsuccessful again, and as the strong current toward the north threatened to drive my vessel toward the dangerous and but little-known waters off Smölen, I had to return without having accomplished anything. On our return voyage we got in a thick fog near the remarkable reefs called the "Nightingales," which extend for miles; fortunately we escaped without injury, with the only exception that some panes of glass in the cabin-skylight were broken by the waves.

Although both these trips were failures on account of the weather, I nevertheless made several observations which were of the greatest interest to me. On my first trip I reached a point in the open sea about 8–10 Norwegian miles west of Christianssund. One forenoon, when the weather was tolerably calm, I noticed a place where the bottom rose considerably, and was very rocky. I immediately let down my boat and put out the line, which I had constantly kept prepared and baited with fresh fish, in order to ascertain whether there were any fish on this elevation, which I took for a continuation of the large ridge ("Storeggen"). But the current was so violent that the yacht was soon driven so far away from the boat that there was the greatest danger in delay, and I was compelled to haul it in although it had scarcely been more than half an hour in the water. I did not expect to see anything on it. All the more surprised was I to find that nearly every other hook had a good-sized fish. My haul was really so large that even my men, who were all old and experienced fishermen, were very much astonished. Seventy-seven

fish on one line is something very unusual even during the best winter-fisheries, and it was thus clearly demonstrated that the wealth of fish in these waters must be very great. The fish were mostly cusk (*Brosmius vulgaris*), large ling, cod, and halibut (*Hippoglossus maximus*), or the same kinds which are caught on the large ridge off Aalesund.

On my next trip I endeavored to strike the ridge in another place; and when, by my soundings, I thought I had reached there I let down my line. When I hauled it in I noticed, however, that it had got into deep water where the bottom consisted of soft clay; the number of fish which I caught was therefore considerably less than the last time, and consisted chiefly of hyse (haddock), skates, and haa (dogfish, *Squalus acanthus*), all fish which prefer a clayey bottom. The weather, unfortunately, prevented me from making any more observations during this trip.

This was all the practical result I could obtain. At the same time I made several observations of great scientific interest. I will here only mention that my examination of the nature and fauna of the raised bottoms has led me to the astonishing supposition that the greater portion if not the whole of the wide extent of ground between the coast and the so-called "great ridge" (Storeggen) has far back in time been raised above the level of the ocean, and that the outer edge of the great ridge has constituted our original coast-line. This supposition so far, it is true, only rests on a few experiments with the bottom-scraper and some frequently-interrupted soundings. But all these observations seem to point so distinctly in this direction that I can scarcely doubt their correctness, although I would have wished to obtain still more convincing data, which unfortunately proved impossible on account of the unfavorable weather. There are likewise several natural conditions which should be more closely examined, not only on account of their scientific interest, but because they most assuredly have a considerable influence on the life of the fish. One of these is the very circumstance which hindered me most in examining the large ridge, viz, the violent current, going in a northerly direction, which, whatever way the wind might be, is found near the great ridge, while nearer the land the current may flow in an entirely opposite direction. In connection with this investigation it was of great interest to me to make thermometrical observations at different depths, which might throw much light on the nature of the different currents. Of all this I could only get a very faint idea, as I did not have the necessary instruments, and even if I had had them I could have done little or nothing on a sailing-vessel.

There is therefore a great deal to be investigated both practically and scientifically; and it was very trying to me as a scientist to know what a wide field for observation was before me and then to lie still day after day undergoing great suffering and unable to accomplish anything. I certainly endeavored to make use of every moment when the weather was in the least favorable; but all these moments when added up would

only constitute an extremely small portion of the long time which I spent on these trips. And still I think that even these sporadic observations have produced some results not only of scientific but also of practical interest, *e. g.*, that off the coast of Christianssund and not near as distant from the coast as at Aalesund rich bank-fisheries might be carried on. I have not the slightest doubt that the same will apply to many other points of our long-stretched coast. But in order to obtain certain results, which can only be done by systematic scientific observations, a common sailing-vessel will be comparatively useless, while a great deal might be accomplished in a short time if these observations could be made from a steamer.

As I of course do not expect that the government will risk the considerable expense, and place a steamer at my disposal, I have thought of a way in which this difficulty might be solved without any great increase of expenditure. I have an idea that the examination of the raised bottoms might easily be connected with the soundings made along our coast, which have been made for several years from a government steamer, and which are to be continued. I consider it absolutely certain that my investigations would not only be very closely connected with these soundings but would also serve to supplement these soundings and aid in reaching the object in view, viz, a complete knowledge of the formation and nature of the bottom. Various conditions can only be examined very imperfectly with the sounding-line, other apparatus and another method of taking observations being required.

I will here only mention that in the map of the Söndmöre district published from these surveys the large ridge is always marked as a solid rock, which, according to my observations, is an error; it is not a solid rock, but consists of numberless large and small loose stones rounded off and polished by the constant action of the waves. It is quite natural that mere soundings could not give a correct idea of the bottom, as only a clayey or sandy bottom will leave traces on the line and plummet, while stones or rock will not leave the slightest trace. It is well known that a bottom consisting of loose stones is always considered the best fishing-ground, much better than when it consists of solid rock; so that from a mere practical point of view it is of the greatest importance to know the exact nature of the bottom. A sounding-line will not suffice to ascertain this, but bottom-scrapers are required which will bring up specimens of the bottom. In order to ascertain in how far a bottom may be suited for the sojourn of large numbers of fish it is very important to examine the fauna of the bottom, which also can only be done with the bottom-scraper; it is also desirable that experiments be made with various fishing-implements.

If all these investigations are combined with other purely physical experiments regarding the direction of the current and the degree of temperature at the different depths, I believe that we would obtain a much more complete and useful picture of our sea-bottoms than mere

soundings could furnish. Other countries have fully recognized the importance of such thorough investigations. Not to speak of the grand, chiefly scientific investigations made by the English government, the United States of North America have recently combined the most extensive physical and zoölogical observations with the surveys of their eastern and southern coasts, which have already yielded many important practical and scientific results.

It is self-evident that if these investigations are to be successful, and are, by supplementing each other, to yield the desired result, the work of sounding must be somewhat modified, so as to leave sufficient time for other observations. The number of soundings made within a certain given time will consequently be smaller than when no other observations are made. But I think that these observations are so important that some time might well be devoted to them.

The expenses of this change of method would be but very small. The crew of the steamer would probably have to be increased by two or three men, to be placed at my disposal. I ought as regards my board to be placed on the same footing as the officers engaged in sounding; and as I scarcely could spend all my time on the steamer during its whole cruise, my traveling-expenses to and from the steamer ought to be refunded. An appropriation should likewise be made for the necessary apparatus, &c.

C.—REPORT FOR 1872.

I shall briefly report the observations made by me during the summer, for which an increased appropriation had been allowed to the coast-surveying expedition.

In my preliminary report of last year on my practical and scientific investigations of the bank-fisheries near Söndmöre I spoke of the many difficulties in the way of these investigations, and asked the department if it was not possible to combine my observations with the systematic soundings of the sea for which the government furnished a steamer. I mentioned the fact that other countries, *e. g.*, England and the United States, had combined zoölogical and other scientific investigations with their coast-survey. The government entered upon my ideas, and I therefore resolved to make another attempt this very summer, although the location where this year's surveys were to be made, viz, the sea outside of the Jader, is, properly speaking, beyond the limits of the well-known fishing-banks. It was to be supposed, however, that the almost uninterrupted row of banks which extends along our western coast would also stretch farther south; that new fishing-places might thus be discovered, and that my zoölogical observations would in any case yield interesting scientific results. As that portion of the sea where the surveys were to be made is in close proximity to the spring-herring district I was commissioned by the department also to give special attention to the herring, and, if possible, to throw new light on the still somewhat

dark question of the nature and migrations of the herring. This I promised to do, with the intention of communicating all the results of my observations of the herring to Mr. A. Boeck, whom the government had specially commissioned to investigate the herring-fisheries.

As soon as my official duties at the university had come to an end, and I had procured the necessary instruments and apparatus, I left Christiania by steamer for Stavanger on the 27th June. Here I found the coast-survey steamer Hansteen, and the day after my arrival at Stavanger I went on board.

