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HYDROGRAPHIC-BIOLOGICAL INVESTIGATIONS

OF

THE SKAGERRAK AND THE CHRISTIANIA FIORD

BY

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1.

The Skagerrak.

The hydrographical character of the Skagerrak is determined by its forming the connection between the Cattegat and the North Sea, or between the Baltic and the Atlantic. The central, and Northern part of the Skagerrak, forms a continuation of the Norwegian depression which there attains its greatest depth. Along the coast of Jutland and Bohuslæn, the bottom slopes gradually downwards, as will be seen from the following account. From the Swedish coast of the Skagerrak, the depth of 50 fathoms is not reached for 8 geographical miles off land; and the same depth off the Jutland coast is not to be found, as a rule, for over 20 miles. The curve of soundings, for a depth of 100 fathoms, cannot be met with under 14—16 miles off Bohuslæn, and 24—32 miles to the north of Jutland.

Review from earlier investigations

All along the Norwegian side, however, this curve is found at about 4 miles's distance from the shore, between Lindesnes and Jomfruland. At Langesund there is a deep depression extending still closer towards land, while, further North, however, the sea is shallower, and, outside the Christiania Fiord, only isolated depressions are to be found attaining a greater depth than 100 fathoms.

The different currents on the surface of the Skagerrak, are, mainly, dependent on causes which originate beyond the Skagerrak itself. From the Baltic, for instance, there flows a constant stream of brackish water, which keeps, chiefly, to the coast of Sweden, and which, at Koster, turns towards the Norwegian side. During the greater part of the year, at all events, it runs further along the coast from Svenør to Lindesnes.

On the charts of the Geographical Survey, this current, is plainly marked, and is, moreover, well known to all seafaring people. Professor Mohn has estimated its velocity at 10 geographical miles in 24 hours, 0.22 metres a second ([87]* page 168).

Again, on the coast of Jutland, there is a still stronger current, the so-called «Jutland Current», flowing into the Skagerrak, which, like the former, has been known to seamen for generations. According to annual observations, made on board Danish Lightships, and Mohn's theoretical calculations, the average speed is 18 geographical miles in 24 hours, 0.38 metres a second (Mohn l. c. p. 168). Even this is a coastal current, forming a continuation of those North Sea coastal currents which, of late, have been subjected to most accurate investigations by *Fulton* [97].

Investigations of the deep lying currents, long proved very difficult by the old methods, viz., the direct registration of the current. However, thanks to the services of Swedish hydrographers, a new method has been introduced, and generally adopted, by which one may, at any time, ascertain the hydrographical situation on the surface, as well as in deep water. The method consists in the determination of a layer's origin by investigating its salinity and temperature, it being known that layers of different salinities are of so different a specific gravity, that they move, the one below the other, for great distances and length of time, without intermixing. Pettersson and Ekman found, that all water in the Skagerrak of a lower salinity than 30‰, comes from the Baltic with *the Baltic Current;* furthermore, that water, exceeding 32 ‰ salinity, originates from the North Sea and the Atlantic Ocean.

The Jutland Current, according to their investigations, brings a preponderate quantity of water, with a salinity of 32—34 ‰ *(Bank water)*, into the Skagerrak.

In the deep-water regions of the Skagerrak vast bodies of water are found in which the salinity exceeds 35 ‰. This water, being connected with the Gulf Stream, enters the Skagerrak as an under current through the Norwegian depression. Also those layers whose saline contents range from 34 to 35 ‰ (the so called *North Sea Water*) proceed from oceanic sources.

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*) [ ]. This form of brackets, with figures inside, indicates the date of literary publications, *vide* the Bibliography.

Pettersson and Ekman have given these results in their fundamental work: «Grunddragen af Skageracks och Kattegats Hydrografi» [91] the exactitude of which has been proved by all succeeding researches.

By means of these statements, one may arrive at a far more comprehensive understanding of the hydrographical character, than was, previously, possible. According to earlier experiments, one had to be content with a survey of the average distribution and strength of the oceanic currents, and of the mean temperature of many years, during each month of those years, &c. &c.

In applying the method of Pettersson & Ekman, it is possible to ascertain the hydrographical situation at any time. Thus one may follow the changes throughout the year, as the different currents increase or diminish in strength and thickness.

Pettersson & Ekman shew [91], that the distribution of the water-layers in the Skagerrak do change, according to the time of year. The Baltic current is found to be very extensively diffused during Summer, covering the entire surface of the Skagerrak with a warm layer of low salinity, extending to a depth of some 20 metres. Simultaneously, the Atlantic under current, of 35 ‰ salinity, rises to a depth of 50 métres from the surface, even close to the shore.

The Bank Water, however, at that time of year is but slightly represented, being met with in thin layers along the coasts, and, in the central parts of Skagerrak, may be entirely wanting, so that the Baltic layers rest, directly, on the 34 ‰ water.

During the course of the autumn, the Baltic current decreases, and is surplanted by considerable quantities of Bank water in the Skagerrak. As the final result of these interchanges, it may be seen that, in November, the entire surface becomes covered with a layer of bank-water to a depth of 20—30 metres, while the remainder of the Baltic water is forced up into the Northern, and Eastern part of the Skagerrak. Coincident with this, the 35‰ water's level sinks over the whole of the Skagerrak, particularly along the coast, not even surmounting the banks off the Swedish coast. This condition is generally maintained during the winter, and, not until May, does the Baltic current overcome the Bank-water, which partly flows away, and, partly, remains as under currents below the Baltic layers.

The surface water of the Skagerrak thus changes twice a year, in

May and November. These changes in the waters, which, according to Pettersson's and Ekman's recent experiments may, possibly, appear still more complicated than represented by us, seems to be closely connected with the gradual approach of the herring to the shores of the Skagerrak.

G. Ekman could, even in 1878, perceive that the approach of the herring, off the Bohuslæn (26—28 December), occured directly after the expansion of the Bank-water. Pettersson and Ekman also publish several observations which indicate, that the herring come in with the Bank-water layers, but, that a great accumulation of Baltic water prevents the herring from approaching the shore.

It was most requisite, and of great interest, to see if such hydrographical variations really took place from one year to another, in order that the great irregularities of the herring fisheries might be, thereby, explained.

All researches made in the Skagerrak during the interval (1893 97), by the Swedes and Norwegians, have, therefore, been mainly directed towards solving the question, whether the gradual approach of the herring towards Bohuslæn, and the south east coast of Norway, can be connected with the influx of the Bank-water.

In order to obtain a more comprehensible view of these hydrographical conditions, at different periods of the year, it would be necessary, so far as is possible, to make *simultaneous* observations throughout a large area of water.

The Swedish and Norwegian Hydrographers have, therefore, worked in cooperation. Surface observations have been procured through the kindness of private Steamship Companies, and deep water observations, have, in some instances, been made, at one and the same time, in both countries.

When, in the present work, we, are about to give an account of the Norwegian investigations and their results, we must, also, menter into the details of the work performed by the Swedish scientists.

Hjort in his treatise «Hydrographic-biological studies of the Norwegian Fisheries» [95], has given an account of his labours during 1893—94.

The Swedish Hydrographers have published several papers on this subject, but the principal results are given in Pettersson and Ekman's treatise [97]: «De hydrografiska förändringarne inom Nordsjöns och Östersjöns område under tiden 1893—1897».

Pettersson and Ekman, in their first endeavours [91] towards solving the origin of the water layers, laid special weight on determining their temperature and salinity.

Since then another method has been largely adopted, viz., determining the origin of the water from the organisms it contained. The algæ have been determined by *Cleve*, who has issued several publications concerning them [94, 96, 97], and the animals by *Aurivillius* [96, 98].

This method may, undoubtedly, in many cases, be adopted with favourable results, although a profound knowledge of the organisms, their life and distribution, be required.

When, in the autumn, southern organisms are found in the Skagerrak, which are absolutely extraneous (as for instance *Pilema octopus*, *Loligo Forbesi*), one has unequivocal proof of currents entering from the southern oceanic regions. Thus, in a like manner, it must be assumed that northern organisms, such as *Clione limacina*, *Calanus hyperboreus* must be brought in by cold currents from the North.

One needs, however, to be very cautious in drawing these conclusions, as we have endeavoured to indicate in an account of the Northern Ocean [99]. The Swedish scientists not only determine the Baltic and Atlantic, southern and northern currents, by their organisms, but they also separate, in like manner, Western Atlantic, Central Atlantic and Eastern Atlantic waters, which enter the Skagerrak at different periods of the year, the one from the other.

As the distribution of the Plankton organisms in the Northern Atlantic throughout the year is, still, but little known, *Aurivillius*, l. c. p. 130 [98], had to arrange them in groups, chiefly in accordance with the period during which they remain in the Skagerrak. Species existing in the Skagerrak, from September to February (for instance *Plagiacantha arachnoides*, *Parathemisto oblivia*), are supposed to be brought by the so called Northern Bank-water from the Northern Ocean's eastern area of admixture off the Norwegian coast. Others, which are not found in the Skagerrak until November—December, and which remain in the surface layers until April—June, are supposed to originate from the West Atlantic area of admixture near the shores of Iceland and Jan Mayen (for instance *Tintinnus urnula*, *Fritillaria borealis*). Again, others may be observed in the surface layers of the Skagerrak from September to the months of May —June, which, otherwise, exist as well in the Eastern, as in the Western area of admixture, and probably also in the Arctic itself (*Tintinnus denticulatus*, *Pseudocalanus elongatus*, *Temora longicornis* and others).

This geographical classification, by Aurivillius, is based on the occurrence of Plankton Organisms in the Skagerrak, while their distribution in the Northern Ocean, and surrounding coasts, is but little known*. We therefore consider it rather premature to form *hypotheses*, concerning the origin of the water-layers in the Skagerrak, founded on these biological results.

In our opinion, it is of little advantage to set up, and carry out in detail a hypothesis on the different movements of the oceanic layers, while but little is known of the hydrographical and biological conditions of the Northern Atlantic at various periods of the year. We will therefore confine ourselves to acknowledging that, all the year round, a body of water from the North Sea makes its way into the Skagerrak, mainly through the Jutland surface current, and, as undercurrents, through the Norwegian depression.

Moreover, these volumes of water must, partly, originate from the English Channel, and partly from the northern entrance to the North Sea, between Scotland and the west coast of Norway.

When the inflowing water layers change their character with the seasons of the year, such may be explained by alterations in the Hydrographical and Biological conditions in the North Sea, and its two openings, during course of a year; but these alterations may be influenced by factors of a local character, without it being necessary that periodical changes take place in the entire system of the North Atlantic currents.

As already indicated, Pettersson and Ekman have shewn that, during the autumn, large quantities of *Bank-water* flow into the Skagerrak, and that these Bank-water layers, generally in November, force the Baltic water from the surface.

In the course of the autumn, the Bank water, being the warmest layer in the Skagerrak, retains, until the latter part of November, a temperature of 11°, and contains considerable quantities of southern organisms (*Pilema octopus*, *Loligo Forbesi*, *Rhizosolenia styliformis*, *Rh.robusta*, *Guinardia flaccida*, *Biddulphia mobiliensis*).

*) The very valuable treatises on the Plankton of the Northern Ocean in 1898, of *Cleve* («Plankton collected by the Swedish Expedition to Spitsbergen in 1898», and «On the seasonal distribution of some Atlantic Plankton-Organisms»), and *Ostenfeld* (Iagttagelser over Overfladevandets Temperatur etc.) were not published when this was written.

It flows, to a great extent, along the coast of Jutland, then, subsequently, across to the Bohuslæn, where it partly runs as an undercurrent southward through the Cattegat, the remainder forming a coastal layer towards the entrance of the Christiania Fiord. From here, it, probably, moves down the south east coast of Norway. This Bank-water has a great influence on the Bohuslæn climate, like the Gulf Stream on the west coast of Norway; thus, for instance, one may find there, in Bohuslæn, some of the West European coastal vegatation, which, likewise, exists on the west coast of Norway from Lindesnes to Stadt, but which is entirely absent between, for instance, Lindesnes and Færder, where it cannot survive the severe winter-climate.

In 1893, the annual fluctuations took place, as described by Pettersson and Ekman, during good fishing years. 1893.

In November, Swedish investigations were made in the Skagerrak, while Hjort [95] examined the Norwegian Channel off Ekersund, the Hardanger Fiord, and the Sogne Fjord. By means of international cooperation, observations of the surface were simultaneously taken along the numerous steamship routes, in order that a complete surface map of the Skagerrak and the North Sea might be produced (see Pettersson and Ekman [97] pl. VI—VII, Hjort [95] pl. B.). The central and outer portions of the Skagerrak were covered with a Bank-water layer, of a thickness of about 30 metres, which drove back the Baltic water, to such an extent, that that formed but a narrow stripe along the coast of Sweden, and covered the Northern corner of the Skagerrak outside the Christiana Fiord.

We subjoin a profile (Fig 1), made by the Swedish Hydrographers on the 16th November 1893 (P. & E. [97] Pl. IX, Sect. 11), from Christiansand to Skagen *(The Scaw)*.

The Bankwater, and the subjacent $34^{0}/_{00}$ water (The North Sea water), attained the highest temperatures, mostly $9—10^{0}$, while the surface water had commenced cooling; the deep Atlantic water, however, was, again, colder, its boundary, upwards, about coinciding with that of a temperature of 8^{0}.

Fig 2, gives a section of the Gullmare Fjord in Bohuslæn (13—16 November), which, likewise, was made by Pettersson and Ekman. The Bank-water covered the bar of the Fiord, which prevented the layers of a higher salinity from entering. Thus, while the $34^{0}/_{00}$ water outside the bar, was of a temperature of 10—11°, the layers inside, or the same salinity, were only about 4.5°.

The Plankton along the coast of Bohuslæn contained, according to

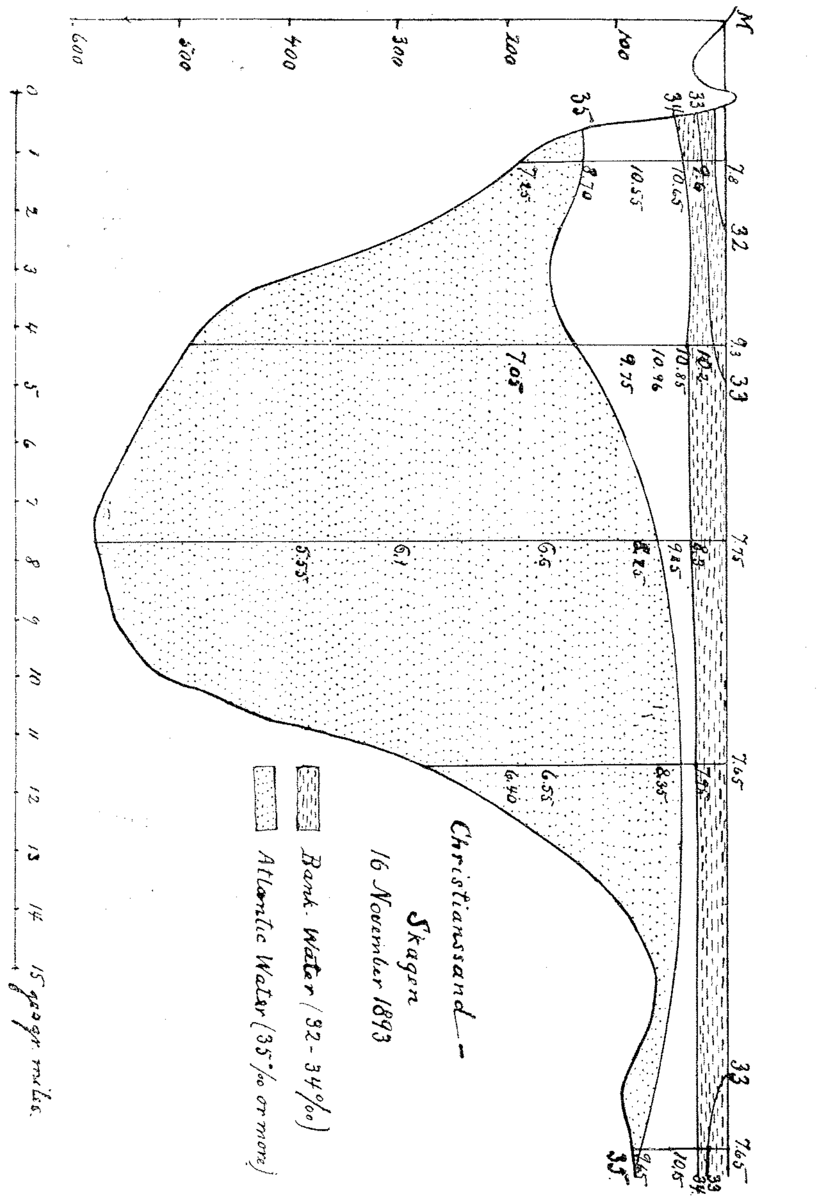

Fig 1. Copy of Petersson and Ekman's chart.*

Cleve's investigations [94], great quantities of Diatoms; Neritic forms, of a southern origin, agreeing with Cleve's Didymus Plankton (*Chætoceras didymum, Ch. curvisetum, Ch. Schüttii*) predominating.

*) «1 geographical mile» in this and the following figures = 4 nautical miles.

A similar Plankton was, at the same time, found off Øster-Risør, at the Swedish Hydrographical Station S IX, and S X (Cleve l. c. p. 8—9), and at Vallø (Hjort [95] p. 41).

Wherever this Diatom Plankton was found in quantities, the surface still consisted of Baltic water from the preceding summer. On the other hand, where the Bank water reached the surface, for instance at the Swedish Stations S VII, and A XV, only small quantities of Diatoms were found, but, practically, the same species as those obtained at the other stations. (Cleve l. c. 8—9).

Off Ekersund, Hjort found a rich Plankton [95] p. 41, containing the same species of Diatoms (Didymus Plankton), but only as subordinate constituents, together with Crustacees, Chætognathes and Peridiniaceæ.

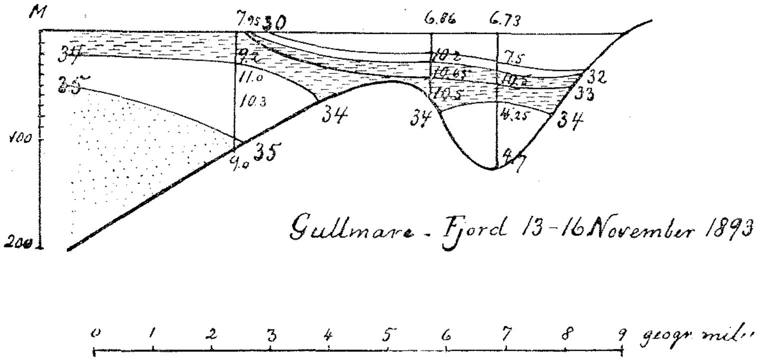

Fig. 2. Copy of Pettersson and Ekman's chart.

All this indicated, that the Neritic Diatoms had been developed during the summer, and autumn, on the surface of the inner Skagerrak.

In 1893, the herring fisheries proved exceptionally remunerative. The herring then advanced even in between the islands outside the Christiania Fiord. Off the coasts of the Skagerrak there was a take of more than 2 800 000 hektolitres. There must, consequently, have been particularly favourable conditions for the approach of the herring during that year.

In the autumn of 1894, international cooperative observations of the surface were undertaken; the results of which have been the production of a surface map for November, which also is published in Hjort's treatise [95] Pl. C. This map shews, that the spread of the Baltic layers was much greater than that of the previous year. 1894.

While the Baltic current, in November 1893, was confined to the Skagerrak and the Cattegat, it ran, in November 1894, all along our west coast, at several spots attaining a width of 16—20 geographical miles, the Bank-water being less represented than in 1893.

Outside the entrance of the Christiania Fjord, Hjort thus found, that (l. c. p. 26) the Baltic water layers obtained a depth of 50 metres, while, in 1893, they only reached to a depth of about 8—10 metres.

The herring did not then approach land, but remained out in the Skagerak. The Plankton, during that year, consisted, mainly, of Peridiniaceæ, while the Diatoms were only first found further out in the Skagerrak.

New Investigations in the Skagerak, Decr. 1896.

Still more divergent were the conditions in 1896. As the herring fisheries during that year proved a dead failure, the Swedish and Norwegian hydrographers made a joint exploration of the Skagerrak and the North Sea in the middle of December. In addition to the usual surface observations taken on the private Steamship Companies' routes, rich materials from the deep-sea investigations were, likewise, obtained, the Swedish scientists examining the S. Eastern part of the Skagerrak, while Hjort, from H. M. S. »Heimdal«, took observations on the lines, Christiania Fiord—Skagen (the Scaw), and Cattegat—Arendal.

All these investigations resulted in the publication of a popular reatise [97] by Cleve, Ekman, Hjort, and Pettersson. Since then the Swedish Hydrographers have published their researches in a more detailed report by Pettersson and Ekman [97].

Here we shall chiefly account for all that was accomplished by the Norwegians; this we cannot do, however, without, at the same time, mentioning the Swedish investigations.

The Norwegian material subjected to our observations is given in our Hydrographical Table I, and in the Plankton Table, No. 1.

The results prove that the Hydrographical conditions in 1896, really varied considerably from those of good herring years, such as 1893.

First of all it will be seen that the Baltic water covered almost the entire surface of the Skagerrak, extending to a depth of about 20 metres. It was only in the S. W. corner, and in a wedge along the shores of Skagen (the Scaw) that layers of high salinity could be found on the surface.

The Bank-water in 1896, was represented in comparatively less quantities, than usual, as thin layers under the Baltic waters, especially along the coasts where it was of much less extent than usual. Moreover it may be noticed, that the salt Atlantic water rose to an exceptionally high level, mainly on the coast of Sweden.

This is best seen from Fig. 3, which gives a profile of the Gullmare Fiord, reproduced from Pettersson and Ekman's. It shews that the Atlantic water has even crossed the bar of the Gullmare Fiord; otherwise it does not usually reach the coastal banks, and the bar of the fiord, during this period, is, generally, covered by Bank-water (see Fig. 2). Fig. 3 also shews the thinness of the Bank-water layer on the coast of Sweden.

The results of the Norwegian investigations of the Skagerrak are presented in Figs. 4 and 5. The former shews a section from Færder to Skagen (the Scaw), from which it is clear that the Baltic water (with a salinity up to 32 $^0/_{00}$), covered the whole of the surface with a thin layer, whose temperature ranged from 2.°5—3.°5 on the surface. Only close to Skagen, (the Scaw) Station VI, did the warmer Bank-water reach the surfac (7.°3).

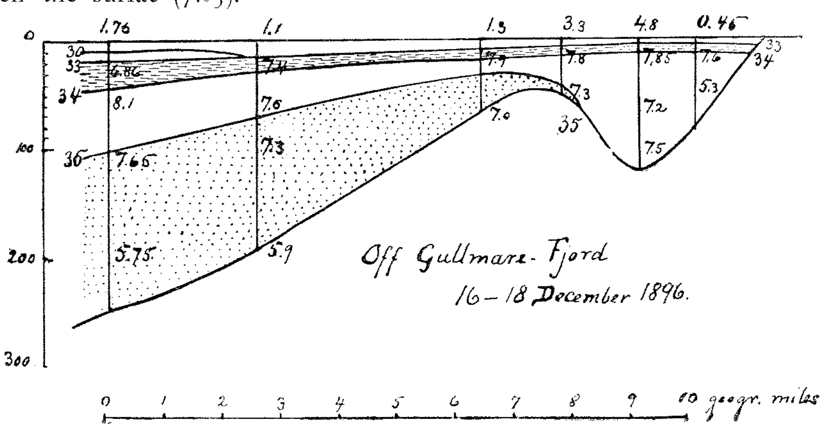

Fig. 3.

The highest temperatures, 8.°5—9.°5, lay at a depth of some 40 metres, about on a level with the isohaline for 34 $^0/_{00}$, consequently on the boundary of the Bank-water and the North Sea water.

At Station VI, close to Skagen (the Scaw), no higher temperatures than 7.°5 were met with, which shews, that the body of water flowing in with the Jutland current during that period, is colder than the warmest layers in the Skagerrak.

The maximum temperature in the Skagerrak, 9.°7, was found oft Hvaløerne (Station XV) at a depth of 20 metres; farther up the Christiania Fiord, at Vallø (Station XVI) even 10.°3 was met with at the same depth. Some days later, Pettersson and Ekman found a temperature of 9.°6 at 5 metres depth in the Gullmare Fiord, between Bornø and Holma. (l. c. p. 103), otherwise a temperature exceeding 9°

was but rarely found in the Eastern part of the Skagerrak. The Atlantic water boundaries, on this section, will generally be found at a depth of 100 metres, except at Færder, (St. 1)where it rises to 70 metres below the surface

If this section be compared with that of the Gullmare Fiord, (Fig. 3), and with the profile of Christiansand—Skagen (the Scaw), from November, 1893, (Fig. 2), it will be seen, that the Atlantic water in the central part of the Skagerrak, stands at a comparatively normal level; it is, thus, only along the eastern coast that an exceptional rise can be observed.

As is remarked by Pettersson and Ekman, this phenomenon may probably be explained as a reactionary or compensatory current, produced by the unusually strong, and lasting Baltic surface current.

The other section (Fig. 5) was taken from Arendal to the Cattegat, and runs to the north of Skagen. It is, furthermore, seen, that the Baltic water covered the whole surface; only at Station X, was it surplanted by the Bank-water.

