

VI.—REPORTS MADE TO THE DEPARTMENT OF THE INTERIOR
OF INVESTIGATIONS OF THE SALT-WATER FISHERIES OF
NORWAY DURING THE YEARS 1874-1877.*

By Prof. G. O. Sars.

I.

REPORT FOR 1874.

As there is an item in the appropriation bill for next year for the practical and scientific investigations of the fisheries, I shall give a brief report of the observations made by me this year, and I shall also give my opinion as to how they should be continued.

As I mentioned in a former report to the department, it was my original intention this year to investigate the fisheries in Finmarken. It was my opinion that these investigations should be made chiefly in the months of March, April, and May; but as Professor Rasch had sent in his resignation in the beginning of the year I had to abandon this plan, since my office as assistant professor of zoölogy obliged me as long as the professorship was vacant to attend to its duties, lectures, and examinations, which could not be taken by any one else. I had thus no time at my command before the beginning of the midsummer vacation, *i. e.*, the end of June. But as already the year before reports had been made to the department by the governor of Finmarken by fishermen and several gentlemen interested in the fisheries, all expressing the fear that the whale fisheries, which during the last years had been carried on in the Varanger fiord by S. Foyu, might exercise a hurtful influence on the other fisheries, and since the department had at the same time been requested to have this matter investigated as soon as possible by a competent scientist, I thought that I must adhere to my original plan and make my investigations this year in Finmarken. It is true that the general fisheries had closed everywhere by the time I could leave my duties at the university, but on the other hand it was the most convenient season for investigating Foyu's whale fisheries, as they are chiefly carried on during the months of July and August. As I moreover expected to make some preliminary observations on the general fisheries, which I considered necessary before the direct investigations could be commenced, I concluded to proceed to Finmarken, even if I should get there at a time when no important fisheries were carried on.

* Indberetninger til Departmentet for det Indre fra Professor Dr. G. O. Sars om de afham i Aarene 1874-1877 anstillede Undersøgelser vedkommende Saltvandsfiskerierne. Christiania, 1878. Translated by Herman Jacobson.

As soon as I had finished my examination work and had gotten the necessary apparatus I started for the North and arrived at Vardö on the 15th of July. After a stay of eight days, which I chiefly spent in gathering information regarding the fisheries which had just come to an end, and in investigating the physical conditions of those localities where the fisheries are principally carried on, I went to Vadsö, where I staid three weeks. Here I had every opportunity to study Foy'n's whale fisheries, which just then were in very successful operation. Nearly every day I could examine whales which had been caught by him, and several times I had a chance of witnessing the way in which these fisheries are carried on.

The result at which I arrived regarding the influence which the whale fisheries may have on the other fisheries coincides exactly with my opinion which I had formerly expressed to the department. It is my firm conviction, now as then, that no danger whatsoever need be apprehended from the whale fisheries. I have in a former report to the department given my reasons for this view, and now, after having personally examined the matter, I can add a fact which proves still more fully that the complaints made against Foy'n's fisheries are entirely unfounded. The kind of whale which Foy'n catches almost exclusively, the so-called blue whale (*Balaenoptera Sibbaldii*), has in all probability nothing whatever to do with the other fish. Repeated investigations of the contents of its stomach have convinced me that its food consists almost exclusively of a small transparent shrimp (*Thysanopoda inermis*), which by the inhabitants of this coast is called "kril." Although there was no lack of herrings of different sizes during the time I staid in the Varanger fiord, I never found the slightest trace of herrings in the stomach of the blue whales, and Foy'n himself has assured me that he never had found any herring in the whale. The whale which is mostly found here is of a much smaller kind (probably *Balaenoptera laticeps*), a whale which Foy'n does not care for at all, because it is neither as large nor as fat as the blue whale. Besides this whale two other kinds of whale come here during the herring fisheries (so I have at least been informed), viz, the *Balaenoptera musculus* and the *Megaptera boops*, but both of them in smaller numbers. All these three kinds of whales seem to leave the coast when the herring fisheries have come to an end and follow the herring to the ocean; while the blue whale only begins to approach the coast in any considerable number after the herring fisheries, in order to feed on the enormous masses of "kril," which at this time are by the current driven toward the coast, especially in the Varanger fiord. Even those who still hold to the old opinion, that the whales chase the herrings toward the coast, will thus have no reasonable cause for anxiety, as Foy'n does not catch the so-called herring-whale, but chiefly a different kind which comes near the coast at a later season of the year.

Besides these investigations (concerning Foy'n's whale fisheries) I

made during my stay at Vadsö a number of zoölogical and physical observations in the Varanger fiord, which will prove very useful when, as I hope, I shall have an opportunity to stay here during the herring fisheries, which, however, it would lead us too far to give here in detail. From Vadsö I returned to Vardö, in order to make some observations which want of the necessary apparatus had prevented me from making during my first stay. After having thus studied to some extent the condition of things in the eastern portion of the herring district, I desired for comparison's sake to examine one or more points in the western portion of this district, and, after a sojourn at Vardö, I went west to Hammerfest, where I intended to begin my observations. I found, however, that this place was less convenient for such observations, and I therefore took the first steamer and went to the next stopping place, Hasvig, at the southwest point of the island of Sörö, an old and well-known fishing station, which forms the western boundary of the herring district.

My observations at this point, which I found very convenient in every respect, yielded several interesting results; the observations of the temperature of the sea-water at different depths, which I made here, were of special interest to me in comparing them with the observations which I had made in the eastern district. Here, my attention was also first directed to some physical conditions which I consider very important.

I had now, by the observations which I had made at the four points mentioned, obtained a tolerably correct idea of the condition of things in the whole herring district; and besides this, I had endeavored to get all the possible information regarding the herring and the cod fisheries dependent thereon, which I considered necessary as a basis of future direct investigations of these fisheries. Thus far, I had therefore accomplished the object of this journey.

Besides the cod-fisheries, however, another important fishery is carried on in our northern coasts, which, especially of late years, had made a most remarkable progress, and to which my attention was naturally directed, all the more as the conditions under which this fishery is carried on are to a great extent still enveloped in darkness. I here refer to the great herring or sea-herring fisheries. I was therefore anxious to gather during this journey all possible information regarding this fishery, especially as it seems that during the last few years remarkable movements are going on among the herring masses, which seem to take them farther north than has formerly been the case. It is well known that formerly the great herring fisheries as a general rule commenced at Längaenes in Vesteraalen, and have then gradually gone south along the coast of Helgeland. Last year (and probably this year too) the great herrings made their appearance very early and much farther north, considerable numbers coming even as far as East Finmarken, while the fisheries did not extend much farther south than Bodö. This seems to

indicate a change in the line of travel of the great herring masses, and it will be of great interest to find the cause of this. I was very anxious to examine various points in the great-herring district, but as my vacation had almost come to an end, I could only devote about a week to it.

Several reasons determined me to select Bodö as my place of observation. Last winter the great herrings had come here in unusually large numbers, and as this was about the southernmost point where any considerable fisheries are carried on, I hoped to obtain here more light regarding the dark problem of the spawning of the great herring, and in case spawning had been going on, to make a thorough investigation of this whole locality. But here, as everywhere else, I was told that the great herring does not spawn at all when near the coast. Only in one solitary case had spawning—a phenomenon which even the most inexperienced fisherman can understand—been observed in a bay near Landegade where a school of herrings had remained an unusually long time, till the end of January. Here the herrings are said to have actually spawned. But at that time the great-herring schools had long since left the coast. The remarkably stormy weather which prevailed during my stay at Bodö unfortunately prevented me from examining that point, and the same cause prevented me from making other observations, as had been my original intention.

The information regarding the great herring which I gathered during my journey in connection with observations of the physical conditions of our northern coast, has to a certain extent modified my views regarding the migrations of the herring, and has suggested to me the idea of a more intimate connection between the great-herring fisheries and the spring-herring fisheries on our western coast, than I had formerly considered possible. I shall, however, defer giving my views until, as I hope, I shall have an opportunity to witness the great-herring fisheries in person, and on the spot make those observations which I consider necessary for giving weight to my views. I believe I have found, at least, a partial cause of the remarkable change in the migrations of the great herring which have taken place during the last few years in the peculiar physical conditions of the outer sea. I shall here only draw attention to some points which I consider important. I was there told by members of the Austrian Polar Expedition whom I had the good fortune to meet, that during this and partly during the preceding year the condition of the Northern Polar Sea had been exceedingly favorable, as the sea had been more open than had ever been the case before.

During my stay at Hasvig I learned to know another circumstance which probably is intimately connected therewith. During this year an unusual quantity of driftwood began to show itself on the west coast of the island of Sörö, chiefly composed of a species of spruce which is not found in our country. Such a thing has not occurred for many years; but some of the oldest inhabitants say that such driftwood had come to this coast a long time ago. This seems to point distinctly to peculiar

changes in the current of the sea which certainly must have some influence on the distribution of the herrings (compare my last report and the new theory there advanced by me concerning the places of sojourn and the migrations of the herring). So far, however, the data which I have gathered are not sufficient to base on them any positive opinion regarding the great herring. I consider these data, however, as significant hints, and have no doubt that continued investigations will bring to light more facts of a similar character which will finally solve the dark problem of the migrations of the herring and some of our other fish.

II.

REPORT FOR 1875.

It was my intention during this journey—

a, to investigate the *mackerel-fisheries*, in order to ascertain the conditions under which these fish come near our coasts ;

b, to investigate the *lobster-fisheries*, chiefly with a view of obtaining a firm scientific basis for settling the vexed question as to the best way of protecting the lobster ; finally,

c, to ascertain in how far the government would be justified in taking steps with regard to the memorial from the governor of Sarlsberg and Laurvig, advocating certain *limitations in the use of the drag-net* for that portion of the coast extending from Nevlunghavn to the Tonsbergfiord.

I started on the 19th of June, and was absent from home till the 19th of August, therefore altogether two months. During this time I visited the following places: Lurhavn, Tananger, Hvitingsö, Skudesnaes, Akrehavn, Flekkerö, Langesund, Nevlunghavn, Fredriksvaern, Kjaerringvig, Sandefjord, Bogen. I made observations at all the places, in the six first-mentioned chiefly regarding the mackerel and lobster fisheries, and in the six last-mentioned ones likewise regarding the cod-fisheries.

I have the honor herewith to submit the results of these investigations to the department.

I shall divide my report into three chapters:

a. On the mackerel-fisheries.

b. On the lobster-fisheries.

c. On dragnet-fishing on the coast from Nevlunghavn to Tönsbergfiord.

1.—MACKEREL FISHERIES ON OUR SOUTHERN AND WESTERN COAST.

These fisheries have only become important of late years, since people have commenced to pack mackerel in ice and export them to England. At present these fisheries are, next to the herring and cod fisheries, the most important of our salt-water fisheries. They are carried on not

merely along our whole southern coast, but likewise on the western coast, at least as far as the heights of Bergen, and during the summer give employment to a large number of fishermen, who during a favorable season make a right good living. These fisheries are at present chiefly carried on by means of floating nets from May till the middle of July, and generally at a considerable distance from the coast, sometimes 6-8 (Norwegian) miles.

As has been the case with several of our well-known fish, many erroneous notions have likewise prevailed with regard to the nature and the migrations of the mackerel. Some of these notions are even entertained at the present day, and are brought forward in ichthyological works. Although it is of course impossible for me, after having studied the nature of the mackerel only for a comparatively short time, to pronounce a definite opinion on every point in its natural history, I nevertheless feel competent to correct some of the erroneous notions which have been entertained hitherto, and through direct observations to supplement our knowledge of this fish.

The first question which presents itself is this: "Where is the proper home of the mackerel?" It is well known that the grown mackerel like the spring herring and the codfish only visits our coasts during a certain season of the year, and then disappears without leaving the slightest clue as to its whereabouts. Where does it go, and where does it stay during the remaining portion of the year? The opinion which at present is most prevalent among zoölogists is, that the mackerel stay in the great depths immediately outside the coast, an opinion which has also been advanced with regard to the spring herring, but which—in my report for 1873—I have endeavored to prove is erroneous.