My functions were to be those of a zoölogist, and a special place on the ship had been arranged for me. But besides my zoölogical investigations, I also intended to make practical observations on the fisheries, especially with the view of ascertaining whether by means of the soundings new and suitable fishing-banks might not be discovered. In that portion of the sea where soundings had to be made (the portion near the coast had already been surveyed before I came) the bottom proved but little suited for any kind of fisheries. At a depth of 140–150 fathoms it extends for miles without exhibiting any perceptible change. Everywhere you find the same soft tough clay, and this kind of bottom is the very worst for the fisheries. Only at a considerable distance from the shore (about 20–30 Norwegian miles) the bottom rises somewhat toward the so-called "reef," a continuation of the Jutland reef, and gradually changes its character. Instead of the soft clay, void of animal life, we find first clay mixed with sand; then a fine yellow sand, which near the reef is mixed with gravel and small stones. The water here is only about forty fathoms deep, and keeps at that depth for a considerable distance farther out. After I had with my bottom-scraper brought up a portion of this bottom and found it to be suitable for fish, I one fine day when the steamer was lying at anchor let down several lines, and although the time of the day was not the one most favorable for fishing (it was noon, and the sun was shining brightly), I soon hauled in some very fine cod. I was much interested in examining this so-called "reef-cod," which formerly was considered as a separate species, said to live near the reef all the year round. I found that it did not differ in any respect from the winter-cod or skrei, with the only exception that the generative organs (roe and milt), as might be expected about this season of the year, were not yet fully developed. It is well known that occasionally genuine winter-cod (skrei) are caught outside the Jader and on the Stavanger coast, and this had been especially the case last winter. A great number of these winter-cod certainly keep near the reef during the summer, and are then called "reef-cod." If this "reef-cod" was a separate species, peculiar to the reef, one would also find young "reef-cod" besides the older fish. But this is not the case. The fish found here are all of an equal size (all the specimens caught by me measured about forty inches, and were therefore all full-grown) and old fish. The younger fish have quite a different place of sojourn; here, as everywhere, they

are found on the algæ-bottoms near the coast, and are known by the name of "algæ cod," "small-cod," &c. The youngest fish I observed several times in that peculiar transition period when they go under the medusæ. On calm and clear days, when carefully watching the large number of medusæ which were floating past our steamer, I was always sure to see some with the little fish sticking out underneath. But I only succeeded in catching two of them, which, however, convinced me that they were really young cod, and not the young of other fish. All this I had already observed during my former journeys to the Loffoden, so that all my investigations could only be of interest as corroborating my former observations of the development and mode of life of the cod.

As regards the zoölogical results of my observations, which were obtained incidentally by means of the bottom-scraper, they were quite considerable, and all the more interesting, as so far at least these portions of the sea had never been explored by a naturalist. I was specially interested in gathering specimens of the different bottoms, with a view of ascertaining the influence of the bottom on the development of animal life. The results of these investigations will be published in the reports of the Academy of Sciences ("*Videnskabs selskab*") as soon as all the material has been collected and arranged.

But as it was likewise my desire to make practical observations of the fisheries, and as I soon found that that portion of the ocean where the surveys were to be made was but little suited for such observations, I considered it my duty to change my original plan, and exchange the comfortable life on board the steamer for the more difficult and dangerous method of making observations from an open fishing-boat. I was furthermore induced to take this resolution as two weeks after I had gone on board the Hansteen festivities began in honor of the Crown Prince (our present King) in connection with the unveiling of the Harold monument, which would take the steamer for some time out of its regular line of duties. I therefore respectfully bade adieu to the life on board and the pleasant company of Lieutenant Wille and Lieutenant Kröpelin, and with all my apparatus left the Hansteen on the 14th July to continue my observations on my own account.

Since I was not, as in my previous voyages, in a cod-district, but in a herring-district, my attention was of course chiefly devoted to the herring. It was my special object to examine the so-called fat or summer herring, because I had a lingering suspicion that its true nature had not been properly described by older naturalists and by Mr. Boeck. With this intention I took my first station in the city of Stavanger, from which point I made excursions to the different fiords in the neighborhood. The Stavanger fish-market likewise afforded ample opportunity for examining herrings, which about this time were brought to town in large quantities. After these observations had come to an end, it was my intention to visit one of the outer fishing-stations where the spring-herring fisheries are going on during winter, partly to get information

regarding the spring-herring fisheries, partly to make if possible more direct observations. I chose for this purpose the fishing-station of Hvitingsö, lying far out in the sea, an old and well-known spring-herring place, where I made the best arrangements I could for investigations during the time that was still left before my lectures at the university commenced. From here I made excursions in various directions, principally examining the bottom in those places where the herring-fisheries are carried on, but also gathering much interesting and valuable information from experienced fishermen. It was of great interest to me to observe the enormous number of young herrings which at this time filled all the sheltered sounds and inlets, and which, on closer examination, proved to be almost exclusively young spring-herring, and, as could be judged with certainty from their size, this year's young ones. The fishermen of these regions know well how to distinguish these young herring from the "brisling" (the sprat?), whose size they almost reach, and call them by a special name, viz, "*Æsja.*" They were used partly for fishing-bait, partly for bait for eel-traps, and were caught, whenever occasion demanded, with fine nets in the quiet grass-grown inlets. When somewhat later I examined the "brisling" brought to the Stavenger fish-market from various parts, I always found mixed with them a large number of these little spring-herrings. There must this year have been a remarkable abundance of these young herrings, as the fishermen of Hvitingsö also assured me that they could not remember so large a number of young herrings ever since the memorable rich spring-herring fisheries. From this circumstance we are justified to conclude that a large number of spring-herring must have been near the coast and must have spawned here. The failure of last year's spring-herring fisheries is therefore not caused by any decrease in the number of herrings or by a change in the migrations of the herring, but solely by the fact that from some reason or other the great mass of herrings have not come so near the coast as formerly, but have spawned farther out at sea on the outer bottoms. This opinion was confirmed by testimony received from various quarters. All the fishermen here are agreed that great masses of herrings came near the coast at the usual time, which could be seen from the extraordinary number of whales and birds, and that for a time everything indicated that there would be large herring-fisheries near Hvitingsö. But people waited too long, hoping that the herrings would come to the usual fishing-places, and the consequence was that the herrings spawned with the greatest ease and comfort on the outer bottoms, and had actually finished spawning when the fishermen attempted to catch them farther out at sea.

As a further proof of the correctness of these statements, I will mention what a very reliable fisherman, the pilot Henni Larsen, has told me. Shortly before the close of the herring-fisheries this man was out line-fishing on the outer bottoms and caught an unusual number of large cod, so that his boat was loaded in a very short time. The most remark-

able circumstance, however, was this, that all these fish had their stomachs filled with herring-roe which they threw up in great quantities as soon as they were put in the boat. A considerable number of herring must therefore have been in these waters if such an enormous mass of roe was left as to cover the bottom, as it must have done. It is nothing new that cod and other fish of prey devour a great deal of the flowing roe; and it is an old experience that after the herring-fisheries a large number of cod come to the spawning-places, especially on the west side of the island of Karmö. Nor is there any cause to be alarmed at this. In accordance with the laws of nature only a certain portion of the enormous quantity of spawn left by the schools of spring-herring is destined to develop, while the remainder is intended as food for fish and other marine animals, which I have also shown to be the case with the roe of the cod. I feel convinced that the usual number of herrings have also visited the coast this year and have spawned in suitable places. Even if the great mass of spring-herrings have this year and partly also in the preceding year, from some unknown cause, spawned at a greater distance from the coast than usual, this does not prove that they will do so always, much less that they will leave the coast entirely. I think there is no absolutely certain indication of such a sudden change in the migrations of the herring. The idea that the Bohuslän herring-fisheries should have any connection with our herring-fisheries, seems to me to be still more absurd. I think, on the other hand, that there are many reasons for encouraging the hope that the herring-fisheries on our western coast, under more favorable circumstances, will also in the future prove successful in the old fishing-places, of course with slight variations in the number of fish caught. The careful observations of the summer-herring which I have made this summer have confirmed this opinion.

