

XI.—NEW CONTRIBUTIONS TO THE HERRING-QUESTION.—THE DISPUTE BETWEEN AXEL BOECK AND OSSIAN SARS REGARDING THE NORWEGIAN SUMMER-HERRING.—SARS'S RECENT OBSERVATIONS AND HIS NEW THEORY ON THE MIGRATIONS OF THE HERRING.*

I.

In accordance with a proposal made by Mr. G. O. Sars, the "practical and scientific observations on the Norwegian sea-fisheries" were, in 1872, combined with the soundings made by the Norwegian navy in the sea outside the Jæder stream; and as this portion of the sea is in the immediate neighborhood of the spring-herring district, the "department of the interior" commissioned Mr. Sars—we presume, in accordance with his own suggestion—to throw, if possible, some new light on the hitherto somewhat obscure question regarding the nature and the migrations of the herring. Mr. Sars intended to direct his attention particularly to the so-called *fat-herring* or *summer-herring*, as he always suspected that its true nature had not been properly understood by other naturalists, and particularly by Mr. Axel Boeck. Mr. Sars's report was noticed in the "*Morgenbladet*," and was subsequently printed in full in that journal (October 29, 1872†). It called forth some remarks by Mr. Axel Boeck in a later number of that journal, (November 5, 1872,) and a discussion ensued between the two gentlemen, which, in the beginning especially, was of a violent character, perhaps to some extent excused by the circumstances, but in itself very deplorable. It seems, however, that both of them during the subsequent discussion (which elicited but little that was new) endeavored to treat the matter in a calmer spirit. It is not our intention to judge between the persons of these two gentlemen, or to revive a discussion which for one of them bears the melancholy souvenir that his colleague and opponent—to the great sorrow of all Scandinavian naturalists—did not long survive it. All we desire in this article is to give a brief review of the data which have been gained, by Mr. Sars's observations of the "summer-herring," respecting the herring whose natural history is still enveloped in so much obscurity. Every step toward throwing more light on the sub-

* "Nye Bidrag til Sildespørgsmaalot. Striden mellem Axel Boeck og Ossian Sars angaaende den norske Sommersild. Sars's senere Undersøgelser og hans nye Theori om Sildens Træk:" in *Nordisk Tidsskrift for Fiskeri*. New series. Aargang 2. Part 2. 1875. pp. —, with map.

† Later it has been printed separately, (1874,) together with the reports of 1870, 1871, and 1873.

ject is of unusual interest; for no one knows to what important discoveries it may lead. We will, therefore, in this place give an extract of Mr. Sars's "Report," and in connection with it review the more important remarks called forth by it on both sides.

On the 17th July, Mr. Sars began his sojourn in Stavanger, and from that place made excursions in the neighboring fjords. In the city itself he had an excellent opportunity of examining herring, which about this time were brought to market from various places in large quantities. He subsequently visited one of the fishing-stations on the outer coast, where, during the winter, the so-called spring herring fisheries are carried on, partly for the purpose of obtaining information regarding those fisheries, partly for the purpose of making personal observations. The place he visited was "Hvittingsö," an island far out in the sea, and an old and well-known spring-herring fishing-place. From that point he made excursions in all directions, examining particularly the bottom of the ocean in those places where the herring-fisheries are carried on. Mr. Sars also collected much information regarding the spring-herring fisheries from conversations with experienced fishermen. He reports that at that season enormous numbers of young herring were found in the more sheltered sounds and bays, which, on closer examination, turned out to be almost exclusively young spring-herring,* and, as could be ascertained, of this year's spawning. The fishermen know this herring-spawn very well, and call it "*Aesja*."† They use it partly as bait, partly as food in eel-boxes, and take it as often as required with fine nets in quiet, grass-grown inlets. In examining the "*Brisling*," (*Clupea sprattus*,) brought to the Stavanger fish-market from various places, it was frequently found mixed with a great number of young spring-herring. The Hvittingsö fishermen testified that during that year the spring-herring was found in unusual quantities; in fact, they did not remember so good a spring-herring year since the old extraordinarily rich spring-herring fisheries. Sars concludes from this that during the previous winter a large number of spring-herring must have remained near the coast and have spawned there; and that, therefore, the poor spring-fisheries of the previous year cannot have been caused by any decrease in the number of herrings, nor by any change of route in the migrations of the herrings, but only by the circumstance that for some reason or other the great mass of the herrings did not come as near the coast as formerly, but spawned farther out at sea. All the fishermen agreed that large schools of herring approached the coast at the usual time, which could be judged of from the unusual number of whales and birds; and for some time there was a prospect that the

* It seems that the author by this term only wishes to convey the idea that they were the young of the genuine herring, (*Clupea harengus*,) in contradistinction from the "*Brisling*," (*Clupea sprattus*,) not that they were the young of that variety of herring which is called "spring-herring;" but as he does not seem to allow that there are several varieties of herring on the coast of Norway, it amounts to the same thing.