As far as the mackerel is concerned another erroneous opinion is very widely spread, viz, that while living in the deep it is blind and lies at the bottom in a sort of torpor. Although this is highly improbable, we still find it mentioned in many ichthyological works; and so far, at least, this opinion has not been seriously refuted anywhere. The fishermen, who of course were the first to advance this opinion, are thoroughly convinced of its correctness. They say that experience has taught them to believe it. They maintain that in the beginning of the fisheries the mackerel enters the nets much easier than later in the season; and this, they say, can only be explained by the circumstance that the mackerel cannot see very well, while later when it has got its full sight, it is more cautious. They say that any one can see the opaque skin which covers the eyes of the mackerel, and that its disappearance and growth may be observed during the summer. With the first mackerel which are caught early in spring, this skin covers the greater portion of the eye, with the exception of the middle portion. Later in summer the skin becomes more transparent and recedes from the middle of the eye; while toward fall when the mackerel is about to return to the deep, it begins to grow aud become more opaque.

All this is certainly correct, but it is a very rash conclusion to suppose that this skin ever covers the whole eye, so that in the end the fish becomes entirely blind. With a view of ascertaining the truth in this matter I have examined mackerel both in the beginning of the fisheries and later in the season, and it is my firm conviction that the mackerel can see as well early in the year as later, although the above-mentioned skin decreases in size toward summer. This skin is nothing else but two folds of skin, which are also found in other fish (*e. g.* the herring), and which from both sides extend over the eyeball. These folds never reach over the pupil of the eye, which, as is well known, is the only channel through which rays of light can enter the eye. The faculty of seeing would, therefore, not be affected in the least, whether these folds are transparent or opaque, whether they cover a larger or a smaller portion of the opaque parts of the eye. The greater development and smaller degree of opaqueness of these folds earlier and later in the year are simply occasioned by the mackerel's being fatter at that time. In the middle of summer immediately after spawning the mackerel is thinnest, and that fat which formerly was found in the above-mentioned folds has therefore been absorbed, which of course has an influence on their extent and transparency. A completely blind mackerel has never been seen yet, and will never be seen; and still it is by no means rare to catch stragglers late in autumn and winter, or at that time when, according to popular opinion, the mackerel ought to have lost its sight long since.

As long as it was supposed that the mackerel was blind in winter and lay in a sort of torpor, it followed necessarily that it must keep on the bottom. But as this, as I believe, is not only improbable, but an absolutely foolish notion, we must again discuss the question regarding the supposed place of sojourn of the mackerel when it is not near the coast. The oldest supposition, given up long since (Andersson's), is, that the mackerel came from the sea near the North Pole, and that from here at certain seasons of the year a large school travels south, like a swarm of bees leaving its hive. This school was then supposed to pass through the Polar Sea and the Atlantic Sea like a dense phalanx, and having reached the heights of Europe to divide into smaller schools, each of which sought a special part of the coast, to return by the same route and spend the rest of the year in undisturbed repose under the ice of the Polar Sea. Andersson's migration theory, which was applied not only to the mackerel but also to the herring, has recently given way to an entirely opposite theory, viz, that the mackerel is a stationary fish having its winter quarters in the deep places immediately outside that portion of the coast where later in the season it comes to spawn. This theory is in my opinion just as erroneous as the other. I have in other places given my theory regarding the herring, according to which I suppose that this fish leads a pelagian or roving life all the year round, and is found in smaller or larger schools in different places in the outer sea wherever it finds most food.

As far as the mackerel is concerned I do not doubt for a moment that it is a genuine pelagian fish. Its whole build and its looks indicate this, its slender form, its compressed, wedge-shaped head, its small fins, its powerful muscles, its shining sides, glittering like silver and gold, and the beautiful sea-blue and sea-green shading of the back. All genuine bottom-fish have a plump and compressed body, a flat head, large fins, and generally gray, white, or black colors, or a mixture of the three, but very rarely any brilliant colors. Any one who is acquainted with the sea on our southern and western coasts knows the playful nature of the mackerel when near the land, how they gambol about on the surface of the water, so it resembles a seething caldron; how, in a stiff breeze, it races with the swiftest sail-boat. All this is by no means in keeping with the character of a bottom-fish. It seems improbable in the highest degree that during the rest of the year the mackerel should suddenly change its nature and lead a melancholy life down at the bottom of the ocean. The mackerel has got its elegant and well-proportioned body, in order to move quickly about in the water, and there are very few fish which excel it in this. It is therefore also well adapted for long journeys, and, although I do not approve of Andersson's migration theory, I incline to the opinion that the mackerel which every summer come to our southern and western coasts in large schools, come from a great distance. If we examine the geographical distribution of the mackerel on the coasts of Europe, we find that it is very different from that of the herring. While the herring is only found on the northern coasts from the Channel to the northernmost boundaries of our continent, the mackerel is found much farther south. It is not found in any very large numbers on the heights of Söndmöre, while farther south it is found more frequently. Besides our southern and western coasts, it is found on all the other coasts of the North Sea, viz, in Denmark, Germany, Holland, and England, also on the Atlantic coast of Scotland and England, near Ireland, in the Channel, on the coasts of France, Spain, and Portugal, and in the Mediterranean as far as the Black Sea; and it is even said to have been found as far south as the Canary Islands. It is also found on the eastern coast of North America.

We see from this that it is a much more southern fish than the herring. Its proper home is, in my opinion, the Atlantic Ocean along the whole western coast of Europe from the Orkney Islands and the north coast of Scotland to the Mediterranean, while the home of the herring is chiefly the Atlantic Ocean north of Scotland, and the Polar Sea. Its mode of life while out in the open sea is unfortunately but little known. I have been told, however, that grown mackerel are at different seasons of the year occasionally caught by sailors off the coast of France and Portugal. In all probability they live more scattered here than when they are near the coast, perhaps, also, at different depths under the surface, but never on the bottom. It is not improbable that some of those mackerel which come to our coasts do not leave the North Sea. I incline, however, to

the opinion that these can only be a very small portion of the enormous masses which come to the coasts of the North Sea. I have good reason to suppose that the greater portion come from a greater distance, viz, from the Atlantic Ocean, chiefly by way of the Channel, and some along the northern coast of Scotland. The largest mackerel fisheries are carried on in the Channel, and several things seem to indicate that the mackerel which are caught on the coast of Holland belong to the same schools which have entered the Channel from the Atlantic. At the end of July and the beginning of August, the very time when our mackerel fisheries have closed, mackerel are, according to Lowe (*Fauna Orcadensis*), seen in large schools near the Orkney Islands. These are, probably, schools returning from the coast.

The next question to be answered is: "What are the conditions of the regular visits which the mackerel pays to our coasts?" It is a fact which should have been known long since, that the same phenomenon which, at other seasons of the year, causes the coming of the spring-herring and the codfish, viz, the spawning process, brings the mackerel to our coast. Zoölogists have hitherto had no idea regarding the peculiar circumstances under which this spawning process is going on, no idea where the mackerel drops its roe, whether in shallow or deep places, nor have they known anything concerning the development and further growth of the mackerel. All these important points in the natural history of the mackerel have remained in the dark up to the present day, and this in spite of the mackerel's being one of the most common fish in Europe. The cause of it is this, that ichthyologists have formerly taken too little pains to study the mode of life of the different fish while in the water, and have confined their investigations to the specimens preserved in museums, or, at best, to dead fish which they had obtained from some fisherman. In this way exact descriptions of fish may be written, and diagnostic data given serving to separate one species from the other, but all that important part of the natural history of fish, comprising their mode of life, their migrations, spawning, and development, will remain in the dark. On these important points nearly all information has been obtained from fishermen and other persons utterly ignorant of zoölogy, and numberless erroneous ideas have consequently been advanced.

The first preliminary investigations of the spawning of the mackerel were made by me during one of my zoölogical tours, in the summer of 1865. During the journey I made this summer I had an opportunity to supplement and corroborate my former observations. The mackerel spawns on the surface of the water, sometimes near and at other times far from the coast, without regard to the depth and the nature of the bottom. The roe does not sink to the bottom as is the case with the roe of the herring, but floats near the surface and there goes through all the stages of its development. In this respect the mackerel resembles closely the codfish and some other salt-water fish whose spawning

process I observed several years ago. In the beginning of July the roe of the mackerel begins to loosen, and about the middle of July most of them have done spawning. The spawning period may, therefore, as a general rule, be placed about the first half of July. By gently pressing the sides of mackerel caught during this time, mature roe may be procured for investigations. It comes out of the genital opening of the mackerel in the shape of small beads, clear as crystal, which when placed in a vessel containing sea-water keep floating near the surface as long as the roe is fresh. The grains of roe or the eggs are of about the same size as those of the codfish (or a little larger), but are distinguished from these, as a closer examination will show, by a large and very distinct and clear oil-bladder near the upper pole (that side of the egg which is uppermost). By this peculiar oil-bladder, which is invariably found in every egg, the roe of the mackerel can easily be distinguished from that of most other fish. Impregnated and developed roe may be obtained in a very simple manner by dragging a fine net along the surface of the water, especially during westerly or southerly wind when the current goes toward the coast. I have in this manner obtained as much as I desired, and have been enabled to follow its whole development, which, in all essential points, agrees entirely with what on former occasions I have stated concerning the development of the roe of the cod. I also succeeded in hatching young fish from roe obtained in the above-described manner, but was not able to keep them alive for any length of time. When coming out of the egg they are comparatively less developed than the young codfish, entirely transparent and clear as water with the exception of a little sulphur-colored spot on each side of the neck. Mackerel which have been recently hatched may easily be recognized, not only by these spots, but also by the same bright oil-bladder which characterized the individual grains of roe. This oil-bladder, which formerly occupied the top part of the egg, is now inclosed in the back part of the belly in the residue of yolk matter.

I was unfortunately prevented from following up the further development of the young mackerel. This summer was very unfavorable to such observations, as the mackerel spawned at an unusually great distance from the coast, and as a constant land-wind drove the roe and the young fish far out into the sea. Both this year, however, and on former occasions, I have about the same time or somewhat later observed small mackerel, measuring about a finger's length, on the surface of the water and invariably at a considerable distance from the coast. These young mackerel, which had already assumed the definite shape and color peculiar to the mackerel, are doubtless one-year-old fish. In the Christiania fish-market one may see large quantities of these one-year-old mackerel, every year somewhat later in the season; and besides these a somewhat larger kind, the so-called "spir" or small mackerel, about the size of a common herring, which must therefore be about two years old. When a mackerel is three years old I consider it capable of spawn-

ing. Like all pelagian fish, it then goes out to sea, while during the first two years of its life it roams about in the neighborhood of the coast.

Immediately prior to and during the spawning process the mackerel are generally very restless and roam about in dense schools (males and females together) in different directions near the coast and so near the surface that they can be seen from quite a distance by the curly appearance of the water. The schools always go against the stream and are liveliest when a fresh breeze is blowing. The natural cause why the mackerel enters the nets easier at this season than later is this, that it is completely taken up by the spawning process, and by no means defective sight. When the spawning process is finished, the schools begin to scatter and gradually go out to sea again. The fish will then not enter the net so readily, although they will bite a baited hook, because they have scarcely taken any food during spawning, and are, consequently, very hungry.

Concerning the general mode of life of the mackerel many incredible things have been said. One of these fabulous reports is this, that mackerel, like sharks, attack men swimming or bathing in the water, and that if their number is very large they will overcome even the strongest man. The improbability of this report, which is very generally believed, is self-evident. A close examination of the mackerel will convince any one that it cannot possibly hurt a man. Its jaws are too weak and its teeth too fine. To smaller fish and marine animals, however, it may certainly prove a dangerous enemy. I have several times observed the greedy manner in which mackerel scarcely a finger long have chased young herring and decimated their schools. It will be seen from this that the grown mackerel must be a very dangerous enemy to the young herring; and personal observations have convinced me that this is really the case. On this circumstance the so-called autumn-mackerel fisheries are based, which are carried on in the deep fiords long after the time when the great mass of mackerel have left the coast. The so-called autumn-mackerel are schools which have separated from the chief school, which instead of going out to sea have commenced to chase the small herring and followed them into the deep fiords where they remain as long as they find sufficient food. The fatness of the autumn-mackerel is caused by its rich food, generally consisting of small herring, but also of other small pelagian animals. As soon as this food begins to get scarce the mackerel gradually disappear and go out to sea again, and toward winter it is merely accidental if mackerel are caught on hooks with other fish. That the autumn-mackerel later in autumn generally goes deeper than the summer-mackerel, is easily explained by the circumstance that there is so much fresh water near the surface in our fiords, and likewise by the change in the temperature of the surface-water. But the mackerel will never be found constantly near the bottom like flounders and other bottom-fish, but always some distance from it.