With regard to the nature of this herring (the "summer-herring") very erroneous ideas have been prevalent among naturalists, as it has been considered as a different variety from the spring-herring, or as a separate species of herring. Mr. Boeck has spread this erroneous opinion by repeating the statement of Professor Nilsson which is based on a mistake,* that the summer-herring spawns in autumn while the spring-herring spawns in winter and early in spring. If this were really the case, that the summer-herring spawned at such a different season of the year, it would, in spite of its close resemblance to the spring-herring from a zoölogical point of view, have to be considered not only as a different variety but rather as a separate species. There may be herrings which spawn in autumn, and this is especially the case with the so-called "Kulla-herring," found on the Swedish coast of the Kattegat; but this different spawning-season is caused by different natural conditions. On

* Professor Nilsson's statement is, *verbatim*, as follows: "This kind of herring (the Norwegian summer-herring) resembles, as has been said before, the Kulla-herring, and is, like this one, said to approach the coast in July and August and to spawn in September and October." Skandinavisk Fauna, T. 4, part 3, p. 511.

a coast where herrings occur which spawn in spring, there cannot be any which spawn in autumn, or *vice versa*. Any one who will calmly think about the matter will be convinced that the summer-herring cannot possibly spawn in autumn.

The fatness and excellent quality of the summer-herring is caused by the circumstance that, as has been said, it "has fat instead of roe and milt." Zoölogists may succeed in finding underneath the fat in the lowest portion of the body those organs in which roe and milt are formed, but these organs are as yet so little developed, that it could not be definitely decided whether they in any possible way could reach maturity as early as autumn. Nor do the fishermen know anything about such herrings which spawn in autumn; and when asked at what time the summer-herring spawns, they will generally express the utmost astonishment at this question and say, "Why, the summer-herring don't spawn at all; it has not got roe and milt, but only fat." They consider this as an established fact; and have never thought about it that every and any kind of fish, in order to exist, must have the faculty of propagating the species. The fact of the matter is that when the summer-herring spawns—and it does so, of course, at some time—it is no longer a summer-herring or fat-herring whose body is filled with fat and not with roe or milt.

Which are then the real facts in the case? Why, simply these: *The summer-herring is not, as has been formerly believed, a separate variety of herring, but nothing more nor less than the offspring of the spring-herring of different ages, and must, therefore, according to the laws of logic, at last become a genuine spring herring.*

This opinion already previously entertained by me, and which in a very striking manner was confirmed by the observations made by me during this summer, appears in reality so self-evident, that it seems very strange that no ichthyologist has so far hit upon this very simple explanation. The chief cause of this must be the mistaken idea that the summer-herring comes into the fiords and bays for the same purpose as the spring-herring, while, as every one who is acquainted with the herring-fisheries will know, it does not come at all for the purpose of spawning, but in order to feed on the various small marine animals gathered here by the current.

By examining the different fat herrings which are brought to the fish-markets of our western towns, their size will be found to be very different. They have, therefore, as is well known, got different names in the trade, *e. g.*, "Christiania herring," "middle herring," "merchants' herring." These different sizes represent the different ages, which may also be recognized by the different development of the generative organs. If the smallest Christiania herring is laid side by side with this year's young of the spring-herring, the so-called "Æsja," we will, if we look away from the difference of size, find the most complete agreement in all particulars, so that no one would ever consider them as be-

longing to different varieties, just as little essential difference can be noticed between the "Christiania herring" and the "middle herring" and the "merchants' herring." We have, therefore, before us all the successive stages of the spring-herring: (1) this year's young ones, *Æsja*; (2) the young ones of the preceding year, *Christiania herring*; (3) the young ones of the year before that, *middle herring*; (4) the young ones of the year preceding the one last mentioned, *merchants' herring*; and, finally, the young ones of the fifth year, the genuine *spring-herring* or "*Graaben herring*."* This must not be understood in this way, that all the fish called "Christiania herring" are of one and the same year, those called "middle herring" from another, and those called "merchants' herring" from a third year. It is well known that all the transition-stages are found among these different kinds of summer-herring (thus there are small and large "Christiania herring," small and large "middle herring," small and large "merchants' herring") which has its natural cause partly in the fact that the spawning of the spring-herring and, consequently, also the development of its young, is extended over a considerable part of the winter and spring, partly in the fact that not all fish reach the same size in the same given time. A fish, *e. g.*, which, according to its size, ought to be counted among the "Christiania herring," may be just as old as another which, to judge from its size, would pass in trade as a "middle herring," &c. But as a general rule the herring caught during summer can be classed under the four above-mentioned heads.† Of these neither the "Æsja" nor the "Christiania" herring will be able to propagate during the following spring, which may be supposed, if one sees how little developed the generative organs are. Of the "middle herring" only very few are found with whom such a thing is possible; but of the "merchants' herring" a larger number may by this time have become capable of propagating. It will then make its appearance at the same time as the spring-herring, and as in that case it will, like the spring-herring, have fully developed roe and milt, it will not generally be considered a fat herring, as formerly. It will then pass for young spring-herring. It is quite probable, however, that on closer examination, especially when these young herring, spawning for the first time, are found in large numbers among the older spring-herring, some difference will be discovered, caused chiefly by the circumstance that they have not yet become familiar with life out in the open sea, to which the older spring-herring are accustomed, and which they will not try until the spawning is over. It is also possible that the spawning of these younger herrings does not agree entirely with that of the older herrings in point of time, but that it possibly takes place

*See, with regard to these names, Sars's correction in the report for 1873, p. 41, footnote.

†Of these four different classes I have preserved excellent specimens in spirit-of-wine, and sent them to the Zoölogical Museum of the Christiania University, labeled in accordance with my views as given above.

somewhat earlier. I was thus very naturally led to think of the so-called "mixed herring," which has frightened people so much, because its occurrence was considered as an indication that the genuine spring-herrings would disappear. With regard to this "mixed herring" the fishermen could not mention any other difference between it and the spring-herring save that it is fatter, therefore of a better quality, only somewhat smaller, and spawns a little earlier. Although I have not personally examined this so-called "mixed herring," I nevertheless will here express my conviction that it is nothing else but summer-herring in its transition-stage towards "Graaben" herring; in other words, the youngest spring-herring, which in the following year will return as genuine "Graaben" herring.

But, people will say, the "mixed herring" is a kind of herring formerly quite unknown, which only has made its appearance on our coasts during the last few years. This, in my opinion, erroneous view of the matter, is explained in a very natural manner by the circumstance that formerly no attention had been paid to it, because it was mixed with the "Graaben" herring, while just during the last few years it has been less mixed with these, since the great mass of the older herring ("Graaben herring") coming in from the sea have spawned on the outer bottoms. I can, therefore, not see in the unusually large number of these "mixed herrings," which have made their appearance during the last few years, any indications that the spring-herrings will disappear; on the contrary, it seems to me to indicate the very opposite.

As will be seen from the above, the conditions of development and mode of life of the herring correspond in every respect with the results of my careful observations of the life of the cod. Here, likewise, it was thought that there were two different varieties, one belonging to the open sea and one to the coast. I have proved, however, and as I think in an incontrovertible manner, that the coast variety is the same fish as the open-sea variety, only differing in age. Just as the winter-cod, or offspring of the skrei, spends the first years of its life near the coast and only at a more advanced age migrates to the distant banks, thus also do the offspring of the spring-herring spend the first years of their life near the coast, and under the name of "fat-herring" gather in large schools during summer in order to feed on the numerous small marine animals which current and wind have piled up in the different fiords and bays.

Since the determination of the fact that the summer-herring, or fat-herring, is not a species or variety of herring different from the spring-herring, but only its offspring at different ages, has been sufficiently proved, our views of the future of the spring-herring fisheries must be considerably modified. If, as has been supposed, the spring-herring fisheries on our western coast would cease completely, because the schools of spring-herrings either decreased in number or migrated to other coasts, a corresponding decrease of the summer-herrings ought to

be noticed; but this is not the case. The summer-herring fisheries were particularly rich this year on the ledges of Stavanger; at any rate, no decrease could be noticed, but rather an increase.