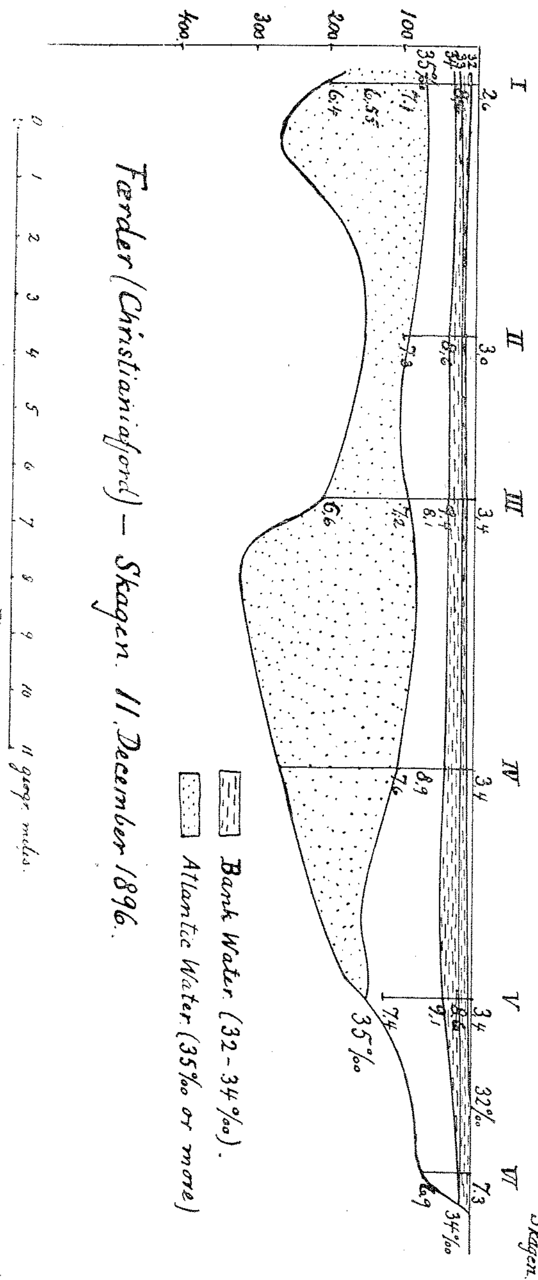

Fig. 4.

The temperature on the surface was uniformly higher, about 5°. The Bank-water attained about the same thickness as on the former profile; at the eastern stations, the isohalines for 32 ‰ and 33 ‰, lay very close together; in other words, there was very little water containing a salinity of 32—33 ‰.

The Atlantic water, in the middle of the Skagerrak, at St. IX, rose up to the same depth (70 metres) as at Færder; off the coast of Jutland it did not even rise to the depth of 100 metres, nor even off Arendal. On the coast of Norway all these isohalines turn slightly downwards; consequently no rise of the subjacent layers had taken place, as was seen on the coast of Bohuslæn (Fig. 3) and, partly, at Færder. (Fig 4).

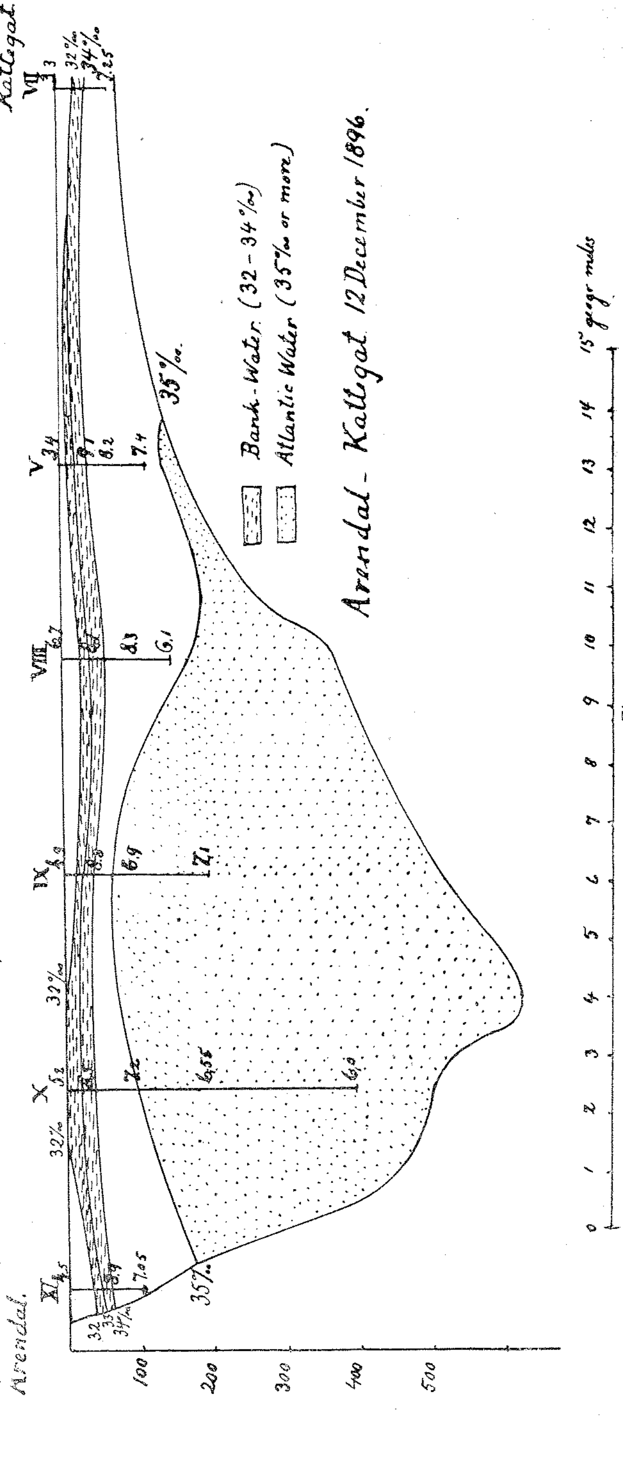

Fig. 5.

At that time of the year, the Skagerrak *Plankton* yielded very important information. Table 1 denotes a survey of the vegetable Plankton at all the hydrographical stations.

From this table one gets a strong impression of the exceptional similarity of the Plankton in all the surface layers of the Skagerrak; the same species being found, in greater or less numbers, in all the samples. On the other hand, there are certain stations which furnished a much poorer Plankton than all the others; the most remarkable being St. VI (Skagen), and Sts. XIX—XX. (in the inner portion of the Christiania Fiord); St. X had also an excessively poor Plankton. These are just the stations which had no Baltic water on the surface; at Skagen it had been displaced by salt water which had flowed in with the Jutland current; in the Christiania Fiord it was forced out by the prevailing northerly winds. This will, subsequently, be dealt with more closely by us.

Moreover at Station X, in the centre of the Skagerrak, the Baltic water was, likewise, supplanted by the Bank-water.

The same may be observed from the samples of Plankton, gathered by the Swedish hydrographers during the same period, and which have been examined by Cleve; the results being published in Cleve's great work [97] Table VII. He states, that more Plankton was found on the surface than at a depth of 15—30 metres; the surface consisted, mainly, of Baltic water, of a temperature not exceeding 4.°8; only at two Stations, *Ramsø* and «*W. of Väderø*» did the Bank-water reach the surface with a salinity of 33.3, and respective temperatures of 5.°6 and 6.°0. The Plankton samples from these stations were poorer, especially as regards diatoms, than any of the remaining surface samples. From this, one may safely conclude, that the rich vegetable Plankton belongs to surface layers of less salinity.

As the species are so evenly distributed all over the surface, it may be further concluded, that those water layers had remained on the surface of the Skagerrak for some length of time, so that the algæ had time to develop itself evenly, and become plentiful.

It is, however, another question, whether the germs of this abundant Plankton vegetation had been brought in with the oceanic currents, or if it had grown on the shores of the Skagerrak itself. To prove this, it will be necessary to examine, more closely, the species which appear most characteristic for the samples.

The samples contained both peridiniaceæ, and diatoms, in great quantities; of the former, the *Ceratium tripos* is the most prevalent, while the diatoms are represented, chiefly, by the oceanic species *Chætoceras boreale**, *Thalassiothrix Frauenfeldii*, and *longissima*, as well as by a number of neritic species, especially *Skeletonema costatum*. Amongst these the *Ceratium tripos* is so common, both in the Skagerrak, and the circumjacent waters at all times of the year, that no definite conclusions can be formed from its occurrence.

The Neritic Diatoms, probably, belong to the coasts of the Skagerrak itself. At that time of the year no large quantities of them are to be found, as the rich neritic autumnal plankton (*Didymus-plankton*) is then on the decrease, while species, which, in the cold season, form the other annual maximum, *the Sira plankton*, are not yet numerously represented. We find, however, species representing both these biological groups, but the main portion consists of species, which attain their maximum at periods differing from those of the two main maxima, viz., *Skeletonema*, *Thalassiosira gelatinosa*, and *Rhizosolenia setigera*.

Chætoceras boreale, and the *Thalassiothrix*, are oceanic species which *may* have entered with the inflowing currents from the North Sea. Cleve's Plankton Map of the North Atlantic [97] Pl. III, shews, that *Thalassiothrix longissima*, in the summer, has its greatest distribution in the N. Western part of the Atlantic, near the coast of Greenland, and Iceland («*Tricho plankton*»), while *Chætoceras boreale* is supposed to originate from a wedge in the central part of the Atlantic, which runs in the direction S.W.—N.E., past the Faröe Islands.

There is, however, no ground for assuming that these species have been brought into the Skagerrak from the above mentioned places. It has recently been proved by us (Hjort & Gran [99]), that the oceanic diatoms are almost always sufficiently numerous in the North Atlantic, to develop into a rich plankton, under favourable circumstances. *Ostenfeld* has shewn (Wandel & Ostenfeld [98]), that the area between Scotland and Iceland, in May, contains a rich Diatom Plankton, but that very small quantities are to be found during the remainder of the year.

*) *Cleve* has mentioned this form, which appears in these samples, under the name of *Chætoceros boreale* var. *Brightwellii*; the characteristics which are said to distinguish it from the main species, are, however, of no systematic value, and in my opinion, it does not require any specific name. H. H. G.

The above named oceanic species, also exist in the Skagerrak in small quantities, nearly all through the year; it is therefore no easy task to decide, whether the main portion has, originally, come from outside, or if it has been developed in the Skagerrak itself. We have, however, already shewn, that, during December 1896, these species were found in the greatest numbers in the Baltic water layers which covered the surface of the Skagerak; while the North Sea, at the same time, had quite a different plankton (*Rhizosolenia styliformis*, *Coscinodiscus concinnus*, *Biddulphia mobiliensis*).

A similar Plankton seems to have prevailed on the surface of the Skagerrak, till later on in the winter; Cleve examined the Skagerrak, and North Sea Plankton in January 1897, the results of which are given in Table IX [97], and on the map, Pl. IV*).

He found great quantities of *Thalassiothrix longissima* in the Skagerrak, somewhat less of *Chætoceras boreale,* whilst the neritic species were but poorly represented, and mainly belonged to winter groups *(Thalassiosira Nordenskiøldii).* On his map, Cleve denotes the Skagerrak Plankton as a mixture of *Tricho-Plankton* and *Sira-Plankton (Thalassiosira).*

On the other hand, the North Sea continued to contain quite a different plankton, which more resembled the December plankton of the North Sea, than that of the Skagerrak *(Coscinodiscus concinnus, Biddulphia mobiliensis, Halosphæra, Peridiniaceæ).*

The change in the character of the plankton that took place from December to January, can thus hardly be due to any influx from the North Sea.

On the other hand, it might very well have arisen from a local development, as the species in December are nearly identical with those in January, the quantative character, only being somewhat altered.

Thalassiothrix, and the neritic winter forms, appeared to have increased in numbers, while *Chætoceras boreale* decreased, and the neritic autumn forms had almost disappeared. Furthermore, we think it possible that the changes, which took place in the plankton on the surface of the Skagerrak, from the summer till the beginning of December, may be owing to a gradual local development, though, we do not consider it improbable that oceanic forms were brought in from outside. The Plankton

*) *Vide* Cleve l. c. Table VIII. The first 5 Stations are situated in the Skagerrak, the others in the North Sea.

Investigations thus lead to the same results as those obtained from the hydrographical studies, viz., that the surface layers of the Skagerrak remained stationary since the autumn; no changes of the water had occurred in November, as is generally the case during successful herring fishing years. In November 1893, the Bank water forced its way in, and covered the whole of the surface, forcing the Baltic water into the Norh Eastern corner, while, in the autumn of 1896, the Bank-water was exceedingly scarce in the Skagerrak.

In the above mentioned work [97], on the conditions of the Skagerrak during the then existing herring period, Cleve, Ekman, Hjort and Pettersson have endeavoured to prove, that those conditions caused the non-success of the herring fisheries during the autumn of 1896. They also state that the exceptional hydrographical conditions, during that year, were, probably, connected with the Meteorological, as the atmospheric pressure in the North of Europe, during the autumn, proved to be very high everywhere, with a succession of E. N. E. and S. E. winds in the Skagerrak and the North Sea.

That this was the case may be seen by comparing the annual report of the Norwegian Meteorological Institute in 1896 (Mohn [97]), with Mohn's Climatic Tables for Norway (»Klimatabeller for Norge»).

From these we find the average pressure in November, viz.,

	Average for 1866—95	1893	1896
Færder	757.2 mm.	755.2 mm.	762.5 mm.
Mandal	756.9 —	756.1 —	763.1 —
Skudenes	757.4 —	757.6 —	763.5 —
Bergen	755.7 —	756.0 —	761.2 —

	December Average	1893	1896
Færder	756.6 mm.	756.0 mm.	759.9 mm.
Mandal	756.5 —	755.9 —	759.1 —
Skudenes	756.6 —	755.0 —	758.3 —
Bergen	754.8 —	753.0 —	756.3 —

It will be seen that the atmospherical pressure at these Stations, that is, all along the Norwegian Skagerrak and North Sea coast, in November and December 1893, was practically normal, or just below the average.

During the same months in 1896, however, the pressure exceeded the normal by several millimetres, especially in November (5.3—6.2 mm), though rather less in December (1.5—3.3 mm.).

The atmospheric pressure at the same stations in January 1897, likewise appears to be 3.3—4.3 mm., above the normal, while in January 1894, it was 2.5—3.6 mm., below the average of the period 1866—95.

In addition to this, *Fulton* has found that the system of currents of the North Sea in December 96—January 97, went in an opposite direction to the general flow, on account of the incessant easterly, and south easterly winds. Thus, along the southern shores of the North Sea, the current ran in a westward direction, instead of the ordinary course towards the east, and north east.

It is evident that these circumstances must have affected the influx of the Bank water to the Skagerrak, as the in-going current along the coast of Jutland, is but a continuation of the coastal currents usually existing in the North Sea.

The perpetual north easterly winds must, further, have assisted in spreading the Baltic water over the entire surface of the Skagerrak; for short periods they even succeeded in forcing the Baltic surface water away from the northern part of the Bohuslæn coast, as is shewn on the surface map for December (Pettersson and Ekman [97] Pl. XII).

The north easterly winds indirectly caused the Atlantic deep water layers to be drawn so high up, along the east coast of the Skagerrak, in order to compensate for the out flowing surface currents.

The results arrived at by the four authors of the treatise »Skageraks tilstand» are, therefore, that, in the last instance, it was the meteorological conditions which caused the failure of the herring fisheries during the winter 1896—97.

Investigations Autumn 1897.

The hydrographical investigations in the autumn of 1897, were restricted to the north eastern corner of the Skagerrak, about the entrance to the Christiania Fiord.

It appears, from earlier researches, that the hydrographical conditions in the central part of the Skagerak are, comparatively, settled, while all changes are more marked in the neighbourhood of land. Along the shore there is a continual flow, while in the centre of the Skagerrak the water may remain stationary.

Langesund was chosen as the starting point of the Norwegian hydrographical investigations, partly because a branch of the deep channel in

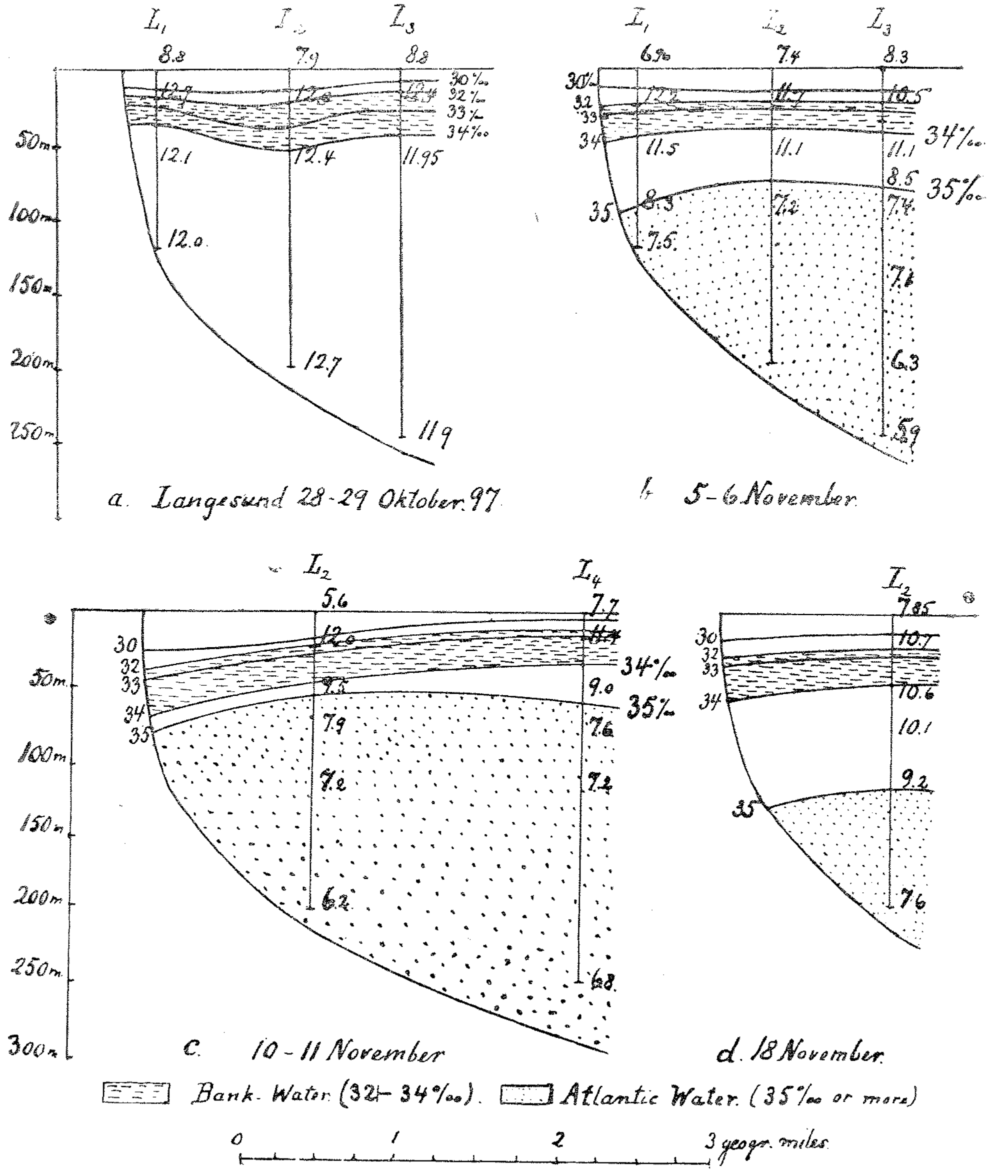

Fig. 6 a—f. Sections off Langesund — autumn 1897.*

the Skagerrak advances there close to the shore, and, partly, on economical grounds, as the Association for Saving Life at Sea permitted investigations to be made from its vessel «Langesund», on her daily cruises.

*) «1 geographical mile» on the figures = 4 nautical miles.

In this manner hydrographical profiles were obtained weekly, up to 10 geographical miles from the shore, from the 28th of October until the 4th of December.

The results of these investigations are given in the Hydrographical Tables II, A.—F, and on the Plankton Table 2. These shew, in a striking manner, that the hydrographical conditions along the coast, vary, to a great extent, with the meteorological conditions.

The first profile, taken on the 28—29 of October (Fig. 6 a.), shews that the Baltic water is 10—15 metres in thickness, below which, are the Bank-water layers of 20—30 metres in thickness; these seem to be thickest at Station L_2, 4 geographical miles from the shore. Below the Bank-water there is a thick layer, with a salinity of 34 ⁰/oo, but no Atlantic water was observed.

The temperatures were, universally, very high, 11—12⁰, though slightly colder on the surface. These thick, and warm layers cannot have been warmed at the spot; they must be of a southern origin, and must have been wedged in along the coast by the currents.

The Plankton mainly consisted of southern neritic forms (*Chætoceras contortum*, *didymum*, *Schüttii*), partly, also, of species capable of standing a low salinity, and which, therefore, may originate from the Cattegat and the Baltic (*Chætoceras danicum*, *radians*). Most remarkable is the appearance of *Rhizosolenia robusta*, an oceanic form belonging to warmer regions.

It is commonly found in the Mediterranean, and was, previously, never found further north than Plymouth. This Alga was undoubtedly, brought up with the southern currents. Its occurrence strengthens, still more, the hypothesis that, the warm water layers — the Bank water and the North Sea water, — are of extraneous origin. They, probably, have come with the Jutland current, which, every autumn, carries great quantities of southern organisms into the Skagerrak.

There was an essential change on the 5th and 6th of November (Fig. 6 b). The surface, it is true, was, as before, covered with Baltic water to a depth of about 20 metres, but the thickness of the Bank water, had decreased, considerably, while the warm 34⁰/oo water had also diminished. At the outside stations, Atlantic water was found even at the depth of 80 metres.

The Bank water still retained a warmth of 12⁰ or more, but the Atlantic water, which then filled the entire basin below 80—100 metres, was much colder. The isohaline for 35⁰/oo, almost coincides with the curve of 8⁰, and, in the deep, the temperature fell even to less then 6⁰.

The Plankton on the surface shewed no particular change from the previous week's observations. At Station L_3 a *Hensen* tow net was used, with a Petersen shutter, by means of which it was possible to ascertain the different kinds of plankton in the various layers.

Rhizosolenia robusta was still found in considerable quantities in the warmest layers (temperature above 11⁰), while the surface contained, mostly, neritic diatoms. At a depth of 5—15 metres *Rhizosolenia alata* was found in great quantities.

On the 10—11th of November (Fig 6 c), the Atlantic water had risen still higher, to but 60 metres below the surface, the Baltic-water being still of about the same thickness as before, but the warm, intervening layers had diminished, while the Bank-water and the North Sea water had become reduced, so that they together, at St. L_2, were only some 30 metres in thickness. Of the Plankton Diatoms, the Cattegat forms were somewhat more predominant than before (*Chætoceras danicum*). During the whole of that period, the atmospheric pressure on the Skandinavian peninsula proved exceptionally high, with fine weather, and northerly, or gentle N. E. winds. On the 11th November, however, the weather changed, together with a fall of atmospheric presssure, and, during the following days, strong south, to south westerly winds prevailed in the Skagerrak, the result of which was soon perceptible in the rise of both salinity and temperature on the surface; thus, on the 13th, Bie obtained at Station L_2, a surface temperature of 11⁰, and a salinity of 30.02 ⁰/oo. The gales had, thus, driven back the Baltic water layers and the water on the surface, therefore, was the same as was found, 3 days previously, at a depth of 15 metres.

As soon as weather permitted on the 18th of November, deep water examinations were made at Station L_2. (Fig. 6 d).

The Baltic water again covered the surface to a depth of 15 metres, but the Atlantic water had sunk to 120 metres below the surface. The 33⁰/oo, and chiefly the 34⁰/oo water, had increased in thickness, their total increase forming a layer of 60 metres. The temperature of the mixed layers was then somewhat lower than before, viz., about 10⁰. On the 18th, another outbreak of south westerly gales occured after but two days of calm weather. This time they lasted until the 23rd. On the 25th, renewed deep water investigations were made.

Fig 6 e, denotes a further increase in the thickness of the Bank-water, and $34^{0}/_{00}$ water; the $33^{0}/_{00}$ water at Station L_2, was about 50 metres thick, while the $34^{0}/_{00}$ water appeared to reach right to the bottom; the temperature of these layers had then dropped to 9^{0}.

Atlantic water was not observed at the outside stations, except at Station L_1, where it still remained, having probably, been prevented from receding by the belt of islands, and the prominent parts of the main land.

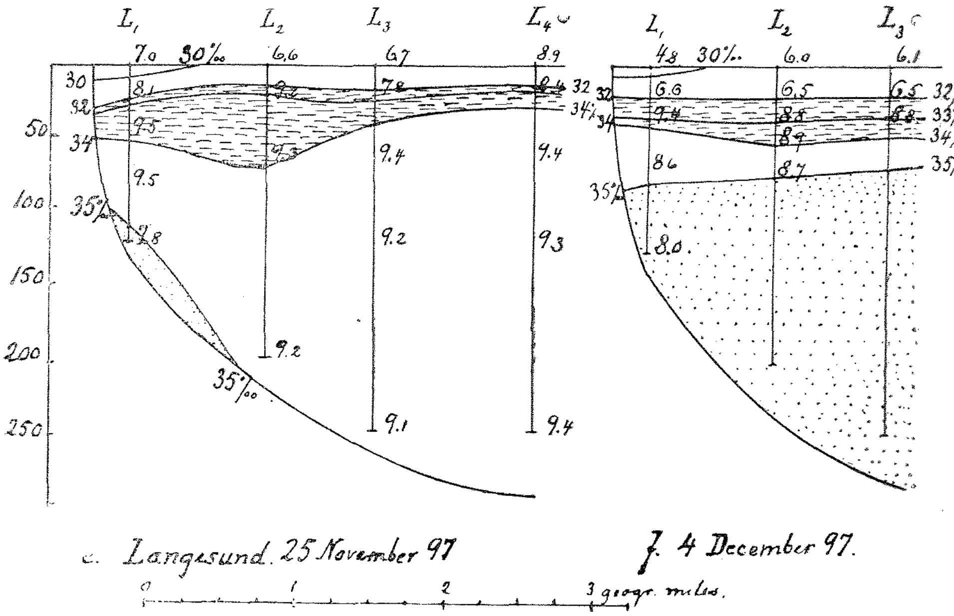

Fig. 6 e—f.

Simultanously with the hydrographical changes succeeding the south westerly gales, was the first approach of the herring towards «Hvaløerne», on the 25th of November, and to the coast of Bohuslæn, about the same time.

A good number were caught in the nets during the following days at the outermost fishing stations near «Hvaløerne». On the 30th, hydrographical investigations were carried on there, to which we shall soon refer, but shortly afterwards the situation became again changed, and the herring fishing ceased.

After a few days of northerly wind in the Skagerrak, the southwest winds returned on the 26th, and lasted till the 28th.

Our assistant, Bie, took observations at Langesund on the 30th, but only at one station, L3; the result denoting that the Bank-water had further increased in thickness, its temperature being then about 8.°5.

The observations at Langesund were ,however, discontinued on account of the persisting northerly winds, lasting from the 29th of November until the 4th of December. A profile was then made by Assistant Bie, (6 f), showing that the hydrographical conditions, characteristic of the first half of November, then, again, prevailed.