From all that has been said concerning the propagating of the mackerel, it will be self-evident that there is no danger whatever of destroying their spawning-places by too extensive fishing, as has often been maintained with regard to the herring-fisheries. Nor do I believe that the floating-net fisheries carried on in the open sea near our southern and western coasts can have any marked influence on the number or migrations of the mackerel. If, therefore, a decided decrease has been noticed in the mackerel-fisheries on our southern and western coasts, the cause of this must not be sought in the manner in which nor in the extent to which the fisheries have been carried on, but rather in the peculiar physical conditions of the open sea, which have induced the great mass of mackerel of late years to spawn at a greater distance from the coast than usual. It is well known that a similar phenomenon has for quite a number of years been observed in the spring-herring fisheries. This similarity between the two fisheries is certainly not purely accidental. In my opinion the herring and the mackerel agree in their pelagian mode of life, and the migrations of both these fish must therefore be dependent on analogous conditions of the open sea; although the distribution of the herring and the mackerel throughout the sea is essentially different, I consider it as certain that the changed physical conditions which must be supposed to have exercised their influence on the kind of fish found in one basin of the sea, cannot have remained entirely without influence on the portion of the sea close to it where the other kind of fish were living.

2.—THE LOBSTER AND THE LOBSTER-FISHERIES ON OUR SOUTHERN AND WESTERN COASTS.

Like the mackerel-fisheries, the lobster-fisheries on our coasts have, of late years, become very important, which may be seen from the large number of lobsters which are annually exported to England, not counting those which are consumed at home and exported to other countries, especially to Denmark. At present, the lobster-fisheries are carried on with varying success along our whole southern coast and along a great portion of our western coast. The northernmost point where I have observed lobsters is the Loffoden, where some years ago I had occasion to examine a recently-caught young lobster which was brought to me as an animal entirely unknown in these regions, and regarded with much curiosity by the inhabitants.

Lobsters are almost exclusively caught in traps made of wicker-work ("lobster-baskets"), which are set at a depth of 1 to 5 fathoms and baited with small fish. As these fishing-implements are, comparatively speaking, cheap and easily worked, so that even infirm and aged people can attend to them from a small boat, these fisheries are of great importance to the poorer portion of our coast population. And as the

exportation of lobsters to foreign countries (especially to England) brings considerable sums of money into the country every year, the government has long since taken steps to prevent the destruction of this important source of income by making regulations for the better protection of the lobster. The views regarding the time and extent of these regulations have been very different, and of late years memorials have been presented to the government from various places asking for a change in the existing lobster-laws. But, unfortunately, very little has been done so far. In order to judge in this matter it is absolutely necessary to have as complete a knowledge as possible of the natural history of the lobster. But in this respect very little progress has been made. Although the lobster belongs to the commonest marine animals on the coast of Europe, and has been made the subject of special investigations by many naturalists, its mode of life is still enveloped in darkness. Even some of the most important points in its natural history have till quite recently been entirely unknown. I have already on former occasions endeavored to throw light on one of these points which, in my opinion, deserves special attention, viz, the propagation and development of the lobster (see "*Vid. Selskabets Forhandling*" for 1874—Transactions of the Academy of Sciences). It was my intention on the present journey to observe other points in the natural history of the lobster, and gather all the information which might throw light on them; I consequently staid for some time at several places on our southern and western coast where lobster-fisheries are carried on, among the rest, Tananger. Although I must confess that the results of these investigations did not come up to my expectations, I, nevertheless, will briefly report my experience, chiefly with a view of gaining a basis for my opinion regarding the protection of the lobster and the best time for it.

As to its organization and its analogy with similar crustaceans, the lobster must doubtless be on the whole considered as a stationary animal. It never undertakes long migrations like some of our fish. The lobster certainly moves about with great swiftness and ease aided by its strong tail and the swimming apparatus attached to it; but this mode of moving about is evidently not the rule. The hard-shell and ponderous lobster must always make an extra exertion in moving about, and its movements can therefore not be of long duration. People certainly talk of the so-called "traveling lobsters" ("*Færd-hummer*") which are said to come from the open sea in large schools; and some even say that they have seen such schools many miles from the coast moving about rapidly near the surface of the sea. If this is really so, I consider it as absolutely certain that these schools come from no very great distance, possibly from some of the elevated bottoms off the coast. The grown lobster is, as every lobster-fisher will know, in its whole mode of life, a genuine bottom-animal, and prefers a stony or uneven bottom overgrown with algæ where it finds good hiding-places for lying

in wait for its prey. During summer and part of autumn the lobster goes on higher bottoms in the bays and inlets, and is then frequently caught quite near the coast among the algæ at a depth of less than a fathom. Toward winter it again retires into the deep; and still later in the season it has almost entirely disappeared from those places where it was quite common during summer. Occasionally, however, it is, even in the middle of winter, found in deep water, and I have reason to believe that the lobster never leaves our coasts entirely, but considers it as its proper home.

As may be judged from its powerful claws, the lobster is a greedy animal of prey, which is not satisfied with small marine animals, but occasionally attacks all kinds of small fish which are unfortunate enough to come within its reach. The bait used for catching lobsters consists exclusively of fish, principally small codfish and herrings. These must, however, be tolerably fresh; as soon as they begin to get old the lobster leaves them to his cousins, the crabs, which are less fastidious in their taste, and they enter the baskets in great quantities.

The lobster is cautious and cunning. It never pursues its prey openly, but either endeavors to surprise it, in which it is greatly aided by its very highly-developed sense of smelling, or waits patiently among the algæ till some marine animal comes within reach of its claws. I have observed several times with what cautiousness and evident distrust the lobster, attracted by the bait, has gone round the traps and examined them several times on all sides before it has gone in. Only when it is very hungry, as is especially the case later in summer after the spawning and changing of shell is over, it is less cautious and will enter the traps more readily.

The lobster is best and fattest in spring and early summer, while later in summer and autumn it gets thin, from which cause the Englishmen will not take it then.

The propagating of the lobster does not seem to be strictly confined to a certain season of the year, as lobsters with roe may be found nearly all the year round. But the rule seems to be that the development of the young goes on during the summer months from the beginning of July till the early part of September. The more developed roe can easily be distinguished by its lighter color and partly also by the larger size of the grains. A closer examination shows distinctly in every grain of roe two dark spots which are the eyes of the embryo. The more distinct these spots are the more developed is the embryo. When its development is complete, the egg-shell bursts, and the young lobsters come out. These are in the beginning very helpless and sink to the bottom, where within a very short time they undergo their first change of skin; soon afterward the swimming apparatus, which has so far been surrounded by skin, begins to work, and the young lobsters soon gambol about in the water, and come up to the surface, where they remain during the whole time of their further development.

I have in the above-mentioned work (*Vid. Selskabets Forhandlinger* for 1874—Transactions of the Academy of Sciences) described the young lobster during this and the three succeeding stages of its development, and accompanied the description with plates. Each of these stages is characterized by a preceding change of skin; and each one of these changes makes the young lobster which in the beginning looks very unlike its parents, resemble them more closely. At the fifth change the metamorphosis is complete, and therewith ends its pelagian life. The young lobster has then entirely lost its swimming apparatus attached to the fore part of its body, and in its place the well-known fringes have grown at the lower side of the back part of the body. These fringes are the only swimming apparatus which the grown lobster possesses; in the female lobster, they likewise serve to keep the roe in position. The lobster now leaves the surface and goes to the bottom, there to lead the same life as its parents. I am not positively certain how long a time is taken up by the whole metamorphosis, but I am inclined to think that it takes at least a couple of months.

Even after the lobster has reached its final development, it continues to change its skin regularly at any rate once a year, and continues to do so as long as it grows. Only when it has stopped growing, this change of skin does not occur so often. We shall therefore always find that very large lobsters are more or less thickly covered with scales which is not so frequent in smaller specimens. The process of changing skin is very tedious and dangerous for the lobster, which may be imagined when it is known that not only the outer shell is changed, but even some of the inner parts, *e. g.* the stomach-bag. The process occupies a considerable time, and while it is going on the lobster is sick and utterly unable to fly from its enemies or to defend itself against them. It is therefore but natural that under such circumstances it very easily dies in the traps. Even after the change of skin is over the lobster remains weak for some time. It therefore hides among the stones at the bottom of the sea and remains there until the new shell has become sufficiently hard and its strength has returned.

The earliest changing of shell which I observed during my journey was in the first days of July near Tananger. I here had an opportunity to observe a lobster engaged in this process. It had just been taken out of a lobster-box and could be handled without offering the slightest resistance. The shell on its back was burst in the middle, and the tail and the feet were nearly all out of the old shell, while the largest claw only stuck out half its length. This latter portion of the change of shell is evidently very dangerous, and although I observed it for quite a while, I could see little or no progress. It is certainly a painful and dangerous process, and probably many a lobster loses its life through it. Immediately after the changing of the shell the lobster is lean and miserable and only reaches its former size after a considerable time has elapsed. According to my observations, the change of shell takes place

chiefly during the month of July. It certainly happens that some change later, but by far the larger number seem to change during that month.

I did not succeed in obtaining lobsters measuring from one inch to a finger's length, and as far as I know none are found in any museum. I consider it as certain, however, that the lobster keeps near the coast also during this stage of its development. The reason why they cannot be caught with the bottom-scraper is partly their quick movements and partly the circumstance that they hide among the algæ on the bottom of the sea. The fact that they cannot be caught in the common lobster-baskets is easily explained by these having such wide openings.

It is a remarkable fact that the lobsters on our southern coast never get as large as those farther north. I have never seen an unusually large specimen among the many lobsters which I examined at the different fishing-stations. The lobsters which are occasionally caught farther north are generally much larger, and to judge from their appearance much older. At Florö I once saw a lobster which was not much smaller than the immense specimen in the Bergen Museum. This specimen, as far as I remember, comes from a still more northerly point of our western coast.

As to its geographical distribution, the lobster is more of a southern animal than its cousin, the crab, which is found all along our coast as far as Vadsö. Its northern boundary is the polar circle. It is found very generally along the coasts of the North Sea and on all the Atlantic coasts of Europe, and even goes into the Mediterranean, where, however, it is not found in great numbers. The lobster found on the eastern coast of North America belongs to a different species, of which I convinced myself by examining its young ones, a picture of which I have given in the above-mentioned work.

From these scientific remarks I return to the practical side of the question. The principle which has been followed in framing laws for the better production of the lobster is the same which forms the basis of all similar protective laws, viz, a desire to let the propagating of the lobster go on as undisturbedly as possible. If one considers what an enormous quantity of roe a grown female lobster can carry under her tail, and also that this roe becomes impregnated, and that, consequently, every little grain of roe develops into a lobster, it is very natural to suppose that if only a sufficient number of female lobsters could hatch their young ones undisturbedly, ample compensation would be made for the number of grown lobsters caught every year. It was also very natural to suppose that the decrease in the quantity of lobsters, which had been observed in various places, was caused by catching grown female lobsters during the hatching-season. With other fisheries the use of certain fishing-implements has proved hurtful to the fish; but the implements employed in lobster-fishing are of such a kind as to preclude this possibility.

On general principles, the above-mentioned view seems to be entirely justified and logical. There is no doubt that if the lobster is let alone during the hatching-season a number of young ones will be produced large enough to compensate, under favorable circumstances, for all the lobsters which are caught. It is, therefore, only right that the lobster should be, as much as possible, protected during the hatching-season. It is likewise possible that reckless fishing during the hatching-season will hinder the increase of the lobsters. It must be remembered, however, that there are many other disturbing causes. I have already on another occasion shown that the young lobster during the first period of its life is exposed to many dangers, and that probably a large number perish on account of unfavorable influences during their development. If, therefore, in spite of protective measures a decrease in the quantity of lobsters has been observed in various places, it must not be supposed that the only cause of it is lack of protection or too short a season of protection. The season of protection is, in my opinion, correct on the whole, and if I now consider it best to set it a little earlier, viz, to begin the 1st July, I do this from another reason, viz, out of regard to the change of shell of the lobster, which begins during the first days of this month. The lobster is at that time entirely unfit for transportation, and many die even in the boxes. I believe that if the lobster is thoroughly protected during the months of July and August, there will be some guarantee at least that a sufficient number of young ones are produced to make up for all losses occasioned by the lobster-fisheries during the other months of the year.