† Danish: *Aes*, i. e., food.

fisheries near Hvitingsö would be very good; but people waited too long, hoping that the herring would come in to the usual fishing-places, and the consequence was that they quietly spawned in the outer deep, and had already done spawning before attempts were made to take them out at sea. That large numbers of herring spawned there is also corroborated by the fact that soon after the close of the herring-fisheries there were found in the outer deep an unusual number of torsks, whose stomachs were full of herring-roe, which must have entirely covered the bottom of the sea. There is therefore reason to suppose that the usual number of herring have also visited the coast in 1872, and have deposited their roe in suitable places. It need not follow, however, from the circumstance that the spring-herring in this and partly in the preceding year, from some unknown reason, has spawned at a greater distance from the coast than usual, that it will always do so, much less that it will entirely leave the coast. Mr. Sars thinks that there are no sure signs of such a sudden change in the migrations of the herring, but that there is good reason to hope that, under more favorable circumstances, the herring-fisheries on the west coast of Norway will again be carried on in the usual places; of course, with more or less variable results. He was confirmed in this view by his observations of the so-called *fat-herring*, or *summer-herring*.

Regarding this fish, the (according to Mr. Sars, erroneous) opinion has formerly been prevalent that it was a different variety from the spring-herring, or an entirely different species of herring, which was said to go to different parts of the west coast of Norway, and not to belong to the ocean proper, but to the islands and sounds. It was even said that it had a special spawning-season of its own, viz, *autumn*, while the spring-herring spawns in winter or early in *spring*. We cannot entirely agree with Mr. Sars when he says, "if it were really the case that the summer-herring spawned at an entirely different season of the year, it would, in spite of its great zoological similarity, have to be considered not only as a distinct variety, but as a separate species. There certainly may be herring which spawn in autumn, and this is particularly the case with the so-called 'Kulla'* herring, occurring on the Swedish coast of the Kattegat. but this different spawning-season is caused by different physical circumstances—by varying conditions of life." "On the same coast, therefore, where herring are found which spawn in spring, *none can* (!) occur which spawn in autumn, and *vice versa*." Natural phenomena cannot unfortunately be so easily and with such certainty deduced from simple premises; and Boeck did not find it difficult to point out certain facts, which cannot be argued away, and which show that two races of herring, one spawning in spring and the other spawning in autumn, occur on one and the same coast. Thus Münter has shown that on the east coast of Rügen, on a space scarcely extending four German miles, there are two varieties of herring—a southern,

* Kulla, a promontory on the western coast of Sweden.

spawning in spring, and a northern, spawning in autumn. In connection with this we may mention Nilsson's and Ekström's report, that in the Baltic there are two varieties of small herring, ("Strömming,") the more slender of which spawns in May and the beginning of June, and the stouter one in August and the first half of September. On the other hand, in the present case, where the Norwegian summer-herring is spoken of, Sars has given satisfactory proof that in general it does not spawn in autumn. Its fat and general good quality are caused by its having, as one says, "fat, instead of roe and milt." The roe and milt are there, in the lowest part of the abdominal cavity, covered by the fat, but in so undeveloped a condition, that it may be taken for granted that they cannot possibly mature as early as autumn. The Norwegian fishermen, therefore, do not know the autumn-spawning herring. According to their short-sighted view, the summer-herring does not spawn at all; and they are led to take this view because it has neither roe nor milt, but only fat, quite forgetting that every variety or species of fish must be able to propagate itself in order to exist. By denying the power of propagation, (which of course is only correct in so far as it does not spawn as summer-herring,) they actually deny it all independence as a separate variety. When the "summer-herring" finally spawns, it has ceased to be a summer-herring, or fat-herring, (the distinguishing mark of the latter being that it is filled with fat and not with roe or milt,) and has become a spring-herring; in other words, it is only the younger herring, not yet fit to spawn, in different stages of its life, but ends invariably by becoming at last a genuine spring-herring. The reason why people have been so long blind to this very simple state of facts, in Sars's opinion, flows from the erroneous idea that the summer-herring goes into the fjords and bays for the same purpose as the spring-herring, while, as every one acquainted with the nature of the herring knows, in reality it does not go at all for the purpose of spawning, but merely to feed.

If this theory is correct, the summer-herring must occur in different forms, corresponding with the different stages of its life; and this is actually the case. It is consequently brought into trade under different names, which, on the whole, represent as many years or ages. In the second year it is called *Christiania herring*; in the third, *middle herring*; and in the fourth, *merchants' herring*. In its fifth year, it has become a genuine *spring-herring*.* There is no essential difference between these varieties except the size and the greater or less development of the sexual organs; but in all other points they are alike, even in the subdivisions of these varieties, viz, small and large *Christiania herring*, small and large *middle herring*, *merchants' herring*, &c. It must not be imagined that these divisions in all cases agree exactly with the age; for all fish do not reach the same size in the same period of time, and the

* A correction, where, instead of five years, the whole period of this development embraces six years, is given below.