The Atlantic water was found at a less depth than 80 metres, the total thickness of the Bank-water and the North-Sea water being about 50 metres. At the same time the herring fishery at Hvaler terminated.

All these observations indicate that the hydrographical conditions along the coast vary extremely, and that the variations are closely connected with the nature and direction of the winds.

The Tables, given on the following page, will tend to create a still stronger impression of this fact.

On these we have given the daily observations (according to Mohn's Meteorological Journal [Jahrb. 97]) of the atmospheric pressure, direction and force of wind at 8 o'clock a. m., at Færder and Mandal, and for the same period that our observations at Langesund (28th October—4th December) were carried out.

We have italicized the different figures representing an atmospheric pressure *below* the normal pressure for the respective months throughout a long period (1866—95), as recorded by *Mohn* in his Climatic Tables [96].

Thus in October,	November,	December,
At Færder 767.0	757.2	756.6
» Mandal 756.6	756.9	756.5

We have, moreover, italicized the winds which might be regarded as sea winds; thus at Færder all south westerly and southern winds from WSW. to S., and, at Mandal, all western or southerly winds from WNW. to S.

Finally, in the third column there will be found simultaneous observations from *Skagens Rev,* of the direction of the current, its velocity and surface salinity. These observations we have obtained from the Danish Meteorological Institute's «Nautisk Meteorologiske Observationer» for 1897.

Station.	Date	Færder. Atmospheric pressure	Færder. Direction of wind	Færder. Force of wind	Mandal. Atmospheric pressure	Mandal. Direction of wind	Mandal. Force of wind	Skagens Rev (Reef). Drift of current	Skagens Rev (Reef). Force of current	Skagens Rev (Reef). Salt per mille
Octr.	28	72.6	NNW.	0—1	71.7	E.	1	S.	1.5	25.1
	29	70.2	NNE.	1	70.2	E.	1	SSW.	0.7	28.6
	30	69.3	N.	1	70.2	NE.	1	*WSW.*	*1.5*	30.5
	31	69.0	WNW.	1	69.6		0	SSW.	1.0	29.3
Novr.	1	72.8	NW.	0—1	73.4		0	SSW.	1.7	25.9
	2	73.0	N.	1	73.2	NNE.	3	SSW.	1.3	26.7
	3	74.3	NNE.	1	75.3		0	SSW.	1.0	24.6
	4	75.8	N.	1	75.3	NNE.	2	S.	2.0	22.2
	5	70.7	*WSW.*	*1*	70.2		0	S.	2.0	22.7
	6	72.4	NNE.	2	71.6	NNE.	1	S.	3.0	23.8
	7	79.0	NE.	1	78.2	ENE.	2	SSW.	2.5	23.5
	8	76.1	NNE.	1	76.0		0	S.	1.0	23.7
	9	77.1	NNE.	1	76.6		0	S.	1.0	24.1
	10	79.2		0	78.3	SE.	1	S.	1.7	21.5
	11	73.2	*S.*	*2*	71.7	E.	1	SSW.	2.3	24.9
	12	62.8	*SSW.*	*2*	62.1	NE.	2	*SW.*	*0.5*	30.4
	13	*46.8*	*SSW.*	*3*	*47.0*	*SW.*	*3*	*W.*	*2.0*	*32.9*
	14	*51.0*	*SW.*	*2*	*51.5*	*SW.*	*2*	*W.*	*1.3*	*33.7*
	15	*43.3*	N.	3	*44.8*	*W.*	*1*	*W.*	*0.3*	*33.9*
	16	63.5	WNW.	2	66.5	NE.	1	S.	0.3	*33.1*
	17	65.3	E.	1	62.7	SE.	1		0.0	*32.8*
	18	*50.4*	*SSW.*	*2*	*53.4*	*WSW.*	*2*	*WNW.*	*1.3*	*32.3*
	19	*52.5*	*SW.*	*3*	*56.8*	W.	*3*	*W.*	*1.0*	*33.2*
	20	*56.1*	*WSW.*	*3—4*	63.1	*WNW.*	*2*	*WNW.*	*3.0*	*33.4*
	21	68.4	*W.*	*2—3*	71.5	*W.*	*1*	*WNW.*	*0.3*	*32.2*
	22	65.1	*WSW.*	*3*	69.8	*WSW.*	*2*	*W.*		31.2
	23	*56.8*	NW.	3	60.9	*NW.*	*1*	*W.*	*2.0*	30.9
	24	62.7	NW.	2—3	66.4		0	S.	0.5	31.3
	25	68.7	NNW.	2	70.1		0	S.	1.3	31.2
	26	65.9	*WSW.*	*2*	66.7		0	S.	1.5	30.7
	27	*49.4*	*WSW.*	*3*	*53 6*	*W.*	*1*	*NW.*	*2.3*	31.1
	28	*38.7*	*SW.*	*2—3*	*40.9*	*W.*	*2*	*WNW.*	*2.0*	*32.1*
	29	*35.5*	NNE.	3—4	*31.7*	NE.	4—5	*SW.*	*0.3*	31.5
	30	*41.8*	WNW.	1	*44.3*		0	NNE.	0.7	31.6
Decr.	1	*45.8*	NNE.	3	*44.5*	NE.	4	SSW.	0.3	*32.3*
	2	60.6	NNW.	3	63.0		0	S.	0.5	31.9
	3	67.7	NNE	2	68.4		0	S.	1.5	31.5
	4	67.8	NE.	1	67.9	NNE.	2	SE.	0.5	31.5

The lightship is so situated, that all currents from the south (SSE. to SSW.), come from the Cattegat while westerly currents (from WSW.—NW.) bring the surface water from the southern parts of the Skagerrak. We have italicized all currents that flow in from outside, that is, all currents from WSW. and NW.

Surface water, with a salinity exceeding 32⁰/₀₀, has been italicized, as such high salinity, according, to Pettersson and Ekman, is characteristic of the layers flowing into the Skagerrak from outside.

In this instance it is the *Bank-water* which is conveyed with the Jutland current past the Skagen lightship, while the Baltic surface water is carried in a northward direction by the currents from the south. It will be seen that the italicized parts of the table agree in all the columns.

Corresponding with the low atmospheric pressure, are the southern and south westerly winds; and, at Skagen, the inflowing currents get the upper hand, and force the Bank-water to the surface.

A high atmospheric pressure, on the contrary, results in calm weather, or off shore winds, and outflowing currents, containing Baltic water, may be found on the surface at Skagen. Thus during the abnormally high pressure, which prevailed from the 28th of October to the 12th of November, the currents at Skagen constantly flowed in an outward direction — the 30th, however, forming an exception — and Baltic water was found on the surface.

From these above mentioned facts, we may conclude that a smaller quantity of Bank water had entered the Skagerak than is usual at that time of the year. We observed, too, that the Bank water layers at Langesund, at that time, constantly became thinner, and that the Atlantic water from the depths of the Skagerrak was drawn, upwards, to compensate for the outflowing volumes of water.

The two gales from the 12th to the 15th, and from the 18th to the 23rd November, greatly added, however, to the increase of the Bank water at Skagen — the saline contents of the surface rising to 33.9 — while, at the same time, the thickness of the Bank water at Langesund increased, while the Atlantic water decreased.

The storm lasting from the 27th to 29th of November, caused a still further increase of the phenomenon, but, after that, the atmospheric pressure commenced to rise again, the current at Skagen flowed in an outward direction, and the Bank water decreased on the Norwegian coast. The first appearance of the herring on the coast of Norway, after the great south westerly gales, was observed at Hvaler on the 25th of November, where they arrived from the south coast of Sweden.

Hydrographical researches were made at Hvaler on the 30th (fig 7), Table II, G. The net fisheries were still continued, especially at Tisler and Heia. Station H1, is situated close to the best fishing grounds, in the channel between Tisler and Lauer. It will be seen that the Bank water there attained a great hight, about 5 metres below the surface, and was about 30 metres thick, the temperature being 9^0 and upwards.

Further to the westward, at Torbjørnskjær (St H3.), and off the Christiania Fiord (St H4), the Bank water was first met with at a depth of about 15 metres, and the temperature of the uppermost layers was lower throughout. Off Langesund, the temperature was even still lower during that period; (Table II F.); the Bank-water was found there at a depth of 10 metres.

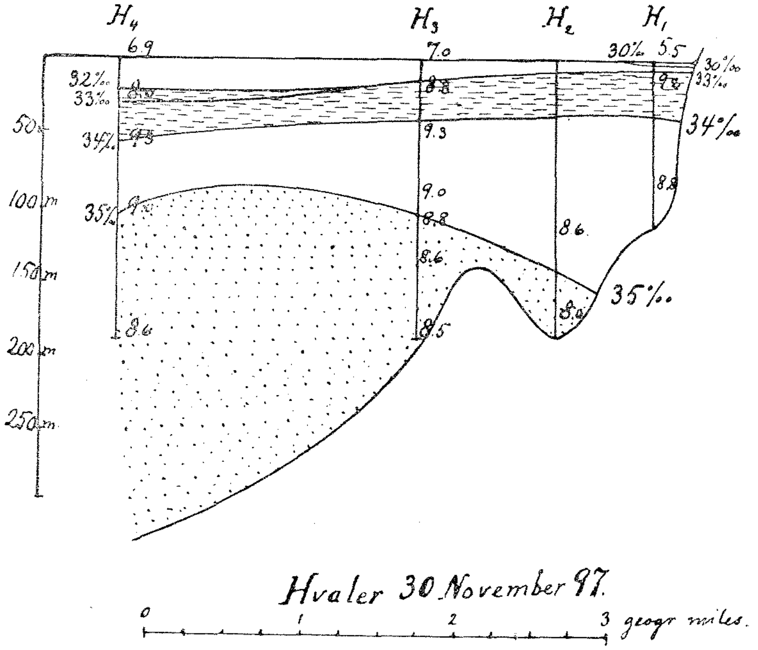

Fig. 7.

As soon as the change in the hydrographical conditions took place, so soon did the herring fishery at Hvaløerne cease.

With reference to the Plankton (see Table 2), the vegetable plankton remained, chiefly, in the upper layers, and showed no important change in its composition, although the hydrographical conditions of the deep may have been altered. The Plankton appeared to have undergone a gradual development during the autumn, the diatoms giving way to the peridiniaceæ, which then predominated.

The results thus arrived at from the investigations in 1897, respecting the herring fisheries, shew that the little approachments of the herring occurred, simultaneously, with a brief change in the hydrographical conditions. And as the results correspond with the experience gained from earlier years, it strengthens the hypothesis, that a connection exists between the approach of the herring, and the appearance of the Bank water along the coasts of the Skagerrak.

But the material at present to hand, is too inconsiderable to allow of a definite conclusion being formed. Still less easy is it to decide the question, as to how the herring-fisheries are dependent on the inflowing Bank water.

Hitherto the Swedes and Norwegians, in common, have succeeded in ascertaining that, the approach of the herring, during the last few years, has had a certain connection with the influx of Bank-water, and that, to a given extent, the number of herring has corresponded to the thickness of the Bank-water along the coast.

Furthermore, we have been able to shew that, the appearance of Bank-water along the coast is connected with the meteorological conditions. Little is yet known, however, as to the origin of the herring, or why it moves into the Skagerrak. So long as this remains a mystery, it is impossible, with any certainly, to foretell the future prospects from the basis of hydrographical investigations.

The hydrographical conditions along the coast of the Skagerrak are very variable, and the least factors will, in no time, suffice to cause great changes. It is, therefore, probable, that the great periodical fluctuations in the fisheries are founded on deeper grounds, and that the hydrographical changes viz., the struggle between the Bank water and the Baltic current, are but of secondary consideration.

The Swedish scientists (Pettersson, Ekman, Aurivillius) have set up the hypothesis that, the herring may be regarded as a plankton animal, drifting with a body of water like the crustacea etc., on which it lives.

The herring which makes its appearance in the Skagerrak during the summer and autumn, is, according to their presumption, brought in with the «Southern Bank-water» from the southern part of the North-Sea, while the Winter Herring, belongs to the «Northern Bank-water», which is supposed to proceed from the west coast of Norway.

Aurivillius states that the Summer Herring subsists on the southern plankton animals, while northern forms are found in the stomach of the Winter Herring.

A great deal might be said in favour of the supposition that the herring,, during its migration in the Skagerrak, goes with the ocean currents.

All experience shows, that it first approaches the shore on the coast of Sweden, and then moves in a northward direction towards the the entrance of the Christiania Fjord. Only later on in the winter may it advance further westward, towards Arendal and Christiansand. This is the same course as that of the principal current of the upper layers, and if the herring follows this current, it will be constantly moving in the warmest layers of the Skagerrak, which, even at the end of November, are of a temperature of 9^0, or more.

The distinction between the Autumn and Winter-Herring, is in our opinion, rather artificial, as would be the distinction between southern and northern Bank-water.

During the successful years, the fishing is pursued without interruption throughout the entire autumn, and no racial distinction between the shoals of herring has been proved as yet. That the Bank water is colder in December than in October, may, easily, be explained, even though it be assumed that the inflowing water layers always run in the same direction, and from the same pale of Sea.

The cooling effect of winter appears in the southern part of the North Sea, as well as on the coast of Norway, and the Bank water that enters in December, must be colder than the warm water of October and November, whether it originates from the northern or southern part of the North Sea.

As not a single fact indicates that the surface water along the S. E. coast of Norway can flow in, towards the Skagerrak, for any length of time, it will, most naturally, be assumed, that, the autumnal current system of the Skagerak pursues the same direction as it does during the remainder of the year.

Whence the herring comes, and where the various layers of water originate can only be discovered, when, on a sea going steamship, the conditions at sea can be investigated at all times of the year. Until then we deem it of no avail to put forward hypotheses, the correctness of which cannot be proved.

II.

The Christiania Fiord.

The hydrographical conditions of the Christiania Fiord are closely connected with those of the Skagerrak; the upper layers are constantly flowing out and in, partly on account of the tide, and, partly, from the winds.

The Fiord, however, retains a hydrographical character of its own, inasmuch as the inner part attains a great depth (up to over 200 metres), while, at the entrance, it is about 80 metres. The huge body of water below the depth of 80 metres is, therefore, quite shut off from direct communication with the deep water layers of the Skagerrak. As the salinity of the surface layers is much less than that of the deep, no great admixture takes place, and the changes of temperature are but slowly conducted to the deep downwards.

The water at the bottom of the Christiania Fiord may, thus, through a considerable space of time, retain an unaltered hydrographical character, by which the Fiord presents the greatest contrast to the sea just outside it, where the deep lying waters may be forced upwards, and carried away in a very short time, as we have previously shown.

The conditions in the depths of the Fiord show a much greater similarity, for instance, to those of the central part of the Skagerrak, where, all through the year, Atlantic water may be found at a depth of 50, to 100 metres, or more, with a temperature of 6—8^0.

As yet, the Christiania Fjord has not been subjected to any close hydrographical examination. We regret to say that the observations which will be given in the following pages are not so complete as we should wish, for they could only be carried out, when occasion offered, at the same time as other investigations, and with certain biological ends in view. But they are, however, sufficient to throw a light upon a number of characteristic features of the hydrographical physiognomy of the Fiord.

Summer. We will commence with its condition during Summer. (Table III d).

The salinity of the surface is then very low; in the inner parts of the Fiord, that may be less than 20‰; the temperature is high, up to 20^0 or more. It is, however, only in the surface layers, that the temperature may exceed 15^0. The salinity greatly increases downwards towards the bottom; thus at Drøbak at a depth of 60—100 metres, a salinity of 34‰ may be met with, simultanously with a rapid decline of the temperature. Thus on the 17th of July 1897, off Hvitsteen, the temperature was:

at the depth of		10	metres	$11.^09$
—	—»—	20	»	$10.^02$
—	—»—	30	»	$7.^025$
—	—»—	40	»	$5.^078$
—	—»—	50	»	$5.^060$
—	—»—	60	»	$4.^091$

The heat in the Summer finds no means of penetrating towards the bottom, as the uppermost, heated, layers do not mix with the bottom ones.

At the entrance of the Fiord, the higher temperatures, generally extend to a greater depth, 40—50 metres. In the one case this is, probably, due to the coastal currents of the Skagerrak, and in the other to the winds which can disturb the water more easily there and cause the upper layers to become mixed. The open, exterior basin of the Christiania Fiord, between Færder and Horten, forms, as regards the hydrography, a link between the coastal waters of the Skagerrak and those of the inner Fiord.

The heating of the upper layers thus extends to a greater depth than at Drøbak.

Hjort thus obtained on the 20th of August, 1894, the following temperatures from the centre of the Fiord (see [95] p. 75)

20	metres	16.06
30	—	16.00
40	—	14.06
60	—	12.00
80	—	7.08

and Gran found, on the 6th—7th of August 1897,

	at Færder	at Vallø	at Drøbak (Hallangspollen) the 12th of August
0 metres	20.13	19.70	
10 —	16.74		18.9
20 —	14.32	14.10	12.2
40 —	12-63	10.70	8.8
60 —	9.54	7.84	6.3

The uppermost layers of the innermost part of the Fiord are replenished by the influx of water from the Skagerrak, and the water flows, daily, out and in. This may easily be observed, especially in the narrow sound at Drøbak, where the body of water is pressed together during its motion, and the velocity increased.

The currents appear to be principally regulated by the winds, and it may be clearly observed, how the warm surface layers, of little salinity, are wedged up in the innermost part of the Fiord after a southerly wind, while the northern winds drive them in an outward direction, thus allowing the Bank water to rise nearer to the surface in the inner portion of the fiord.

Little is known, however, to what the depths these daily currents may go. In one instance at Drøbak we have seen that the surface current was but 5 metres in depth; and, if this forms the rule, it may well be understood how, with reference to the hydrography, the inner basin of the Fiord can deviate so greatly from the outer portion.

The bottom layers, as will be noticed from the tables, are wonderfully cold, a minimum existing, during the Summer, at a depth of about 60 metres, and, below this, the temperature, throughout, is 5—6°, with a salinity of 34.5°/oo or more. Further up the Fiord, the salinity of the bottom does not amount to 34°/oo; the temperature, however, being still lower.

During Summer, a fairly rich *Plankton* is frequently met with in the uppermost, heated, layers. Deeper down only a few crustaceans are found, chiefly, northern forms which keep to the cold water. Table 7, denotes the result of some quantitative plankton investigations, carried out with *Petersen's* self closing vertical net.

To assign the quantitative contents of the samples, we have adopted the weighing method, the samples preserved in spirits being filtered through a piece of silk-gauze, the surplus spirit being removed by means of filtering paper. A certain amount of spirit, however, does always remain which is retained by capillary attraction between the small organisms, and the greatest defect of the method is, therefore, that the various organisms do not retain each a proportionate amount. We consider the results, however, as being more reliable than other not too time-wasting methods, for instance, volumetric measurement.

The figures, given in the Table, indicate the weight of the quantity of Plankton obtained. Our net was of the same size and construction as that used by Petersen, and our results, may thus be directly compared with those derived from Petersen's researches in the Lim-Fiord [98].

The Table shows that the water, from the surface down to the depth of 20 metres, in August—September, contains many times greater an amount of Plankton than the deep lying layers.

At Aasgaardstrand, on the 30th of August, but 0.43 gr. was obtained from 20—50 metres, while 1.97 gr. was obtained, with the same net, from 40 metres to the surface, and in the deep water layers still less.

At Drøbak the difference is even more prominent, thus, according to the Table,

0— 20	metres	1.78	grammes
40— 60	»	0.18	»
80—100	»	0.03	»
120—140	»	0.05	»

The latter weights are so minute that they come under the defects of the method; such a quantity might be obtained in letting down the net, even if every attention was paid to lower the net with the opening up.

Thus the plankton vegetation is, practically, non-existent in the deep water layers of the inner part of the Fiord, except along the bottom. As to the distribution of the species, it will be observed from the Table, that the diatoms were found, exclusively, in the upper layers, while some of the peridiniaceæ also frequent a greater depth, though the majority of these, be mainly found near the surface.

Petersen's investigations prove, however [98], Tab. III, that diatoms may also be found in the deep; he having obtained considerable quantities of *Guinardia flaccida*, off Skagen, at depths of 40—90 fathoms.

It is possible in this case, that the currents off Skagen have drawn, towards the deep, layers which originally existed on the surface. Our Table also shews, that the diatoms may be found at greater depths. Further down the fiord, at Rauø, several species were found on the 16th of October, chiefly *Chætoceras contortum*, below the depth of 80 metres. Even in this case such may be ascribable to the currents, as the outer part of the fiord is closely connected with the coastal waters of the Skagerak.

Towards the end of the autumn, the quantity of plankton increased in the fiord; thus at Vrængen, on the 19th of September, 4.21 gr. was taken from the depth of 20 metres up to the surface, and at Drøbak on the 23rd, 3.92 gr. from 10—0 metres. This, for the coast of Norway, may be considered a very fair quantity, though, compared with the Lim Fiord and the Cattegat, quite insignificant. Thus, according to Petersen's investigations of the Lim Fiord, 27 gr. was obtained from depths of 5 fathoms to the surface; but as the sample was weighed in a fresh state, when saturated with salt water, (*vide* Petersen l. c. p. 8) this figure will need to be reduced to stand comparison.

The hydrographical features became somewhat changed during the autumn; the surface becoming cooler, while the warmth worked its way downwards. At that time, somewhat thick layers of warm water were found in the outer portion of the fiord, while, in the inner part, the warmth did not attain a great depth. Autumn.

This will be observed, *inter alia,* from the hydrographical section, Vallø—Bygdø, during the latter half of September 1897, Tab. III, b, from which we give the temperature, and salinity, at the depth of 30 metres.

	Temperature		Salinity	
	0 metres	30 metres	0 metres	30 metres
Vallø	13.5	15.7	18.65	32.48
Horten	13.8	13.	20.94	31.67
Drøbak	13.5	11.1	20.34	32.43
Spro } inside	13.78	6.4	19.37	32.26
Dyna } Drøbak	13.4	6.3	17.01	31.78

Thus, at Vallø, the temperature, at 30 metres depth, is higher than that of the surface; at Drøbak 2° less, and, inside, 7° less. This indicates, that the warm layers in the outer part of the fiord are not formed on the spot by mixing with the surface water, but come from without.

They, probably, are connected with the Bank water currents, which, according to the researches of Pettersson and Ekman, flow into the Skagerrak in September, and are of great depth.

In October (Tab. III c) the warm water layers are even thicker than in September; the hydrographical section, Fig. 8, denotes that, the

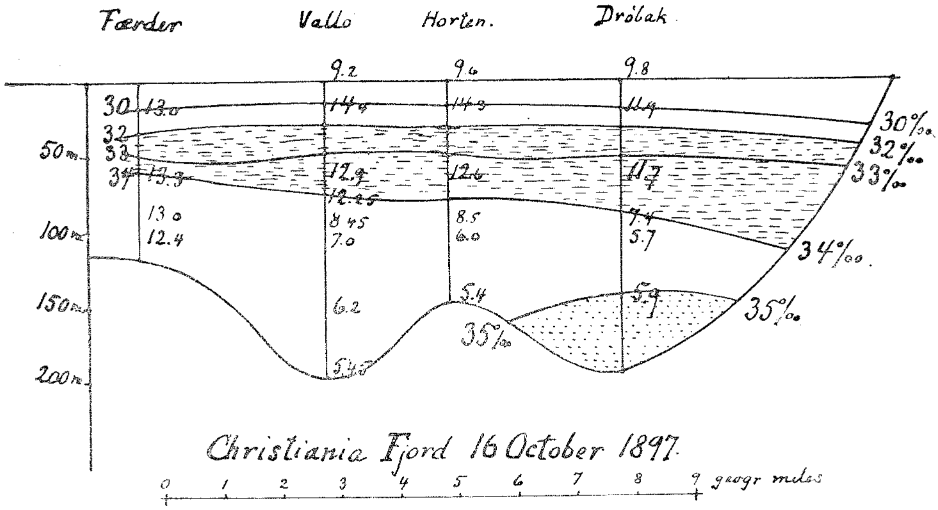

Fig. 8.

water at Færder is of a temperature ot 12—13° to the very bottom. These hydrographical conditions are identical with those of the coastal waters of the Skagerrak during the Autumn.

In the outer basin of the fiord, at Rauø and Bastø, the warm water does not go so deep, though it descends to nearly 80 metres below the surface. In the deep lies the cold bottom water, with a salinity of 34.5—35.0‰, which has remained stationary in the Fiord throughout the entire Summer.

In the upper layers, however, at a depth of 10—30 metres, a higher temperature may be found than at any other part beyond, or within the fiord (14.3—14.4°). If these warm layers originated from outside, they have, consequently, remained longer in the fiord than outside the entrance.

At Drøbak the upper layers are not even so warm as at Færder, their temperature does not rise to 12^0.

The boundary between the warm and cold water, the 10^0 curve, lies at about the same depth as in the outer part of the Fiord. In the deep, the water is remarkably salt, being $35^0/_{00}$ at the depth of 200 metres; this being a salinity rarely experienced in the fiord. An influx of Atlantic water must, therefore, have made its way along the bottom from the outside, and then remained stationary in the deepest depressions of the fiord.

Fig. 9, gives a section of the fiord in December 1896 (Tab. I d.). Winter.

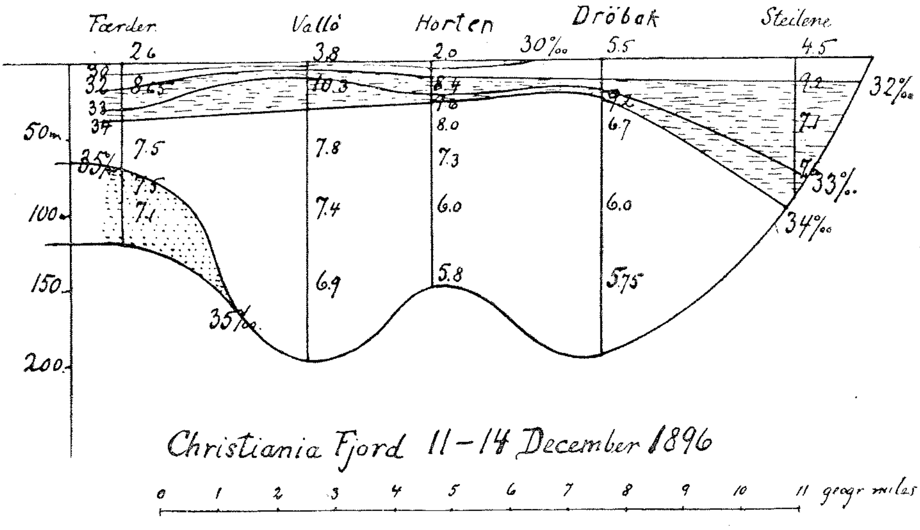

Fig. 9.