It is well known that Mr. A. Boeck has, chiefly from historical data, reached the result that a so-called "herring period" should now have come to an end, and that consequently there would be a period of poor herring-fisheries. The same signs are said to show themselves now as when many years ago the herring-fisheries came to an end. No one is more ready than I to acknowledge the great merits of Mr. Boeck in having compiled the truly astonishing number of historical documents which had never before been printed, the collecting and arranging of which must have taken considerable time and trouble. I likewise acknowledge the great value of such documents as materials for a history of the herring-fisheries. But I believe that in using these documents, whose completeness and reliability decreases the farther back they date, we ought to be very careful, and, at any rate, first and foremost consider an accurate and exhaustive knowledge of the *natural* history of the herring as the only really sound basis of our opinions. It is not at all decided to my mind whether there are really such regular "herring-periods." If we wish to talk of real periods, it is not sufficient to know that once upon a time the herring-fishery proved a failure, and that after a number of years it revived again. This must be repeated several times under similar conditions in order to justify us in speaking of regular "herring-periods."

D.—REPORT FOR 1873.

As in the preceding year, I again intended to make use of the regularly established connection between the investigation of the fisheries and the coast-survey, and therefore resolved to go again on board the steamer Hansteen, and stay there as long as anything worth observing should show itself. I considered this all the more important this year, as surveys were to be made near the southern herring-district and as thus I would be enabled to gather valuable information regarding these fisheries.

On the 6th of June I left for Hangesund, where I arrived on the 8th, and immediately went on board with all my apparatus. On the following day we went out to sea. After soundings had been made at different points outside the herring-district, I arrived at an agreement with First Lieutenant Wille, according to which we would first follow a line from the coast to the reef, lying about in the middle of the district which had been selected for this year's surveys. This line ran in a westerly direction from the Selbjörn's fiord. On this trip, which occupied several days, the bottom was carefully examined with the bottom-scraper, specimens brought up by the sounding apparatus were likewise examined, and frequent thermometrical observations were taken at different depths. Besides this, a careful comparison was instituted for every point with

the former lines followed toward the reef during this and the preceding year by following parallel lines. I thus found that this part of the sea is much more monotonous than I had expected. Both the nature of the bottom and the depth, the animal life, the temperature of the water, and other natural conditions corresponded exactly with the results of observations made in following other lines, so that one could generally say beforehand from the location what depth and what bottom a certain place would have. I was thus enabled by this one trip to get a complete idea of the natural conditions of this whole district; and I consequently saw but little use in watching the soundings, from which I could only look for very insignificant results as far as *my* investigations were concerned, at least in comparison with the great amount of time spent. After I had been about eight days on board the steamer I determined, as last year, to leave it and endeavor to make observations on my own account on such points of the coast as I thought would be most suitable. On account of the season, these observations could, as during the previous year, only refer to the so-called "summer-herring" and the tender young ones of the spring-herring, with a view of still further corroborating the opinion advanced in my former report, that all these fish only represent different phases of one and the same herring. It was likewise my desire, if possible, to gain some information regarding the winter-fisheries, partly by direct examination of the bottom, partly by listening to the accounts of experienced men.

My investigations commenced at Bukken, three Norwegian miles south of Bergen, from which place I made several excursions, especially in a southerly direction toward the mouth of the Korsfiord, where last winter there had been considerable fisheries of so-called "mixed herring." During my stay several hauls of summer-herring were made, of a smaller size but of a remarkably good quality, which I state here with considerable satisfaction as refuting the opinion held by some people that the herring coming to our southwestern coast has deteriorated in quality. After having staid here about three weeks, I went farther south to the old and well-known spring-herring fishing station Espevær, at the mouth of the Bömmelfiord, where I staid about one month, and where I carefully examined the bottom, likewise gathering information concerning former herring-fisheries. At the last-mentioned place I had an excellent opportunity of observing the summer-herring and the conditions under which they approach the coast, all of which went to still further corroborate my former view regarding their relation to the spring-herring; a view which I found, to my great satisfaction, was shared by experienced fishermen and other persons well acquainted with the fisheries. During my stay considerable hauls were made, in the beginning nearly exclusively large "merchants' herring," later mostly herring of different sizes, but all of a very fine quality. On my arrival at this place I could already predict the speedy approach of the herrings from the

enormous quantity of small marine animals which had come in with the current; and I was not disappointed. The herrings staid for a long time in the bay of Vespestadvaagen, which cuts deep into the west side of the island of Bommelö, where very rich hauls of herrings were made even long after the little marine animals had disappeared from the outer islands.

As I knew that last winter considerable spring-herring fisheries had been carried on, though only for a short time, at the fishing station of Lyngholmen, on the other side of the fiord, I took an interest in examining that locality in order to compare it with Espevær, where this year there had been no spring-herring fisheries. I therefore stationed myself there for some time, and took several excursions, both in a westerly direction round the Nyvarden light-house and farther up the fiord. It is true that during my stay I did not succeed in witnessing any summer-herring fisheries; but I had occasion to make another observation which was of great interest to me, because I had heard that the spring-herrings during the last winter-fisheries had "whitened" the sea, *i. e.*, had spawned. The sea was everywhere filled with young herrings, which roamed about in dense schools partly near the land and partly farther out in the fiord, followed by flocks of sea-gulls and terns. In one of the well-known fishing-places east of Lyngholmen, called Eltrevaag, people thought one day that they could see many young cod ("*mort*"), and let down a small net, but when it was hauled in, it was found to contain nothing but young herrings, which were so small that most of them slipped through the meshes of the net.*

Also, during the continuation of my journey up the fiord, I repeatedly noticed large schools of the same year's young ones even as far up as the sounds, where I was told they had never been seen before, at any rate not in any large number. I must lay stress on the fact that these fish were not young "brisling." The fishermen know very well how to distinguish the two by their size and other characteristics.

Before I concluded my investigations for this year, I desired for comparison's sake to visit a few points in the northern herring district where the fisheries last winter had been of a very peculiar character, the herrings staying away from the old and well known fishing-stations and coming in considerable number to places where in former years there had been no fishing at all.

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*I here take occasion to correct a mistake made in my last report (for 1872). I had supposed that the small herrings, about the size of the "brisling," which at Stavanger is called "Æsja," were the young ones of that year. The observations made by me this summer, however, have inclined me to the opinion that they are older herrings, young ones from the preceding winter. Another year must therefore be added to the time which it takes the herring to become fully matured; therefore, first year, "musse"; second year, "æsja" (bladsild); third year, "Christiania herring"; fourth year, "middle herring"; fifth year, "merchants' herring"; sixth year, "spring-herring."

As my first station I selected Florö, from which place I intended to visit Kinn and the small outer islands in the neighborhood. At Florö my observations were chiefly directed to the young herrings, which I found here in large numbers both near the coast and farther out at sea, where they were chased by different fish of prey, chiefly small mackerel. I had no opportunity, however, to examine the summer-herring, as the fishery had closed before my arrival. On account of the stormy weather I had to abandon my project of visiting the outer fishing-stations near Kinn, and determined instead to visit some points on the Nordfiord, where I knew there had been rich spring-herring fisheries last winter. As I thought Moldö would be the most convenient station for me, I went there. From Moldö I made several excursions farther out at sea and along the coast, especially along the south and west coast of the island of Vaagsö, where I visited the fishing-stations of Torskangerpollen, Buevigen, Hovdevaagen, and Svartteigene, all well known on account of their winter-fisheries. My chief object was, if possible, to throw some light on the following question: "Is it possible that the constant use of fishing-implements during winter (especially the nets now in use) within a limited extent of water causes large masses of dead herring to lie and rot on the bottom, and thus make the bottom so full of corruption that it does no longer form a suitable spawning-place for the following winter?" I was all the more eager to investigate this matter, as several men of experience really thought this to be the cause why the herring-fisheries had proven failures in formerly good fishing-places. Although my observations did not positively confirm this view, I nevertheless believe that it is a matter which deserves attention in the future. But as only observations made *during* the fisheries could lead to certain results, I do not feel at liberty to express any definite opinion.

From Moldö I had intended to visit one of the northern stations near Stadthavet, but as the season was far advanced and the weather was very stormy, so that I could not have accomplished much, I had to abandon this trip and conclude my observations for this year. After having staid eight days at Moldö I took the steamer going south on the 18th of September and arrived in Christiania on the 21st.

After having in the above given a short account of my journey and the plan which I had followed in my investigations, I shall endeavor in the following to give a more detailed account of the more important results and the opinion regarding the herring and the herring-fisheries to which these results have led me.