spawning-season of the spring-herring, and the consequent development of the young fish, extend over quite a portion of winter and spring. Sars, however, supposes that a large number of the "merchants' herring" (or, in other words, a large portion of the common herring) spawns by the end of the fourth year. "It will then be found together with the older or genuine spring-herring, and, as in that case it will have completely matured roe and milt like this one, no one will, as a general rule, think of considering it as former fat-herring, but as young spring-herring, (which it is in reality.) It is probable, however, that, on closer examination, (especially when this young herring is found in large numbers without being mixed with the older spring-herring,) some slight differences will be found, chiefly caused by its not yet being familiar with life far out at sea, to which the older spring-herring have become accustomed, while it only commences that life now after having done spawning. It is likewise possible that the spawning-season of this younger herring does not occur exactly at the same time, but somewhat earlier." Sars, therefore, supposed that the so-called Blandsild, mixed herring, (whose occurrence has been looked upon as a precursor of the disappearance of the spring-herring proper, but which he had no opportunity to examine,) according to the description given of it, which says that it is fatter (and consequently better) than the spring-herring, but somewhat smaller and spawns earlier, is not a previously unknown kind of herring, which has shown itself only during the last few years on the coast of Norway, but a summer-herring, in its transition period toward being a "Graabensild" (graybone herring); in other words, the youngest spring-herring, which, during the following year, will return as a genuine Graabensild. (We shall later return to this subject.) The reason that it has been formerly overlooked is that it was mixed with the Graabensild; but during the last few years it has not been found so much mixed with it, because, as has been said above, the great mass of the old herrings coming in from the sea have spawned farther out at sea. "Just as the young of the torsk spend the first years of their life near the coast, and only go out in the open sea at a more advanced age, so do the young of the spring-herring spend the first years of their life near the coast, and during summer gather (under the name of fat-herrings) in large schools, to feed in the inner fjords and bays." Since the summer-herring fisheries on the heights of Stavanger were very productive in 1872, rather more so than usual, Mr. Sars thinks there is no reason to fear any diminution in the schools of spring-herrings, or that they should begin to go to other coasts; if this were the case, the summer-herring fisheries must have decreased in the same proportion.

With regard to this, it must be said that nothing of the kind has ever been supposed. Boeck himself has shown that if the spring-herring fisheries are not successful, the reason is that the spawning herring does not, as in other cases, go near the coast, where it could be easily caught, but spawns farther out in deep water, where it cannot be caught so well,

at least not according to the usual method. What causes the herring to remain so far from the coast has, up to this date, (1872,) not yet become known. Mr. Sars could not say either what *favorable* circumstances should induce the hope that the herring-fisheries on the west coast of Norway would again return to the old places, or what *unfavorable* circumstances kept the majority of the herring during the two preceding years away from the fishing-places. (We shall again return to this question.) Mr. Boeck furthermore proves, what need not be mentioned here, as it has been spoken of in the "*Tidsskrift for Fiskeri*," 7de Aargang, p. 13, that under no circumstances has the cold anything to do with it. He also protests against having advanced the opinion that a herring-period (*i. e.*, a period of successful herring-fisheries) should now have come to an end as far as Norway is concerned. He has only, from the sources accessible to him, cited a number of facts "which show under what conditions the herring-fisheries came to an end in former times and in different localities; how they again returned, and in what manner the fisheries were carried on year after year. From these historic facts, a certain law can be deduced regarding the movements of the great masses of herring, which do not come and go irregularly on certain parts of the coast, but whose movements occur with a certain regularity." He lets every one from this draw his own conclusions, which he considers justified, and gives his opinion on the whole with great reserve: "That even if it does not follow, from all which has been said, that the spring-herring will leave our coasts, (the southern spring-herring district,) all the appearances are not favorable to the opposite opinion." We must agree with Mr. Sars that in so far as Mr. Boeck has given any opinion on this question, it must be that the appearances are not favorable for the nearest future of the Norwegian spring-herring fisheries; but whether or not Mr. Boeck will stand by this prophecy, whose correctness only the future can show, it seems that the experience of last year will bear it out. The important question, why does the herring during a certain period of years go to the inner spawning-places, while during another period it remains outside, has so far (1872) not been answered; just as little as the question, what may cause the gradual change in the spawning-season, which, according to Boeck's investigations, always seems to precede the end of the herring-fisheries. Mr. Sars believes, as we shall see in another chapter, (1873,) that he has found satisfactory answers to all these questions; but we have not yet reached this point.