The conditions of the Skagerrak, as already mentioned, were, that year, most extraordinary, owing to the unusual deficiency of Bank-water, while the Atlantic water rose up high towards the surface, especially on the eastern side of the Skagerrak. This was also noticeable at Færder (St. I), where Atlantic water was found at a depth of 80 metres. Atlantic water was, certainly, not to be met with in the upper part of the fiord, but the North Sea water ($34—35^0/_{00}$) rose to 30 metres from the surface, right up to Drøbak. Only at the innermost Station, «Steilene» (XX), was the salinity, down to the very bottom, lower than $34^0/_{00}$. The temperature was much lower than in the autumn; the maximum ($10.^03$) being then found at Vallø, at a depth of 20 metres.

It was remarkable that, at the two innermost Stations, Drøbak and Steilene, the temperature and salinity of the surface were higher than those of the outer Stations, higher even than the whole of the northern portion of the Skagerrak. This can only be explained by the surface water having been forced in an outward direction by the prevailing northerly winds, and replaced by warmer, and salter water from the deep.

The Plankton Table (1), shews the same; the two innermost Stations wanting the characteristic plankton which, otherwise, is spread over the entire surface of the Skagerak, and the Christiania Fiord. In the course

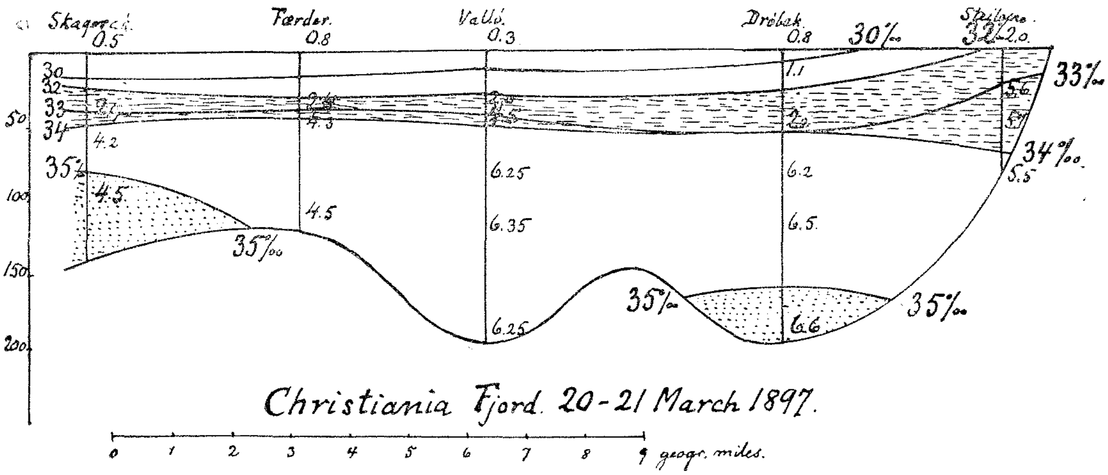

Fig. 10.

of the winter, the upper layers gradually became cooler, both in the Skagerrak, and inside the fiord.

Fig. 10, shows a section of the fiord during the period, in which the sea is at its coldest, March, 1897.

Out in the Skagerrak, and at Færder, the temperature was low, throughout. Even the Atlantic water, which, in the Skagerrak, rose to 80 metres below the surface, was of a warmth of but $4.^{0}5$, and, at Færder, the North Sea water of a like temperature ($4.^{0}5$), was found along the bottom.

In the outer basin of the fiord, at Vallø, the surface layers down to a depth of 40 metres, were somewhat colder than at the entrance; but, in the deep, water layers were found of a temperature above 6^{0}, and these layers rose to, not quite 80 metres below the surface. They could not have been connected with the water layers of the same salinity (34.8—35.0) outside the entrance of the fiord, as the temperature was 2^0 higher. They had, thus, remained in the fiord since the autumn.

The cold surface layers, at Drøbak, lay 10 metres deeper than those at Vallø, but the bottom layers, were, still, a trifle warmer ($6.^05$ —$6.^06$). At the depth of 200 metres, a small body of water was found with a salinity exceeding $35^0/_{00}$, and, as the salinity is so great, it shews that this must have come in from outside. On the other hand it could not be related to the cold Atlantic water, which was found, at that time, out in the Skagerrak; it must, therefore, have entered at an earlier period, during the course of the autumn or winter.

In the innermost basin of the fiord, at Steilene, the salinity and temperature along the bottom, were lower than those of eqvivalent depths at Drøbak; but nevertheless, the salinity was exceptionally high compared with other observations in that part. During the summer and autumn, the salinity at Spro, and Steilene, never exceeded 33.0—33.5 $^0/_{00}$ at the depth of 70—80 meters; only at the bottom of the Bunde-Fiord was salter water met with. By that time, however, it had risen to 34.04 $^0/_{00}$, and 34.18 $^0/_{00}$, at depths of 70 and 85 metres.

If the salinities of the upper layers in the outer fiord be compared with those of the inner, one may perceive a condition which, probably, corresponds with the above.

Table III a, shews the following distribution of the salinity in March 1897.

	Vallø	*Drøbak*	*Steilene*
0 metres		29.66	32.03
10 »	29.93	30.30	32.33
20 »		31.69	32.69
25 »	31.42		
30 »		32.28	33.20
40 »	32.69		33.62
50 »	33.97	32.65	33.70

The farther the advancement up the fiord at that time of the year, the higher, therefore, will be the salinity of the upper layers down to a depth of 40—50 metres. In the summer and autumn, the salinity was invariably lowest in the inner part of the fiord, both on the surface and in the deep.

The temperature of the upper layers, also indicated a tendency to rise inside the fiord in the winter time, as will be seen from the Tables for March, 1897.

	Vallø	*Drøbak*	*Steilene*
0		0.8	1.95
10 metres	0.32	0.3	1.85
20 »		1.1	3.
25 »	0.35		
30 »		1.8	5.6
40 »	2.02		5.7

This could only be explained in one way viz., through the bottom layers of the upper fiord, having moved in an inward and upward direction, while the surface layers flowed outward.

The northerly winds having, probably, prevailed for a time, forced the surface water outwards, and the inflowing under currents ascended as a necessary compensation.

It is, also, commonly known, that the surface water of the Christiania Fiord is saltest during northerly winds, while southerly winds dam up the fresh water, as it were, in the inner portion of the fiord. It may therefore happen, that the fiord, during winter, is free from ice as long as the weather keeps cold, with northerly winds; but when milder weather sets in with southerly winds, it freezes, as the cold fresh water on the surface remains stationary, and the inflowing warm under currents are stopped.

The compensating currents which appear in the deep when the surface water flows in an outward direction, are of the greatest significance to the hydrographical conditions of the entire fiord, as new layers of water are brought in with these currents along the bottom of the fiord, where, otherwise, the water is apt to remain stationary.

The entrance to the fiord, as already said, is obstructed, on the bottom, by a ledge or bar rather more than 80 metres from the surface; the basins existing inside the fiord below this depth, can, therefore, only obtain fresh supplies, when bodies of water, of higher specific gravities than that of the bottom layers of the fiord, surmount the ledge.

We have, moreover, as mentioned previously, seen that, bodies of water — with the exception of the uppermost layers — have a great tendency towards remaining stationary in the fiord, even at depths, where there are no obstructions. The compensating currents are, probably, the only effective means of renewing the water at the bottom of the fiord.

In the Christiania Fiord the outward flowing currents of the surface seem to culminate in the winter. As yet, however, our materials are not sufficient to allow of any decisive conclusion being arrived at on this point, but there is another circumstance which points in that direction.

The course of the surface currents is, as a rule, dependent on those of the winds, thus, in the Christiania Fiord, the northerly winds produce an outward flow of the surface layers. Mohn's investigations, during the course of many years, ([98] pp. 15—16) indicate, that the northerly and north easterly winds prevail in the Christiania Fiord during the winter months (October—April), while south, and south westerly winds predominate in the summer (May—September).

During the winter, therefore, the surface currents chiefly run in an outward direction, and the compensating currents are drawn in along the bottom. In the summer, however, this will not so easily occur, as the surface layers more frequently flow in an inward than outward direction. We observed, too, that the saline contents of the surface, in summer always became less the further one advances up the fiord; while the series of observations which, hitherto, have been obtained during the winter season, shew a higher salinity in the inner than in the outer part of the fiord.

Drammen Fiord. Frier Fiord.

The Drammen Fiord, which was subjected to Hjort's researches in November 1898, has a deep basin, the water of which is still more isolated than the remainder of the water along the bottom of the Christiania Fiord. This fiord is separated from the Christiania Fiord at Svelvik, by a bar, which lies 6 metres below the surface.

The Tables of salinity and temperature (III e) shew, that the layers inside the Drammen Fiord are of quite a different character to those on the outside, at Filtvedt.

We give the following parallel:

	Salinity.		Temperature.	
	Drammen Fiord. $^{10}/_{10}$ 98.	Filtvedt. $^{11}/_{10}$ 98.	Drammen Fiord. $^{10}/_{10}$ 98.	Filtvedt. $^{11}/_{10}$ 98.
20 metres	25.03	32.40	9.65	13.2
30 »	28.41		4.8	
40 »	29.58	32.87	4.6	11.0
60 »	30.05	33.58	4.6	6.8
80 »	30.31		4.6	6.55
120 »	30.43	34.53	4.6	6.2

In the Drammen Fiord, the salinity, in November, was thus below $31^0/_{00}$ right to the bottom, and the temperature remained at $4.^06$ from a depth of 40 metres downwards; while, outside, comparatively high temperatures were to be found to a great depth.

It was, however, still more remarkable that the water obtained with the water bottle from the deep layers, had a most incontestible odour of sulphuretted hydrogen, or «rotten egg gas» (H_2S), the bottom being in a decaying state from 20 m below the surface, and no organisms were procured there in a living condition.

Hjort found a similar condition obtaining in the Frier Fiord, inside Brevik, on the 30th of September. The salinity at the bottom was there much higher, slightly exceeding $34^0/_{00}$, while the temperature was $6.^04$; but even there the bottom water smelt of sulphuretted hydrogen.

This fiord is obstructed by a bar, rising to 18 metres below the surface, and, in addition to this, it has even another feature similar to that of the Drammens Fiord, viz., that the salinity of the surface is very low, as an important river has its outlet in the fiord.

In December, the Frier Fiord was subjected to a close examination by our assistant, Mr. Schmidt Nielsen, who analysed the volumes of gas from the samples obtained at various depths both in the Frier Fiord, itself, and outside it at Brevik.

Fig 11. Brevik Fiord.

The results, being of great interest, are inserted in the following table, though these conditions will subsequently be reserved for more acurate study.

		Date.	0 m.	30 m.	60 m.	90 m.	100 m.
Salinity	Frier Fiord	30/9	5 .68	33 .65	33 .89	34 .07	
		6/12		33 .05	34 .03	34 .03	
»	Brevik Fiord	1/10	18 .33		33 .95		35 .55
		6/12			34 .56		34 .70
Temperature	Frier Fiord	30/9	11°.8	7°. 4	6°. 4	6°. 4	
		6/12		9°. 2	6°. 0	6°. 3	
	Brevik Fiord	1/10	12°.6		12°. 1		6°. 9
		6/12			8°.95		8°. 1
Nitrogen cc m. pr. l.	Frier Fiord	6/12		13 .0	19 .71		
	Brevik Fiord	6/12		13 .28	12 .96		
Oxygen. cc m. pr. l.	Frier Fiord	6/12		3 .7	2 .57		
	Brevik Fiord	6/12		6 .23	5 .67		
Oxygen % Gas vol. of	Frier Fiord	6/12		22 .16	11 .54		
	Brevik Fiord	6/12		31 .92	30 .43		
CO_2 cc m. pr. l.	Frier Fiord	6/12		48 .75		60 .23	
	Brevik Fiord	6/12			47 .87		49 .74

The water at the bottom of the Frier Fiord was thus very deficient in oxygen, but carbonic acid excessively plentiful. The quantity of sulphuretted hydrogen was not ascertained.

In April 1899, Hjort and Schmidt-Nielsen studied the hydrographical conditions at the bottom of the Christiania and Drammen Fiords, from Færder to the head of the fiords. The results will be found in the following Tables (page 45). The volume of Oxygen was normal at Færder; in the deep pool at Rauer it was somewhat below the normal, and still less at Rødtangen. In the Bunde Fiord less than 1 ccm. of oxygen *per* litre of sea water was met with, and, at the bottom of the Drammen Fjord, so little oxygen was found, both absolutely and relatively, that it need not be taken into account. The volume of Carbonic Acid was, on the other hand, very great at the bottom of the Bunde Fiord,

Conditions like those of the Drammen and the Frier Fiords, are, hitherto, only known to exist in one place, viz., in the Black Sea, where an abundance of sulphuretted hydrogen is to be found, in the deep, below 300 metres. The Black Sea was investigated by Russian expeditions in 1891—92 *(Spindler, Wrangell, Andrussof, Lebedintsef)*, and the results have been published in Petermanns Mitteilungen by *Wojeikow* [91], and refered to in Annalen d. Hydrographie, by Köppen [92], and Lebedintsef [93], and in *Geographisches Jahrbuch,* by Krümmel [93].

It appears from, these investigations, that the salinity of the Black Sea is exceedingly low on the surface (17—18⁰/oo), while in the deep regions it is greater; thus a salinity of 26⁰/oo was observed at a depth of 1185 fathoms, and, probably it was still greater along the bottom. The temperature scale for the summer, denoted a minimum ($7.^{0}2$) at 53 metres depth, but, farther down, the temperature gradually rose, and slightly exceeded 9^{0}. If the salinity be the same during the winter, the vertical circulation, which occurs through the cooling of the surface layers, would, according to Wojeikows calculations, reach down to a depth of 55 metres. These top layers may thus, possibly, absorb fresh air once a year from the atmosphere.

The vast bodies of water which lie below that depth, can, however, only be replenished by under currents flowing from the Bosporus.

Makarow has shewn, that such currents are to be found throughout

Locality	Date April, 1899	Depth from which the sample was taken. Metres	Temperature at that depth Celsius	Cl. per litre	Salt $^0/_{00}$	N ccm per litre	O ccm per litre	$\frac{100\ O}{N + O}$	CO_2 ccm per litre	Remarks
Færder.	15	About 200	4.8	19.83	34.96	13.71	6.92	33.54		Near the bottom
Rauer	15	50	4.72	19.52	34.43	13.62	6.60	32.65		
	„	350	5.6	19.79	34.89	13.38	6.05	31.13	48.24	—„—
Rødtangen	15	120	6.1	19.76	34.84	13.25	5.89	30.77	46.82	—„—
Langaaren	21	160	5.7	19.05	33.63	13.84	5.84	29.67		—„—
Steilene	21	20	4.9	17.91	31.57	13.95	5.84	29.51	38.94	
Bunde Fjord	21	50	6.1	18.87	33.32	14.58	4.58	23.90		
	„	160	5.8	19.05	33.63	13.63	0.79	5.49	51.36	—„—
Drammen Fjord	15	25	4.55	16.18	28.69	14.71	3.80	20.48	45.08	
	„	120	4.55	17.16	30.38	14.60	0.13	0.83		—„—

the entire year; but as the Bosporus is very narrow, and extends to no great depth, but comparatively small quantities can find their way in.

Wojeikow has calculated, from Makarow's observations, that 3180 years would be required in order to replenish the water of the Black Sea.

In order to explain the conditions of the Black Sea, Andrussof set up the following hypothesis: In the pliocene period, the Black Sea formed a landlocked basin, containing, chiefly, brackish water, and a brackish water fauna on the bottom. When, however, the straights of the Bosporus subsequently opened, the sea water from the bottom of the Mediterranean forced its way in, and exterminated the brackish water organisms, which, on putrefying, produced a poisonous substance (H_2S) which prevented any new fauna entering from the Mediterranean. Meanwhile the decay continued, as a perpetual supply of organic sediments from the rivers, and the littoral fauna, poured in.

Several observations seem to comfirm the correctness of this interesting hypothesis; but the formation of sulphuretted hydrogen in the stagnant water layers, at the bottom of the Black Sea, may, probably, be explained, solely from those factors which are at work at the present time.

The conditions of the Norwegian fiords appear to be of a parallel kind. In them, too, may be found saltwater basins, whose only connection with the sea consists of shallow inlets, while much fresher water may be obtained on the surface than at the bottom, so that the vertical circulation in the winter is but of little consequence. The bottom layers, inside the fiord, are, therefore, more or less stationary, and the investigations made in the Drammen Fiord, during November 1898, denote, that the water, from the bottom, upwards, to 30 metres from the surface, had remained in the fiord, in any case from the preceding winter.

The layers must, necessarily, have crossed the bar, which lies but 6 metres below the surface, and outside, it is only during the winter that water of a corresponding temperature can be found so near the surface.

Pettersson and Ekman's investigation of the Swedish fiords shew that, the volume of oxygen declines in those bodies of water which, for some time, remain stationary in a fiord, while the carbonic acid increases. This change is owing to the change of substance in the organisms, and as animals were, exclusively, found at great depths, and no plants, the changes will always tend to the same result. If then the bodies of water remain stagnant for a very long period, they must become so deficient in oxygen that they are no longer capable of sustaining animal life. This has occurred in the Frier Fiord.

The high salinity (34.03 ‰) along the bottom of the Frier Fiord shows that, the salt water supply must, nevertheless, occur more frequently than that, for instance, of the Drammen Fiord, the salinity of which never exceeded 30.5 ‰.

The low amount of oxygen at the bottom, is bound to affect, not only the higher organisms, but also the bacteries and their change of substance. Putrefaction invariably occurs at the bottom of the sea, even if a great quantity of organic matter is consumed by higher animals. It depends, however, on the conditions of the surrounding medium, which bacteria shall attain the supremacy, and what products will arise from the decomposition. When oxygen is sufficiently represented, putrefaction takes place in a different way to that where oxygen is wanting.

In many instances it frequently happens that oxygen, freely supplied, causes a complete change of the organic substances, to carbonic acid and ammonia.

On the other hand, when oxygen is wanting, medium products are more easily formed, as leucin, tyrosin, while malodorous substances such as sulphuretted hydrogen are formed at the same time.

The fermentation arising from a small supply of oxygen constitutes a reductional process; besides the formation of H_2S, hydrogen is also formed, and this may, *in statu nascenti,* have a reductional effect on the sulphates of the sea water, so that sulphuretted hydrogen may, therefore, be a secondary product of the reduction.

Thus, possibly the formation of H_2S, along the bottom of our fiords, can be attributed solely to the stagnation of the bottom layers, by which any access of oxygen is precluded.

As is stated by Pettersson and Ekman, in respect to the Swedish fiords, this stagnation is caused by a bar, at the mouth of a fiord, which prevents a connection between the deep layers outside, and those within, while the low salinity of the surface only allows the vertical circulation during the winter to descend to a limited depth.

Of all the fiords which, hitherto, have been subjected to close observations, only the Drammen Fiord, and the Frier Fiord appear to have a «dead bottom» with any appreciable quantity of sulphuretted hydrogen; the remainder yielding a, more or less, plentiful fauna of oceanic deep water forms.

In those the fresh supply of water along the bottom is sufficient to support the respiration of the animals, and prevent anaerobiotic fermentation.

The results hitherto arrived at, will not suffice in determining the minimum quantity of oxygen required to prevent the formation of sulphuretted hydrogen on the bottom. In the Frier Fiord, at 60 metres depth, it amounted to 2.57 cm. pr. litre, but, at the bottom, the water was, probably, still more devoid of oxygen.

A very rapid change in the conditions of a fiord are not precluded; it being known, that deep water shrimps, *(Pandalus borealis)* were, at one time, caught in the Drammen Fiord at spots where now no living organisms exist below the depth of 20 metres. The conditions of the Black Sea may, in our opinion, be explained in a like manner, the character of its depths being in no way dependent on whether, in olden geological epochs, there was brackish or salt water at the bottom. The Christiania Fiord differs from the Drammen Fiord, and the Frier Fiord, in the fact that, the bar, being situated at a greater depth, allows of a more frequent renewal of the bottom layers. Moreover the access of fresh water to the surface is not so great as that of the other two fiords. Both these conditions probably contribute in causing the bottom water of the Christiania Fiord to maintain a comparatively less stationary position than those of the Drammen Fiord, and the Frier Fiord. We are, however, already acquainted with the fact that, even in the Christiania Fiord, large volumes of water remain throughout a great part of the year without renewal or blending. This is a most characteristic feature in the hydrography of the Christiania Fiord.

On the other hand, however, it is quite as characteristic that the surface water is invariably connected with the upper layers of the Skagerak. This may be observed not only from the hydrographical conditions, but also from the plankton of the surface layers.

Table 4 gives a general view of the vegetable plankton at Drøbak throughout the various seasons.

Firstly, it will be seen that, the various organisms have their maxima at certain times of the year; this is especially clear as regards the neritic diatoms. *Biddulphia aurita*, *Thalassiosira Nordenskiøldii* and *Th. gravida* vegetate, for instance, most exuberantly during the coldest season, in the month of March; *Chætoceras constrictum* and *Leptocylindrus* *danicus* rather later, in May; *Chætoceras curvisetum* in the summer; *Chætoceras didymum*, *Ch. Schüttii* in September; *Ch. contortum* in October; *Skeletonema costatum* in November.

The oceanic species vegetate more regularly all through the year (for instance *Thalassiothrix Frauenfeldii*), even though these have their decided maxima at fixed seasons. (*Coscinodiscus oculus iridis*, *Chætoceras decipiens*, *Thalassiothrix longissima* during the winter, *Rhizosolenia alata* during the summer). A comparison with Cleve's investigations of the Bohuslæn coast [97], shows that the same species are represented there, and have their maxima, and minima, practically at the same period.

The Christiania Fiord has thus no neritic plankton different from that on the coasts outside, or like that found in the Lim Fiord by Petersen [98]. Again it may be seen from the Table that the Plankton, may for a short period become very scarce. Such a gap in the Table, may, for instance, be found in the Table for December, 1896. On the first of December the plankton still retained considerable quantities of, for instance, *Thalassiothrix Frauenfeldii* Throughout the middle of the month it was absolutely wanting, and appears again on the 28th, in about the same quantity as before. Table 1, shews that the entire Skagerak, and the outer part of the fiord, just at that time, contained a rich plankton; it was only in the innermost part of the fiord that the plankton had, temporarily, disappeared. This coincides with the fact, that the surface water at that time was carried out of the fiord by the out flowing currents; the distribution of the temperature and salinity in the upper layers, moreover, also shew that this has been the case (see Fig. 9, Pag. 37). A similar gap will be observed in the Table during the first half of February 1897. In March, too, the hydrographical investigations (Fig. 10) shewed that there had been an outward flow of the surface currents. However they had not extended sufficiently deep to convey, with them, all the Plankton algæ (see Tab. 3). In March the Pelagic Diatoms had developed into enormous quantities, both outside and in the fiord.

The Plankton Investigations effected during the year 1898, also shewed, that the plankton in the Christiania Fiord is closely connected with that of the Skagerrak. Table 5, shews the vegetable plankton outside the fiord, at Hvaler, and Table 6 gives the results of some quantitative determinations, which were carried out, at the same time at Drøbak.

At Hvaler the plankton was poor in January and the first half of February; still it contained considerable quantities, chiefly of peridiniaceæ, and some oceanic diatoms. On the 19th February a rich diatomic plankton became developed, which during the following weeks, increased very considerably.

At Drøbak the Fiord was practically free of plankton throughout the entire month of February. The figures, denoting the weight of the Plankton, are so low, that they, for the most part, lie within the defective boundaries of the method.

But from the 23rd of February, until the 2nd. of March, the quantity of plankton in the upper layers, to a depth of 25 metres, had increased from 0.08 gr. to 3.49 gr., and it consisted of the same species as those which, from the middle of February, had grown luxuriantly outside the fiord. Even if these diatoms possess great powers of development, it is hardly possible that such great quantities could have sprung up on the spot.

Outside the fiord a gradual development took place, and it is more likely that outward currents kept the inner part of the fiord free of plankton throughout the entire month of February*), but that in the later days of the month a rich plankton was brought in by an inflowing current. All these conditions seem to shew, that the plankton of the Christiania Fiord originates, chiefly, from the Skagerak. This was also to be expected when the hydrographical conditions were taken into consideration. The conditions of life of the neritic forms, greatly depend upon whether the water, wherein they exist, comes in contact with the bottom; but in the Christiania Fiord the greatest part of the bottom is covered with more or less stationary layers, which during the summer, contain very little plankton (see Tab. 7).

This fiord is not, therefore, as is the Lim Fiord, a suitable centre for the development of neritic organisms. The oceanic plankton organisms are not adapted for life under changeable conditions, they cannot, therefore, remain in the upper layers of the fiord, but are frequently brought in from the Skagerrak.

In the deep layers, however, the oceanic organisms may subsist for a considerable period; thus several northern forms may be found in

*) Compare with this the results given in the preceding treatise, shewing that the pelagic fishes' eggs are driven out of the fiord.

the depths of the fiord, viz., *Calanus finmarchicus*, and *Metridia longa*, which probably exist there throughout the entire year.

But, quantitatively, they are of no great significance compared with the great number which invariably flow in from the Skagerrak with the surface currents, and which also, for a time, can continue their development inside the fiord.

We have already stated in the first part of this work, and in a former treatise, all we had to say of the Skagerrak Plankton up to the present. We believe that this plankton may be regarded as consisting, first of the neritic species, which annually are developed in the shallow water near the edge of the shore, and, secondly, of extraneous (»allogenetic«) organisms, which arrive, mainly, by the Jutland and Baltic currents.