During my stay on board the Hansteen it was my chief object to examine the deep basins outside of the herring district, where it is generally supposed the spring-herrings live during the time they are not near the coast. Such an investigation I considered to be of special importance at the present time, as possibly it might furnish some explanation of the remarkable decrease of the spring-herring fisheries on our western coast during the last few years, and at the same time give us

a better insight into the natural history of the herring. My investigations, made during my stay on board the Hansteen, had led to a definite result in this matter, which, at any rate, throws more light on the natural history of the herring. This result is of a purely negative character, but nevertheless it is undoubtedly of great importance, as in connection with the observations of the last two years it leads to a definite and, as I think, more correct and more important opinion regarding the nature and migrations of the herring.

As I have said above, it was quite a common opinion among modern zoölogists that the spring-herrings when not near the coast, therefore during summer and autumn, live in the deep valleys or basins of the sea, off that same coast where they spawn during winter and spring, an opinion which I shared as far as the cod was concerned.* This opinion was first advanced by Professor Nilsson, and is chiefly based on the great difference exhibited by the various herrings found on the Swedish coast. Also regarding *our* coast, similar views have been expressed, viz, that the spring-herrings, when not near the coast, live in the great deep, chiefly in the very deep trough, which, varying in breadth from ten to fifteen Norwegian miles, extends along our western coast as far as Stat and empties into the North Sea.† The results of the investigations of the depths of the sea, which of late years have been carried on, on a large scale, do not seem to contradict this opinion, since it has been shown that even in the great deep there may be a rich and varied animal life, so that the herring would find sufficient food all the year round even at the greatest depth. These same investigations, however, have proved that the nature of the deep is not the same everywhere, but that just as on the dry land there are barren places with very little animal life—submarine deserts—which are traversed by the greedy schools of fish, but which could never be their permanent place of sojourn. This is chiefly dependent on the nature of the bottom, and, to some extent, on the varied depth. Where the nature of the bottom is such as to allow the smallest animal to live and develop in any considerable quantity, animals of a higher grade, which live on these, will make their appearance, and from the same reason the place will become a convenient place of sojourn for fish and other large marine animals. But where the conditions are not favorable for the development of lower animals, the higher animals (*e. g.*, fish) cannot live.

On account of this actual dependence of the various marine animals on each other, it will be comparatively easy for a zoölogist to decide from the nature of the bottom whether it will be suitable as a permanent place of sojourn for fish. The investigations made by me on board the Hansteen during this and the preceding year have sufficiently

* I have, however, as will be seen from my second report, changed my opinion, as I consider the large banks off the coast as the home of the winter-cod.

† See A. Boeck's work: "Om Silden og Sildefiskerierne" (on the herring and the herring fisheries), p. 47.

convinced me that along our southwestern coast there is no deep basin of a nature calculated to form a place of sojourn for the enormous mass of spring-herrings during that part of the year when they are not near the coast. The whole extent of bottom from the outer fishing-banks to the reef forms a very monotonous plane at an average depth of about 150 fathoms, covered everywhere with a thick layer of loose, sticky clay, a portion of which in all probability fills the lower depth of water; and this kind of bottom is the least suited for the development of animal life. A careful examination of the specimens of bottom brought up by the sounding-apparatus and the bottom-scraper has fully corroborated this. This whole portion of the sea must be considered a desert where only here and there some animals of a low grade (*e. g.*, worms) eke out a miserable existence. Only where the bottom at a distance of 12–14 Norwegian miles from the coast begins to rise toward the reef it gradually assumes a different character, becoming firmer and more mixed with sand; but even here animal life is not very strongly developed. On the reef itself the bottom chiefly consists of fine brown sand, which is so fine that it is almost impossible to get anything off with the bottom-scraper.

From the above it will be clear that the schools of spring herrings which usually spawn on our western coast, cannot possibly, as was formerly supposed, live at the bottom of the deep, immediately outside of the coast waters, but must come from some other place. If one asks whence these immense schools of fish come which year after year visit the same coasts at the same time, to disappear again without leaving the slightest trace, the answer might be returned that for the present this cannot be decided with absolute certainty; in fact, not until our *whole* coast has been carefully surveyed, as has been done with regard to its southwestern portion. One might then expect to find further north the deep basins whence they come.

It is my opinion, however, that even such an exact knowledge of the bottom along our widely-extended coast would not bring the problem any nearer to a solution. As long as the surveys are made at the same distance from the coast as hitherto, they are still far from those places where the spring-herrings generally stay. All that we can for the present consider as certain, and which also agrees with the observations made during the fisheries, is this, that the spring-herrings in the southern district come from the northwestern part of the ocean, as great schools of herrings have been seen before the beginning of the fisheries in that direction as far as 15 (Norwegian) miles out at sea, and in one case even as far as 20 miles.* The schools of spring-herrings in the northern district (at Kinn) also come from this direction; and even to the great herring-fisheries in Nordland the same rule seems to apply, which seems self-evident from the successive migration of the fisheries

*See Boeck's work, "Om Silden," &c. (on the herring, &c.), p. 47.

in a southerly direction. If we look at a map we find that all these lines point to the large and so far but little investigated portion of the sea between Scotland, Iceland, and Norway. Many other reasons have determined me to consider this as the proper home of the spring-herring. Occasional soundings made in that portion of the sea have shown that the depth is certainly very great, so great that fish like the spring-herring, which undoubtedly pass part of the year near the surface, could not be supposed to find an inviting place of sojourn at the bottom of this basin. There is in my opinion no necessity for supposing this to be the case.

When thinking about the above-mentioned hypothesis advanced by many modern zoölogists regarding the place of sojourn of the spring-herring, it has always appeared to me very improbable and contrary to nature that a fish like the herring, whose whole build and inner organization (its compressed wedge-shaped form, its large swimming-bladder, wide respiratory organs, &c.) seem to be calculated for a free and roving life near the surface of the sea, should follow such a mode of life only during the short time of its spawning season, but should all the rest of the year hide in the deep valleys of the ocean. Still less probable did this seem to me after it had become perfectly clear to my mind that the so-called summer-herring is not, as zoologists formerly believed, a different variety from the spring-herring, but simply the same herring at a different age. The roving mode of life of the summer-herring can easily be observed on our coasts during summer and autumn. It will soon be seen that these herrings do not keep in the deep, unless it were during the time that the full-grown herring (the spring-herring) leaves it, and that they then are again chased away when the old herrings return to the deep. The food of the summer-herring consists almost exclusively of small crustaceans of the order of Copepods swimming about freely, the so-called "herring-food," which, on account of the unusual quantity of fatty oil contained in their bodies, are very nutritious. All these small crustaceans keep more or less near the surface of the water, never at the bottom, and it is their very wealth of oil which enables them to keep continually near the surface.

It is true that there are similar crustaceans near the bottom, but in the first place their number is very small compared with those near the surface, and in the second place they do not contain so much oil, which circumstance is really what makes crustaceans such an important article of food for fish. The spring-herrings would therefore scarcely find sufficient food at the bottom, unless they would (which, however, is highly improbable) be satisfied with a totally different food. The surface of the sea, on the other hand, will all the year round richly supply them with that food to which they have been accustomed from their earliest age.

It is likewise my conviction that the spring-herrings use exactly the

same food as the summer-herrings, viz, small Copepod* crustaceans, which freely float about in the water, from which it follows that, like the summer-herrings, the spring-herrings must spend the greater portion of their life near the surface of the water. It is well known that these small crustaceans ("herring-food") are not only found near the coast, but everywhere in the open sea, and it is a fact proved not only by many sailors and fishermen, but also by zoölogists (*Kröyer*), that that very portion of the sea mentioned above is particularly rich in these small animals, so that by their enormous mass they will color the water for miles and even furnish an important article of food to the monsters of the deep, the whales, &c. There would consequently be no lack of food in these regions for the enormous schools of spring-herrings which visit our own and the Scottish coasts for the purpose of spawning; and I consider it therefore as highly probable that this portion of the sea is the true home of the spring-herring.