But no laws and no protective measure can change the unfavorable physical conditions which have caused a decrease of the lobsters on certain portions of our coast. The only means to be employed under such circumstances is the artificial raising of lobsters. I shall have occasion to return to this point, and merely to avoid misconception, I will say here that I consider a reasonably arranged protection of the lobster not only desirable, but also necessary; but the protective measures should be somewhat uniform in the different districts. At any rate, on that portion of the coast which I visited, I found but very little difference both with regard to the time of hatching and the time when the lobsters change shell; so there is no reason for having a different season of protection in these districts. But as memorials have been sent to the department of the interior from several places asking for an extension of the protective season, it will probably be best, in order to avoid dissatisfaction, to leave it to each community to extend the season of protection wherever there is a very general demand for extension. But I must say that if protection is to answer its purpose, it will be necessary for the different districts to organize a system of superintendence, so the laws may be strictly carried out. As matters are now, there is—and I speak from personal observation—as much fishing going on on our southern coast during the season of protection

as at other seasons. Where the season of protection only lasts a month, those lobsters which have been caught when fishing is prohibited are generally kept in large boxes until the season of protection is over, when they are brought into the market. But many of these closely-packed lobsters die in the boxes, and those which are left are so lean and miserable that they are of little or no value, and are necessarily thrown away.

There is another point which I must briefly mention, viz, the artificial raising of lobsters. I have in another place expressed my opinion that this is a subject which possibly in the future may prove a very important aid to our lobster-fisheries. The exceedingly simple manner in which the artificial raising of lobsters can be carried on seems to encourage people in different places to make experiments in this direction. Mr. Hansen, a merchant of Akrevig, assisted by Mr. Olsen, superintendent of schools at Kobbervig, has already made several experiments, which, on the whole, have proved successful. During my journey of last summer I visited the place and examined the hatching apparatus, which had already produced a large number of young lobsters. Mr. Hansen has determined to make a kind of lobster-park, where the young lobsters, after their metamorphosis is completed, may live and develop. I consider these experiments of great importance, and would like to see Mr. Hansen receive sufficient aid from the government to enable him to carry them on on a larger scale and in a practical manner.

3.—ON DRAG-NET FISHING ON THE COAST FROM NEVLUNGHAVN TO TÖNSBERGFJORD.

With a view to examine in how far there was any cause for the government to take active steps regarding the memorial from the governor of the districts of Jarlsberg and Laurvig asking for authority to limit the use of drag-nets (beam trawls) on the above-mentioned coast, I made a journey (mostly by boat) along that coast, and staid a few days in each of the following places: Nevlunghavn, Fredriksværn, Kjærringvig, Sandefjord, and Bogen.

The result of my investigations is briefly as follows: Most of this coast is open toward the sea, with only short bays and inlets. Only in three places fiords run farther up the country, viz, the Laurvigfiord, with its branches, the Vigfiord, the Sandefjord, and the Meford. An investigation of these fiords, in connection with information gathered from fishermen, has convinced me that there are no stationary schools of codfish in any of them, and that, in this respect, they are like the inner portion of the Christiania fiord and part of the Langesunds fiord. The codfish caught in these fiords come doubtless from outside, and most of them again return to the sea. It is quite probable that young codfish are found on this coast, and I certainly consider the reckless

fishing of these young fish with drag-nets as hurtful; but the same may be said of every other coast; but as the law proposed in the above-mentioned memorials only refers to fishing in the larger fiords where the codfish must be supposed to be rather stationary, it would not apply so well to this coast which is so open and unbroken. From what I have learned, drag-nets are rarely or never used here. Frequent conversations with fishermen have convinced me that there is no general dissatisfaction with this kind of fishing-implement, which is scarcely known here, but that there are complaints of an excessive use of hooks and lines. With the exception of the Christiania fiord, drag-net fishing has only been carried on to any extent in and near the Langesunds fiord, chiefly owing to local causes (the many quiet shallow inlets with even, sandy bottoms), which have made the use of this net more convenient here than on the other portions of the coast, which, both on account of the nature of the bottom and the open or unbroken character of the coast itself, is scarcely suitable for any extensive drag-net fishing.

Under these circumstances, I see for the present no necessity for the government to take any steps in the matter, and from another reason I would most decidedly advise not to make any law at least for the present. During my stay on the Langesunds fiord I learned that the regulations made in former times regarding the limitation in the use of the drag-net in the Langesunds fiord and its neighborhood, which are fully justified by local circumstances, do by no means produce the intended result, for I was told that drag-net fishing is carried on now to the same extent as before the law was passed. This is easily explained by the fact that there is no supervision whatever, although such supervision is absolutely required, since drag-net fishing is chiefly going on during the night or very early in the morning (before the break of day). Before there can be any talk of more rigid regulations of the drag-net fishing on coasts where the carrying out of such regulations would be doubtful, there must be some guarantee that these regulations are really observed, at any rate in those places where there is urgent necessity for such regulations. If this is not done, such rigid laws, far from doing any good, will do positive harm, as the moral influence on the sense of justice of the common people will be very bad, if there are laws which only exist on paper and can be transgressed with impunity at any time.

III.

EXTRACTS FROM PROF. G. O. SARS'S REPORT ON THE NORWEGIAN ATLANTIC EXPEDITION OF 1876.

1.—ZOOLOGICAL OBSERVATIONS.

Among the various scientific problems to be solved by this expedition the most important was the examination of the biological condition of

those portions of the sea through which its route lay. The expedition was well supplied with all the necessary apparatus (bottom-scrappers, or dredges, trawl-nets, sieves, &c.), all according to the most recent English models; also a considerable quantity of cordage of different thickness, as well as heavy iron weights for keeping the apparatus on the bottom. A large number of glass jars of every size and quality, from small tubes to cylinders measuring one foot in diameter, were also on board, as well as a considerable quantity of spirits of wine for preserving the specimens which would be collected.

In order to take the best possible care of the zoölogical material obtained by the above-mentioned apparatus, and in order to make those preliminary observations which are of great importance for all future observations, it was thought best to have as many zoölogists as possible on the expedition, as well as an experienced draughtsman. The zoölogists were: Dr. Danielsen, Mr. Friele, and Professor Sars, and the draughtsman's place was filled by the well-known landscape-painter, Mr. Schiertz, whose skilled pencil and unusually sharp faculty of observation proved of great use to the expedition. He has produced a series of masterly colored sketches, which will form a great ornament to those zoölogical treatises which are going to be published as one of the results of the expedition.

The zoölogical work had been distributed in the following manner: Dr. Danielsen, assisted by Dr. Koren, was to observe and describe the echinoderms, gephyreans, and the coral animals; Mr. Friele, the mollusks; Dr. Hansen, the annelids; and Professor Sars, the other classes—crustaceans, pyenogonidæ, the polyzoans, hydroids, sponges, and those lowest organisms forming the connecting link between the animal and vegetable kingdoms (foraminifers, radiolariar, and diatoms). Professor Sars was also to make those observations which referred to the salt-water fisheries.

Every one of these gentlemen is now, and has been for some time, employed in working up his part of the material. But as this is exceedingly rich, it has not been possible so far to finish the observations and give a detailed report. As all the special results will, moreover, go into the general report which will be published at the close of the expedition, it will suffice in this place to give a brief account of the manner in which the biological part of the work has been done, and give some of the more important general results. It must be remembered that these observations, made far out in the open sea from a comparatively small vessel, and at a depth of nearly 2,000 fathoms, are, even under the most favorable circumstances, connected with very great difficulties, and take up considerable time. If, in spite of the long-continued unfavorable weather, a very large quantity of zoölogical material has been collected, this is chiefly owing to the zealous and skilful supervision of the work by the second officer, Lieutenant Pettersen, into whose charge it had been given by Captain Wille.

During the expedition the dredge was used sixteen times; the trawl-net, twelve times; the two combined, twice; and the swab, once. Altogether, not less than thirty-one separate hauls were made, and of these only very few were entire failures, while most of them yielded very satisfactory results. Besides this apparatus, the surface-net has been used very frequently for the purpose of examining the pelagian animals living near the surface. The dredge has also been used from boats in the Sognefiord, near Husö, near Thorshavn, on the Faroe Islands, and in the bay of Reykjavik. Without specifying the numerous animals brought up from the depth of the sea in this manner, it must be said that of nearly all classes new and interesting specimens have been obtained, extensive descriptions of which, accompanied by plates, will be published.

The greatest depth reached during the expedition was 2,000 fathoms, about half-way between Norway and Iceland, and several hauls were made at a depth of upward of 1,000 fathoms. The zoölogical observations were begun in the Sognefiord, where the considerable depth of 650 fathoms was reached, the greatest depth which had ever been examined near our coasts. Here the usual deep-water fauna was found, well known from former investigations, especially those of the Hardangerfiord, although several very rare specimens were also obtained; among the rest, a well-preserved specimen of the species *Brisinga*, given by Asbjórnsen (*Brisinga coronata*, G. O. Sars), several specimens of the interesting Gephyre *Priapuloides bicaudata*, Danielsen, hitherto only observed near Vadö, and large numbers of a beautiful red crustacean with brilliant eyes shining like gold, formerly only found in very small numbers, *Munida tenuimana*, G. O. Sars.

The observations became more interesting when the expedition reached the barrier stretching at some distance from our western coast, whose outermost boundary is the so-called "sea-bridge"—(*Havbro*). Here begins, below a depth of 300 fathoms, the cold area or Polar Sea deep, which hitherto has been but little explored. It has a bottom-temperature of 0° to—1.6° C., and the fauna in accordance with this temperature has a very peculiar character, entirely different from that of our southern and western coast. Seventeen of our hauls were made in this cold area, and from these a tolerably correct idea may be formed of the peculiar physical and biological condition of this region. All over the large depression which occupied the greater portion of the bottom of the sea between Norway on one side and the Faroe Islands and Iceland on the other, the bottom at a depth of more than one thousand fathoms seems to consist of a peculiarly loose, sticky, light, almost grayish-white clay, which contains a great deal of lime, and, after being washed or sifted, proves to consist almost exclusively of shells of a very low organism, a foraminifer, the *Biloculina*. The expedition therefore called this deep-water clay "biloculina clay," to distinguish it from that kind of clay which is found in the warm area at a great depth in the Atlantic, and

which from a totally different foraminifer is called "*Globigerina*." The biloculua clay contains a great deal more lime than the globigerina clay of the Atlantic. When acids are mixed with it, gas develops very freely, and when pressed and dried, it soon turns into a very hard and compact limestone. We see here a complete lime or chalk formation during its period of growth, and its fauna also shows distinct traces of its ancient origin and its near relation to the remnants of organisms preserved in the fossil-bearing layer from the end of the Secondary Period.

We must here mention a beautiful stone lily (*Crinoid*) which measures a span in length, and is probably quite new, of which many live specimens were obtained, and which shows an unmistakable similarity to some of the oldest fossil forms of this group of animals, which is now almost extinct; also a very peculiar and interesting animal of the holothurian kind, enormous chalk-sponges, large numbers of a new and very peculiar pycnogonide, and a remarkable blood-red crustacean with integuments as thin as paper (*Hymeniscaris*), besides several other new crustaceans. The mollusk which is most frequent in these parts is the *Siphonodentalium vitreum*, M. Sars, so characteristic of the older glacial clay, which on our coasts is only found alive in the northernmost part of Finmarken. Although the fauna of this great deep is of special interest from a zoölogical and geological point of view, it is on the whole rather monotonous. But where the bottom begins to rise toward the banks, a great difference may be noticed. At a depth of 400 to 900 fathoms, but still within the cold area, we find an exceedingly rich and varied animal life. Contrary to what might be expected from the low temperature prevailing here, we find, in comparison with our coast-fauna, no deterioration of animal life, but a remarkably luxuriant fauna showing itself in the numerous and varying animal forms, and in the comparatively colossal size which some of them reach, one of the polyps (*Umbellularia*) taken here measuring fully four yards in length.