The oceanic species, which keep throughout the year, in greater or less quantities, to the deep and central portions of the Skagerrak, are, probably, also of importance as food for the bottom fauna, and they may also, during some seasons of the year (i. e. winter and spring) give important contributions to the plankton of the surface layers, so that we, at such periods, find, in all the water layers, a uniform oceanic plankton, which, however, seldom lasts for any length of time.

Remarks on the Hydrographical Tables.

The Sea-water samples have been obtained with O. Pettersson's isolating water bottle, and the temperature of the water procured has been registered.

In some cases, the ascertainment of the temperature has been controlled by the reversible thermometer of Negretti & Zambra.

The chloric quantity of the sea-water has been determined by titration, which was effected by Dr. O. A. Heidenreich (Tabs I, II, III a, b, c, d, f, V) and Mr. Schmidt-Nielsen (Tab. III e, IV).

Remarks on the Plankton tables.

The occurrence of the various species is denoted in the following manner:

cc = very common
c = common
+ = rather common
r = rare

The samples mentioned in Tabs. 6 & 7 were captured with a quantitative net, Hensen's model, of gauze No 20, the upper opening being of an area of 0.09 square metres. The opening could be closed by means of C. G. Petersen's shutter.

The weighing process was carried out with preserved materials, the organisms being preserved in 70 per cent. of alcohol, and the alcohol removed, so far as possible, by means of filtering paper.

Bibliography.

96. **Aurivillius, C. W. S.** Das Plankton der Baffins Bay und Davis Strait. 1896. *Festskrift för Liljeborg.*

98 — Vergleichende thiergeografische Untersuchungen über die Planktonformen des Skageracks in den Jahren 1893—97. 1898. *Kongl. Svenska Vetenskaps-Akademiens Handlingar. B. 30 no. 3.*

94. **Cleve, P. T.** Planktonundersökningar. *Bihang til kongl. svenska Vetenskaps-Akademiens Handlingar. B. 20. Afd. III, no. 2.*

96. — Vegetabilsk Plankton. *Ibidem B. 22, Afd. III, no. 5.*

97. — A Treatise on the Phytoplankton of the Northern Atlantic and its Tributaries. 1897.

97. **Cleve, P. T., Ekman, G., Hjort, Johan og Pettersson, Otto.** Skageraks tilstand under indeværende sildefiskeperiode.

97. **Fulton, J. W.** On the Currents of the North Sea, and their Relation to Fisheries. 1897. *Fifteenth Annual Report of the Fishery Board for Scotland, for the Year 1896.*

95. **Hjort, Johan.** Hydrographic-biological Studies of the Norwegian Fisheries. 1895. *Videnskabsselskabets Skrifter. I Mathem.-naturv. Klasse 1895. No. 9.*

99. **Hjort, Johan and Gran, H. H.** Currents and Pelagic Life in the Northern Ocean. *Bergens Museums skrifter. B. VI.*

92. **Køppen, W.** Neue hydrographische Forschungen im Schwarzen Meere. *Annalen der Hydrographie. Jahrg. 20. 1892.*

93. **Lebedintsef, A.** Chemische Untersuchung des Schwarzen und Azofschen Meeres in den Jahren 1891 und 1892. *Annalen der Hydrographie Jahrg. 21. 1893.*

87. **Mohn, H.** Nordhavets Dybder, Temperatur og Strømninger. 1887. *Den norske Nordhavs-Expedition 1876—78.*

96. — Klimatabeller for Norge. II. Lufttryk. *Videnskabsselskabets skrifter. I Math.-naturv. Klasse 1896. No. 1.*

98. — Klimatabeller for Norge. IV. Vind. *Ibidem 1898. No. 2.*

Jahrb. 93—97. — Jahrbuch des Norwegischen metereologischen Instituts. für 1893—1897. Christiania 1895—98.

Ostenfeld, see **Wandel og Ostenfeld.**

98. **Petersen, C. G. Joh.** Planktonstudier i Limfjorden. 1898. *Beretning til Indenrigsministeriet fra Den danske biologiske Station. VII.*

91. **Petterson, O. and Ekman, G.** Grunddragen af Skageracks och Kattegats Hydrografi. 1891. *Kongl. Svenska Vetenskaps-Akademiens Handlingar. B. 24, no. 11.*
97. — De hydrografiska förändringar inden Nordsjøns och Østersjøns Område under tiden 1893—97. *Ibidem. B. 29, no. 5.*
98. **Wandel, C F., og Ostenfeld, C.** Iagttagelser over Overfladevandets Temperatur, Saltholdighed og Plankton paa islandske og grønlandske Skibsruter i 1897.
91. **Wojeikow, A.** Dis Tiefseeforschungen im Schwarzen Meere im Jahre 1890. *Dr. A. Petermanns Mittheilungen. B. 37, 1891.*

HYDROGRAPHICAL TABLES

1. Sections of Skagerak and the Christiania Fjord, December 1896 (Hjort).

I. Sections of Skagerak and the Christiania Fjord. December 1896. (Hjort).

No.	December 1896. Date	Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille	Remarks
				a) Færder — Skagen.							
1	11	12 noon.		59°1'N. *) 10°39'E.		0 m	2°. 6	15.37	27.82	27.28	*) Færder.
						10 —	3°. 6	16.10	29.15	28.55	
						15 —	6°. 8	17.63	31.88	31.15	
						20 —	8°.65	18.47	33.40	32.61	
						40 —	8°. 4	19.63	35.51	34.61	
						60 —	7°. 5	19.81	35.80	34.89	
						80 —	7°, 5	19.94	36.04	35.12	
						100 —	7°. 1	19 87	35.91	35.00	
						150 —	6°.55	19.84	35.86	34.95	
						200 —	6°. 4	19.89	35.96	35.04	
2	11	2¼ p.m.		58°44' 10°37'		0 —	3°. 0	15.35	27.79	27.26	
						10 —	3°. 6	16.50	29.85	29.22	
						20 —	8°. 3	18.83	34.05	33.20	
						40 —	8°. 6	19.38	35.03	34.16	
						60 —	8°.05	19.60	35.43	34.53	
						80 —	7°. 6	19 81	35.84	34 89	
						100 —	7°. 3	19.89	35.96	35.04	
3	11	4 p.m.		58°33' 10°35'.5		0 —	3°. 4	14.80	26.83	26.32	
						12 —	5°. 9	18.10	32.74	31.98	
						20 —	7°. 8	18.75	33.91	33.09	
						40 —	9°. 4	19.46	35.16	34.30	
						60 —	8°. 1	19.53	35.30	34.40	
						80 —	7°. 4	19.84	35.86	34.96	
						115 —	7°.18	19.94	36.04	35.12	
						200 —	6°. 6	19.91	35.99	35.07	
4	11	6¼ p.m.		58°14' 10°33'		0 —	3°. 4	13.41	24.34	23.92	
						10 —	7°. 2	18.01	32 58	31 85	
						20 —	8°.35	18.92	34.23	33.38	
						40 —	8°.55	19.30	34.89	34.04	
						60 —	8°. 9	19.53	35 30	34.40	
						80 —	7°.65	19.83	35.85	34.93	
						100 —	7°. 6	19.87	35.91	35.00	
5	11	8½ p.m.		57°59'.5 10°30'.5		0 —	3°. 4	14.57	26.42	25 92	
						10 —	6°. 3	17.44	31.56	30.84	
						20 —	8°. 6	18.92	34.23	33.38	
						40 —	9°. 1	19.40	35.06	34.20	
						60 —	8°. 2	19.71	35.62	34.71	
						80 —	7°.65	19.77	35.72	34.81	
						120 —	7°. 4	19 81	35.80	34.89	
6	11	11 p.m.		57°47' 10°32'		0 —	7°. 3	18.61	33.66	32 81	
						10 —	7°. 5	18.65	33.68	32.86	
						20 —	7°. 2	19.56	35.35	34.47	

No.	December 1896.		Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour						Cl. per litre	Salt per litre	Salt per mille	
6	11	11 p.m.		57°47′N. 10°32′E.		40 m	7°. 1	19.74	35 68	34.77	
						60 —	6°. 8	19 75	35 71	34 80	
						75 —	6°. 9	19.74	35.68	34.77	

b) Kattegat — Arendal.

No.	Date	Hour	Weather	Locality	Soundings	Depth	Temperature	Cl. per litre	Salt per litre	Salt per mille	Remarks
7	12	2 a.m.		57°52.5′ 11° 2′		0 m	3°. 3	12.60	22.88	22.51	
						10 —	3°. 3	12.73	23.11	22.74	
						20 —	7°. 9	17.49	31.64	30.91	
						30 —	7° 8	18.78	33.98	33.15	
						50 —	7°. 4	19 61	35.45	34.54	
						70 —	7°.25	19.75	35.71	34.80	
8	12			58° 6.5′ 10°10′		0 —	6°. 7	15 01	27.19	26.67	
						10 —	7°. 3	16.67	30 18	29.53	
						20 —	6°. 7	18.07	32.68	31.93	
						40 —	8°. 0	19.09	34.51	33.66	
						60 —	8°. 1	19 30	34.89	34 02	
						80 —	8°. 3	19.49	35.23	34.34	
						100 —	7° 6	19.81	35.80	34.89	
						150 —	6°. 1	19.85	35.88	34.96	
9	12	7¼ a.m.		58°13 5′ 9°44′		0 —	4° 9	16 44	29.76	29.14	
						10 —	5°. 1	16.56	29.97	29.34	
						20 —	6°. 3	18.51	33.47	32 67	
						30 —	7°. 6	18 90	34 18	33.35	
						50 —	8°. 8	19.46	35.16	34.28	
						70 —	7°.35	19 90	35.98	35.05	
						100 —	6°. 9	19.89	35.96	35.04	
						200 —	7°. 1	19.90	35.98	35.05	
10	12	9¼ a.m		58°20.5′ 9°18′		0 —	5°. 2	18 24	32.99	32.21	
						10 —	5°. 9	18.24	32.99	32 21	
						20 —		18.52	33.49	32.68	
						30 —	8°. 5	19 23	34.76	33 89	
						50 —		19.74	35.68	34.77	
						100 —	7°. 2	19.87	35 91	35 00	
						200 —	6°55	19.91	35.99	35 07	
						400 —	6°. 0	19.98	36.10	35.19	
11	12	11 a.m.		58°26′ 8°57′		0 —	4°. 5	17.36	31.41	30.71	
						15 —	4°.85	17.54	31.72	31.01	
						30 —	5° 65	18.17	32.83	32 08	
						50 —	8°. 9	19.16	34.65	33.79	
						60 —	8°. 8	19.42	35.10	34.23	
						70 —	7°. 6	19.63	35.51	34.61	
						100 —	7°. 5	19.70	35.61	34.69	

No.	December 1896. Date	Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille	Remarks

c) Fredriksværn — Hvaler.

No.	Date	Hour	Weather	Locality	Soundings	Depth	Temperature	Cl. per litre	Salt per litre	Salt per mille	Remarks
				58°58.5'N.		m.	° C.				
12	13	1/2 p.m.		10° 6'E.		0	2. 3	15.52	28.12	27.56	
						15	2. 8	15.82	26.64	28.07	
						30	5. 9	18 26	33.03	32.25	
						50	8. 4	19.46	35.16	34.30	
						70	8.15	19.55	35.32	34.45	
						100	7. 5	19.62	35.47	34.56	
				58°55'							
13	13	2 1/4 p.m.		10° 7'		0	2. 7	15.82	28.64	28 07	
						15	3. 9	16.41	29.75	29.10	
						30	6.29	18.47	33.40	32.61	
						50	7. 8	19.49	35.23	34.34	
						70	7. 4	19.64	35 52	34.62	
						100	6. 8	19.75	35.71	34.80	
				58°58.5'							
14	13			10°24.5'		0	3. 3	15.77	28.57	27.97	
						15	3. 4	16.33	29.57	28.93	
						30	6. 7	18.58	33.63	32.74	
						50	7. 9	19.49	35.23	34.34	
						70	7. 0	19.74	35.68	34.77	
						100	7. 4	19.65	35.53	34.63	
				59° 2.5'							
15	13			10°50'		0	2. 5	15.62	28.30	27.74	
						10	6. 0	17.25	31.22	30.54	
						15	8 35	18.31	33.12	32.33	
						20	9. 7	18.67	33.78	32.94	
						30	8. 8	19.26	34.81	33.95	
						40	8.35	19.53	35.30	34.40	
						50	7. 8	19.58	35.40	34.51	
						70	7. 7	19.55	35.32	34.45	

d) The Christianiafjord.

No.	Date	Hour	Weather	Locality	Soundings	Depth	Temperature	Cl. per litre	Salt per litre	Salt per mille	Remarks
				59°15'							
16	11	10 3/4 a.m.		10°37'		0	3. 8	16.67	30.18	29.53	Valle.
						10	9. 6	18 82	34.04	33.20	
						20	10. 3	19.06	34.46	33.63	
						40	8. 4	19.47	35.19	34.32	
						60	7. 8	19.72	35.65	34.71	
						80	7. 5	19.73	35.66	34.75	
						100	7. 4	19.76	35.72	34.81	
						150	6. 9	19.86	35.89	34.97	
						300	5. 2	19.82	35.85	34 92	
				59°23.5'							
17	14	8 a.m.		10°37.5'		0	3. 5	16.70	30.23	29.57	
						10	5. 1	17.20	31.12	30.43	
						20	8. 8	18.64	33.71	32.90	
						30	9. 0	19.41	35.08	34.21	
						40	7. 9	19 52	35.29	34.40	
						50	7. 8	19.64	35.52	34.62	
						70	7. 4	19.68	35.58	34.68	

No.	December 1896. Date	Hour	Weather	Locality	Soundings	Depth from which sample at that depth	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille	Remarks
				$59^0 26.7'$N.		m.	^{0} C.				
18	14			$10^0 32.5'$E.		0	2. 0	16.67	30.18	29.53	Horten.
						10	4. 0	16.96	30.69	30.02	
						15	7. 5	18.19	32.90	32.11	
						20	8. 4	18.46	33.37	32.58	
						30	9. 6	19.34	34.96	34.10	
						40	8. 6	19.47	35.19	34.32	
						50	8. 0	19.57	35.38	34.50	
						70	7. 3	19.71	35.62	34.71	
						100	6. 0	19.74	35.69	34.78	
						150	5. 8	19.71	35.62	34.71	
				$59^0 37'$							
19	14			$10^0 38.5'$		0	5. 5	17.62	31.87	31.14	Drøbak.
						10	6. 4	17.80	32.19	31.44	
						20	8. 9	18.66	33.76	32.93	
						30	9. 2	19.36	35.00	34.13	
						40	7. 6	19.40	35.06	34.20	
						50	6. 7	19 54	35.32	34.42	
						70	6. 2	19.52	35.29	34.40	
						100	6. 0	19.61	35.45	34.55	
						150	5.75	19.67	35.56	34.66	
				$59^0 47.5'$							
20	14			$10^0 33'$		0	4. 5	17.48	31.64	30.90	
						10	6. 2	17.48	31.64	30.90	
						20	9. 2	18.46	33.37	32.58	
						30	8. 8	18.51	33.47	32.67	
						40	8. 1	18.65	33.68	32.86	
						50	7. 1	18.61	33.66	32.81	
						75	7. 6	18.72	33.85	33.01	
						100	7. 6	18.76	33.93	33.11	

II. Sections off Langesund and Hvaler Autumn 1897. (Gran and Bie).

II. Sections off Langesund and Hvaler (Gran and Bie).

Station.	Autumn 1897. Date	Hour	Weather	Locality	Soundings	Depth from which the sample obtained	Temparature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille	Remarks

A. Section off Langesund 28—29th October 1897.

Station.	Date	Hour	Weather	Locality	Soundings	Depth	Temp.	Cl. per litre	Salt per litre	Salt per mille	Remarks
	Octbr.			58°59′ N.		m.	° C.				1/2 mile SSO of
L_1	28	10 a. m.		9°46′.5 E.	135	0	8. 8	7.29			Langesund.
						20	12. 7	18.41	33.31	32.52	
						40	12. 6	19.35	34.98	34.12	
						60	12. 1	19.49	35.23	34.34	
						80	12. 0	19.59	35.42	34.53	
						120	12. 0	19.55	35.32	34.45	
				58°55′.5N.							4 miles SSO
L_2	29	9 1/2 a. m.		9°49′ E.		0	7. 9				of Langesund.
						10	11.85	16.55	29.97	29.33	
						20	12. 0	18.13	32.80	32.03	
						40	12. 1				
						60	12. 4	19.32	34.92	34.06	
						80	12.35				
						120	12.45				
						200	12. 7				
				58°53′ N.							
L_3	29	3 p. m.		9°51′ E.		0	8. 8	12.62	22.92	22.55	
						10	11. 8	17.35	31.40	30.70	
						20	12. 4	18.41	32.31	32.52	
						40	12. 0	19.07	34.48	33.64	
						60	11.95	19.35	34.98	34.12	
						80	11. 5				
						120	11.35				
						200	11. 4				
						250	11. 9	19.42	35.10	34.20	

B. Section off Langesund 5—6th November 1897.

Station.	Date	Hour	Weather	Locality	Soundings	Depth	Temp.	Cl. per litre	Salt per litre	Salt per mille	Remarks
	Novbr.			58°59′ N.							
L_1	6			9°46′.5E.	135	0	6.96	9.72	17.59	16.37	
						10	9. 9	14.87	26.96	26.44	
						20	12. 2	17.81	32.24	31.50	
						40	12.12	19.14	34.60	33.76	
						60	11. 5	19.63	35.51	34.61	
						80	10.10	19.83	35 85	34.93	
						100	8. 3				
						120	7. 5				
				58°55′.5N.							
L_2	5			9°49′ E.		0	7. 4	12.97	23.55	23.15	
						20	11. 7	17.49	31.66	30.95	
						80	8. 5	19.91	35.99	35.07	
						100	7. 2				
				58°53′ N.							
L_3	5	2 p. m.		9°51′ E.		0	8.26	13.18	23.92	23.52	
						10	10. 6	15.22	27.60	27.05	
						20	10.48	17.35	31.40	30.70	
						40	11.92	19.07	34.48	33.64	

Station	November 1897 Dato	Hour	Weather	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Salt per litre	Salt per mille	Remarks
						m.	⁰ C.				
	Novbr.			58⁰53′ N.							
L_3	5	2 p. m.		9⁰51′. E.		60	11.14	19.63	35.51	34.61	
						80	8. 5	19.88	35.93	35.01	
						100	7. 4	19.98	36.10	35.19	
						120	7. 2				
						150	7.08	20.11	36.34	35.43	
						200	6.32	20.11	36.34	35.43	
						250	5. 9	20.11	36.34	35.43	

C. Section off Langesund 10—11th November 1897.

Station	Dato	Hour	Weather	Locality	Soundings	Depth	Temperature	Cl per litre	Salt per litre	Salt per mille	Remarks
	Novbr.			58⁰55′.5N.		Meter					
L_2	10	1 p. m.		9⁰49′ E		0	5. 6	11.87	21.57	21.24	
						10	9. 0	14.54	26.37	25.87	
						20	12. 0	18.10	32.74	31.98	
						40	12. 0	19.22	34.75	33.88	
						60	9. 5	19.96	36.07	35.15	
						80	7. 9	20.00	36.14	35.21	
						120	7. 2	20.00	36.14	35.21	
						150	7. 0	20.10	36.32	35.37	
						200	6. 2	20.03	36.19	35.26	
				58⁰50′ N.							
L_4	11	1 p. m.		9⁰54′ E.		0	7. 7	13.49	24.48	24.06	
						10	11. 5	18.07	32.69	31.92	
						20	11. 4	18.48	33.43	32.64	
						40	11. 2	19.66	35.54	34.64	
						60	9. 0	19.87	35.91	35.00	
						80	7. 6	19.93	36.03	35.10	
						120	7. 2	19.93	36.03	35.10	
						200	7. 0				
						280	6. 8				

D. Observations at Langesund 13—24th November 1897.

Station	Dato	Hour	Weather	Locality	Soundings	Depth	Temperature	Cl per litre	Salt per litre	Salt per mille	Remarks
	Novbr.										
	13					0	11. 1	16.95	30.68	30.02	4 miles S of Langesund.
	15					0	9. 0	14.54	26.37	25.87	1 mile S of L.
	17					0	7. 9	14.31	25.96	25.48	8 miles S of L.
				58⁰55′ N.							
L_2	18	2 p. m.		9⁰49′ E.		0	7.85	13.76	24.96	24.52	
						10	8. 3	14.17	25.71	25 24	
						20	10. 7	17.76	32.15	31.41	
						40	10. 8	19.02	34.39	33 55	
						60	10. 6	19.70	35.61	34.69	
						80	10. 1	19.80	35.79	34.88	
						120	9. 2	19.87	35.91	35.00	
						200	7. 6	20.00	36.14	35.21	
	20					0	9. 4	13.70	24.86	24.42	Langesund E of the lighthouse.
				58⁰50′ N.							
L_4	22	12 noon.		9⁰54′ E.		0	8. 9	16.34	29.54	28.96	
						10	8. 6	16.85	30.51	29.85	
						20	8. 4	18.41	33.31	32.52	
						40	9. 3	19.66	35.54	34.64	

Station	November 1897 Date	November 1897 Hour	Weather	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Saline contents Salt per litre	Saline contents Salt per mille	Remarks
						m.	° C.				
L_4	22	12 noon.		58°50′ N. 9°54′ E.		60	9.4	19.73	35.60	34.75	
						80	9.35	19.80	35.79	34.88	
						120	9.3	19.83	35.85	34.93	
						200	9.3	19.80	35.79	34.88	
						250	9.4	19.83	35.85	34.93	
	24					0	8.2	17.96	32.49	31.74	8 miles. } S. of L.
						0	7.7	16.88	30.56	29.90	1 mile } S. of L.

E. Section off Langesund 25th Novembər 1897.

Station	Date	Hour	Weather	Locality	Soundings	Depth	Temperature	Cl per litre	Salt per litre	Salt per mille	Remarks
L_1	Novbr. 25	9 a. m.		58°59′ N. 9°46′.5E.	135	0	7.0	15.80	28.63	28.05	
						10	7.7	17.76	32.15	31.41	
						20	8.1	18.10	32.74	31.98	
						40	9.5	19.12	34.57	33.71	
						80	9.5	19.66	35.54	34.64	
						120	7.8	20.00	36.14	35.21	
L_2	25	10½ a. m.		58°55′.5N. 9°49′ E.		0	6.6	17.29	31.29	30.59	
						10	7.45	17.97	32.51	31.75	
						20	9.2	18.88	34.15	33.29	
						40	9.35	19.12	34.57	33.71	
						60	9.3	19.21	34.74	33.87	
						80	9.3	19.39	35.04	34.18	
						200	9.2	19.46	35.16	34.30	
L_3	25	1½ p. m.		58°53′ N. 9°51′ E.		0	6.7	17.56	31.79	31.07	
						10	7.6	17.97	32.51	31.75	
						20	7.8	18.14	32.81	32.05	
						40	9.1	19.29	34.87	34.01	
						60	9.4	19.46	35.16	34.30	
						80	9.4	19.46	35.16	34.30	
						120	9.2	19.40	35.06	34.20	
						200	9.25	19.50	35.25	34.36	
						250	9.1	19.50	35.25	34.36	

F. Observations at Langesund 30th November—4th December 1897.

Station	Date	Hour	Weather	Locality	Soundings	Depth	Temperature	Cl per litre	Salt per litre	Salt per mille	Remarks
L_3	Novbr. 30	3 p. m.		58°53′ N. 9°51′ E.		0	6.7	17.99	32.54	31.78	
						10	7.2	18.13	32.80	32.03	
						20	8.1	18.59	33.63	32.82	
						40	8.5	18.93	34.24	33.40	
						60	8.6	19.32	34.92	34.06	
L_1	Decbr. 4	10 a. m.		58°59′ N. 9°46′.5E.		0	4.8	16.40	29.70	29.07	
						10	6.5	18.06	32.67	31.91	
						20	6.6	18.09	32.72	31.96	
						30	7.6	18.43	33.34	32.55	
						40	9.4	19.29	34.87	34.01	
						60	8.7	19.85	35.88	34.96	
						80	8.6	19.89	35.96	35.04	
						120	8.0	20.05	36.23	35.29	

Station	Autumn 1897 Date	Hour	Weather	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Salt per litre	Salt per mille	Remarks
						m.	⁰ C.				
L_2	Decbr. 4	2½ p. m.		58°55'.5N. 9°49' E.		0	6. 0	18.06	32.67	31.91	
						10	6. 5	18.06	32.67	31.91	
						20	6. 3	18.13	32.80	32.03	
						30	7.45	18.36	33.22	32.43	
						40	8. 8	18.96	34 29	33.44	
						60	8. 9	19.62	35.47	34.56	
						80	8. 7	20.02	36.18	35.25	
L_3	4	12 noon.		58°53' N. 9°51' E.		0	6. 1	18.06	32.67	31.91	
						10	6. 3	18.06	32.67	31.91	
						20	6. 5	18.09	32.72	31.96	
						30	7. 0	18.16	32.86	32.08	
						40	8. 8	19.12	34.57	33.71	

G. Observations at Hvaler 30th November 97.

H_1	Novbr. 30			58°59'.8N. 10°59' E.		0	5. 5	15.70	28.45	27.88	
						9	9. 0	19 06	34.46	33.63	
						19	9. 2	19.14	34.60	33.76	
						28	9. 2	19.16	34.65	33.79	
						38	9. 2	19.29	34.87	34.01	
						56	9. 2	19 39	35.04	34.18	
						75	9. 1	19.59	35.42	34.53	
						94	8. 8	19.79	35 78	34.86	
						113	8. 5	19.81	35.80	34.89	
H_2	30			59° 0'.3N. 10°55' E.		113	8. 6	19.79	35.78	34.86	
						188	8. 0	19.92	36.01	35.09	
H_3	30			58° 0'.7N. 10°47' E		0	7. 0	17.32	31.35	30 64	
						9	7. 0	17.33	31.36	30.66	
						19	8. 8	18.72	33.85	33.04	
						28	9. 0	19.16	34.65	33.79	
						38	8. 9	19.29	34.87	34.01	
						56	9. 3	19.46	35.16	34.30	
						75	9. 0	19.79	35.78	34.86	
						94	9. 0	19.82	35.85	34.92	
						113	8. 8	19.92	36.01	35.09	
						141	8. 6	19.92	36.01	35.09	
						188	8. 5	19.95	36.05	35.13	
H_4	30			58°57'.4 10°34'		0	6. 9	17.66	31.97	31.24	
						9	7. 2				
						19	8. 0	18.22	32 96	32.19	
						28	8. 9	18 99	34.34	33.48	
						38	9. 0	19.16	34.65	33.79	
						56	9. 3	19.27	34.83	33.97	
						75	9. 1	19.51	35.28	34.38	
						94	9. 3	19.79	35.78	34.86	
						113	9. 0	19.92	36.01	35.09	
						188	8. 6	20.09	36.30	35.36	

Station	November 1898		Weather	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour						Cl per litre	Salt per litre	Salt per mille	

H. Observations at Hvaler, November 1898.

				58°57'.8N		m.	° C.				
H_1	7			10°59' E		0	6. 7	9.06			
						5	9. 0	14.05	25.49	25.03	
						10	9. 1	15.23	27.61	27.07	
						20	9,85	16.80	30.42	29.77	
						30	10. 0	17.47	31.62	30.91	
						40	10. 2	—	—	—	
						50	10. 2	18.41	33.31	32.52	
						60	10.28	—			
						80	10. 2	18.65	33.74	32.92	
						100	9. 0	19.48	35.21	34.33	

III. Observations in the Christiania Fjord.

a) Skagerak—Christiania, March 1897.
b) Vallø—Bygdø, September 1897.
c) Færder -Drøbak, October 1897.
d) Observations in the inner Christianifjord, Summer 1897.
e) Sections of the Christianiafjord, Autumn 1898.
f) Observations at Drøbak, February—April 1898.