The objection might be raised that if this were really the case schools of herring ought to have been seen here. But it must be remembered, in the first place, that this portion of the sea has so far been but little investigated, and in the second place, that it cannot reasonably be supposed that the herrings are gathered here in those dense schools which we see when they come near the coast in order to spawn, but that in order to obtain the required amount of food they have to live more scattered, and be distributed over a very wide area. It must likewise be borne in mind that only in the height of summer, and when the sea is as smooth as a mirror, the small crustaceans will be found near the surface of the water, while when there are even the smallest waves they immediately go down several feet, in which case the scattered schools of herrings are of course withdrawn from observation. Not till the middle of winter, when roe and milt develop, do the scattered schools, driven by their instinct, gradually gather and approach the coast in order to spawn on suitable bottoms. Thus, the scattered fish gather into schools and form enormous compact masses of densely packed herrings, a so-called "herring mountain," which, like a solid wall of considerable dimensions, extending not only in a horizontal but also in a vertical direction, approaches the coast. It will be easily understood that the great masses of spring-herrings while approaching the coast must generally accommodate themselves to the formation of the bottom; *i. e.*, follow the deep troughs or valleys.

The fact that they approach the coast chiefly in a southeasterly, and

* A. Bœck has also (see his work, "Om Sildeu," &c., p. 46), by a microscopic examination of the contents of the entrails of recently caught spring-herrings, found pieces (chiefly feelers and feet) which undoubtedly had belonged to the Copepods. But as he started from the supposition that the spring-herrings come from the deep, he also supposed that these remains could only belong to such Copepods as lived near the bottom, although he grants that they do not seem to correspond exactly with the deep-water varieties formerly examined by him.

not in a directly easterly direction, and that it is just the coast from the ledges of Christianssund to Stavanger which is visited by the spring herring, can I think be explained by purely meteorological reasons, among which the temperature of the sea seems to play an important part. Through the indefatigable exertions of Professor Mohn, a large number of observations on the temperature of the sea-water near our coast, taken at different seasons, and extending over many years, have been collected; and some of these observations were taken at a considerable distance from the coast. In the pamphlet published by him in French, in 1870, entitled *Température de la mer entre l'Islande, l'Ecosse et la Norwège*, these observations are given, and on the accompanying maps isothermal lines drawn for the different seasons give a very clear idea of the peculiar conditions of temperature in that portion of the sea. What immediately strikes us is the remarkable change which the isothermal lines undergo during the greater portion of the year as soon as they come nearer to the coast of Norway. Instead of running in a northeasterly direction, as before, they here suddenly bend toward the southeast, following more or less the coast.

It will also be seen that the extent of coast from the ledges of Christianssund to Stavanger, therefore the spring-herring district proper, is during winter distinguished above every other part of the coast by the remarkably uniform temperature of the sea-water. This temperature (41° F. to 43° F.) is, therefore, the very temperature which is considered most favorable to the hatching of young herring. Both these favorable conditions of temperature near the coast and the curving of the isothermal lines out in the ocean seem thus to furnish quite a natural explanation of the fact that the spring-herring, although it probably lives originally under more northern latitudes, always seeks this portion of the coast, and not, as might be expected, the one immediately north of it. From the map which shows the condition of the temperature in the middle of winter, therefore at the very time when the coming in of the spring-herrings begins, it will be seen that the herrings, in order to reach the coast near the ledges of Trondhjem, would have to pass no less than 3–4 isothermal lines, or from a temperature of 6° to one of less than 2° (43° F. to 35½° F.), while by taking a southeasterly direction they would have the same temperature (43° F.) nearly all the time. And as it is well known that the fish are very sensible of changes of temperature, we seem justified in drawing the conclusion that the migrations of the herring, both when approaching the coast and when leaving it, are chiefly governed by the temperature, and will, therefore, naturally follow the above-mentioned direction.

By this theory, which differs very much both from the older theories and from more recent ones, *e. g.*, that of Professor Nilsson, I think I am able to explain in a natural manner many hitherto entirely inexplicable phenomena in connection with the spring-herring fisheries. In order that I may not be misunderstood, I must state expressly that it is by no

means my opinion that *all* the herrings which spawn on the coasts of Northern Europe come from the above-mentioned part of the ocean. There are doubtless different tribes of herring; this seems to be especially the case in the more inclosed portions of the sea, although I am inclined to think that the number of these tribes has been greatly overrated. The northern and southern part of the Baltic has certainly each its own tribe, likewise the Kattegat, and partly the Skagerak and the North Sea. I am also of opinion that the Nordland great herring belongs to a special tribe, whose place of sojourn is farther north than that of the spring-herring, viz, in the Polar Sea. But those schools of herring which are referred to in this report which spawn on our western coast, from the ledges of Christianssund to those of Stavanger, I certainly consider as belonging to one and the same large tribe; and this opinion is confirmed by the fact that even the most experienced fishermen are not able to point out any real difference between the spring-herrings found at different points along this coast.

The chief difference between my theory and the one generally entertained in former times is this, that the various tribes of herrings are not limited in their occurrence to certain deep basins near that coast where they spawn, but that they are found all over the adjoining sea, since the herring, either singly or gathered in large and smaller schools, roam about from place to place more or less near the surface of the water in search of its food, which is the same as that which it uses when younger (as summer herring). It is evident that this leads us to the conclusion that the spring-herring is much less stationary in its mode of life than might have been supposed according to the former theory, and that many physical conditions of the sea (direction of the current, occurrence of food, temperature, &c.) exercise a very important influence on the distribution of the herrings, so that, *e. g.*, the chief mass of them will one year at a given time be found either nearer to or farther from the places where they spawn. This point is, in my opinion, of great importance, as I think I can thereby explain in a natural manner the irregularity in the spring-herring fisheries on our western coasts, which have been observed for a long time, and which have been called "herring periods." I shall have occasion to return to this point, and I will here briefly give my idea concerning the mode of life and the migrations of the herring from the time it is hatched till as fully-matured spring-herring it returns to the coast where it has first seen the light of the world, basing my views on observations made by me during this and the preceding year.

The young of the spring-herring, according to A. Boeck's observations (Om. Silden, &c., p. 14, 15), spend the first period of their existence near the bottom in those places where they have been hatched, therefore chiefly on the raised bottoms near the outer coast, where the spring-herrings generally spawn. As soon as the umbilical bag has been completely absorbed and the fins have developed, making the movements

of the fish freer and easier, it follows its instinct and goes to the surface of the water to snap at the different small animals which are found here. But as here among the outer islands it is, in its rather helpless condition, exposed to many dangers occasioned partly by physical conditions, *e. g.*, high waves, current, &c., partly by its numerous enemies, both among birds and fishes, instinct has taught it to go nearer to the coast, where it finds better protection in the less exposed bays and sounds. These young of the spring-herring are well known on our west coast by the name of "musse," and may often be seen near the coast in enormous numbers. Even when measuring only a few inches they begin to gather in schools, which constantly increase in size and which roam about from place to place, thus beginning that roving mode of life which, in my opinion, is highly characteristic of the herring; a mode of life which, in a very natural way, is occasioned by its food. The small pelagian crustaceans, which, as I think, constitute the principal food of the herring, not only in its youth, but all through its life, are very irregular in their occurrence and depend very much on the different currents near the coast. Even at a very early age, therefore, the young herrings may be found far from the places where they were hatched; and from the same reason they will very naturally, at a later period of their life, gradually distribute themselves over a comparatively large portion of the coast. It must be supposed, however, that as a general rule, at any rate during the first year, they keep near the coast where they usually find sufficient food. As the fish grow up they require more food, and in order to get it they have to go farther out into the ocean where there is greater abundance of food. Herewith those migrations begin which the young herring must sooner or later undertake to those places out in the ocean whence its ancestors, the spring-herrings, came.

If there were no disturbing elements these migrations would go on quite gradually, the herring as it grew up going out farther and farther into the open sea; and in that case we would not know anything of the often very extensive and important summer-herring fisheries, which are carried on along the greater portion of our coast and far up the deep fiords. The irregular occurrence and distribution of the small crustaceans on our coast, which is influenced by various physical conditions, changes and interrupts these migrations in many ways. These little animals are generally found in larger quantities the farther you get out into the open sea; but sudden changes of the weather and consequent changes of the currents may often drive them together in certain localities, as may during the summer months often be observed off our coasts. Wind and current may drive this dense mass of crustaceans, constantly followed by schools of herrings, toward the coast, where in the deep bays and fiords they sometimes keep the schools of herring near the land for a long time. When the crustaceans have again been scattered, or have by other currents again been driven into the sea, the herrings generally follow them. In exceptional cases, however, especially in

those fiords which run very far up into the country, it may happen that schools remain all the year round and even longer; and the herrings composing such schools will naturally assume a somewhat different appearance from the common herring or gradually form themselves into a special variety. But on the whole the occurrence of the summer-herrings near our coast must be considered as entirely transient; in other words, the summer-herring is not, as has formerly been believed, a stationary coast-fish, but, like the older herring (the spring herring), it comes from the open sea.