From the specimens taken by the dredge, the trawl-net, and the swab, an approximate idea may be formed of the peculiar character of the bottom in these parts; forests of peculiar tree-like sponges (*Cladorhiza*) cover large portions of the bottom. Between their branches are seen magnificent medusa-heads (*Euryali*) and gaudy-colored animals of the *Antedon* kind, also different crustaceans; amongst the rest the fantastically shaped *Arcturus Baffini*, well known in the Polar Sea, and lazy pycnogonids, some of them of enormous size (measuring a span between the points of the feet), crawl about between the branches sucking their organic juices with their enormous beaks; also a large number of fine plant-like animals (polyzoans and hydroids) which live among the dead trunks and branches which have been deprived of their organic bark-substance. On the open plains among these swamp-forests, beautiful purple-colored sea-stars (*Astrophyton*) and long-armed snake-stars (*Ophiura*) may be seen, as well as numberless *Annelides* of different kinds; crusta-

ceans are swarming everywhere, long-tailed decapods (*Crangon*), finely built musidæ (*Erythropus*, *Parerythropus*, *Pseudomma*), large numbers of amphipods (*Anonyx*) and isopods (*Mumiopsida*). Like tall pine-trees rising above the lower forest trees, the gigantic umbellularia tower above all the rest with their straight trunks and beautiful tops garnished with fringed polyps. The light of day does not penetrate into these depths, but the animals themselves illumine these submarine forests, as nearly all of them are phosphorescent to a high degree, having the faculty of emitting from their bodies a very strong bluish, greenish, or reddish light.

Whenever the dredge or the trawl-net reached this region, which from its most characteristic animal form may well be called the region of the umbellularia, rich zoölogical results were obtained, and in most cases a day was too short a time to examine and preserve all these treasures brought up from the deep. Higher up, at a depth of 200-100 fathoms, and at a distance of 10-20 (Norwegian) miles from the coast, the long-stretched barrier commences, which, so to speak, forms the foundation on which our country rests and which separates it from the so-called Polar deep. This barrier generally commences with a hard stony bottom, and our dredgings were therefore connected with considerable difficulties. Numerous boulders, whose smooth round shape shows distinctly that once upon a time they have been exposed to the powerful influence of great masses of ice, are scattered about on the very uneven bottom, consisting of firm rock, and hinder the operation of the dredge or stop up its opening, so that in most cases only very imperfect specimens of the fauna of this region could be obtained. This fauna has a very different character from the preceding one, and resembles more the usual coast fauna; but it seems to be a rule that at this very point, the edge of the barrier, it is richer than nearer the coast, which seems to agree with the great wealth of fishes known to exist in these regions from olden times.

If in conclusion we combine all the physical and biological conditions—of which only a very superficial idea has been given here—in the portions of the ocean traversed by our expedition, the deeps surrounding our country may from a physiographic and zoögraphic point of view be divided into two very different regions, viz, the warm and the cold area. The former embraces the whole Skagerak and the North Sea and farther north the sea near our coasts, till within a distance of 10-20 (Norwegian) miles, including all the fiords, and extends north to the northernmost point of Finmarken. The cold area begins where the bottom slants from the banks towards the great outer deep, extends in a southerly direction as far as the heights of Stadt, and continues in a south-westerly direction in the shape of a narrow wedge between the Faroe Islands and the Shetland Islands to the 60th degree of northern latitude. Towards the north the cold area extends to the North Pole, which is its central point. This area has been examined by the expedition at one

of its southermost points, where it was found throughout to be very sharply defined from the warm area. The farther north one goes, the less marked does this boundary appear, as the cold area gradually rises from the deep, until in the Polar Sea it is even with the surface and then also occupies the littoral region, thus entirely excluding the warm area. The inner connection with the above-mentioned peculiar physical conditions of the seas surrounding our coast has been made a great deal clearer by the experience gathered during our journey, and an important contribution has been made to the meteorology of the sea in general. A further explanation of these purely physical conditions is also of the greatest importance to zoölogists for the better understanding of the different biological conditions of the sea; but as such an explanation belongs to the physico-meteorological observations, we shall confine ourselves to the purely zoölogical side of the question.

The character of the fauna in the cold area is purely arctic or glacial without any southern specimens whatever, and some of our varieties have already been identified with those gathered in the Polar Seas by the Swedish, German, British, and American Polar expeditions. In a higher latitude these animals, which in the sea traversed by us live only below a depth of 400 fathoms, and are therefore essentially deep-water varieties, live in comparatively shallow water, even up to the surface of the sea. This interesting fact seems to confirm the opinion expressed by several naturalists, that the distribution of animal life in the sea is chiefly dependent on the temperature, whilst the depth has but little influence on it. The purely arctic fauna found on our coast during the glacial period, and which has left its traces in the older glacial shell-banks, was gradually forced to retreat towards the deep, and this was chiefly occasioned by a change of temperature, which of course would be less perceptible in deep water. The place of this arctic fauna was then taken by animals immigrating from the south. In the deepest waters of some of our long and narrow fiords a remnant of this original arctic fauna may yet be found. But it evidently ekes out a miserable existence, which is sufficiently proved by the small size and crippled appearance of the animals. Their ultimate extinction is probably only a question of time. After the temperature of the sea has been studied more thoroughly, this can be fully explained from purely physical causes; for the influence of milder climatic conditions has finally also reached these deep waters of our fiords, so that even at a depth of 650 fathoms the average temperature is $+6^{\circ}$ C., a temperature which must certainly have a hurtful influence on the life of these arctic animals. The temperature outside of our sea-banks, even at a much lower depth, has, however, remained the same as it was in the glacial period here as well as close to our coasts. And we consequently find here, although remarkably far south, no sickly or crippled arctic or glacial fauna, but one fully as luxuriant as that of the Polar Sea.

The light which meteorology will be able to throw on some dark

phenomena in the development and distribution of animal life, and likewise the great aid which purely biological facts may furnish to meteorological investigations, make it desirable that these two sciences seemingly so different in their character should no longer remain strangers to each other, but should form an intimate union for the purpose of each contributing its share towards the scientific solution of several hitherto unexplained physical and biological problems which have greatly perplexed the man of science.

2—INVESTIGATION OF THE SALT-WATER FISHERIES.

Besides making strictly scientific investigations, it was likewise intended to observe, whenever an opportunity offered, everything which might have a bearing and throw some light on our important salt-water fisheries. As Professor Sars had studied our fisheries for a number of years, he was commissioned to make these investigations. A number of different fishing implements were therefore furnished to the expedition; *e. g.* hooks and lines and floating nets with different sized meshes. These implements could of course only be used in favorable weather, when the sea was tolerably smooth, which it was hoped would be the case at least part of the three months of the best season of the year occupied by this voyage. But the weather was unfortunately exceedingly unfavorable all the time, so that these fishing implements could scarcely be used at all. From the same reason another important apparatus for measuring the current, chiefly intended for physico-meteorological observations, could not be used. During the few days that the expedition enjoyed fair weather, it was too near the coast to make these investigations specially interesting.

Although the weather placed insurmountable hinderances in the way of the above-mentioned observations, several facts were nevertheless gained, which, in Professor Sars's opinion, are of importance and will serve as guides in future practical and scientific investigations of our fisheries.

The soundings show that there are several fishing-banks near our coast which hitherto have been entirely unknown, and where rich fisheries might be carried on during the summer months.

The so-called "Storegg" off the coast of the Romsdal District has from time immemorial been famous for its immense wealth of fish, and there are mysterious traditions that this is not the only point where similiar extensive fisheries could be carried on, but that there were other rich fishing-banks far out in the ocean, "if people only were fortunate enough to find them."

The mystic idea of the "Havbro", sea-bridge, has been to a great extent explained by the investigations of this expedition. The "Stor-

egg" is nothing else but a portion of the edge of that long barrier which forms our western boundary towards the cold polar deep. The natural reason why that portion of the barrier has been known for so long a time, without, however, leading to any correct knowledge of its exact nature, is this, that here the polar deep approaches nearer to the coast than at any other point, forming a very distinct bay. Even during the soundings made from the steamer *Hansteen* a new portion of the northern continuation of this edge was found, and its existence at several other points has now been proved, as well as the fact that both farther south and farther north it recedes from the coast to a distance of 20–30 (Norwegian) miles. Although this is not the case everywhere, the general rule seems to be that the bottom near the outer boundary of the barrier before sloping toward the great outer deep, rises a little and assumes a hard stony character, exactly like that of "Storegg."

The first line of soundings running from Husø in a northwesterly direction struck this edge at a distance of 20 miles from the coast (stations 16 and 17.)* The bottom, which had so far been soft, suddenly became hard and stony at a depth of 221 fathoms, and continued so even after it had fallen off 70 fathoms toward the outer deep. That the bottom here sloped off very abruptly was proved by the circumstance that at the next station the cold area was reached at a depth of 412 fathoms, and a bottom temperature of -1.3° C. Farther north, on the heights of Trondhjem, at a depth of 190 fathoms, and likewise on the boundary-line between the cold and the warm area, a similar edge of rocky bottom was discovered, falling off abruptly toward the west (station 89†). Similar discoveries were also made in the other portions of the sea traversed by the expedition.

Northeast of the Faroe Islands, and at a considerable distance from the same, the expedition was, in spite of the very unfavorable weather, fortunate enough to strike the outermost edge or the most northeasterly point of the long-stretched Faroe bank (station 38),‡ from which its extent and configuration could be somewhat determined, and the nature of this point seems to be very similar to that of the "Storegg." By the line of very careful soundings made from the *Namsemfiord* in a westerly direction, the existence of a hitherto unknown and very sharply marked cross-bank of considerable extent was proved; this bank extended at a comparatively short distance from the coast, at a depth of only 62–92 fathoms, and had a hard bottom (stations 63, 64, 65§). Outside of this bank the bottom sloped off very imperceptibly towards the great deep;

* The exact location of these points is given from the journal of soundings. Station 16: latitude, $62^{\circ}23.9'$; longitude, $2^{\circ}17'$ east of Greenwich. Station 17: latitude, $62^{\circ}33'$; longitude, $2^{\circ}4'$ east of Greenwich.

† Station 89: latitude, $64^{\circ}1'$; longitude, $6^{\circ}7.5'$ east of Greenwich.

‡ Station 38: latitude, $62^{\circ}57.4'$; longitude, $3^{\circ}47'$ west of Greenwich.

§ Station 63: latitude, $64^{\circ}41.3'$; longitude, $9^{\circ}0'$ east of Greenwich. Station 64: latitude, $64^{\circ}42'$; longitude, $8^{\circ}50'$ east of Greenwich. Station 65: latitude, $64^{\circ}42.5'$; longitude, $8^{\circ}39'$ east of Greenwich.

but nothing like the "Storegg" could here be discovered. It must likewise be mentioned that in the outer portion of the Sognefjord an extensive plateau was discovered with hard stony bottom and sloping both towards the coast and towards the deep (depth from 260 to 211 fathoms).

There can be no doubt that all the above-mentioned places are excellent fishing-stations. Wherever at some distance from the coast similar banks are found with hard or stony bottom, there have always been large quantities of fish, and although all attempts made during the expedition to attach a short line and baited hook to the plummet proved fruitless, no negative conclusion must be drawn from this very unpractical method of investigation, which under the circumstances was the only one possible.

The kinds of fish found on the banks are chiefly ling, cusk, halibut, and large codfish, the so-called bank codfish. Professor Sars has in his former reports to the department expressed his opinion that the so-called bank-codfish is not a different fish from the well-known winter codfish which comes to our coasts in winter and the beginning of spring for the purpose of spawning. The views formerly entertained of the migrations of the codfish from distant seas have been entirely abandoned by the professor, after he had thoroughly studied the nature of this fish, and the experience gained during this expedition has only served to corroborate his opinion. According to Professor Sars's opinion, all the codfish which visit our coast during the winter and which form the object of our most important fisheries are during the rest of the year found only in that portion of the sea whose bottom forms the barrier towards the outer polar deep as especially the outer side of this barrier (the so-called "Havbro") with its richly-developed animal life and the favorable character of its bottom forms a convenient place of sojourn for enormous numbers of codfish.