III. Observations in the Christiania Fjord.

Station	1897 Date	Hour	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Salt per litre	Salt per mille	Remarks
			a) Section Skagerak—Christiania March 1897. (Hjort).							
	March				m.	⁰ C.				
21	20		Skagerak		0	0. 5	14.07	25.53	25 06	
					10	1.12	16.65	30 15	29.49	
					20	1 30	17.61	31.87	31 12	
					40	2.85	18.83	34.05	33.20	
					60	4 20	19.75	35.71	34.80	
					80	4. 4	19 90	35.98	35.05	
					100	4. 5	19.90	35.98	35.05	
22	20		Færder		0	0. 8	14.07	25 53	25.06	
					40	2. 4	18.57	33 60	32.73	
					50	4 3	19.39	35.04	34.18	
					80	4.32	19.75	35.71	34.80	
					120	4. 5	19.82	35.85	34.92	
23	20		Valle		10	0.32	16 91	30.61	29.93	
					25	0.35	17.76	32.15	31.42	
					40	2.02	18.53	33.50	32.69	
					50	4.55	19.27	34.83	33.97	
					80	6.25	19.78	35.75	34.83	
					120	6.35	19 75	35.71	34.80	
					200	6.25	19.86	35.89	34.97	
24	20		Drøbak		0	0. 8	16.75	30 32	29.66	
					10	0. 3	17.13	30.98	30.30	
					20	1. 1	17.94	32.44	31.69	
					30	1. 8	18.28	33.07	32.28	
					50	2. 2	18.50	33.45	32.65	
					60	4.78	19 38	35.03	34.16	
					80	6. 2	19 6[illegible]	35 58	34.68	
					120	6.53	19.86	35 89	34.97	
					200	6. 6	19.90	35.98	35.04	
25	21		Steilene		0	1.95	18.16	32.80	32.03	
					10	1.85	18.31	33.12	32.33	
					20	3. 0	18.53	33.50	32.69	
					30	5. 6	18 83	34.05	33.20	
					40	5. 7	19.05	34.44	33.62	
					50	5. 7	19.11	34.55	33.70	
					70	5. 4	19.31	34.91	34.04	
					85	5. 5	19.39	35.04	34.18	
			b) Section of the Christianiafjord September 1897. (Hjort).							
	Septbr.		59°14'8.N.							
26	21		10°37' E.		0	13. 5	10.40	18 90	18.65	Valle-Rauer
					30	15. 7	18.39	33.27	32.48	
					50	13. 2	18.77	33 94	33.12	
					75	8. 1	19.17	34.67	33.81	
					100	5. 8	19.55	35.32	34.45	
					150	5. 2	19.72	35.65	34.76	
					200	5. 1	19.75	35.71	34 80	
					250	5. 0	19.75	35.71	34.80	

Station	1897		Locality	Soundings		Depth from which the sample obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour						Cl per litre	Salt per litre	Salt per mille	
	Septbr.		59°14′.8N.								
27	22		10°37′ E.			0	13. 8	11.70	21.26	20.94	Horten
						15	15. 0	16.59	30.04	29.40	
						30	13. 0	17.92	32.42	31.67	
						75	7. 5	19.07	34.48	33.64	
			59°37′. N.								
28	23		10°38′.5E.			0	13. 5	11.36	20 64	20.84	Drøbak
						5	14. 7	15.50	28.09	27.53	
						10	13. 0	16.18	29.30	28.69	
						20	11. 0	17.54	31.75	31.04	
						30	11. 1	18.36	33.22	32.43	
						40	9. 9	18.46	33.40	32.60	
						50	8 7	18.70	33.82	33.00	
						60	8. 2	18.84	34.06	33.24	
						80	5. 7	19.31	34.91	34.04	
						100	5 65	19.58	35.40	34.51	
						150	5.75	19.82	35.85	34 92	
						200	5. 8	19.82	35.85	34.92	
29	23		Spro			0	13.78	10.81	19.64	19.37	
						10	13. 9	15.13	27.43	26 90	
						20	10. 0	17.27	31.26	30 56	
						30	6. 4	18.26	33.03	32.26	
						40	5. 5	18.73	33.87	33.05	
						60	5. 3	18.90	34.15	33.35	
						80	5. 2	18.95	34.27	3[illegible].43	
30	23		Dyna			0	13. 4	9.52	17.24	17.01	
						5	14. 2	10.81	19.64	19 37	
						20	9. 4	17.07	30.99	30.22	
						30	6. 3	17.99	32.54	31.78	

c) **Section of the Christianiafjord, October 1897.** (Hjort).

	Octbr.		59° 1′ N.								
31	16		10°37′.5E.			10	12. 0	15 78	28.59	28.02	Færder
						20	13. 0	17.49	31.66	30.95	
						30	12. 3	18.02	32.60	31.84	
						40	12. 2	18 34	33.18	32.40	
						65	13. 3	19.42	35.10	34.23	
						85	13. 0	19.56	35.35	34.47	
						100	12. 4	19.67	35.56	34.66	
			59°13′.5N								
32	16		10°40′ E.			0	9. 2	8.84	14.39	14.24	Raue
						10	12. 4	15.57	28.21	27.65	
						20	14.42	17.67	31.99	31.26	
						30	14.30	18.34	33.18	32.40	
						40	13. 6	18.58	33.61	32.81	
						60	12. 9				
						75	12.25	19.28	34.85	33.99	
						80	8.45	19.35	34.98	34.12	
						100	7. 0	19.63	35.51	34.61	
						150	6. 2	19.81	35.80	34.89	
						200	5.45	19.85	35.88	34.96	

Station	1897 Date	Hour	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Salt per litre	Salt per mille	Remarks
	Octbr.			Bastø.	m.	^{0} C				
33	16				0	9. 6	9.87	17.84	17.61	
					20	14. 3	17.56	31.79	31.07	
					40	13. 7	18.41	33.31	32.52	
					60	12. 6	19.04	34.42	33.58	
					80	8. 5	19.28	34 85	33.99	
					100	6. 0	19.60	35.42	34.53	
					150	5. 4	19.70	35.61	34.69	
34	16			Drøbak.	0	9. 8	11.43	20.77	20.45	
					20	11. 9	17.18	31.09	30.42	
					40	11. 9	18.37	33.23	32.45	
					60	11. 7	19.11	34.55	33.70	
					80	7. 4	19.11	34.55	33.70	
					100	5. 7	19.63	35.51	34.61	
					150	5. 9	19.97	36.08	35.16	

d) Observations in the inner Christianiafjord, Summer 1897.

Station	Date	Hour	Locality	Soundings	Depth	Temperature	Cl per litre	Salt per litre	Salt per mille	Remarks
	July 17			Hvitsten	0	18. 0	12.17	22.11	21.76	
					10	11. 9	17.03	30.82	30.15	
					20	10. 2	17.88	32.36	31.61	
					30	7.25	18.02	32 60	31.84	
					40	5.78	18.53	33.52	32.72	
					50	5.60	18.63	33.70	32.89	
					60	4.91	19.26	34.81	33.95	
					100	5.70	19.72	35.65	34.76	
					200	5.15	19.72	35.65	34.76	
	Aug. 11			Sandspollen.	7	19.25	12.99	23.58	23.18	
					10	11.70	16.48	29.84	29.21	
	12				0	19. 8	19.21	22.18	21.83	
					5	19. 9	12.24	22.23	21.88	
					7	19. 7	12.41	22.54	22.18	
					10	19. 4	12.62	22.92	22.52	
	12			Inner part of Hallangspollen.	10	18. 0	13.46	24.43	24.01	
	12			Hallangspollen.	10	18. 9	13.02	23.64	23.24	
					15	17. 8	13.50	24.50	24.08	
					20	12. 2	16.01	29.01	28.41	
					24	9. 0	17.51	31.69	30.98	
					30	8. 8	17.58	31.82	31.11	
					40	8. 8	17.65	31.95	31.23	
					50	6.65	18.53	33.52	32.72	
					60	6. 3	18.67	33.77	32.96	
	13			Off the Sætrepollen	0	20. 0				
					38	5.45	18.70	33.82	33.00	
	13			Kaholmen.	41	5. 7	18.77	33.94	33.12	

Station	Aug. 1897 Date	Hour	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Salt per litre	Salt per mille	Remarks
					m.	⁰ C.				
	14				1	19.25	8.23	14.89	14.72	Borøen
					7	20. 8	12 44	22.59	22.23	
					10	16. 7	13 26	24.07	23.66	
					15	7. 5	17.07	0.99	30.22	
					24	6. 2	18.53	33.52	32.72	
	14				6	21. 0	11.90	21.62	21.29	Næsøen.
	14				7	19. 4	12.48	22.66	22.30	Sandviken.
					10	17. 1	13.02	23.64	23.24	
	15				0	19.75	11.97	21.75	21.42	Sandviken.
					7	19. 2	12.65	22.97	22.60	
					10	18. 3	13.46	24.43	24.01	
					20	7. 4	17.27	31.26	30.56	
					30	5. 6	18.02	32.60	31.84	
					40	5. 7	18 70	33.82	33.00	
					50	6. 1	18 90	34.18	33.35	
					60	6. 0	18.90	34.18	33.35	
	26	10 a. m.		120	0	18. 1	11.63	21.73	20.81	Steilene.
					10	18. 0	12.17	22.11	21.76	
					20	8.85	17 00	30.77	30 10	
					40	5. 3	18.77	33.94	33.12	
					60	5. 4	18.77	33.94	33.12	
					80	5.45	18.77	33.94	33.12	
	26	11.30 a. m.		80	0	18. 2	11.76	21.37	21.05	Spro.
					10	18.15	12.04	21.87	21.54	
					20	8. 8	17.20	31.13	30.45	
					30	5. 7	18.29	33.09	32.31	
					40	5. 5	18.70	33.82	33.00	
					60	6. 1	18.78	33.96	33.14	
	26	1 p. m.		65	0	18. 2	11.56	21.01	20.69	Næsodden.
					10	18 2	12.34	22.41	22.06	
					20	8. 4	17.34	31.38	30.68	
					30	5. 2	18.43	33 34	32 55	
					40	5. 4	18.87	34.13	33.27	
					65	5. 8	18.90	34.18	33.35	
	26	2.30 p. m.		142	0	19. 1	11.76	21.37	21.05	Bunde-fjord.
					10	18. 2	12 38	22.48	22.13	
					20	8. 2	17.00	30.77	30.10	
					40	4. 9	18.36	33.22	32.43	
					60	4. 1	17.78	32.18	31.45	
					80	4.95	18.29	33.09	32.31	
					100	5.35	18.70	33.82	33.00	
					142	5. 5	18.77	33.94	33.12	
	Septbr. 6				0	16.58	8.91	16.14	15.94	Drøbak.
					5	15. 5	13.26	24.07	23.66	
					10	15. 0	15.50	28.09	27.53	

Station	September 1897 Date	Hour	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Salt per litre	Salt per mille	Remarks
					m.	⁰ C.				
	Septbr 6				20	14. 0	16.39	29.68	29.05	Drøbak.
					30	12. 2	17.27	31.26	30.56	
					40	11. 2	17.78	32.18	31.45	
					60	9. 5	18.26	33.03	32.26	
					80	8. 8	18.70	33.82	33.00	
					100	7. 2	19.38	35.03	34.16	
					120	6. 3	19.65	35.53	34.63	
					150	6. 0	19.72	35.65	34.76	
					180	6. 0	19.82	35.82	34.92	
	10				0	15. 2	9.62	17.41	17.18	Bunde-fjord.
					10	15. 5	14.21	25.78	25.31	
					20	9. 0	17.00	30.77	30.10	
					40	5. 5	18.84	34.06	33.24	
					60	6. 0	19.11	34.55	33.70	
					80	6. 0	19.24	34.77	33.91	
					100		19.38	35.03	34.16	
					150	6. 0	19.31	34.91	34.04	
	14				0	16. 2	10.74	19.51	19.25	Næsod-tangen.
					10	13. 8	15.37	27.87	27.30	
					20	9. 0	17.48	31.64	30.93	
					40	6. 2	18.80	33.99	33.17	
					60	6. 0	19.04	34.42	33.58	
					80	6. 0	19.11	34.55	33.70	
	14				0	16. 1	10.88	19.77	19.49	Langaaren
					10	14. 3	14.89	27.00	26.48	
					20	11. 5	17.41	31.51	30.81	
					40	6. 2	18.84	34.06	33.24	
					60	5. 8	18.90	34.18	33.35	
					80	5. 5	18.97	34.31	33.46	
					100	5. 5	19.04	34.42	33.58	
					140	5. 3	19.07	34.48	33.64	
	19				0	14. 5	14.69	26.63	26.13	Vrængen.
					13	15. 0	15.98	28.95	28.36	
					33	14. 4	18.56	33.58	32.77	E of Vræng.
					10	15. 0	15.03	27.25	26.72	W. of Vræng.
					20	15. 2	17.68	32.00	31.28	
	20				0	14. 5	14.48	26.26	25.77	Off Ule-holmen
					9	15. 0	15.78	28.59	28.02	
					18	15. 5	17.20	31.13	30.45	
					27	15. 8	17.88	32.18	31.45	

Station	September 1898		Locality	Soundings		Depth from which the sample obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour						Cl per litre	Salt per litre	Salt per mille	

e) Section of the Christianiafjord, Autumn 1898. (Hjort and Schmidt-Nielsen).

Station	Date	Hour	Locality	Soundings		Depth	Temperature	Cl per litre	Salt per litre	Salt per mille	Remarks
						m.	⁰ C,				
1						0	15.55	11.91	21.64	21.31	Lysaker.
						5	15. 3	13 23	24 01	23 60	
						10	15. 1	13.66	24.79	24.35	
						20	12 9	15.55	28.18	27.61	
						25	8.25	17.37	31 44	30.73	
						30	6. 9	18 19	32.90	32.13	
						40	6. 5	18.62	33.68	32.87	
						60	6. 3	18.83	34.05	33 20	
2						0	14. 8	13.06	23 71	23 31	Filtvedt.
						10	14. 6	13 34	24.21	23.80	
						20	10. 5	17 41	31.51	30 81	
						40	10. 2	18.19	32.90	32.13	
						60	7. 6	18.76	33.92	33 10	
						100	6.15	19 58	35 40	34 51	
						200	6.15	19.80	35.79	34.88	
8		3 p. m.	59⁰ 0'.5 N. 10⁰55' E.			0	16. 0	8 70			
						10	14.45	17.41	31.51	30 81	
						20	14.05	18.22	32 96	32.19	
						40	13 7	18.69	33 80	32.99	
						60	13. 1	18 90	34.18	33.35	
						8	10 15	19.15	34.62	33.78	
						120	7. 3	19 73	35 66	34.75	
						200	7. 1	19.87	35.91	35.00	
12			59⁰12' N. 10⁰36'.7 E.	75		0	14.85	14.41	26.14	25.66	
						10	14.65	16.16	29.26	28 65	
						20	13. 9	16 94	30.67	30.00	
						40	13.85	18.33	33 16	32.38	
						60	12.95	18.76	33.92	33.10	
						75	8.35	19.08	34 51	33.65	
16			58⁰53' N. 10⁰11' E.			0	13. 7	17.66	31 97	31.24	
						10	13. 6	17.66	31.97	31.24	
						20	12 7	17.80	32.22	31.48	
						40	12. 7	19.29	34.87	34.01	
						60	10.18	19 76	35.72	34.80	
						80	9.15	19.84	35.86	34 95	
						120	8.25	19 87	35 91	35.00	
						160	7. 4	19.95	36.05	35.13	
19		8 a. m.	59⁰ 1' N. 10⁰ 3'.7 E.			0	14. 4	12.81	23.26	22.88	Larviks. fjord.
						10	14. 4	16.05	29.08	28.47	

Station	1898 Date	Hour	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Salt per litre	Salt per mille	Remarks
	Septbr.				m.	⁰ C.				
	19				20	14. 2	16.66	30.17	29.53	Larviksfjord.
					40	13. 9	18.41	33.31	32 52	
					60	13.05	18.83	34.05	33.20	
					80	12. 4	19 01	34 38	33.54	
					120	8. 3	19.76	35.72	34.80	
	Octbr 8		59⁰ 1′ N. 10⁰39′ E.		0	12. 3				
					10	13. 0	18.09	32.72	31.96	
					20	13. 0	18.41	33.31	32.52	
					40	13. 0	18.55	33.56	32.76	
					60	12. 1	19.29	34 87	34.01	
					80	8 55	19.77	35.72	34.81	
					120	8. 2	19.77	35.72	34.81	
					150	7. 5	19.89	35 96	35.04	
					300	6. 9	19.89	35.96	35.04	
	11				0	11. 1	14 56	26.40	25.90	Filtvedt.
					10	13. 4	17.97	32.51	31.75	
					20	13 2	18.34	33 18	32.40	
					40	11. 0	18.62	33.68	32.87	
					60	6. 8	19.04	34.42	33.58	
					80	6.55				
					120	6. 2	19.59	35.42	34 53	
					200	6. 0	19.77	35.72	34.81	
	10				0	10. 3	0 78		1.40	Drammensfi.
					10	11.85	10.17		17.87	
					20	9.65	14.05	25.49	25.03	
					30	4. 8	16.01	29.01	28.41	
					40	4. 6	16.69	30.22	29 58	
					60	4. 6	16.97	30.72	30.05	
					80	4. 6	17.12	30.99	30 31	
					120	4. 6	17.19	31 11	30.43	

b) Observations at Drøbak, Winter time (Bie).

	Feb. 7	9 a .m.	Drøbak.		0	1. 0	15.80	28.63	28.05	
	8	9 a. m.			0	1. 0	15.74	28.52	27.95	
	9	9 a. m.			0	1. 0	15.64	28.34	27.77	
	10	9 a. m.			0	0. 5	16.00	28.99	28.39	
	10	10 a. m.			0	0. 5	15.70	28.45	27.88	
					10	4 0	17 60	31 86	31.14	
					20	7. 0	18 79	33.97	33.15	
					40	7. 5	19.26	34.81	33.95	

Station	February 1898 Date	Hour	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Salt per litre	Salt per mille	Remarks
					m.	⁰ C.				
	10		Drøbak.		60	7. 8	19 42	35.10	34.23	
					80	7. 6	19 65	35.53	34.63	
					120	7. 0	19.69	35.60	34.70	
	11	9 a. m.			0	1. 5	16.33	29.57	28.94	
	12	9 a m			0	2. 2	16.70	30.24	29.60	
	13	9 a. m.			0	3. 5	17.20	31.13	30.45	
	14	9 a. m			0	3. 0	17.00	30.77	30.10	
	15	9 a. m.			0	2. 5	16.67	30.19	29.54	
	16	9 a. m.			0	3. 5	17.46	31.60	30.89	
					10	3. 8	17.56	31.79	31.07	
					20	4 0	17.66	31.97	31.24	
					40	5. 0	18.19	32.90	32.13	
					60	6. 8	18 92	34.23	33.38	
					80	7. 2	19 32	34.92	34.06	
					120	7. 4	19.59	35.42	34.53	
	17	9 a. m			0	1. 5	16.17	29.28	28.67	
	18	9 a. m.			0	1. 5	16.10	29.17	28.55	
	19	4 a. m.			0	1. 2	16.17	29.28	28.67	
	20	9 a m			0	1. 4	16.43	29.75	29.12	
	21	9 a m.			0	1. 0	16.30	29.52	28.89	
	22	9 a m.			0	0. 8	16.33	29.57	28.94	
	23	9 a. m.			0	1. 8	16.53	29.93	29.30	
					10	5. 0	18.09	32.72	31.96	
					20	6. 8	19.09	34.51	33.66	
					40	7. 0	19 59	35.42	34.53	
					60	6. 8	19.69	35.60	34.70	
					80	7. 0	19 72	35.65	34.76	
					120	7. 0	19.72	35.65	34.76	
	24				0	0. 7	16.37	29.64	29.01	
	25				0	0. 8	16.33	29.57	28.94	
	26				0	2. 2	17.70	32.04	31.31	
	27				0	1. 8	16 70	30.24	29.60	
	28				0	2. 5	17.33	31.36	30.66	
	March 1				0	2. 5	17.06	30.88	30.21	
	2				0	2. 4	16.50	29.88	29.25	

Station	March 1898		Locality	Soundings		Depth from which the sample obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour						Cl per litre	Salt per litre	Salt per mille	
						m.	° C.				
	2		Drøbak			10	2. 8	16.67	30.19	29.54	
						20	3. 8	16.80	30.42	29.77	
						40	4. 0	17.80	32.22	31.48	
						60	5. 5	19.59	35.42	34.53	
	3					0	2. 0	16.57	30.01	29.37	
	4					0	1. 5	16.80	30.42	29.77	
	5					0	1. 0	16.80	30.42	29.77	
	6					0	1. 4	16.80	30.42	29.77	
	7					0	0. 8	16.91	30.61	29.95	
	8					0	0. 7	17.06	30.88	30.21	
	9					0	0. 9	17.06	30.88	30.21	
	10					0	2. 0	17.27	31.26	30.56	
						10	4. 8	18.79	33.97	33.15	
						20	6. 0	19.52	35.29	34.40	
						40	6. 0	19.59	35.42	34.53	
						60	6. 2	19.70	35.61	34.69	
						80	6. 5	19.70	35.61	34.69	
	11					0	2. 2	17.64	31.93	31.21	
	12					0	2. 0	17.56	31.79	31.07	
	13					0	2. 0	17.67	31.99	31.26	
	14					0	2. 5	17.20	31.13	30.45	
	15					0	2. 2	17.34	31.38	30.68	
	16					0	2. 0	16.83	30.48	29.82	
	17					0	2. 0	16.30	29.52	28.89	
						10	2. 2	16.34	29.57	28.94	
						20	2. 5	16.41	29.72	29.09	
						40	5. 0	17.49	31.66	30.95	
						60	6. 0	19.59	35.25	34.36	
						80	6. 0	19.70	35.61	34.69	
						120	6. 0	19.73	35.66	34.75	
	18					0	1. 8	13.12	23.82	23.41	
	19					0	1. 7	14.17	25.71	25.24	
	20					0	1. 7	14.60	26.47	25.97	
	21					0	1. 8	14.60	26.47	25.97	
	23					0	2. 7	16.45	29.79	29.16	

Station	March 1898		Locality	Soundings		Depth from which the sample obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour						Cl per litre	Salt per litre	Salt per mill	
						m.	⁰ C.				
	23		Drøbak			10	4. 1	18 41	33.31	32.52	
						20	5. 5	19.62	35.47	34 56	
						40	6. 1	19.83	35.85	34.93	
						60	6. 1	19.83	35.85	34 93	
						80	6. 0	19.83	35 85	34 93	
						120	6. 0	19.83	35.85	34.93	
	24	9 a. m.				0	2. 2	16.35	29.61	28.97	
	25	—				0	1. 8	16.63	30.11	29.47	
	26	—				0	2. 0	17.20	31.13	30.45	
	27	—				0	2. 4	17.31	31.33	30.63	
	28	—				0	2. 2	18.73	33.87	33.05	
	30	—				0	2. 5	17.77	32.17	31.43	
	31	—				0	3. 0	17.87	32.34	31.59	
	April 1					0	3. 3	17.63	31.91	31.19	
	June 13					0	15. 3	10.45			
						10	15. 2	11.12	20.21	19.92	
						20	7. 1	17.98	32 53	31 77	
						30	6. 3	18 69	33.80	32.99	
						40		18.91	34.19	33.36	
						50	6. 1	18 98	34.32	33 48	
						68	6 2	19 05	34.44	33.62	
						80	6. 2	19 09	34.51	33.66	
						95	6. 3	19.16	34.65	33.79	

IV. Observations from the Southern coast and fjords, Summer and autumn 1898.

(Hjort and Schmidt-Nielsen).