The correctness of this view was also fully proved by the observations which I had made this year. Some time before the large schools of herring came to Espevær, the mackerel-fishers at a distance of 6–8 Norwegian miles from the coast often caught in their nets a considerable number of large and fat summer-herring, and schools of large and small herrings were often observed from the mackerel-boats on their return toward the coast. Soon after there was a sudden change in the weather, and an unusually strong current set in toward the islands near Espevær, carrying with it enormous numbers of crustaceans which filled all the neighboring bays and sounds. These were closely followed by the herrings, first the larger and then the smaller ones. As during winter the number of crustaceans near the coast is not so large, the migration of the herrings toward the sea will be less disturbed than during summer, and there is no instance on record that spring-herrings have returned to the coast after they had spawned.

As soon as the herring has reached a certain distance from the coast and is out in the open sea it will be less apt to be enticed toward the coast by its food, as the currents farther out are generally much more regular than near the coast. Those herrings which come to our coasts in summer are, therefore, chiefly young herrings, whose migrations have not yet extended very far, and very rarely old herrings which have already spawned. I consider it quite probable, however, that among the large "merchants' herring" there are some which formerly as spring-herring have spawned near our coast.

To be brief, we can mark two phases in the migrations of the growing herring: first, a successive distribution of the young from the places where they have been hatched over a larger portion of the coast; then a migration (often interrupted during summer) toward those parts of the open sea where the old herring live. That this migration as well as the distribution of the young along the coast chiefly goes on in a northerly direction is caused not merely by the temperature of the outer sea, but also by the currents, and the decided northeasterly direction of the current which may be observed, at any rate from Stat, will furnish a very natural explanation of the fact that the summer-herring fisheries are generally richest near Trondhjem, although it is well known that the spring-herrings do not spawn anywhere near the outer coast of Trondhjem. The fat herring caught near the coasts of Nordland and

Finmarken belongs, in my opinion, to a different tribe of herrings, and holds exactly the same relation to the Nordland great herring as the summer-herring on our western coast to the spring-herring.

We now come to the difficult and so far very obscure question, "What causes the irregularities in the herring-fisheries, both as regards their location and their results, on our western coast (the so-called 'herring-periods'), which have been observed from time immemorial?" We will see whether the new views which have been advanced will in any way explain this phenomenon. We are justified in supposing that here we are not confronted by an absolutely insoluble problem, but that this phenomenon, like everything else in nature, must have its natural causes, which can be found, and as this is really the all-important question, on which everything depends, all practical and scientific investigations should be directed toward its solution. It is and always has been my opinion that this can only done from a scientific point of view. A detailed historical investigation of the fisheries may be valuable in itself, but it cannot possibly lead to any satisfactory explanation of the problem. The starting-point of the whole investigation must be a most exhaustive knowledge of the nature and mode of life of the herring, and I have therefore endeavored to arrive at all my conclusions in this way. Only if it turns out that the facts obtained in this manner can be harmonized with those gained by historical investigations, these latter will become truly valuable as corroborating the views reached by scientific investigations.

By the indefatigable zeal of the late Mr. A. Boeck, a very large number of historical data regarding the herring-fisheries on our western coast have been gathered—data which extend from the most recent time as far back as documents are extant. Most of these documents have their chief value as material for a complete history of our herring-fisheries, which he intended to publish. But there is no doubt that this great mass of documents will, among the rest, also contain information which, if used in a careful and critical manner, may form a good basis and guide for a continued scientific investigation of our herring-fisheries. Among the numerous historical data given by Mr. A. Boeck in his book, "Om Silden," I would direct special attention to the peculiar circumstance, also specially dwelt on by him, that the spring-herring fisheries on our western coast have not always commenced at the same time of the year, but that at times they have had a tendency to get later and later in the spring, which, according to Mr. Boeck, has particularly been the case toward the end of the so-called "herring-periods." The difference of time has even been as much as a month and a half, as in some years the spring-herrings have come in before New Year, while in other years fishing has not commenced till late in February. As long as the old theory was maintained, that the spring-herrings live in certain limited deep basins of the sea near that coast where they spawn, this phenomenon would be entirely inexplicable, and it would also seem

incomprehensible why the yield of the fisheries should decrease in proportion as they commenced later in spring. But if we start from the modern theory regarding the mode of life and the migrations of the spring-herring, I think it may all be explained in a very natural manner. Since, according to this theory, the spring herrings, outside of the fishing season, are just as much as the summer-herrings dependent on the occurrence of the small crustaceans, and as this is again dependent on various meteorological conditions, especially the direction of the currents in the outer sea, it may easily be imagined that the great mass of the spring-herrings at that season of the year when they gather to go to their usual spawning-places are not always at the same distance from these places, but one year near and another year far. In the former case they will be able to reach their spawning-places in a comparatively short time, and the fisheries will therefore commence early in the season. In the latter case it will take them longer to reach the spawning-places, and the fisheries will commence later.

As it must also be supposed that roe and milt develop at a certain time of the year, and as it is certain that the herrings, like all other fish, commence to approach the spawning-places long before roe and milt are fully matured, and do not leave the coast until they have spawned, it follows that, in the first case, the spring-herrings will be able to stay longer near the coast, going farther up the bays and sounds, and that consequently the fisheries will last longer and yield a more certain result; while, in the other case, they can only stay near the shore a comparatively short time, so that it may often happen, as was the case last year, that the spawning process commences immediately after the arrival of the herrings near the coast, and that the chief mass from this cause remains at the outermost spawning-places, while only small schools are, by pollack and other fish, chased near the coast. It will thus appear that in this case the fisheries will be short and uncertain, although the same number of herrings as formerly have come near the coast. The quality of the herring will also, to a great extent, depend on the same conditions, as it is well known that the herring is better the firmer (less matured) the roe and milt are, and leaner the more the roe and milt begin to loosen. The excellent quality of the Nordland great herrings is chiefly owing to the circumstance that they are caught long before roe and milt are fully matured, as they approach the coast late in autumn, while in all probability they spawn about the same time as the spring-herring. From this early coming in of the great herring it may be concluded that they must live nearer the coast than the spring-herring; and occasional observations made by me have proved that the sea near this coast is by far richer in herring-food than the sea near our southwestern coast.

We thus arrive at the result that the irregularities of the spring-herring fisheries on our western coast must be traced to meteorological causes in the outer sea, and this not so much during the fishing season

as during the rest of the year. As far as I know, it has not yet been shown that there is any regular periodicty (thus causing certain regular herring-periods) in these causes (wind, current, and temperature). Meteorologists will have to decide in how far this may be possible. It is a fact that there is considerable difference in the occurrence of the "herring-food" near our western coasts in summer between one year and the other. Some years the sea near the coast has all through summer been filled with an enormous quantity of various small marine animals, while in other years they have almost entirely disappeared, or have only accidentally been driven near the coast by the current, quickly to disappear again. The most peculiar feature of this "herring-food" is the great quantity of very remarkable little animals which from the earliest times have attracted the attention of the fishermen. These are the so-called "Salper" (Salpæ), little animals which are as transparent as glass and float freely about in the sea, either singly or connected into long chains resembling strings of pearls. They are genuine pelagian animals which every year are found in large numbers far out in the open sea, but whose occurrence near the coast is very irregular. Years may pass without a single one of these animals showing itself near the coast, till suddenly one year they come in in such enormous numbers that every bay and sound is filled with them. It is scarcely probable that the herrings feed on these animals, but they are invariably accompanied by a large number of other small pelagian animals, with which they come from the ocean, and of these the "herring-food" proper (small crustaceans) forms by far the largest part. If such enormous masses of "herring-food" fill the bays and sounds during summer, it may be supposed, from what has been said before regarding this food, that those portions of the sea which are immediately outside the coast must contain a great number of the same animals, and that there likewise must be a considerable number of such animals as feed on these crustaceans.