Mr. Boeck says, in the "Remarks" with which he accompanies Mr. Sars's "Report" in the "*Morgenbladet*" of November 5, that in his work on the herring he has already hinted at the same view regarding the relation of the summer-herring and the spring-herring which Mr. Sars has advanced, and that the reason why he (Boeck) did not describe this relation more fully was merely a want of opportunity to visit the summer-herring fisheries farther north—during the years in question there

was no, or at least a very inconsiderable, summer-herring fishery in the southern district—and that he was prevented from visiting the northern fisheries by Mr. Sars's using the greater portion of the appropriation made for both of them for his journeys to the Lofoten Islands, or in some other manner. However this may be, we cannot but side with Mr. Boeck in his protest against the accusations that he systematically maintained the *historic* mode of investigation, in opposition to the *scientific* mode. He also shows that the different years of the herring given by Sars are nearly the same as those given some years ago by Mr. Dahl, of Bergen,* with the difference only that the latter gave to the spring-herring an age of six years instead of five, which opinion one often hears expressed on the western coast, (and which, as will be seen from Sars's report for 1873, he also shares.) Mr. Boeck, in this important point—the relation between the summer-herring and the spring-herring—does not express an essentially different view. He fully agrees with Mr. Sars that the summer-herring is nothing but the spring herring at a different age; but he does not think that this is the case with *all* summer-herring; and he maintains that there are really *peculiar coast-races* of herring on the coasts of Sweden and Norway,† and that they may spawn at a later season than the spring-herring, viz, in April on the coast of Norway, and in May on the Swedish coast of Bohuslen. In the fact that toward the end of November, on the northern coast, he had an opportunity of examining a “merchants' herring,” which was full of loose roe, he finds a proof that the autumn-herring (probably when it remains in the fjords) *can* spawn before the herring's usual spawning-time in spring, at which time Boeck is also inclined to think the majority of the autumn-herring spawns; and this early-spawning autumn-herring could then, if we understand Mr. Boeck correctly, also be considered as a separate race of herrings.

Boeck further remarks that experience shows that if in a certain place there is during one year a rich spring-herring fishery, such fact does not justify the hope that the next winter or spring there will be a rich spring-herring fishery in the same place. “If there should be

* Dahl's years, with which Sars now entirely agrees, were the following: First year, Musse; second year, Aesja; third year, Christiania herring; fourth year, middle herring; fifth year, merchants' herring; sixth year, spring-herring. It has, therefore, also been supposed that the spring-herring fisheries occur in periods of six years, on the idea that the herring, for the purpose of spawning, would return to the place where it had been hatched; and in many cases this idea has been correct.

† An article in the “*Thronhjems Stiftsavis*” for 1862 makes the following distinction between two varieties of the summer-herring: “*The sea-herring*,” which during summer comes in from the high sea, and “*the fjord-herring*,” which remains in the fjords, and during the summer-herring fisheries mixes with the incoming sea-herring. Boeck, however, supposes that such coast-races have originated, and still originate, by more or less developed sea-herring going into the deeper and more secluded inlets, and remaining there. Their young may possibly again become sea-herring, but more permanent varieties may also form in such places, e. g., the Hösxfjordherring, the Idesfjord-herring, &c.

rich spring-herring fisheries in the same places where, during the preceding summer, great masses of summer-herring have shown themselves, we ought to have had for a long number of years steady and particularly rich spring-herring fisheries on the coast north of Christiansund as far as the Tromsø district, and even farther north; but nothing of the kind is known, no real spring-herring having been caught along that coast during this century." Sars, in answer to this, says, if we understand him correctly, that the northern "sea-herring," or "great herring," is the same as the "spring-herring;" but Boeck draws attention to the fact that the "great herring" does not go farther south than the boundary of the Nordland district, and that, from that point as far as Christiansund, there is a long stretch of coast where large summer-herring fisheries have taken place and still take place, and where no spring-herring are caught. The "great-herring" fisheries did not commence till 1861, and prior to that year there had not been any spring-fisheries in that location for sixty, perhaps for eighty, years. During those years when the spring herring had left the heights of Stavanger entirely, (1784 to 1808,) there were rich summer-herring fisheries in the Stavanger fjord, and in other places, and these fisheries were most successful in the middle years of this period; when the spring-herring fisheries again increased, the summer-herring disappeared altogether. Several printed and manuscript reports particularly deplore the fact that the valuable "summer-herring" has gone away, while the inferior "spring-herring" has come again. Just as little is it known from experience that where there have been rich spring-herring fisheries for a number of years, great numbers of summer-herring could at the same time be caught in the inlets along this coast. It appears, from the Stavanger and Bergenshus districts' reports, published every five years, that, for many years, when the spring-herring fisheries were successful, few or no summer-herring were caught on the same coast. It is only during the last few years that the summer-herring fisheries have been successful in the Stavanger fjords, but during these very years the spring-herring fishery has not amounted to anything. The hopes which have been built on the great quantity of young fish coming in have also but too often been disappointed, and no conclusion can be reached as to the probable fate of the Norwegian spring-herring fisheries in the near future. "When the spring-herring, in 1833, went past the cape (Lindesnæs) as far as Mandal, all the bays were later in the year full of young herring. The inhabitants of that coast for that reason entertained great hopes of continuing the fisheries during the following years, especially when the young from that year would have grown up; but these hopes were not fulfilled, for later no herring appeared on that side of the cape. During the year when the spring-herring left the coast, it had spawned near Flekkefjord, and numerous young fish justified the hope of future rich fisheries, although the fishing during that year had been poor, and the herring had kept in such deep water that

some were taken at a depth of 80 fathoms; but the joy was but short-lived, for it only lasted till the time in the following year when the fisheries were to commence, when no herring appeared, nor have they appeared since." Similar masses of young herring showed themselves on the coast of Bohuslen (Sweden) in the year when the great-herring fisheries on the coast ceased.