IV. Observations from the Southern coast and fiords.

Station	July 1898		Weather	Locality	Sounding	Depth from which sample obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour						Cl per litre	Salt per litre	Salt per mille	
					m.	m.	⁰ C.				
	26	9 a. m.		58°55′ N. 9°51′ E.		0	14.6	17.30	31.31	30.61	
						10	13.95	17.30	31.31	30.61	
						20	13.52	17.37	31.44	30.73	
						40	11.60	18.51	33.49	32.69	
						60	9.6	19.01	34.38	33.54	
						80	8.5	19.65	35.53	34.63	
						120	7.7	19.97	36.08	35.16	
						200	7.15	20.05	36.23	35.30	
	26	9 p. m.		58° 1′ N. 7°50′ E.	170	0	13.7	17.05	30.86	30.19	
						10	13.7	17.26	31.24	30.54	
						20	11.65	18.51	33.49	32.69	
						30	10.2	19.15	34.62	33.78	
						40	9.75	19.26	34.81	33.95	
						60	9.2	19.48	35.21	34.33	
						80	8.8	19.58	35.40	34.51	
						120	8.2	19.80	35.79	34.88	
						170	7.7	19.87	35.91	35.00	
	27	6 a. m.				0	12.5	18.05	32.65	31.89	Lindesnes.
		7 p. m.		58°45′ N. 5°25′ E		0	8.3	19.64	35.52	34.62	Jæderens rev
	30	9 a. m.		58°55′.5N. 5°40′ E.		0	12.4	18.19	32.90	32.13	Hafrs Fiord.
						5	12.4	18.22	32.96	32.19	
						10	10.9	18.62	33.68	32.87	
						15	8.7	18.86	34.10	33.26	
						20	8.3	18.86	34.10	33.26	
						25	7.85	18.86	34.10	33.26	
						30	7.15	18.90	34.18	33.35	
						35	5.49	18.90	34.18	33.35	
						40	5.3	18.90	34.18	33.35	
						45	5.1	18.90	34.18	33.35	
						50	5.1	18.90	34.18	33.35	
	Aug 1			58°49′.4N. 5°28′ E.		0	10.9	19.01	34.38	33.54	
						20	9.2	19.55	35.32	34.45	
						40	8.8	19.55	35.32	34.45	
	8	4 p. m.		58°54′ N. 5°21′ E.		0	12.85	18.41	33.31	32.52	
						10	12.55	18.41	33.31	32.52	
						20	10.0	19.12	34.57	33.71	
						40	8.4	19.60	35.42	34.53	
						60	7.7	19.84	35.86	34.95	
						100	7.0	19.90	35.98	35.05	
	11			58°55′ N. 5°46′ E.		0	12.28	17.12	30.99	30.31	Gaus Fiord.
						10	11.8	17.44	31.56	30.86	
						20	10.45	18.76	33.92	33.10	
						40	9.1	19.15	34.62	33.78	
						60	7.25	19.58	35.40	34.51	
						100	6.8	19.87	35.91	35.00	
						180	6.61	19.87	35.91	35.00	

Station	1898 Date	1898 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Saline contents Salt per litre	Saline contents Salt per mille	Remarks
					m.	m.	°C.				
	Aug. 16	5.30 p. m		59°12′ N. 5°20′ E.		10	13. 5	17.62	31.90	31.17	Skudesnes.
						20	13.18	17.94	32.46	31.70	
						40	12.88	18.12	32.78	32.01	
						60	10.58	18.90	34.18	33.35	
						80	9.60	19.26	34.81	33.95	
						120	7.75	19.58	35.40	34.51	
						200	6.70	19.90	35.98	35.05	
						300	6.65	19.97	36.08	35.16	
	18	noon		57°56′ N. 7°1.5′ E.		0	15. 5	16.34	29.59	28.96	Lister.
						10	14. 9	16.48	29.84	29.21	
						20	13. 5	17.55	31.77	31.05	
						40	12. 1	18.48	33.43	32.64	
						60	9. 5	19.26	34.81	33.95	
						80	8.95	19.87	35.91	35.00	
						120	7. 8	19.87	35.91	35.00	
						250	6. 9	19.97	36.08	35.16	
	18	5.30 p. m.		58° 8′ N. 6°53.5′ E.		0	17. 7	13.84	25.10	24.66	Lyngdals Fiord Sævig.
						5	15. 4	15.41	27.93	27.37	
						10	12.05	18.16	32.86	32.08	
						20*	7. 7	19.33	34.94	34.07	
						30	7. 2	19.33	34.94	34.07	
						40	6. 6	19.40	35.06	34.20	
						90	5. 9	19.44	35.14	34.26	
						200	5. 7	19.44	35.14	34.26	
	18	7 p. m.		58° 6′ N. 6°49′ E.	15	0	17. 1	13.98	25.36	24.91	Lyngdals Fiord. Entrance.
						5	15. 0	16.16	29.26	28.65	
						10	14. 1	16.80	30.42	29.77	
						15	13. 9	16.98	30.74	30.07	
	23	3 p. m.		58° 3′.5 N. 8° 6′ E.	90	0	16. 7	12.88	23.38	23.00	Oxø — Grønningen.
						20	14. 1	16.76	30.35	29.70	
						40	10. 6	19.12	34.57	33.71	
						80	8. 4	19.76	35.72	34.80	
						150	7. 3	19.90	35.98	35.05	
	Septbr 30	8 a. m.		59° 6′.5 N 9°38′ E.		0	11. 3	3.17		5.68	Frier Fiord.
						5	13. 7	16.64	30.13	29.49	
						10	13. 8	17.00	30.77	30.10	
						20	11. 5	17.95	32.48	31.72	
						30	6. 9	19.08	34.51	33.65	
						40	6.05	19.23	34.76	33.89	
						60	5. 9	19.23	34.76	33.89	
						80	6. 0	19.30	34.89	34.03	
						90	5. 9	19.33	34.94	34.07	
	Octobr 1	8 a. m.		58°52′ N. 9°50′ E.		0	12. 4	16.23	29.39	28.77	Langesund.
						10	12. 4	16.27	29.46	28.83	
						20	12. 9	16.95	30.68	30.02	
						40	13. 7	18.25	33.01	32.24	
						60	12. 1	19.55	35.32	34.45	
						80	9. 0	19.77	35.72	34.81	

Station	1898 Date	1898 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Saline contents Salt per litre	Saline contents Salt per mille	Remarks
					m.	m.	°C.				
	Octobr 1	8 a. m.		58°52′ N. 9°50′ E.		120	8. 0	19.97	36.08	35.16	
						200	7. 2	19.97	36.08	35 16	
						350	6. 7	20.01	36.16	35.23	
	1			58°56′ N. 9°48′ E.		0	12. 5	16.34	29.59	28.96	Langesund.
						10	12. 4	16.45	29.79	29 15	
						20	12. 9	17.19	31.11	30.43	
						40	13. 7	18.62	33.68	32.87	
						60	11.75	19 65	35.53	34.63	
						80	9. 1	19.77	35.72	34.81	
						120	7. 8	19 84	35.86	34.95	
						200	7. 3	19.97	36.08	35.16	
	1	noon.		59° 1′ N. 9°46′.5E.		0	12. 1	9.99			Langesunds Fiord.
						10	12. 9	16 30	29.52	28.89	
						20	13. 9	17.70	32.04	31.31	
						40	12. 3	18.48	33.43	32.64	
						60	11. 5	19.26	34.81	33.95	
						80	8. 5	19 61	35.45	34.55	
						120	6. 5	19.61	35.45	34.55	
	1			Brevik.		0	12. 1	10.45	18.99	18.74	
						5	12. 6	16.02	29.02	28.42	
						10	13 4	16.34	29.59	28.96	
						20	13.85	17.47	31.62	30.91	
						40	12. 3	18.48	33.43	32.64	
						60	11. 6	19.26	34 81	33.95	
						80	8. 2	19.37	35.01	34.14	
						100	6. 4	19.61	35 45	34.55	
	7			Lange-sund.		0	12. 6	16.45	29.79	29.16	
						10	13. 5				
						20	13. 4	18.47	33.42	32.62	
						40	13. 2	18.86	34.10	33.26	
						60	12.65	19.29	34.87	34.01	
						80	10.20	19.77	35.72	34.81	
						120	7. 6	19.97	36.08	35.16	
						200	7. 3	19.97	36.08	35.16	
	Decbr. 6			59°6′.5N. 9°38′ E.	85	5	8.55	15.71	28.47	27.89	Frier Fiord.
						20	9.25	18 06	32.67	31.91	
						30	8. 7	18 73	33.87	33.05	
						40	5. 8	19.26	34.81	33.95	
						60	5. 5	19.30	34.89	34.03	
						85	5. 8	19.30	34.89	34.03	
	6			Brevik.		0	4.95	7.18			
						5	8. 2	16.00	28.99	28.39	
						20	8. 2	17.88	32 36	31.61	
						30	8. 5	18.31	33.12	32.34	
						60	8.45	19.62	35 47	34.56	
						100	7. 6	19.69	35 60	34.70	
	6			Stathelle.		20	8. 1	18.06	32.67	31.91	

V. Supplements to the Surface Charts of the Skagerak and the North Sea 1896—1898.

V. Supplements to the Surface Charts of the Skagerak and the North Sea 1896—1898.

a) Christianssand—Antwerp December 1896, S/s Odin, Capt. Eitzen.

Station	December 1896 Date	Hour	Weather	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Salt per litre	Salt per mille	Remarks
							° C.				
	19	5 a. m.		Oxø lighthouse.		0	5.25	17.79	32.51	31.76	
		8 —		57°37′ N. 7°43′ E.		0	4.75	17.67	31.95	31.24	
		10 —		57°18′ 7°28′		0	6	19.30	34.85	33.99	
		12 noon.		56°58′ 7° 9′		0	7.50	19.59	35.42	34.53	
		2 p. m.		56°37′ 6°55′		0	7.50	19.42	35.10	34.23	
		4 —		56°21′ 6°41′		0	7.50	19.56	35.35	34.47	
		6 —		56° 4′ 6°28′		0	8	19.57	35.38	34.50	
		8 —		55°46′ 6°13′		0	8	19.50	35.25	34.36	
		10 —		55°31′ 6° 0′		0	8	19.62	35.47	34.56	
		12 night.		55°13′ 5°45′		0	8	19.54	35.32	34.42	
	20	2 a. m.		54°56′ 5°36′		0	8.50	19.59	35.42	34.53	
		4 —		54°40′ 5°25′		0	8.50	19.55	35.33	34.45	
		6 —		54°22′ 5°15′		0	7	19.55	35.33	34.45	
		8 —		54° 5′ 5° 5′		0	7.50	19.64	35.52	34.62	
		10 —		53°46′ 4°56′		0	8	19.78	35.75	34.83	
		12 noon.		Terschelling Lightship.		0	6.50	18.43	33.33	32.54	
		2 p. m.		53°12′ 4°33′		0	6	18.02	32.60	31.87	
		4 —		Haak Lightship.		0	6	18.29	33.09	32.30	
		6 —		52°41′ 4° 5′		0	7	19.88	35.93	35.01	
		8 —		52°23′ 3°52′		0	7	19.88	35.93	35.01	
		10 —		52° 6′ 3°40′		0	7	19.37	34.76	33.89	
		12 night.		Schouwen Lightship.		0	5.50	17.87	32.32	31.57	
	26	4 p. m.		Schouwen Lightship.		0	6	18.19	32.90	32.11	

Station	December 1896		Weather	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour						Cl per litre	Salt per litre	Salt per mille	
							° C.				
	26	6 p. m.		52° 9' N. 3°43' E.		0	650	19.35	34.98	34 12	
		8 —		52°26' 3°55'		0	7	19.35	34.98	34 12	
		10 —		52°45' 4° 8'		0	7	19.52	35 29	34.40	
		12 night.		53° 2' 4°21'		0	7	19.17	34.82	33.96	
	27	2 a. m.		53°15' 4°36'		0	7	18.93	34 24	33.40	
		4 —		53°32' 4°53'		0	7.50	19.64	35.52	34.62	
		6 —		53°51' 5° 0'		0	7.50	19.44	35.14	34 27	
		8 —		54°10' 5° 6'		0	7.50	19.73	35.66	34.75	
		10 —		54°27' 5°20'		0	7.50	19.84	35.86	34 95	
		12 noon.		54°45' 5°42'		0	7.50	19.73	35.66	34.75	
		2 p. m.		55° 4' 5°50'		0	7.50	19.83	35.85	34.93	
		4 —		55°20' 6° 0'		0	7.50	19.78	35.75	34 83	
		6 —		55°41' 6°10'		0	7 50	19.74	35.69	34.78	
		8 —		55°58' 6°23'		0	7.50	19.74	35.69	34 78	
		10 —		56°15' 6°36'		0	7.50	19.60	35.42	34.53	
		12 night.		56°33' 6°50'		0	7 50				

b) Christianssand—Antwerp November 1897. S/s Anvers, Capt. Eitzen.

	1897 Novbr. 6	10½ a. m.		Oxø lighthouse.		0	9	15.64	28.34	27.77	
		12 noon.		57°51' N. lat. 7°53' E. longd		0	9.25	17.81	32.24	31.50	
		2 p. m.		57°35' 7°40'		0	9.50	18.44	33.36	32.57	
		4 —		57°21' 7°30'		0	10	19.71	35.62	34.71	
		6 —		57° 5' 7°25'		0	10.25	19.71	35.62	34.71	
		8 —		56°50' 7° 0'		0	10.50	19 74	35.68	34.77	
		10 —		56°35' 6°50'		0	10.50	19.80	35.79	34.88	
		12 night.		56°21' 6°40'		0	11	19.85	35.88	34.96	

Station	November 1897		Weather	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour						Cl per litre	Salt per litre	Salt per mille	
							° C				
	Novbr. 7	2 a. m.		56° 7′ N. 6°26′ E.		0	11.25	19.94	36.04	35.12	
		4 —		55°52′ 6°13′		0	11.50	19.91	35.99	35.07	
		6 —		55°39′ 6° 3′		0	11.50	19.80	35.79	34.88	
		8 —		55°25′ 5°50′		0	11.50	19.94	36.04	35.12	
		10 —		55° 7′ 5°38′		0	11.50	19 91	35.99	35.07	
		12 noon.		54°47′ 5°20′		0	11.75	20.01	36.16	35.23	
		2 p. m.		54°33′ 5°13′		0	11.75	19.98	36.10	35.19	
		4 —		54°19′ 5° 5′		0	12	19.91	35.99	35 07	
		6 —		54° 5′ 4°55′		0	12	19.88	35.93	35.01	
		8 —		53°51′ 4°48′		0	12.25	19.77	35.72	34.81	
		10 —		53°37′ 4°40′		0	11.50	19 63	35.51	34.61	
		12 night.		53°23′ 4°28′		0	11	19.63	35.51	34.61	
	8	2 a. m.		53°10′ 4°15′		0	10.50	19.38	35.03	34.16	
		4 —		53° 0′ 4° 0′		0	11	19.56	35.35	34.47	
		6 —		52°46′ 3°52′		0	11.50	20.10	36.32	35.37	
		8 —		52°32′ 3°44′		0	12	20.12	36.36	35.45	
		10 —		52°18′ 3°35′		0	12	20 12	36.36	35.45	
		12 noon.		52°10′ 3°27′		0	11.50	20.10	36.32	35.37	
		7 p. m.		Schowen lighthouse.		0	11.25	18.69	33.80	32.99	

Antwerp—Christianssand, November 1897. s/s Anvers, Capt. Eitzen.

	Novbr. 13	3½ p. m.		Schouwen ligthouse.		0	10.75	18.69	33.80	32.99	
		8 —		52°25′ 3°53′		0	10.75	19.41	35.08	34.21	
		11½ —		Haaks ligthouse.		0	10.75	19 74	35.68	34.77	
	14	4 a. m.		Terschelling ligthouse.		0	10	19.19	34.69	33.84	
		8 —		54° 0′ 5°10′		0	11	19.53	35.30	34.40	

Station	November 1897 Date	Hour	Weather	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Salt per litre	Salt per mille	Remarks
							° C.				
	14	12 noon.		54°30′ N. 5°27′ E.		0	11.75	19.77	35.72	34.81	
		4 p. m		55° 2′ 5°45′		0	11.50	19.96	36.07	35.15	
		8 —		55°35′ 6° 8′		0	11.25	19.83	35.85	34.93	
		12 night.		56° 7′ 6°28′		0	11.25	19.83	35.85	34.93	
	15	4 a. m.		56°36′ 6°50′		0	10.50	19.80	35.79	34.88	
		8 —		56°55, 6°48′		0	10.25	19.87	35.91	35.00	
		12 noon.		57° 5′ 7° 0′		0	9.50	19.80	35.79	34.88	
		8 p. m.		57°18′ 7°20′		0	9	18.17	32.88	32.10	
		12 night.		57°42′ 7°38′		0	9 50	17.79	32.30	31 46	
	16	4 a. m.		Oxø ligthouse		0	9.25	16.18	29.30	28.69	

c) Christianssand—Hamburg, November 1897, S/s Kong Ragnar, O. Jensen.

	Novbr. 7	8 3/4 a. m.		58° 1, N. 8° 4′ E.		0	9	15.43	27.96	27.40	
		9 1/2 —		57°49′ 7°53′		0	9.50	16.23	29.39	28.77	
		10 1/2 —		57°40′ 7°45′		0	10	18.51	33.49	32.69	
		12 noon.		57°27′ 7°33′		0	9.75	19.53	35 30	34.40	
		2 1/2 p. m.		57° 5′ 7°12′		0	9.50	19.11	34.55	33.70	
		4 —		56°51′ 7° 0′		0	10	18.93	34.24	33.40	
		5 —		56°40′ 6°54′		0	10	18.90	34.18	33.35	
		6 —		56°30′ 6°46′		0	10.50	19.00	34.36	33.51	
		7 —		56°19′ 6°40′		0	10.50	19.18	34.69	33.83	
		8 —		56° 9′ 6°35′		0	11	19.25	34.81	33 94	
		9 —		56° 0′ 6°32′		0	11	18.93	34.24	33.40	
		10 —		55°51′ 6°28′		0	11	18 86	34.10	33.26	
		11 1/2 —		55°38′ 6°25′		0	11	18 90	34.18	33.35	
	8	1 a. m.		55°25′ 6°35′		0	11	18.72	33.85	33.04	
		2 1/2 —		55° 9′ 6°46′		0	10.50	18.37	33.23	32.45	

Station	November 1897 Date	Hour	Weather	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Salt per litre	Salt per mille	Remarks.
							°C.				
	8	4 a. m.		54°55′ N. 6°57′ E.		0	10	18.02	32.60	31.84	
		5¼ —		54°42′ 7°10′		0	9.50	17.32	31.35	30.64	
		6¼ —		54°30′ 7°25′		0	9	17.11	30.97	30.29	
		7½ —		54°20′ 7°36′		0	9	17.60	31.86	31 14	
		8¼ —		54°10′ 7°47′		0	9	17.64	31.93	31.21	
		9 —		54°10′ 7°58′		0	9	17.53	31.73	31.02	
		10 —		54° 6′ 8°12′		0	9	17.46	31.60	30.89	
		10¾ —		54° 2′ 8°20′		0	8.50	18.58	33.61	32.81	
		11½ —		53°58′ 8°35′		0	8	15.29	27.72	27.17	
		12 noon.		53°53′ 8°43′		0	7	12.97	23 55	23.15	

d) Grangemouth—Christianssand, November 1897. S/s „Norway".

Station	Date	Hour	Weather	Locality	Soundings	Depth	Temperature	Cl per litre	Salt per litre	Salt per mille	Remarks
	Novbr. 25	12 noon.		56°26′ N. 0°52′ W.		0	9.75	19.88	35.93	35 01	
		1 p. m.		56°28′ N. 0°40′ W.		0	9.75	19 91	35.99	35.07	
		2 —		56°31′ N. 0°24′ W.		0	9.50	19.99	36.15	35.20	
		3 —		56°34′ N. 0° 8′ W.		0	9.50	19.99	36.15	35.20	
		4 —		56°36′ N. 0° 7′ E.		0	9.50	19.96	36.07	35.15	
		5 —		56°38′ 0°21′		0	9.50	20 06	36.25	35 33	
		6 —		56°41′ 0°36′		0	9.25	20 06	36.25	35.33	
		7 —		56°44′ 0°52′		0	9	20 06	36.25	35.33	
		8 —		56°47′ 1° 7′		0	9	20.06	36.25	35.33	
		9 —		56°50′ 1°23′		0	9	20 06	36.25	35.33	
		10 —		56°53′ 1°39′		0	9	20.09	36.28	35.36	
		11 —		56°55′ 1°55′		0	9	20.06	36.25	35.33	
		12 night.		56°57′ 2° 9′		0	8.50	20 09	36.28	35.36	
	26	1 a. m.		57° 0′ 2°23′		0	8.50	20.06	36.25	35 33	
		2 —		57° 2′ 2°38′		0	8.50	20.06	36.25	35.33	

Station	November 1897		Weather	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents			Remarks.
	Date	Hour						Cl per litre	Salt per litre	Salt per mille	
							° C.				
	26	3 a. m.		57° 5′ N. 2°52′ E.		0	8.50				
		4 —		57° 8′ 3° 7′		0	8	20.06	36 25	25.33	
		5 —		57°10′ 3°22′		0	8	19.26	34.81	33.95	
		6 —		57°12′ 3°36′		0	8	19.26	34.81	33.95	
		7 —		57°14′ 3°50′		0	8	19.11	34.55	33.70	
		8 —		57°17′ 4° 8′		0	8	19.11	34.55	33.70	
		9 —		57°20′ 4°26′		0	8	18.94	34.25	33.41	
		10 —		57°23′ 4°44′		0	8	18.94	34.25	33.41	
		11 —		57°26′ 5° 2′		0	8	18.94	34.25	33.41	
	26	12 noon.		57°29′ 5°20′		0	8.25	18.94	34.25	33.41	
		1 p. m.		57°32′ 5°38′		0	8.50	18.65	33.74	32.92	
		2 —		57°35′ 5°55′		0	8.50	18.58	33.61	32.81	
		3 —		57°38′ 6°12′		0	8.50	18.58	33.61	32.81	
		4 —		57°41′ 6°30′		0	8.50				
		5 —		57°44′ 6°48′		0	9	18.65	33.74	32.92	
		6 —		57°47′ 7° 6′		0	9	18.79	33.97	33.15	
		7 —		57°50′ 7°23′		0	9	18.58	33.61	32.81	

e) **Christiania—Fredrikshavn.** s/s **Baldur,** Capt. Olsen.

Station	Date	Hour	Weather	Locality	Soundings	Depth	Temperature	Cl per litre	Salt per litre	Salt per mille	Remarks
	Novbr.										
	4	9 a. m.		Spro.		0	6	11.32	20.57	20.27	
		1 p. m.		Bastø.		0	10. 5	15.32	27.78	27.22	
		3 p. m.		Veierland.		0	6	10.03	18.13	17.88	
		4½ —		Humbjerget.		0	7	12.48	22.66	22.30	
		11 —		58°54′ N. 10°10′ E.		0	8	12.81	23.26	22.88	
	5	1 a. m.		58°39′ N. 10°17′ E.		0	8. 5	16.95	30.68	30.02	
		3 —		58°23′ N. 10°26′ E.		0	8. 5	15.53	28.14	27.58	
		5 —		58° 8′ N. 10°34′ E.		0	9	12.75	23.15	27.77	
		7 —		57°52′ N. 10°42′ E.		0	9	12.07	21.93	21.59	
		9 —		57°34′ N. 10°42′ E.		0	9	13.19	23.94	23.53	

Station	November 1897 Date	Hour	Weather	Locality	Soundings	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents Cl per litre	Salt per litre	Salt per mille	Remarks
							⁰ C.				
	8	4 p. m.		Skagen.		0	9	12.98	23.56	23.17	
		6 —		58⁰ 4′ N. 10⁰36′ E.		0	8. 5	12.68	23.02	22 65	
		8 —		58⁰21′ N. 10⁰27′ E.		0	8. 5	18.24	32.99	32.22	
		10 —		58⁰38′ N. 10⁰18′ E.		0	7	15.59	28.25	27.68	
	1898 Febr. 10	9 a. m.		Spro		0	0	15.57	28 21	27.65	
		10½ —		Kjøvangen.		0	2	16.97	30 72	30 05	
		12 noon.		Revlingen		0	4	18.19	32.90	32.13	
		2 p. m.		Vallø		0	2	17.18	31.09	30.42	
		4½ —		Svenø.		0	2	17.18	31 09	30.42	
		11 —		58⁰52′ N. 10⁰10′ E.		0	3. 5	18.09	32.72	31.96	
	11	1 a. m.		58⁰33′ N. 10⁰18′ E.		0	6	19.75	35.71	34.80	
		3 —		58⁰17′ N. 10⁰25′ E.		0	5. 5	19.62	35.47	34.56	
		5 —		58⁰ 0′ N. 10⁰38′ E.		0	6	20.02	36.18	35.25	
		7 —		Skagen light-ship		0	4	19.36	35.00	34 13	
		9 —		Hisholmen lighthouse.		0	4. 5	18.46	33.40	32.60	
1	March 10	9½ a. m		Degerud.		0	1. 0	16.99	30 75	30 08	
2		1 p. m.		Rævlingen.		0	3. 5	17 49	31 66	30.95	
3		3 —		Vrængen.		0	1. 0	15 94	28 88	28.29	
4		5 —		Larviksfiord.		0	1. 5	10 49	19.06	18.81	
5		11 —		Svenør.		0	1. 5	14 89	27.00	26.48	
6	11	1 a. m.		58⁰38′ N.		0	1. 5	15.43	27.96	27.40	
7		3 —		10⁰20′ E. 58⁰19′ N.		0	1. 0	13.30	24.14	23.73	
8		5 —		10⁰29′ E. 58⁰ 0′ N.		0	1. 0	12.79	23.22	22.84	
9		7 —		10⁰40′ E. Skagensbugt.		0	1. 5	14.89	27.00	26.48	