According to my theory, I therefore also suppose that the spring-herrings in such years are nearer the coast than in years when the quantity of "herring-food" in the coast-waters is not so great; and I am inclined to assign greater importance than is generally done to this circumstance which from time immemorial has been considered as one of the "signs" which indicate good spring-herring fisheries during the winter. I am likewise inclined to ascribe similar causes to the decline of the formerly so productive Bohuslän fisheries. At a time when owing to peculiar currents in the sea an unusual quantity of "herring-food" has filled the North Sea and the Skagerak, it may well be supposed that a portion of the great mass of herrings coming originally from the northwest may have gotten so far into this part of the sea that when the spawning season approached they, in following their usual southeasterly direction, would come near the Bohuslän coast, where they spawned, returning to this same coast in accordance with the innate instinct of all fish; and that in this way they have developed into a tribe of herrings

peculiar to the Skagerak, whose disappearance at a later time may in part at least have been caused by a decrease of "herring-food" in these waters.

There is another feature of the recent spring-herring fisheries which I cannot pass by, as it seems quite inexplicable and has been the subject of much unnecessarily anxious thought. It has been maintained that during the last few years a new kind of inferior herring has made its appearance in the spring-herring district, a kind of herring which has been unknown in former years; and people have considered this as a certain sign that the spring-herring fisheries would soon come to an end. This supposed new kind of herring is the so-called "mixed herring," which especially last winter, in January and February, and in some cases even earlier, has at various points appeared in considerable numbers even outside the herring district proper, among the rest at the mouth of the Korsfiord. Unfortunately I had no opportunity of personally examining these herrings, and the inquiries made of the fishermen have not given me a very clear idea in what respects they differed from other herrings. All seem agreed, however, that they are not the common spring-herrings. But as for the rest the accounts differ very much. Some say that they are of an excellent quality, others that they are lean; some say that they have roe and milt like other spring-herrings, while others maintain that they have neither. Their size is also given very different. The fact of the matter is, that the "mixed herring," as its name indicates, shows great differences, so that among them one may find fat and lean, large and small fish, some with roe and milt, and some without. How can the occurrence of these herrings be explained? There must be a possibility of answering this question satisfactorily, thus removing the darkness which has hitherto enveloped it.

Although I have not personally examined these herrings, I think I am able to give an explanation; and it is again the before-mentioned new theory regarding the mode of life and the migrations of the spring-herring which will materially aid us in solving the problem. The greatly differing accounts as to the appearance of these so-called mixed herrings impressed me very strongly with the idea that they are herrings of different ages, and that only a comparatively small number of them are fit for spawning, as with most of them roe and milt are either not yet fully matured, or are entirely wanting as is the case with the so-called "straal" herring or "blood" herring. As these herrings can therefore not possibly come near the coast for the purpose of spawning, and as they cannot come in search of "herring-food," of which at this time of the year but little is found near the coast, it must be supposed that from some reason or other they are against their wish forced to approach the coast.

From the information which I was able to obtain regarding this so-called "mixed herring", and judging from the time when it first makes its appearance near the coast, I have come to the conclusion that their

coming near the coast is owing to the same cause which brings the so-called "straal" or "sun-head" herrings just previous to the spring-herring fisheries, or the coming in of the so-called "spring-herring mountains." I likewise think that I can in a quite natural manner explain why these herrings which are chased toward the coast, as has been described in another place, have of late years appeared in unusually large numbers and have been so mixed. It is my opinion that the chief mass of the spring-herrings, from reasons which have been given before, have of late years lived at an unusually great distance from the spawning-places, so that the great masses of herrings which approached the coast had to pass a considerably larger portion of the sea than is generally the case. The scattered schools of herrings which in accordance with my theory must be supposed to consist chiefly of young fish which are not yet fit to spawn, fish which have not yet been very far out at sea, are now by the irresistible advance of the great masses of herrings toward the coast forced to give way, and are thus compelled to seek the coast, exactly as is the case with the so-called "straal" herring. Regarding this last-mentioned kind of herring A. Boeck has in his work (p. 24) expressed a view which seems highly probable, viz, that "they are possibly stragglers from the spring-herring schools of the preceding year, which having less access to food, have not taken food enough to complete the development of their generative organs." A. Boeck likewise supposes that in all probability these herrings generally live at a comparatively short distance from the coast, which would also explain their coming immediately before the coming in of the spring-herrings, while the "mixed herrings" must be supposed to come from a greater distance from the open sea. I therefore think that the so-called "mixed herrings" are composed of very different elements, partly barren herrings ("straw-herrings"), young herrings which have not yet become fit for spawning (these would have been called "summer-herring" earlier in the year), and some stragglers from the great mass of spring-herrings.

I have thus, as I think, in a natural manner endeavored to explain some of the most important, and at the same time darkest, points in the spring herring fisheries. Although the theory I have advanced, with the conclusions deduced from it, as well as the explanation of the different phenomena, cannot be said to have been so firmly established in all its details that no possible opposition could be raised to it, it is nevertheless, as we have seen, essentially based on actual observations, and can therefore not be termed "mere philosophizing." As I consider it of the greatest importance to throw some light on these dark problems, I have considered it my duty to express my views quite freely, although I certainly wish that they could have been based on a larger number of actual observations. The field which the salt-water fisheries offer for practical and scientific investigations has been so little explored that we cannot expect to deal exclusively with incontrovertible facts. We would not get very far in this way. It is absolutely neces-

sary, every now and then, to go beyond these facts, or rather with these facts as a basis, to form a distinct idea regarding the causes of the many different phenomena and their mutual connection. This can only be done by forming some theory, and I therefore consider this as necessary if the investigations shall be carried on after a definite plan and in a rational manner.

If, in conclusion, some one should ask me what I think as to the results of the fisheries in coming years; in other words, in how far the spring-herring fisheries will in the future be a success or a failure, as has been the case during the last few years, I must first of all solemnly declare that I never thought I was a prophet, nor intended to pass myself off for a prophet. I consider it necessary to say this, as I learned to my sorrow that many people in reading my former report entirely misunderstood me, as if I had promised that in the following year there would be rich spring-herring fisheries. No such thought entered my mind, especially as there are many unforeseen circumstances which during the fishing season itself may exercise a hurtful influence on the fisheries, even if the mass of herrings should be ever so large. Some of my utterances regarding the spring-herring fisheries may not have been couched in as cautious or conditional language as they should have been, considering how many people are interested in or dependent on these fisheries. The reason of this must be found in the fact that my investigations in the southern herring district revealed a condition of affairs entirely different from what I had expected. I had gone there with the preconceived notion that we were near the end of a "herring period," or near the end of the entire spring-herring fisheries; and I consequently expected to find some signs of this, which I thought must show themselves at this season of the year. To my greatest astonishment, I found no such signs whatever; the young fish were, as always, in their usual places in large numbers, and all accounts agreed that also this year enormous masses of herrings had approached the coast, although they had not come as near as in former years. This, in connection with the fact, proved by my observation of the summer-herring, that this herring was the same as the spring-herring, only at a different age, of course convinced me that there was no decrease in that tribe of herrings which according to the popular notion lived in the deep immediately outside the coast.

As with these facts before me I could not think of any other probable cause why the spring-herring fisheries should come to an end but a decrease or degeneration of the respective tribe of spring-herrings occasioned by some unknown causes, and as I in my capacity as a naturalist could not possibly rest satisfied with the explanation that the spring-herring fisheries would come to an end, because this had been the case many years ago under circumstances which showed some similarity with what had been seen or what people believed they saw during the last few years, I could not possibly entertain the idea that

there were any distinct signs indicating a speedy end of the spring-herring fisheries. I consequently expressed my views perhaps with too great freedom, saying that I had found nothing which would prevent the spring-herring fisheries from being successful in the future in their usual places; and I would direct attention to the fact that this is very different from making a distinct promise that next year there would be rich spring-herring fisheries. My views are the same now as then, viz, that for the present there is no reasonable cause whatever to suppose that the spring-herring fisheries on our western coast will come to an end, although their yield may, through many accidental causes, vary from year to year, just as has been the case in former times.

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