With regard to the objection raised by Mr. Boeck against the opinion that the summer-herring is only a young spring-herring, viz, that the greater or less success of the spring-herring fishery on the coast of Stavanger is in no wise connected with the summer-herring fisheries on the same coast, great spring-herring fisheries having occurred during those years when the summer-herring fisheries did not amount to anything, Mr. Sars says that the difficulty in solving this problem disappears if one maintains the difference between "herring-fisheries" and the "occurrence of herring." "The former is, of course, dependent on many accidental circumstances, and may, therefore, although the number of herring is the same, be very different. This must especially be supposed to be the case with the summer-herring fisheries. The summer-herring may certainly be near the coast in very large masses without any great fisheries being carried on. A rich summer-herring fishery depends exclusively on the accidental occurrence of small crustaceans and their entirely accidental accumulation in certain places which are favorable to the fisheries, and to this, of course, no regard is had in the historical report on the fisheries." This explanation of Mr. Sars of the fact that a rich spring-herring fishery is not always followed by a rich summer-herring fishery is doubtless correct, but it does argue away the experience that, *vice versa*, a rich summer-herring fishery is not followed by a good spring-herring fishery. Other causes must be found for this. He certainly answers the objection that on the coast from Christianssund to Nordland no proper spring-herring fisheries are carried on, by saying that the spring-herring may be there and spawn out in the deep water, without any actual fishery being carried on; and, moreover, that there is nothing which tells us that its offspring, the summer-herring, is entirely stationary in those places where it is hatched, but it is probable that it goes along the coast and gathers in those places where the small crustaceans are chiefly found." We think, however, that in this case it is Mr. Sars who does not distinguish between "herring-fisheries" and the "occurrence of herring;" for of what use is it to the fisherman, as Mr. Boeck remarks, that there are herring enough out in the sea, if they won't come in and let themselves be caught in those places where fishing can be carried on? There is certainly, as has been said before, no doubt that the herring stays outside the coast of Norway every winter and spawns during the spawning-season; and whether it remains outside and spawns there, or approaches the coast, the young will at any rate seek shelter near it. There will, therefore, always be enough young herring, (whether they flock together so that they can be caught to advantage;

or not, which will depend on stream and wind collecting their food; but from the circumstance that there are many "summer-herring," or young herring, no conclusion can be drawn as to the probable result of the spring-herring fisheries. It is in reality only the "occurrence of herring" which Mr. Sars has been able to promise his countrymen, and of this there was no reason to doubt; but so far it is not within anybody's power to predict "herring-fisheries," because we know not the causes—at any rate, not the proper causes which can form the subject of observations and calculations—of the periodical changes in the spawning-season and coming in of the herring, but only know from experience that whenever these changes take place there is reason to fear that the spring-herring for a number of years will not come to its old spawning-places on the coast in order to spawn there, but stay farther out, as is partly also the case with the Nordlands-herring, or the "great-herring."

Mr. Sars, with regard to this, has raised the objection that the "sea-herring" has been known long before 1861, but that it has not been made an object of fishing, probably because formerly it did not come so near the land as during the last years. The Lofoten fishermen took as many of these fish as they used for their households by taking them out of the sea in a very primitive manner—in buckets. Mr. Boeck quite agrees with him in this point, but did not mean anything else than that its "occurrence" before 1861 did not take place *near* the coast so that it could have been fished with the common fishing-implements. Regarding the "great-herring," Mr. Boeck says, on this occasion, that it does not differ from the spring-herring, but that its apparently different shape is only caused by the greater amount of fat it contains, as on approaching the coast it is not ready for spawning. Only at one place did Boeck, toward the end of the fishery, in January, find "great-herring" with loose roe and milt. As a general rule, it does not spawn near the coast, but far out at sea, where large masses of herring have every year been seen, both in this and the last century, from Hammersfest to Hitteren, from which cause a large number of young fish are every year seen near the coast and in the fjords; but in this century, from some unknown reasons, they had not approached the coast so that they could be caught, before 1861. As the great-herring, therefore, does not approach the coast for the purpose of spawning, the great-herring fisheries are always somewhat uncertain. As was said before, we do not know the cause why this full-grown herring, which, however, is not ready to spawn, approaches the coast in this manner; it is only supposed that it has lost its way by following the large troughs of the sea which lead to the coast.