It is entirely different with another very important fish, *the herring*. Here the investigations made by Professor Sars have led him to the opposite view. While the cod is a genuine bottom-fish, and as such dependent on the nature of the bottom and the different depth of water, the herring is in its whole character a genuine pelagian fish, and therefore independent of depth of water and the nature of the bottom, but influenced by the physical and biological conditions of the water near the surface. As these change a good deal, this kind of fish had to be furnished with the means of quickly reaching the most favorable portions of the sea. The herring is therefore distinguished from the cod by its elegant compressed or wedge-shaped form, which enables it to shoot through the water as swift as an arrow and travel long distances in a comparatively short time.

The professor, although not taking the old-fashioned view that the spring herrings come from the ice-covered sea near the North Pole, inclines to the opinion that the herring undertakes long and irregular journeys in the open sea, not only when it comes to the coast for the

purpose of spawning, but all the year round. The distribution of the herring in the sea is dependent on the distribution of the small marine animals which form its food. These are all pelagian animals, chiefly small crustaceans which keep more or less near the surface and are well known to our fishermen by the name of "aat." Only when the herring comes to the coast in winter for the purpose of spawning, its migrations are, to begin with at least, independent of the occurrence of "aat." The rest of the year the schools roam about in the outer sea, chiefly seeking that portion where at different times they find the best supply of food. The great schools of herrings may therefore at the approach of winter or when the development of their generative organs drives them toward the coast in order to spawn there, be quite naturally either at a shorter or longer distance from their spawning places, just according to the quantity of food found in different portions of the sea. The professor thinks that this circumstance chiefly causes the fluctuations in our spring herring fisheries. As the migrations of the young herrings commence long before roe and milt are matured, the great mass of herrings, if near the coast at this time, would reach it so early that they would be obliged to stay here a longer time, and thus naturally get nearer the coast, entering the fiords and inlets. In the opposite case, if the mass of herrings should at that time be at a considerable distance from their spawning-places, such a long period of time would elapse before they reached these, that the spawning process could be performed immediately on their arrival. The herrings would in that case stay only a short time near the coast, and the spawning would chiefly go on on the outer and less accessible banks; in other words, the spring herring fisheries would be of very short duration or prove an entire failure.

This in brief is the theory which Professor Sars advanced several years ago, after having carefully examined our coasts, as the only possible scientific explanation of the remarkable irregularities which in course of time have been observed in the spring-herring fisheries. There were however at that time but few facts to support this theory. Sailors and fishermen had occasionally spoken of large masses of herrings which showed themselves far out in the open sea immediately before the spring-herring fisheries commenced; whilst others had at different seasons of the year observed large masses of small crustaceans in various parts of the sea. Regarding this last-mentioned phenomenon we likewise have the testimony of reliable naturalists (Krøyer), and from the very portion of the sea which is chiefly concerned here. But all this information is too scattered to prove in an incontrovertible manner that the open sea is really a fit place of sojourn for the enormous masses of herrings which come near the coast at different seasons of the year.

Professor Sars considered it as one of his most important objects on this expedition to examine the distribution of the "herring-food." With this view he examined the sea almost every day, frequently several times a day, with the surface-net. The results of these investigations

entirely confirmed his previous supposition regarding this matter. During the whole voyage from Norway to the Faroe Islands the sea was everywhere filled with enormous masses of the so-called "red herring food" (almost exclusively *Calanus finmarchicus*), which are well known as the favorite food of the herring; and it deserves to be mentioned that the quantity of these animals seemed to increase the farther we got away from the coast and reached its height at a distance of about twenty miles. Besides these animals we likewise observed occasionally farther out at sea another kind of a beautiful blue "herring food" (*Pontella Pattersonii*), which seemed to belong more to the Atlantic, and which in contradistinction to the former might be called "mackerel food," as it probably forms the principal food of the mackerel at those seasons of the year when they are not near the coast. This "food" is also occasionally found among the "red herring food" near the coast, especially during rich summer-herring fisheries. When the expedition took a northerly course from the Faroe Islands towards Iceland, it was very striking that the food seemed to have disappeared from the sea almost entirely. The water had at the same time assumed a very different color. While from Norway to the Faroe Islands it had a deep blue color, it now had a light grayish-green color. This peculiar circumstance, whose definite explanation has not yet been found, but which the different currents of the sea have certainly something to do, seems to be closely connected with the occurrence of the "food," and will form a subject of investigation for the next expedition. Professor Sars says that he had a very excellent chance to observe this phenomenon from his state-room, whose window was on a level with the water. Whenever the waves covered the window his whole state-room was formerly filled with a dark blue light, whilst now it was a bright greenish light. This color remained as long as the vessel was in Iceland waters, and here the sea did not contain any food whatever. Only when on our return voyage we approached the coast of Norway the sea again showed its blue color and was full of "food."

It must, however, be supposed that the conditions observed during our voyage are not always the same, as some reports say that the sea near Iceland is peculiarly rich in "food." It seems as if the steady westerly gales which prevailed during the expedition, in connection with the strong eastward current, had brought the great masses of "food" nearer to the coast of Norway. If this should really have been the case, which, however, can scarcely be proved conclusively, it would, in connection with Professor Sars's theory regarding the migrations of the herrings, be an indication that the spring-herring fisheries would again be successful in the near future. It may be considered as absolutely certain that wherever there is "herring food" herrings will be found. Although there was unfortunately no chance to corroborate this by direct investigations made by means of floating nets, the indications were by no means wanting that there were herrings where the "food"

was most plentiful. Not a few whales were noticed in these localities, also a large number of sea-birds, and at a considerable distance from the coast, near stations 75 and 76,* large brown spots could be observed in the sea resembling extensive algæ-bottoms, which, however, on close examination proved to be enormous masses of closely packed "food," on which the *Procellaria glacialis*, the constant companion of our voyage, was feeding to its heart's content. It is evident that these enormous masses of "food" had not come here accidentally, nor could it be supposed that far out in the open sea the current alone could have done it. It is much more probable that the schools of herring had chased it here, and that under these brown spots there were dense masses of herrings.

It was very unfortunate that unfavorable circumstances did not allow the use of floating nets, by which the occurrence of the herring in the open sea could easily have been proved. It is to be hoped, however, that the next exhibition will be more successful as regards the weather, and that the herring question will be made more of an objective point, all the more as the expedition will go farther north, *i. e.*, nearer those waters which Professor Sars considers the home of the spring-herring and the great-herring.

IV.

PRELIMINARY REPORT ON THE ZOÖLOGICAL OBSERVATIONS MADE DURING THE SECOND NORWEGIAN POLAR EXPEDITION OF 1877.

The expedition left Bergen on the 11th of June and returned to that place on the 23d of August, and therefore lasted about three months. Its outfit was about the same as during the preceding year. The zoölogical *personnel* was also the same, with the sole exception that Dr. G. A. Hansen accompanied the expedition as passenger, and during the first month also as zoölogist instead of Mr. H. Friele, who was detained by his business and only joined at Tromsö.

Different from last year, the weather was nearly all the time unusually calm, with northerly wind and a comparatively smooth sea, so that even the finest microscopic observations could be made on board. In consequence of the favorable weather the number of working-days was a great deal larger than last year, and the number of stations, which had been ninety-five last year, was almost twice as large.

This expedition investigated a considerable portion of the Northern Sea, viz, from the height of the Vigten Islands (65° northern latitude), which were reached last year, as far north as 71½° northern latitude, and as far west as 11½° western longitude. Eleven different cross-lines were followed in different heights, and some of them a very considerable

* Station 75: Latitude 64° 47.2'; longitude 7° 13' east of Greenwich. Station 76: Latitude 64° 47.4'; longitude 7° 3.6' east of Greenwich.

distance from the coast. Two of these lines go across the Northern Sea, or across 20-24 degrees of longitude. Observations have also been made at other points wherever there was anything of interest, thus in some of our deep fiords, the Saltenfiord, the Westfiord, and the Ulfsfiord north of Tromsø. Our stay on the isolated volcanic island of Jan Mayen, which lies far out in the Northern Sea, was of the greatest interest both from a physical and biological point of view. We spent a week on this island, examining its fauna, flora, and geology, as well as the surrounding sea. The results obtained by these observations will throw light in many directions and extend our knowledge of the Northern Sea, with its peculiarly grand scenery.

The dredge was altogether used twenty-nine times, and the trawl-net eight times (occasionally both combined), and in most cases with a very satisfactory result. Of all the hauls, twenty-four were made below 200 fathoms, fourteen below 500 fathoms, and six below 1,000 fathoms. The greatest depth reached was about midway between Norway and Jan Mayen, about 2,000 fathoms. Hauls were made from on board the ship, both here and at Jan Mayen, and at different points of our northern coast; but quite frequently hauls were also made from a boat; and important additions were made to our knowledge of the arctic coast fauna. Wherever there was a chance, the surface-net has been used, and a number of important observations have been made in this manner.

I have already in my last report directed attention to the interesting fact that the bottom of the Northern Sea as far as the 60th degree of latitude embraces two faunas totally different in their character, the one of purely arctic or glacial origin, the other chiefly containing southern animals. It has also been mentioned that each of these faunas has its distinctly-defined area at the bottom of the sea, without regard to the degree of latitude, and often side by side, corresponding with the two physically clearly-defined areas, the warm and the cold. Wherever the bottom of the sea outside the outer banks slopes off 300-400 fathoms, the deep-water fauna of our coast-waters suddenly changes to the entirely different and peculiar glacial fauna represented by gigantic and luxuriantly developed animal forms, some of which have been already observed, but only very far north in the ice-filled waters of the polar regions. This characteristic glacial fauna was of special interest to us, and it yielded the most important scientific results. These results have increased by our continued investigations of the cold area, and many new and interesting animals have been discovered. Our knowledge of the general character of the deep-water fauna, of its relation to the faunas of other seas, and of the physical conditions on which the distribution of animal life at the bottom of the sea depends, has likewise been greatly increased.

In the extensive area of the Northern Sea, which was investigated by us during this expedition, we found below a depth of 800 fathoms the light plastic biloculina clay with its limited but to a high degree pecu-

liar and interesting fauna. The richest development of submarine animal life was always found in those places where the bottom began to rise from the great deep toward the banks, especially where it rose abruptly and where the clay was more or less mixed with sand. Here is the home of the colossal Umbellulariæ, and associated with them we generally found a large number of different gaudy-colored marine animals, which give this whole region its peculiar character. This year we likewise obtained some very fine specimens of Umbellularia, but neither as many nor as large ones as last year, which seems to indicate that it is confined to certain localities.

An examination of this region yielded several new and interesting specimens, especially Echinoderms, Actinia, and Mollusks. It was of special interest to us to discover here such highly-organized animals as fishes. In one of our hauls (station 124) two different kinds of a peculiar arctic fish, *Lycodes*, were caught at a depth of about 400 fathoms and a bottom-temperature of 0.9° C.; one of these fish had hitherto only been found in the Polar Sea, and the other was entirely new. Our dredgings did not always yield such good results. Not unfrequently we found even in the Umbellularia region unusually poor and barren places, a kind of submarine swamps, where the dredge like an anchor sank deep into the mud, and was quickly filled with a peculiar soft, tough, bluish clay containing scarcely any sand. Wherever the bottom was of this character we were prepared for poor hauls. The difficult and wearisome examination of this tough clay produced only very few and low animal forms, often nothing but a few *Lumbrineris* and a peculiar *Sipunculide* already observed last year, which seemed to flourish here, as we found them in larger numbers and of greater size than anywhere else. There is no doubt that the nature of the bottom plays a much more important part in the distribution of marine-animal life than has hitherto been supposed. The experience gained during our two expeditions furnishes convincing proof that even the slightest change in the composition of the bottom produces a very noticeable change in the character of the fauna. The different depths which formerly were thought to have a great deal to do with the character of the fauna, seem to have much less influence on it, as our observations have proved that one and the same animal may be found at very different depths, if only the nature of the bottom and the temperature remain unchanged.

As I remarked in my last report, the boundary of the cold area is found in the southern portion of the waters examined by us at a depth of about 300 fathoms. It might be expected that this boundary, the farther north we get, will gradually rise higher, as in the farthest north the cold area embraces the whole sea from the bottom to the surface. We were therefore at first surprised not to find the cold area near Vesterdaalen, until we reached a depth of 400 fathoms, therefore even deeper than where we had found it six degrees farther south. This peculiar circumstance, and the corresponding unequal distribution of animal life

at this point, was satisfactorily explained by the unusually abrupt sloping of the banks toward the outer deep and the exposure of this locality to the warm northeasterly Atlantic current. Last year already we observed near "Storegg" a similar very noticeable depression of the cold area occasioned by the warmer current flowing back from the abruptly rising "havbro."