Although there remain several obscure "herring-problems," it is evident that, by Mr. Sars's report of 1872 and by Mr. Boeck's comments upon it, made during the same year, we have advanced some steps in understanding the connection between the various phenomena, particularly by proving that the summer-herring only represents different

stages in the life of the spring-herring; that it has no separate spawning-time; and that its movements are determined by its favorite food, *i. e.*, small crustaceans. Besides acknowledging the progress that had been made, we thought that we owed it to the whole question, as well as to the memory of Mr. Boeck, to save from oblivion what he had written concerning it during the last days of his life, and which, on account of its being contained in a daily journal, could only be accessible to a few, whose number would naturally decrease every day. Our review of the state of the Norwegian herring-question at the end of the year 1872 will at the same time serve as an introduction to a review of the considerable progress which has been made by Mr. Sars's report for 1873, published in 1874, to which we will now turn.

II.

The above review of the discussion carried on in 1872 had long since been written for insertion in this periodical, when we received Mr. Sars's above-mentioned report for 1873, in which he gives in detail his complete theory of the migrations of the Norwegian herring and the causes which determine them. We likewise take the liberty to give, in the following, a brief extract from this report.

Mr. Sars does not believe that the grown spring-herring, after having spawned on the western coast of South Norway, (from Christianssund to Stavanger,) goes out to the nearest deep water due west—*i. e.*, between the coast and the ridge in the bottom of the sea running parallel with it from north to south, at a distance of from ten to fifteen miles—and stays there near the bottom of the sea during three-fourths of the year when it is not near the coast. This portion of the bottom, which, as Mr. Sars has found by former observations, possesses but little animal life, and must, comparatively speaking, be called a desert, is but little suited for these enormous masses of fish, and there is no reason to suppose that the herring is a bottom fish; it is, on the contrary, in harmony with its form as well as its favorite food—the small fat and oily crustaceans of the surface—a fish which has its home near the surface of the water. We do not deny that the Baltic, the Kattegat, perhaps, also, the Skagerrak, and the North Sea, have each their race of herrings, which do not go beyond the basin of the sea which, by nature and habit, has been assigned to them; but the Norwegian spring-herring comes from a greater distance, from the open sea between Iceland, Scotland, and Norway, not from the bottom of this sea, but from its surface. Here it has lived, especially during summer, very much scattered, on its favorite food, which is there found in great quantities, (more or less near the surface, according to the rising or sinking of this food, caused by the time of day and the weather); and from here it approaches the Norwegian coast, in a southeasterly direction, toward the beginning of the spawning-season, gathering in large and constantly-increasing schools, and following the deep troughs, till at last they are quite near the coast, and form a so-called

“herring-mountain,”—a high, deep, and closely-packed mass of herrings. It has been found, by certain observations which have already been communicated in Boeck’s well-known work on the herring, (p. 47,) that the herring always comes from the northwest. That it follows this direction is easily explained by the fact, settled by Professor Mohn’s meteorological observations, that the sea on this portion of the western coast of Norway, during the winter-months, (December to February,) has a higher average degree of warmth than near the coast farther south, or on the coast a little to the north, a very uniform degree of warmth, (5° to 6° Réaumur,) about the same as in the nearest portion of the sea-basin from which the herring is supposed to come. If the herring would go due east, therefore, to a more northerly portion of the coast, *e. g.*, the neighborhood of Thronhjelm, it would come in contact with water whose degree of warmth would decrease very rapidly toward the north, from 4° to 2° Réaumur. Another school of herrings, the Nordland *great-herring*, lives, in Sars’s opinion, to the northwest of Nordland and Finmarken, but somewhat nearer the coast, because there the sea is richer in small crustaceans than farther south, in the neighborhood of the coast; it, therefore, comes near the coast comparatively early in its migration toward the southeast or south, being fatter, but less ready to spawn.

Immediately after being hatched, the young herring, being born on the bottom of the sea, naturally stays near it on the outer coast, where the spring-herring loves to spawn. As soon as the umbilical bag has been completely absorbed and the fins have become developed, it goes near the surface of the water to snap for small living animals; but as near the outer coast it is exposed to many dangers, (the current, heavy waves, &c.,) and to the persecutions of birds and fishes, instinct has taught it to go nearer to the land, in the more secluded sounds and bays, where it often can be seen in enormous numbers. As soon as it has reached the size of a few inches, it begins to rove about in constantly-increasing schools, in fact to assume its—according to Sars—characteristic roving mode of life, which is again dependent on its food, *viz.*, the small crustaceans of the surface, whose very irregular occurrence is again dependent on the current. It also depends on accidental circumstances how far it goes from its birth-place during this first period of its life, and to what extent it scatters over a larger or smaller portion of the coast. During its first year, however, it probably keeps near the coast; only gradually as it grows larger and its desire for food increases will it be obliged to go farther out into the sea, where the small crustaceans, as a general rule, are found in great quantities, and thus, like the torsk, it gradually approaches those portions of the sea where its ancestors came from. All this would go on with the greatest regularity, if the small crustaceans were not frequently packed together, by sudden changes in the weather and consequent changes of the current, in large masses near the coast and its

bays and fjords, drawing the schools of young herring—the so-called “summer-herring”—after them, and after a while taking them out to sea again when the current changes. In exceptional cases, schools of herring remain in the deep fjords for a whole year and longer, and such herrings will naturally assume a character of their own, so as to pass for a special variety or coast-race. Although, as has been said before, we know all the stages in the life of the herring near the coast of Norway, and would, therefore, reasonably suppose that its *whole* youth, till the period when it spawns for the first time, was spent near the coast, Sars remarks expressly that, on the whole, the occurrence of the summer-herring near the coast must be considered as altogether temporary. It comes, like the older herring, (the spring-herring,) from the open sea, but not from such a distance as this one. “Some time before the large masses of summer-herring came to Espevær, in 1873, the mackerel-fishers often caught considerable quantities of large and fat summer-herrings in their nets at a distance of from five to six miles from the coast, and schools of large and small herrings could often be observed from the mackerel-boats. Soon afterward the current, on account of a very sudden change in the weather, turned with unusual violence toward the islands near Espevær, and carried with it enormous quantities of small crustaceans, which were closely packed in all the neighboring bays and sounds; then the herrings began to come in from the sea, first the larger and then the smaller ones.” As during winter the small crustaceans are not found near the coast in such large quantities, the migration of the young herring toward the sea will, on the whole, be much less disturbed than during summer, and there are no instances of the spring-herring having returned to the coast to seek food after having spawned. As soon as the herring has got farther away from the coast, out in the open sea, it will not be enticed so much toward the coast by the small crustaceans, as the currents there are generally more regular than near the coast; consequently only young herring—at least the majority of them—which have not yet got far enough from the coast, visit the coasts of Norway during summer. Sars, however, does not consider it improbable that among the large “merchants’ herring” there may also be some which formerly, as “spring-herring,” have spawned near the coast. It is a natural consequence of the temperature of the sea and the direction of the current (which from Stat is chiefly northerly) that the distribution of the young herring along the coast and its outward movement chiefly take place in a northerly direction, and, as a consequence of this, the summer-herring fisheries are generally richest along the Thronhjelm coast, although the spring-herring is not known to spawn anywhere outside that coast. The “fat-herring” caught along the coasts of Nordland and Finmarken bears the same relation to the Nordland “great-herring” as the “summer-herring” does to the “spring-herring.”

Among the phenomena which have been brought to light by the historic studies or the regularities and irregularities in the course and

results of the herring-fishery, the most remarkable one is this, that the spring-herring fishery has not at all times commenced at the same period of the year, but that at times it has had a tendency to extend farther and farther into spring, which became particularly evident toward the end of the so-called "herring-periods." The difference in the time of the spring-herring's arrival on the coast may be a month and a half from some time before New Year till some time in February. From these experiences, Boeck could also in a certain manner predict the decrease of the spring-herring fisheries which has taken place now. This circumstance has so far been entirely unexplained; if the herring had its proper home in the deep sea-basins *near the coast*, what should cause it to leave these later and later every year, or to come early after the lapse of many years? It could, on the other hand, easily be understood that its arrival caused a shorter stay, and a disinclination to go near the coast, so that the result of the fisheries would naturally be less.

Sars supposes that on account of the varying strength and direction of the currents in the open North Sea, which depend on the differences of the weather, the distribution of small crustaceans in the sea will differ very much in the different years; and, as the herring naturally stays where it finds food, it will, when its migratory instinct awakens, be nearer the coast, and consequently arrive sooner than in another where it has been farther out and when its journey toward the coast required longer time. As the movement toward the coast, in this case in a southeasterly direction, will probably always occur about the same season of the year, (some time before the roe and milt, which likewise develop at a certain season, are ready for spawning,) it follows of itself that the spring-herring which comes in *early* is of a better quality, stays longer near the coast, and will be able to go farther up the bays and sounds; in other words, that the fishery will yield a much better, richer, and safer result than in the opposite case, when the herring only remains for a season near the outermost coast, and is much thinner and more exhausted, and when only occasionally a small school is chased near the land by large fishes of prey. The herring-fishery may therefore yield a very different result, even if the same mass of herrings has year after year been outside the coast and has produced the same quantity of young ones. The final cause of the irregularity in the spring-herring fisheries must therefore be sought in the changes of weather, current, and temperature of the water in the outer sea, not so much during the fishing-season as during the rest of the year, particularly during the preceding autumn and summer.

Whether there is in this respect a periodicity which corresponds with that of the herring-fishery will be more satisfactorily explained by future observations than by the study of the past. For the present, it cannot be denied that such a thing is possible. "It is a fact that the occurrence of small crustaceans during summer on the western coast of Norway differs very much in the different years. Some years the

sea near the coast during the whole summer has been filled with great masses of different crustaceans; in other years, they disappeared almost entirely, or were only accidentally driven to different points of the coast by the current, soon to disappear again." One of the most convincing evidences that the small pelagic animals, among them the genuine "herring-crustacean," are in certain years driven near the coast by the current, is the existence of salpæ, which are as transparent as glass, and which are found either singly or in long-connected chains resembling pearl necklaces; out in the open sea they are found every year, but near the coast many years may pass before one sees a single one; and all of a sudden in a certain year they approach the coast in such enormous masses that every bay and sound is filled with them. The occasional occurrence of these animals in large masses has attracted the attention of the fishermen, and is counted among the "signs" which augur a good spring-herring fishery during the coming winter, and it would seem probably not without reason. During such a year, the herring will already during summer have come tolerably near the coast, and will consequently arrive early in winter, &c.