Similar irregularities in the temperature of the sea, most of which could be explained by the peculiar formation of the bottom, were observed farther south near the Vestfjord and the coast of Nordland. But as all this belongs more to the physical part of our observations, I will not dwell on it any more, but will briefly relate how we found matters on the opposite (the western) side of the Northern Sea near Jan Mayen. Just as strange as this island appeared to us with its plains covered with black volcanic sand, its shallow lagoons, its chief mountain, the Berenberg, rearing its crater-shaped summit among the clouds, and its mighty glaciers sloping toward the ocean, just as strange was the nature of the surrounding sea. A few fathoms below the surface we found ice-cold water, and even the temperature of the surface-water rarely exceeded a few degrees. There was consequently scarcely any warm area, and the cold area predominated. But it must be remembered that we were here under the direct influence of the Polar current. The warm Atlantic current does not extend its beneficial influence to this barren and monotonous island, which the greater portion of the year is covered with snow and ice and enveloped in the dense fogs of the Polar Sea. The Atlantic current passes a few degrees farther south, bounded by the cold water of the Polar Sea, toward the more favored eastern portion of the Northern Ocean, where its influence is felt as far north as Spitzbergen, which in spite of its more northern latitude, at any rate on its western coast, has a much milder climate than Jan Mayen.

Corresponding with the peculiar physical condition of Jan Mayen, we found that the fauna at every depth, even up to the littoral zone, had a completely arctic or glacial character without any southern elements whatever. The dredgings made near Jan Mayen were of an exceedingly interesting nature, and gave us a very correct idea of the rich animal life which is found here in spite of the unfavorable temperature of the sea. We found a very large number of Echinoderms, some of them of enormous size and beautiful colors; likewise different peculiarly-shaped mollusks, among the rest gigantic live specimens of *Arca glacialis*, so characteristic of our older glacial period.

It was also of interest to us to find here at a depth of 60-80 fathoms some of our old acquaintances from the enormously deep cold area farther south. Nearly all animal types were represented, not even excluding fish. The dredge thus brought up from a depth of 200 fathoms no less than three different kinds belonging to those fish found near Greenland. But not only the bottom of the sea but also its surface was full of animal life, which might be seen from the enormous flocks of birds

which partly covered the water and partly were busy flying to and fro, having to feed besides themselves their greedy young ones sitting in their nests on the barren rocks of Jan Mayen. By means of the surface-net we gained considerable knowledge of this pelagian fauna. In certain places the sea was swarming with the well-known "herring-food" (*Calanus finmarchicus*), but most of them three to four times larger than those on our coast. In other places, we found enormous numbers of a winged snail peculiar to the Polar Sea (*Limacina helicina*) moving about in the water with great rapidity, by means of its wing-like organs of motion, also specimens of the peculiar transparent "whale-food" (*Clione limacina*), the principal food of the Greenland whale. It was exceedingly interesting to observe that the surface-water for miles and miles, especially where the lower temperature indicated the close proximity of ice, was literally filled with a shapeless organic matter which gave a grayish-green color to the water. If a fine tulle surface-net was dragged after the vessel, it could be noticed, after the lapse of a few seconds, by its resistance, that it had become useless. When taken out of the water it was found to be thickly covered and its inside filled with a yellow-brownish gelatinous slime, emitting a peculiar organic odor. All the fine meshes were so completely stopped up that water only flowed through with difficulty. Seen under the microscope (magnified 800-1,000 times in diameter), this gelatinous matter was found to consist of live protoplasm of the simplest composition imaginable, and aggregated in irregular large and small lumps.

Among this protoplasm we found, but only sporadically, diatomic shells and other microscopic bodies, among them not a few of the peculiar calcareous concretions, coccolites and cocco-spheres, known to us from the Atlantic deep. Already at our first station to the northwest of the Vigten Islands we had observed a similar sea-slime, but not in such large quantity, and the microscopic examination proved that it consisted exclusively of formed organisms, especially a peculiar diatom (*Chaetoceros*), each of which has a regular shell terminating in four long horns, all of them being united in long thread-like chains. Many years ago I observed a similar organic slime in the Christiania fiord early in spring or immediately after the ice had broken; the fishermen called it "Gro," and on closer examination it was found to consist almost exclusively of the above-mentioned diatom. I have learned later that this same phenomenon has been several times observed by other naturalists, especially in the Arctic Seas near Spitzbergen and Greenland, where this slime gives a peculiar color to large portions of the ocean. So far, however, no thorough microscopic investigation has been made of this organic matter found in the Arctic Sea. I can, at any rate, not find any record of any one having discovered free protoplasm in this slime such as I certainly found in the slime near Jan Mayen. Wherever I find this sea-slime spoken of, it is said to consist chiefly of diatoms. But what gives such great scientific interest to this phenomenon is the remarkable

fully-proved fact that at any rate in some cases it may consist entirely of a shapeless organic mass which certainly in its composition corresponds with the matter contained in the individual diatoms, but differs from it in this respect that it has not yet become individualized, but forms an unlimited and shapeless aggregation of protoplasm.

I have devoted more time to this phenomenon because it is of vast significance not only from a scientific but also from a practical point of view. This became immediately clear to me, and laying everything aside I devoted two whole days to a continued and searching microscopic examination of the above-mentioned protoplasm, in which I was favored by unusually calm weather and a smooth sea, our steamer lying still or floating with the current, as its boiler was being cleaned at the time. When I made these investigations I certainly did not know that such a slime had been observed by other naturalists, but even now, after I have studied all that has been written on the subject, I am convinced that the time spent by me has not been thrown away, as the sea-slime near Jan Mayen was of a very peculiar character, and as this phenomenon will lead to several highly important conclusions which will not only throw light on the biological condition of the Arctic Sea, but will also touch some other questions of the greatest importance. I hope at some future time to give a full account of this phenomenon, and of the conclusions which may be drawn from it. I will here only direct attention to the important scientific fact that in this protoplasm we have the simplest imaginable organism, neither animal nor plant, standing far below both, without shape, without limitation, not even yet separated into individuals, much less having any organs, a shapeless, indifferent, organic matter, which nevertheless contains life, but life of the simplest and most primitive kind.

It is well known that in the first preliminary reports of the British expeditions a very remarkable and problematic being has been frequently spoken of, which was called *Bathybius*. This *Bathybius* was described as a shapeless organic slime which, below a certain depth, was supposed to penetrate the loose material of the bottom of the Atlantic, and produce its viscosity. But the existence of this mysterious being, which for a time created such a sensation in the scientific world, has recently been doubted by several naturalists; and with very good reason, for the microscopic examination of this bottom-slime was not made on the spot on board the ship, but on the return of the expedition, on specimens preserved in spirits of wine. It is obvious that even the most careful and conscientious examination, if made under these circumstances, would easily lead to mistakes; and it has actually been discovered that when spirits of wine is mixed with sea-water containing decomposed animal matter, a gelatinous sediment is formed, which resembles very closely the picture of the *Bathybius*. Grave and, as it seems, well-founded doubts have thus been raised as to the existence of

any such protoplasm at the bottom of the sea, and the once famous *Bathybius* is gradually being swept away by the stream of oblivion.

It is therefore a fact of the greatest interest that just as simple, just as shapeless, and just as unlimited an organism has been proved to exist not at the bottom of the sea, but near the surface of the Polar Sea whose waters are filled with melting ice. The careful microscopic observations made on board, and the drawings made of the fresh and living protoplasm, will in future exclude every doubt as to its existence. The *Bathybius* has thus in a manner been resurrected, although the nature of the protoplasm spoken of here will make it necessary to give it another name. The scientific interest taken in this protoplasm will be the same as that once taken in the now defunct *Bathybius*.

I said before that this sea-slime would be of great interest even from a practical point of view. I shall return to this subject in the report which I intend to publish on the practical and scientific investigations of the fisheries made during this expedition. It will be sufficient in this place to direct attention to the circumstance that the very occurrence of this organic matter in the arctic waters is the principal cause of its great wealth of fish, and especially of the large number of individuals of certain species which form the chief objects of our most important fisheries, principally pelagian fish, herring and mackerel, but also, though more indirectly, codfish and pollack, in as far as both these fish of prey feed to a great extent on the two first-mentioned fish.

This is scarcely the place to give a detailed account of the many new and interesting discoveries in the different branches of zoölogy which were made on this expedition. I will only say in conclusion that if we review all that has been done by the expedition in different directions, we ought to be well satisfied with this year's results. The practice and experience gained during the preceding year, together with the favorable weather and the lively interest taken in the expedition by all its participants, have all contributed their share toward its success, and we are fully justified in expecting that the next expedition, which is to go out in 1878, will increase still more our knowledge of the physical and biological character of the Northern Sea.

V.

REPORT ON THE PRACTICAL AND SCIENTIFIC INVESTIGATION OF THE SALT-WATER FISHERIES, MADE DURING THE SECOND NORWEGIAN POLAR EXPEDITION OF 1877.

Although the Storting (Norwegian Parliament) has for every financial year appropriated a considerable sum for continuing the practical and scientific investigations which I have carried on for a number of

years, I thought that the favorable opportunity for making these investigations offered by our polar expeditions should certainly be used, instead of making special journeys which would have to be paid out of the appropriation. This arrangement has proved very advantageous both from a pecuniary and a scientific standpoint, as during the last two years only a very small portion of the appropriation has been used, and this although important investigations have been made.

It will be remembered that last year already I published the results of the investigations made by me during the first expedition. During the second expedition I likewise considered it as one of my most important objects, not only to make strictly scientific zoölogical observations, but also to observe everything which might throw more light on our important fisheries. Among the questions touching the practical fisheries there was the exact placing on the maps of the outer banks (the so-called "Håvbro"), and the searching for localities which, like the famous Romsdal banks ("Storegg") might prove successful fishing-places. As the outer banks generally form the boundary between the cold and warm area, and as it was of great importance from a purely scientific standpoint to determine the exact boundary, the physical and biological investigations had in a measure to take the same direction as the practical and scientific observations; and we consequently concentrated our attention on the solution of this problem. On the cross-lines running perpendicularly toward the coast all these points were carefully examined; and the stations which are closer together here will also show on the maps the conscientious methods of our investigations:

It thus became possible to obtain a tolerably correct idea of the configuration of this whole long-stretched barrier which on our western and northern coasts shelters us from the cold area and forms the outermost limit of our coast-waters.

If one connects the different stations examined by us on our two expeditions, by a curved line, at a depth of about 300 fathoms, which depth indicates the boundary-line between the cold and the warm area, it will be found that this curve at a different height has two distinct indentations in a northwesterly direction from the coast, and here the boundary line between the cold and the warm area is consequently nearer the coast than at any other point.

One of these indentations in the submarine barrier is off the coast of Romsdal about ten miles from the land, and is bounded by the well-known fishing-station of "Storegg." The other is four degrees farther north on the outer coast of the Loffoden, and near Vesteraalen, still nearer to the coast, and is bounded by a similar distinctly-marked barrier ("Eg"), the "Lofot-egg" or "Vesteraals-egg." Midway between these two indentations, northwest of the Vigten Islands, the curve runs again more than forty miles from the coast, and north of Tromsö it makes a very sharp turn. If similar curves are drawn at a depth of 400, 500, 600 fathoms, &c., it will be found that at the two above-mentioned places, the

"Storegg" and the "Lofot-egg," these lines are close together, while north and south of these places they diverge again. Even in a curve of 1,500 fathoms depth the two indentations are distinctly marked.

It follows from this that near Romsdal and the Loffoden Islands, the submarine barrier slopes very suddenly toward the great outer deep, while in other places the slope is more gradual. And in connection with this the bottom is of an essentially different character. Wherever the slope is gradual there is a good deal of loose material, clay or mud, but where it is abrupt there was no chance for any loose material to gather, and we find generally only firm rock, bowlders, pebbles, or coarse gravel. It is the very kind of bottom which the fishermen designate as a good fishing-bottom; and wherever this bottom is found far out at sea, there are large numbers of codfish, ling, cusk, and halibut, while the soft clay bottom is by no means so productive, and is chiefly inhabited by skates, dog-fish, and similar fish.