The so-called "mixed herring," which of late years has appeared in the spring-herring district, is described as an inferior kind of herring, which formerly was not known, and in whose occurrence people believe they see a sure warning that the spring-herring fisheries will soon come to an end. It has been described in many different ways. It probably consists chiefly of herring in different stages of life, which are not yet able to spawn, and are driven toward the coast by the "spring-herring mountains," which approach the coast from the sea; *e. g.*, the barren "Straalsild," (ray-herring,) or "Solhovedsild," (sunhead-herring,) which are probably fishes that have been left behind from the spring-herring school of the preceding year, have remained near the coast, and, on account of the want of suitable food, have not become ripe for spawning during this year. The longer the route which the advancing masses of the old spawning herring have to travel, the greater number of these young herring, which have never yet approached the open sea in their slow course, will they drive before them, and all the more mixed will the different schools and ages of the herring be. They drive before them first the older ones, which had got farthest out, then the younger ones, which had not got so far, and mix them with the barren Straalsild; (ray-herring,) which they always meet on their approach to the coast, as well as with some stragglers from the great mass of herrings; these latter, of course, being common spring-herring, which are nearly ready to spawn. The bulk of the mixed herrings, viz, the young herring which are not yet ready to spawn, are therefore in reality the same herrings which earlier in the season were called summer-herring. Their occurrence in unusual numbers may, therefore, undoubtedly be a sign of a less productive spring-herring fishery during *that year*, but does not augur anything regarding the more distant future. As long as the young

herring are every year in largest numbers in their accustomed places, there is no reason to suppose that the spring-herring fishery will come to an end, although the fisheries may, on account of many accidental circumstances, be more or less productive in the different years.

Professor Sars's theory will become clearer to the reader by casting a glance at the accompanying map.* This theory must be plausible in a high degree, and no serious objections to it can be raised, as it seems to explain the most characteristic phenomena of the Norwegian herring-fisheries in a satisfactory manner. The criticism of its details we will leave to those who have made, or are going to make, the herring-fishery and the natural history of the herring the subject of special studies. Its weak points (if they may be termed such) can easily be pointed out: first of all, to use a simile, so many and large drafts are issued on the unknown, the unproved, and the unprovable. It will be difficult to attack Professor Sars in the rear by proving to him that the herring is not found in those places which he assigns it during three-fourths of the year, or that the former relations of wind, current, and weather in the North Sea do not show any periodicity which corresponds with that of the herring-fishery. But, on the other hand, it must be remembered that no proof has been given that all this is not so. Another weak point in Sars's theory is that it cannot easily be applied to herring-fisheries outside of Norway. At least, one cannot read Mr. Sars's application of his theory to the Bohuslen (Sweden) fisheries with *entire* satisfaction: "At a time when the small crustaceans, on account of the peculiar currents of the ocean, have filled the North Sea and the Skagerak to an unusual degree, it can easily be imagined that a portion of the great mass of herrings coming originally from the northwest have got so far into this part of the sea that, on the approach of the spawning-season, by following the usual southeasterly direction, they have come toward the coast of Bohuslen, where they have spawned, and later, in obedience to the instinct common to all fish, have returned to the same coast where they have spawned once, thus gradually forming a race of herrings peculiar to the Skagerak, whose disappearance must at any rate in part be ascribed to the less bountiful supply of small crustaceans in this part of the sea." These possible weaknesses of the theory do not, however, as Professor Sars very justly remarks, reduce it to a mere play of ideas, or detract from its merits as a satisfactory explanation of some of the most important and most obscure points of the whole question, but leave it as a combination of phenomena according with well-known facts, which may form the basis of further investigations, carried on with a fixed plan and in a thoughtful manner. Let us hope that out of the fiery ordeal to which future investigations will put it, it will only come out stronger! For the present we welcome it sincerely as an important step in advance.

C. L.

* The map referred to has not been reproduced.

P. S.—We learn that, at the suggestion of Professor Mohn, the director of the Norwegian Meteorological Institute, an expedition will this summer (1875) be fitted out for exploring the open North Sea between Norway, Iceland, and the Farøe Islands, to which Professor Sars will be attached. We hope that this eminent naturalist will thus have a chance to submit his theory to a test in that direction where we think that its weakest point lies, viz, in the hitherto unknown. We heartily wish that he may have the triumphant satisfaction to clear up every doubt, and dissipate the last clouds of obscurity which envelop the natural history of the Norwegian herring.