The new barrier which we discovered near the Loffoden Islands and Vesterdaalen possesses all the essential conditions for serving as a place of sojourn for large masses of the above-mentioned important species of fish; and not only the barrier itself, but all the inner coast-waters near it possess similar advantages. The place where the "Lofot-egg" is nearest the coast is near the northern point of the island of Langö, about four miles from the land. We thought it best in this place to stop our sounding operations for a while and make a few observations of a more practical nature. Although the current was very strong, driving the ship forward, we nevertheless succeeded very soon, by means of our lines and hooks, in furnishing direct proof of the wealth of fish in this easily-accessible place. Among the considerable number of fish which soon lay sprawling on deck there were large codfish, ling, cusk, and halibut, therefore all the characteristic species of bank-fish. All this portion of the coast-waters from the heights of Röst till north of Tromsö will doubtless furnish suitable places for rich bank-fishing during summer, and rich hauls will be made on the barrier itself, whose exact location has now been determined and has been marked on the map. As this barrier is nearly along its whole length nearer to the coast than the "Stor-egg," the practical value of these waters for fishing will be all the greater.

It has already been mentioned that the physical conditions of the "Lofot-egg" very closely resemble those of the "Storegg." We also find another very significant resemblance: Along the coasts inside of these barriers very extensive spring cod-fisheries are carried on during winter. The cod-fisheries near Aalesund have long been famous, but they can bear no comparison with the immense Loffoden fisheries, which are sure every year. It might, in this connection, not be out of place to ask the old and much-disputed question, "Where do the codfish come from?" It is well known that not only fishermen but also naturalists have generally inclined to the opinion that the codfish come a long distance

across the great ocean; and some even thought they could discover a direct connection between the Newfoundland, Iceland, and Loffoden cod fisheries, according to which theory the same schools of codfish would every year describe the circle of the ocean. The careful observations of the mode of life and development of the codfish which I made during several journeys to the Loffoden Islands have led me, however, to an entirely different result; and I have already in my first reports to the department advanced the same opinion, which I hold still after having gained much more experience, viz, that the codfish is not a migratory fish, like the pelagian fish, the herring and the mackerel, but belongs to the coast-waters, especially their outer portion, the so-called sea-banks.

In my later reports I have endeavored to prove that the so-called "bank fish" differs from the codfish proper only in name, but is really the same fish. This opinion, which, as I was told, for a time met with great opposition among fishermen and other persons interested in the fisheries, has been fully corroborated by the observations made during our expedition. We have now proved conclusively that the nature of the bottom near each of the two most important codfish districts possesses physical conditions which make it peculiarly suited as a place of sojourn for large numbers of codfish and similar fish. Near the Aalesund district we find the "Storegg," known from time immemorial as a good bank-fishing place; and near the Loffoden district we find a barrier of exactly the same nature. But in the same proportion as the Loffoden fisheries are more important than the Aalesund fisheries, the newly-discovered "Lofot-egg" is of much greater extent than the "Storegg." On this long-stretched barrier, extending along the outer coast of the whole Loffoden group, and as far north as the heights of Tromsø, and in the inner coast-waters, there is sufficient room even for such enormous masses of fish as come near the Loffoden Islands in winter.

The question might finally be asked here, why the codfish and similar fish of prey prefer such places as those mentioned above, and why they do not stay in other parts of our extensive coast-waters? The answer that in these places the bottom is of a peculiar nature will not suffice here. We must also try to explain why this nature of the bottom has such a remarkable influence on the distribution of the codfish. It is doubtless not a mere whim which makes the codfish select these places, and it is scarcely probable that it should show a preference for a certain kind of bottom and an aversion to another merely on account of its character. There must, therefore, be another cause which must have some connection with peculiarly favorable conditions for obtaining food. It would be of the greatest interest to have this question solved; and the exact physical and biological investigations made at these points assumed all the more significance, as they were made not merely in the interest of science, but with a practical purpose. The zoological investigation

of the bottom in these places has shown that there is a rich animal life; but the difference in this respect between these and other points of the wide-stretched submarine barrier was not so striking as to furnish a satisfactory solution of the problem. There is another circumstance, however, which has much greater weight, and which is fully proved by our investigations, viz, that near such abruptly-rising submarine banks as the "Storegg" and the "Lofot-egg" there exist peculiar physical conditions which make it highly probable that the codfish and other fish of prey have a better chance here than in other places to intercept the large herring schools. It is not purely accidental that the two above-mentioned indentations in the submarine barrier, with their abrupt banks, are in close proximity to the two most important herring districts. That there is really some close connection between the two I shall endeavor to prove in the following.

The occurrence and distribution of the herrings in the ocean is, generally speaking—as I have tried to prove on former occasions—undoubtedly dependent on the occurrence of the "herring-food," and this is again dependent on the currents of the sea. Wherever different currents strike each other the "herring-food" is always piled up in enormous masses, and these are the favorite "feeding-places" of the herrings.

It is well known to fishermen and sailors that wherever the banks slope abruptly toward the sea, *e. g.*, near the "Storegg," there is a particularly strong current, so that the location of the bank may be determined by this. The different, often entirely contrary, currents which meet here produce a very striking sort of whirlpools on the surface of the water, which in stormy weather become dangerous for vessels. When, some years ago, attracted by the mystery enveloping the "Storegg," I made an adventurous expedition to one of these distant fishing-places, in an old boat manned by four sailors, I had ample opportunity to observe this phenomenon, whose natural explanation is no longer difficult, after the observations made by our expedition. There is in these northern seas a constant forward movement, not only of the upper but also of the lower portions of the water, in a northeasterly direction, therefore toward the coast of Norway; and this motion is evidently connected with the warm Atlantic current. Wherever the slope toward the deep is gradual, no disturbance will be noticed in this motion; but when the advancing mass of water strikes an abrupt slope the equilibrium will be considerably disturbed, and this will have both an upward and a downward influence. On the surface of the water different currents will be produced, and farther down the reflux of the warmer water will exercise a noticeable depression of the deepest cold strata—a phenomenon which has been witnessed both near the "Storegg" and the "Lofot-egg," where the cold area does not begin till a depth of 400 fathoms is reached.

But what chiefly interests us here are the disturbances near the surface, the different currents. During our first expedition these currents were observed at the same place where I had formerly noticed them, viz,

near the "Storegg"; and during our last expedition the same peculiar currents were, to some extent at least, also observed near the "Lofotegg." It is evident that the "herring-food" and with it the herring-schools will oftener gather here than in most other parts of the sea, and as neither the one nor the other is strictly bound to the surface, but from various causes often go deeper, the fish of prey living near the barrier have ample opportunity to mingle in this game.

Although the bottom codfish or algæ codfish living nearest the coast, which are in reality nothing but younger codfish, are not very fastidious in the selection of their food, there is every reason to suppose that the full-grown bank codfish, or codfish proper, found near our coasts make the herring, if not their exclusive, at any rate their chief food. If the Northern Ocean did not harbor these large masses of herrings, there would not be sufficient food for the enormous number of codfish which in winter come to the coast to spawn, and which during that season form the most important object of our fisheries. Here as everywhere in nature there is a close connection between cause and effect, which from a practical point of view we must explain and follow up to its last consequences in order to get a clear idea of all those conditions which have an influence on our fisheries.

There is, as I said, every reason to suppose that our wealth of codfish and similar fish of prey is chiefly dependent on the herrings in the outer waters. And the herring again is dependent on the "herring-food" found in the open sea. Without its great wealth of "herring food" the Northern Ocean could not support the large masses of herrings, and these again support the codfish found in our coast-waters. The "herring-food" is, like the codfish and the herring, an organism which cannot possibly live on nothing, but which in order to make its appearance in such enormous masses must find a sufficient quantity of food in the sea. But what constitutes its food? We have here reached the last link in the chain of evidence, a link which is of the greatest importance, as all the others depend on it. During our last expedition we had an opportunity to make observations with regard to this important point.

I have already mentioned in the partial report on the zoölogical results of our last expedition, that in the sea near Jan-Mayen, and especially where the low temperature of the water showed that it was mixed with ice-water, we found enormous masses of a peculiar organic matter, a kind of yellowish-brown slime, which colored the sea-water for miles. Accurate microscopic observations proved it to be a shapeless, indifferent, but living protoplasm. Farther south, on the height of the Vigten Islands, we found a similar sea-slime, differing, however, from the former by its consisting of formed microscopic organisms, chiefly a peculiar kind of diatom. In my zoölogical report I have directed attention to the great scientific interest attaching to the slime observed near Jan-Mayen. From a more practical standpoint both kinds will be of equal interest. We have here possibly two different links in our chain of

evidence, instead of one. The first link would be the shapeless Jan-Mayen protoplasm, on which the formation of the diatom-slime occurring farther south depends. It is evident that this sea-slime, which both according to our and to former observations is found all over the Arctic Ocean, plays a very important part in the large household of nature, furnishing an unlimited quantity of organic food, which makes the existence of myriads of small animals—in our seas chiefly the “herring-food”—possible. If we consider that these enormous masses of “herring-food” are, as we have proved conclusively, an essential condition of the great wealth of herrings, and these again of the wealth of cod-fish and other fish on which the welfare of our coast-population depends, it will become evident to every one that the question is a very important one.

In a recent interesting work on the fisheries of British North America, by Professor Hind, of Halifax, in which credit is given to the practical and scientific investigations made on our coasts, the great importance of the sea-slime of the Polar Sea for the Labrador and Newfoundland fisheries is clearly pointed out. It is certain that this sea-slime is of the same great importance for our Northern Sea, and we even go farther, and maintain that its far-reaching influence extends to every sea. The last great British expedition on board the Challenger observed similar sea-slime in the southernmost portion of the Atlantic, increasing in quantity the nearer they came to the Southern Polar Sea. This sea-slime seems everywhere to have its origin in the icy waters near the poles, whence it is distributed by the currents of the sea to a greater or less distance into the more temperate sea. We therefore arrive at the very unexpected result, that the inhospitable icy sea of the polar regions furnishes the fundamental condition of the inexhaustible wealth of the more temperate seas.

The origin of this primitive food is an unsolved problem. It is certain, however, that it is found in largest quantities in places where the ice melts under the influence of the summer warmth, and whalers are said to have observed that the lower side of the melting and floating ice is covered by a thick layer of a similar slime. Near the coast of North America this sea-slime is brought direct by the polar current from the Greenland Sea to Labrador and Newfoundland. On our coasts, which are not under the direct influence of the polar current, but under that of the warm, northeasterly Atlantic current, this addition of polar water to our seas is less regular, but evidently takes place, as the sea-slime from the Polar Sea was by our expedition observed in several places, even as far south as the Vigten Islands.

Regarding the distribution of the “herring-food” in those parts of the sea which we traversed, I must say that the great mass of this slime, perhaps in consequence of steady northerly winds, seems to have been driven unusually far south, as in the open sea between Jan-Mayen and Norway there were for long distances only very small indications of its

existence, while the sea nearer the coast, especially in the most southernly portion examined by us, was swarming with "herring-food." In this we could only see a favorable sign of a possible return of the spring-herring fisheries; and later reports from the spring-herring district seem to confirm our expectations. Near Jan-Mayen we also observed, every now and then, below the above-mentioned sea-slime, great quantities of unusually large "herring-food," besides other animals peculiar to the Polar Sea.

The sea immediately surrounding Jan-Mayen seems both from a physical and biological point of view to resemble the Western Greenland Sea, and like this it is a genuine glacial sea, which all the year round is subject to the direct influence of the polar current, and even near the surface its temperature is very low, falling to 0° at the depth of a few fathoms. In such water no herring or codfish can live. The "herring-food" here chiefly serves as food for numberless sea-birds, and farther north, also, for the giant of the sea, the Greenland whale. The Northern Ocean, properly so-called, is, on the other hand, a partly temperate sea, through the warm Atlantic current, even as far as Spitzbergen. The waters of the Polar Sea only mingle with it occasionally, bringing with it some of the above-mentioned sea-slime, which here in warmer water begins to play the significant part to which we referred above, viz, forming the primary cause of success of one of the most important industries of our country, the salt-water fisheries.