1. Skagerak and Christiania-Fjord December 1896.

Date	11 December 1896												12 December 1896					
Stations	1		2		3		4		5		6		7		8	9		10
Depth in meter	0	0—50	0	0—50	0	0—50	0	0—50	0	0—50	0	0—50	0	0—50	0	0	0—50	0
Temperature	2.6		3.0		3.4		3.4		3.4		7.3		3.3		6.7	4.9		5.2
Salinity (°/₀₀)	27.28		27.26		26.32		23.92		25.92		32.81		22.51		26.67	29.14		32.21
Cilioflagellata.																		
Ceratium tripos*)	r	+	c	c	c	c	+	c	+	c	r	r	c	c	+	r	+	r
— v. macroceros	+	r	r	r	r	r	r	r	r	r	r	r	r	+	+	+	+	r
— v. longipes	r	r	r	r	r	r	r	r	r	+			+	+	r	r	r	
— fusus		r		r		+		r		r				+	+	+	+	+
— furca	r	r	r	r	r	+		+	r	r			r	r			r	r
Peridinium divergens					r		r	r									r	
Dinophysis acuta					r													
Silicoflagellata.																		
Distephanus speculum					r	r							r					
Bacillariaceæ																		
a) Oceanic forms.																		
Coscinodiscus concinnus	r	r	+	r	r	r	r	r	r	+			r		r		r	
— radiatus																	r	
Guinardia flaccida	+	+	+	r	+	+	+	+	r	r		r	r	r	r	r	r	
Rhizosolenia alata	c	+	c	c	c	+	+	+	+	+	r	r	+	r	+		+	
— semispina	+	+	+	+	c	c	+	+	+	+	r	r	+	+	r	r	+	
— calcar avis		r	r	r		r		r		r			r	r	r		r	
— Shrubsolei		r																
Chætoceras atlanticum												r					r	
— boreale	c	+	c	c	c	c	c	c	c	c	+	+	c	c	c	+	c	+
— criophilum		r		r													r	
— danicum							r	r	r									
— decipiens	r		r	r	r	r	r	+	r					r			r	
Thalassiothrix Frauenfeldii	c	c	cc	c	cc	cc	c	c	c	c	r	+	c	c	c	+	c	+
— longissima	c	+	c	+	c	c	c	+	+	+	r	r	c	+	cc	+	+	+
Nitzschia seriata	r	+	+	r	c	+	+	r	+	r		r		+			r	
— delicatissima					+													
b) Neritic forms.																		
Stephanopyxis turris	r	r	r	r	r	r		r							r		r	
Skeletonema costatum	+	c	c	c	c	c	c	c	+	+	r	+	c	c	+	+	+	+
Thalassiosira Nordenskiöldii	r	r	+	r	r	r	r	r	r	r			+	r	r			
— gravida		r																
— gelatinosa	+	+	c	+	+	+	c	+	+	+		r	c	+	r	r	+	r
Coscinodiscus polychordus	+	+	c	+	c	r	+	+	+	+			+	r			r	r
Corethron Hystrix																		
Lauderia annulata	r	r		r	r	r	r		r						r			
Leptocylindrus danicus		+	+	r	+	r	+	r	r				r	r		r	r	
Rhizosolenia setigera	r	+	+	r	+	r	r	r	r	r	r	r	r	+			r	
Chætoceras teres	r	r																
— contortum	r	r	r	r	r	+		r						r			r	
— didymum						r	r	r	r			r						
— laciniosum	r	r	+	r	+	+			r	r				r	r	r	r	
— breve							r											
— constrictum	+	r	r	r	r	r		r	r	r				r	r			
— simile		r		r	r	r		r									r	
— curvisetum	+	r	+	r	+	+	+	r	r	r			r					
— debile		r		r				r									r	
— diadema	r	r	r	r	r	r	r	r	r			r					r	
— scolopendra		r		r				r	r		r						r	
Eucampia Zoodiacus	r	r		r	r	r	r		r		r							
Ditylum Brightwellii	r	r	+		r	r	r	r	r	r	r	r					r	
Biddulphia aurita	r			r	r	r	r			r					r		r	
Cerataulina Bergonii							r		r	r								

Date	12 December 1896	13 December 1896								11 December		14 December 1896							
Stations	11	12		13		14		15		16		17		18		19		20	
Depth in meter	0—50	0	0—50	0	0—50	0	0—50	0	0—50	0	0—50	0	0—50	0	0—50	0	0—50	0	0—50
Temperature	4.5—8.9	2.3		2.7		3.3		2.5		3.8		3.5		2.0		5.5		4.5	
Salinity (°/₀₀)	30.7—33.5	27.56		28.07		27.96		27.74		29.53		29.57		29.58		31.14		30.90	
Cilioflagellata.																			
Ceratium tripos*)	c	+	c	+	c	c	c	+	+		+	+	+	r	+		r		
— v. macroceros	c	r	+	+	+	+	+	+	+	r	+	+	r	+	+		+		
— v. longipes	r		r	r	r	r	+	r				r	r		r				
— fusus	+	r	+	r	+	r	+	r		r		r	r	r	+		r		
— furca	+		c	r	r		+	r			r	r	r	r	r	r	+	r	r
Peridinium divergens			r			r	r	r	r		r			r					
Dinophysis acuta																			
Silicoflagellata.																			
Distephanus speculum																			
Bacillariaceæ																			
a) Oceanic forms.																			
Coscinodiscus concinnus	r		r	r	r	r		r		r	r	r		r	r				
— radiatus																			
Guinardia flaccida	+	+	+	r	r	r	r	+	r	r		r		r	r				
Rhizosolenia alata	+	+	c	+	c	+	+	c	+	c	+	+	r	+	+	r			r
— semispina	+	+	+	r	+	r		r	+	c		r	r		r				
— calcar avis	r		r		r		r	r	r	r		r							
— Shrubsolei	r	r																	
Chætoceras atlanticum												r							
— boreale	c	c	c	c	c	cc	c	c	+	c	+	c	c	c	c	r		r	
— criophilum					r			r		r		r							
— danicum				r															
— decipiens	r	r	r			r	r	r		r		r			r				
Thalassiothrix Frauenfeldii	c	c	c	c	c	c	c	+	+	c	+	c	+	+	c	r	r		
— longissima	cc	+	+	c	c	cc	+	+	+	c	+	+	+	c	c		+		
Nitzschia seriata	r	+	+	r	r	+	+	+	+	r	r	r		r	r				
— delicatissima																			
b) Neritic forms.																			
Stephanopyxis turris			r	r	r		r			r	r	r	r	r	r				
Skeletonema costatum	c	c	c	c	+	+	+	c	+	c	+	+	+	+	+				
Thalassiosira Nordenskiöldii		r	r	r	r	r	r	r				r		r	r				
— gravida			r					r											
— gelatinosa	r	c	c	+	+	+	+	r	r	r	r	r		r	r	r			
Coscinodiscus polychordus	r	r	+	r	+	r	r	+	r	r	r	r		r	r				
Corethron Hystrix			r																
Lauderia annulata	r		r					r	r	r				r	r				
Leptocylindrus danicus	r	+	+	r	+	r		r		r		r							
Rhizosolenia setigera	+		+		r					r					r				
Chætoceras teres			r				r			r			r	r					
— contortum		r	r					r											
— didymum															r				
— laciniosum	r	r		r			r	r	r	+		r		r	r				
— breve			r																
— constrictum	r	r	r				r		r	r		r		r	r				
— simile	r		r	r		r				r									
— curvisetum	r	+	+	r	r	r	r	+	r	c	r	+	r	r	r				
— debile										r									
— diadema	r	r	r	r			r	r		+		+		r	r				
— scolopendra	r	r	r			r	r	r		r		r							
Eucampia Zoodiacus	r	r	r	r	r		r	r		r		r		r	r				
Ditylum Brightwellii	r		r		r		r	r				r			r				
Biddulphia aurita		r		r		r	r	r										r	
Cerataulina Bergonii																			

*) incl. var. bucephala.

2. Sections out off Langesund and Hvaler, Autumn 1897.

Date	28/10		29/10				5/11			6/11		10/11		11/11		18/11		20/11	22/11	25/11						30/11		4/12						30/11			14/12
Stations	L_1		L_2		L_3		L_3			L_1		L_2		L_4		L_2		L_1	L_4	L_1		L_2		L_3		L_3		L_1		L_2		L_3		H_3		H_4	H_1
Depth in Metres	0	0—100	0	0—100	0	0—100	0—5	5—15	40—60	0	0—50	0	0—50	0	0—50	0	0—50	0	0	0	0—50	0	0—50	0	0—50	0	0—50	0	0—50	0	0—50	0	0—50	0	0—50	0	0
Temperature	8.8		7.9		8.8		8—10°	10.5	11.5—11.9	6.96		5.6		7.7		7.85		9.4	8.9	7 0		6.6		6.7		6.7		4.8		6.0		6.1		7.0		6.9	6.7
Salinity					22.55		23.5 – 25	25—28	33.6—34.6	16.37		21.24		24.06		24.52		24.42	28.96	28.05		30.59		31.07		31.78		29.07		31.91		31 91		30.64		31.24	
Cilioflagellata.																																					
Ceratium tripos	c	c	c	cc	c	+	c	+	+	cc	c	+	+	c	+	cc	c	c	c	cc	c	cc	c	cc	cc	cc	c	cc	cc	cc	c	c	cc	cc	cc	cc	cc
— — v. macroceros	+	+	+	+		c		+	+		c		r	r	+		c	c	+		r	r	+	r		r	r	r	+	+	+	+	+		+	+	
— — v. longipes				r		+		+	+			+		r		r	+		+		r		+			r		r	r						r		r
— — v. bucephala						+		+	+				r		r		+		+		r		+	r		r	r	r			r				r		r
— fusus	+	c	+	c	c	c	c	c	+	c	+	+	+	+	+	+	c	r	+	+	c	c	c	c	cc	c	c	cc	cc	+	c	c	cc	+	c	c	c
— furca		c	+	c	c		c	c	+	c	c	+	+	r	+	+	c	+	c	+	c	c	c	c	c	c	c	cc	cc	cc	c	c	c	c	c	cc	c
— — v. baltica					r											+												r			r			r			
Peridinium divergens		c	+	c			c	+	+			+		+	+		c	r	+	+	c	+	c	+	+	+	c	+	+	+	c	c	+	+	+	c	
Dinophysis acuta				r			c		r			r		+	+		+				r	r		r			+	r			r	r	r	+		c	
Diplopsalis lenticula																																r					
Silicoflagellata																																					
Dictyocha fibula			r				r				r																				r		r	r			
Distephanus speculum					r	r	+	r		r		r	+	r	+		r																	r			
Bacillariaceæ																																					
a) Oceanic forms																																					
Coscinodiscus concinnus																	r					r	r			r	r				r			r	r	r	r
— oculus iridis								r									r																				r
— radiatus																r	r										r			r		r		r			
— stellatus																	r					r	r								r	r	r	r			r
Guinardia flaccida								+	r	r	r	r	r	r	r		r		r		r		+		r	r			r		r	r	r	r		r	
Rhizosolenia alata						+	+	cc	+	+	c	c	+	+	+	cc	c	+	c	r	+	r	c	r	+	+	r	r	r	r				+		r	
— semispina							+	r	r	r	+	r			r	r	c		r	r	r			r	+	r	+		r		r	r	r	r	r	+	
— styliformis		r							+																r			r	r	r			r	r		r	r
— calcar avis								r									r						+						r		r						
— Shrubsolei							+	+			+	r	r	r	r	r	r										r				r						
— cylindrus			r																																		
— Stolterfothii																					r		+						r								
— robusta						r			+												r																
Chætoceras boreale		r					+	+	+		+	r	+	+	+	r	+		+		+	+	+	r	+	r	r		r		r	r	r	r	r	+	
— danicum		+	cc	c	c	c		r		+	+	cc	cc	cc	c	r	r		r						r											r	
— decipiens			r				r		r		r	r		r			r									r	r		r					r			
Thalassiothrix Frauenfeldii		+	+	+	+			+				+	+	+	+	r	r	r	+		r	r		r		+	r	r						r	r	+	+
— longissima							r	r			r					+	c		+	r	r	r	+	r		+			r	r	r	r	r	r	r		+
Nitzschia seriata														r																							
b) Neritic forms																																					
Stephanopyxis turris															r		r											r			r				r	r	
Skeletonema costatum				r		r	r							r			r		r		r	r	+		r	r	r	r	r					+	r	+	+
Thalassiosira Nordenskiøldii																r																					
— gelatinosa															r				r										r				r	+		r	
Lauderia annulata													r							r					r				r					r			
Leptocylindrus danicus							r	+						r				r			r		r				r		r								r
Rhizosolenia setigera							+	r		+	r		r	r	+	r	+			r	r		+	r	+	r	r		+			r	+	r	r	r	r
Chætoceras contortum		+	cc	c	c	c	cc	c	r	+	cc	cc	cc	cc	c	r	r		+	r	+	r	+	r	+	r	r	r							r	r	r
— didymum		+		r	r	r	cc	c	+	+	cc	r	c	r	+	+	+				r	r	+		+	r											
— laciniosum								r				r				r	r			r	r		r		r	r					r					r	r
— breve										r																											
— constrictum							r	r			r	r		r		r						r	r	r		r		r						r		r	r
— curvisetum		+	+	+	+	r	cc	c	+	+	cc	c	c	+	c	+	+		+	r	+	+		r	+	+	r	r	r		r	r	r	+		+	r
— debile		+		r				+			r		r								r			r								r					
— coronatum			r	r																		r															
— seiracanthum		r	r	r							r	r													r												
— Schüttii		r	+		r	r	r				+		+	r	+		r								r												
— scolopendra							r	r			r					r	r			r		r					r						r				
— radians			c	r		+					+	r																									
Eucampia Zoodiacus								r			r				+		r																				
Ditylum Brightwellii			r				+	+	r	r	r	+	r	+	+	r	+	r	+		+	+	+	r	+	r	r		+			r	r	+	r	+	+
Biddulphia aurita																																					r
— mobiliensis									r	r				r			+		r		r										r	r	r		r	r	
Cerataulina Bergonii						r																							r								
Chlorophyceæ																																					
Halosphæra viridis	r		r		r																	r	r		r												+

3. Christiania-Fjord. March 1897.

Date: March.	20									21	
Station.	21		22		23	24				25	
Depth in m.	0	0—40	0	0—40	0—40	0	0—40	0—100	0—200	0	0—40
Temperature.	0.5	(2.85)	0.8	(2 4)	(2.02)	0.8		(6.2)	(6.6)	1.95	(5.7)
Salinity ‰.	25.06	(33.20)	25.06	(32.73)	(32.69)	29.66		(34.68)	(35.04)	32.03	(33.62)
Cilioflagellata.											
Ceratium tripos v. longipes.	r	+	r	+		+	+	+	+		r
Peridinium divergens . . .		r									
Bacillariaceæ.											
a) Oceanic forms.											
Coscinodiscus concinnus .		+		+				+		+	+
— oculus iridis	c	cc	cc	c	c	c	cc	cc	cc	cc	cc
Rhizolenia alata	r	+		+	r	+	+	+	+	r	+
Chætoceras boreale	r	+	r	c	+	+	+	+	c		r
— criophilum					r	r			r	r	
— decipiens				r			r	+	+	r	r
Thalassiothrix Frauenfeldii.				r	+	+	r	+	+		r
— longissima					r						
Nitzschia seriata		r			r		+	+	+		+
b) Neritic forms.											
Thalassiosira											
Nordenskiøldii	+	c	r	cc	cc	cc	cc	cc	cc	cc	cc
— gravida				r	r		r	r	r	+	r
— gelatinosa									r		
Coscinodiscus polychordus.										r	r
Leptocylindrus *danicus* . .		r			r						
Rhizosolenia setigera . . .				r		r	r	r	r		
Chætoceras teres		r		r	r	+	r		+		r
— breve		r		r			r	r	+		
— constrictum				r	r	r	r		r		
— curvisetum					r						
— debile				r	r	r	r	r	r	r	r
— diadema				r		+		r	r		
— sociale		r				+	+		+		
— scolopendra									r		
Biddulphia aurita			r	r	+	+	+	+	c	c	c

4. Drøbak, Samples from the surface water 1896—97.

Year	1896														
Date	14/2	26/3	9/8	4/9	10/10	30/10	4/11	10/11	16/11	24/11	1/12	10/12	18/12	23/12	28/12
Temperature					9.0		6.5	6.0	5.5	5.5	6.0		6.5	4.5	3.5
Cilioflagellata.															
Ceratium tripos*)	c	+	r	c	r	+	r	r							+
— — v. macroceros					r	+		+		r					
— — v. longipes															
— fusus	r	r		c	+	+	+		r	r			r	r	
— furca	r	+	r	cc	c		r		r	r	r	r	r		r
Peridinium divergens	+	r		c											r
Dinophysis acuta															
Diplopsalis lenticula		r													
Prorocentrum micans				+		r	r								
Silicoflagellata.															
Distephanus speculum				+											
Chlorophyceæ.															
Halosphæra viridis	+	+													
Bacillariaceæ															
a Oceanic forms.															
Coscinodiscus concinnus	c	+													
— oculus iridis	c	r													r
Guinardia flaccida		r			r										
Rhizosolenia alata	r		r	r	r	c	r	+	+	r	r				
— semispina	r					r									
— calcar avis				r											
— cylindrus															
Chætoceras atlanticum		r													
— boreale	+	+				+		+			r				+
— eriophilum		r				r									
— danicum															
— decipiens	c	+													r
Thalassiothrix Frauenfeldii	c					+	r	+	+	+	+				+
— longissima	c	+								r	r				+
Nitzschia seriata		+								r	r				
b) Neritic forms.															
Skeletonema costatum						r		r	+	+	+	r			
Thalassiosira Nordenskioldii	c	c													
— gravida	+	c													
— gelatinosa	+	+								+	+				r
Coscinodiscus polychordus	+	+													
Leptocylindrus danicus		cc				r									
Rhizosolenia setigera	r	r				r	r		r	r					
Chætoceras teres		+	r												
— Weissflogii				r											
— contortum		+	r	+											
— didymum	r					r									
— laciniosum	r	+													
— breve															
— constrictum	c	cc				r									
— curvisetum	r	c	c	r	r										
— debile	r	+													
— diadema		+													
— Schüttii			+	c											
— coronatum			r												
— seiracanthum				+											
— crinitum		r													
— scolopendra		+				r									
— simile		r													
— sociale	+	cc													
— radians				+											
— anastomosans			r												
Ditylum Brightwellii		r				r									
Cerataulina Bergonii	r	+								r					
Biddulphia aurita	+	c													
— mobiliensis															

Year	1897																												
Date	6/1	11/1	19/1	26/1	1/2	11/2	22/2	2/3	9/3	17/3	24/3	31/3	8/4	13/4	23/4	28/4	1/5	3/5	7/5	11/5	22/5	26/5	31/5	3/6	10/7	8/9	23/9	28/9	16/10
Temperature	1.5	1 5	1.0	1 0	÷0.5	2.0			2.0	2.0	0				4.5	6.0	7.3	7.0	7.3				14.5	18.0					
Cilioflagellata.																													
Ceratium tripos*)	+	r	+	r		r			r							r			r	+		+	r		+	c	+	+	+
— — v. macroceros																										r			
— — v. longipes	r			r	+	r	r	r	r	r	r	+	r	r	+	r	r	r	r	r	r		r						
— fusus			r										r			r		r	r	+	r	+	r		cc	cc	+	+	+
— furca																		r	r				r		+	c	+	r	+
Peridinium divergens			r									r			r			r							r	+	+	+	+
Dinophysis acuta																										r			+
Diplopsalis lenticula																													
Prorocentrum micans																										r	r		
Silicoflagellata.																													
Distephanus speculum																													
Chlorophyceæ.																													
Halosphæra viridis																													
Bacillariaceæ																													
a Oceanic forms.																													
Coscinodiscus concinnus																													
— oculus iridis	r		r	r		r	c	cc	cc	c	cc	cc	cc	cc	c	r	r												
Guinardia flaccida	r																												
Rhizosolenia alata	r								r	+	+	r	+		+	+	+	+	+	r	+		+		c	r		+	r
— semispina																													
— calcar avis																													
— cylindrus																													r
Chætoceras atlanticum									r												r			+					
— boreale	+		r				r	r	+	r	c	c	c	c	cc	cc	cc	cc	cc	c	c	c	c	c					
— eriophilum																r													
— danicum																											r	+	+
— decipiens							r	r		r		r	r	r	c	c	c	c		+	+	+	+	+					+
Thalassiothrix Frauenfeldii	c	r	+	r	r	r	r			r	+		+	+	+	+	+	+	+	+	+	c		r					r
— longissima	c	+	+	+	r	r	r		r	r	r									r									
Nitzschia seriata	r		r						r	+	c		+	+		+													
b) Neritic forms.																													
Skeletonema costatum																													
Thalassiosira Nordenskioldii							r	+	c	c	cc	+	c	c											r				
— gravida								r	+	+	+	r	+	r		r	r												
— gelatinosa	r		r	r	r																								
Coscinodiscus polychordus									r		r		r			r													
Leptocylindrus danicus															r	r	+	+	+	+	c	c	c						
Rhizosolenia setigera	r			r							r				r	r	r			r									
Chætoceras teres											r						r												
— Weissflogii																											r	r	
— contortum																											+	r	cc
— didymum	r																										+	r	r
— laciniosum																													r
— breve											r					r	r	+	r										
— constrictum	r												+		c	c	cc	c	c	+	c	c	c	c				r	
— curvisetum	r																	r					r	r	c	+	cc	cc	c
— debile										r	r			r	+	c	+	+	+		+	r	+	+					
— diadema	r										+	r			+			+	+	r									
— Schüttii																										c	cc	c	+
— coronatum																													r
— seiracanthum																											+	+	r
— crinitum																													
— scolopendra											r				+		+		r		r								
— simile																													
— sociale																	+												
— radians																											+	c	
— anastomosans																										r			r
Ditylum Brightwellii																													
Cerataulina Bergonii	r																								+				
Biddulphia aurita						r		r	r	c	c	+	+	r															
— mobiliensis																													r

*) incl. var. bucephala

5. Hvaler, Winter and spring 1898. (Capt. Schrader).

1898	24/1	1/2	9/2	19/2	23/2	3/3	9/3	16/3	23/3	31/3	9/4	13/4	20/4	27/4	7/5	15/5
Temperature.	1.2	3.0	2.0	2.0	3.5	2.5	1.5	1.6	2.0	6.0	5.0	4.0	6.0	5.0	9.0	10.0
Salinity 0/00)		25.74	29.46	29.60	31.33	27.40	29.01	23.10	25.10	33.65	23.80	23.92	25.90	25.22		
Cilioflagellata.																
Ceratium tripos	+	c	c	+	+	+	+		r		r	r	+	+	c	c
— — v. macroceros	r	r	r	r	+											+
— — v. longipes	r		r			r	+		r		r	r	r	r	+	c
— — v. bucephala	r	r		r												
— fusus	+	c	+	+	+	r	+				r		r			+
— furca	c	c	c	c	c	+	+	r	r	r	r	+	+	+		+
Peridinium divergens	+	+	+			r	+		r	r	r	r	+	+	+	+
Dinophysis acuta		r														
Bacillariaceæ																
a) Oceanic forms.																
Coscinodiscus concinnus	r			r	r					r	r	r				
— oculus iridis		r	r			+	r		r				r	r	r	r
— radiatus		r	r	+			r			r				r		
— stellatus		r	r	+	r	+	+		r				r			
Guinardia flaccida	r		r				r		r				r			
Rhizosolenia alata							+			r			r	+	+	+
— semispina													r		r	
— styliformis			r													
Chætoceras atlanticum																+
— boreale	r			r	+	r	r			+	+	+	r	c	c	+
— criophilum				r											r	
— danicum													r			r
— decipiens				r	+	c	c	c	+	c	+	+		+	r	+
Thalassiothrix Frauenfeldii	r	+		c	c	cc	cc	cc	cc	cc	cc	c	c	c	c	c
— longissima	+	r		c	+	+					r					
Nitzschia seriata						+	+	r	+	+	+	+	+	+	+	
b) Neritic forms.																
Thalassiosira Nordenskiøldii				c	cc	c	+	+	+	+	+	r	r	r	r	
— gravida					+					r				r		
— gelatinosa	r			+	+	+	+	+	r							
Coscinodiscus polychordus				r	r	r	+	+	r		+	+	r	+	r	
Actinocyclus Ralfsii				+												
Actinoptychus undulatus				+			r			r			r			
Rhizosolenia setigera										r			r	r		r
Leptocylindrus danicus						r	r		+				cc	cc	cc	
Ditylum Brightwellii	r		r		r	r							r	r		
Chætoceras teres				r	+			r		+				r		
— contortum					+	+	+			+	r	+	r	+	+	
— didymum				+	+	+	+		+	+			r	+		+
— laciniosum										r	r					
— breve													r	r	+	+
— constrictum				+	c	c	c	c	c	c	c	c	+	c	c	+
— curvisetum				r	+		r			+		+	r	c		
— debile				+	+	r	+		r	+	+			+	+	
— diadema										+						
— scolopendra					+											
— crinitum							r									
— sociale				+	+	c										
Eucampia Zoodiacus							r							r		
Biddulphia aurita			r	+		+	+			r	r					
— mobiliensis				r	r					r			r			
Cerataulina Bergonii									r				r			r
Chlorophyceæ.																
Halosphæra viridis	r															

6. Drøbak, Winter 1898, quantitative net.

1898	10/2		16/2		23/2		2/3	
Depth in meter	0—25	30—60	0—25	30—60	0—25	30—60	0—25	30—60
Temperature.	0.5—7.0	7.3—7.8	3.5—4.2	4.5 6.8	1.8 6.9	6.9 7.0	2.4 3.9	3.9 5.5
Salinity ⁰/₀₀	27.9 33.3	33.5 34.2	30.9 31 5	31.7 33.4	29.3 33.9	34.0 34.5	29.25 39.2	30.6 34.5
Weigth in gram.	0.26	0.09	0.10	0.16	0.08	0.03	3.49	1.08
Cilioflagellata.								
Ceratium tripos		r	r	r		r	+	+
— — v. longipes	r	r	r	r	r	r	+	+
— fusus					r			
Peridinium divergens	r						+	
Dinophysis acuta							r	
Flagellata.								
Phæocystis Poucheti							+	
Bacillariaceæ								
a) Oceanic forms.								
Coscinodiscus concinnus			r	r	r	r	r	+
— oculus iridis	r							
Guinardia flaccida								r
Rhizosolenia alata							r	+
— semispina							+	
Chætoceras boreale					r			
— criophilum							r	
— decipiens							+	
Thalassiothrix Frauenfeldii			r				cc	cc
Nitzshia seriata							+	+
b) Neritic forms.								
Thalassiosira Nordenskiøldii							c	c
— gravida							r	
— gelatinosa							+	+
Coscinodiscus polychordus							r	
Lauderia annulata							r	
Leptocylindrus danicus								+
Chætoceras teres							+	+
— contortum							c	c
— didymum							+	+
— constrictum							c	c
— curvisetum							+	+
— debile							+	+
— scolopendra							+	+
— sociale							c	cc
Ditylum Brightwellii							r	
Biddulphia aurita			r		r	r	+	+
Chlorophyceæ.								
Halosphæra viridis			r	r	r		+	

7. Quantitative investigations on the Plankton, Christianiafjord, Summer and Autumn 1897.

Locality.	Aasgaardstrand.					Drøbak.				Vrængen.	Drøbak.			Raue.		
Date.	30 August 1897.					8 September 97.				19/9 97.	23 September 97.			16 Oktober 97.		
Depth from which the sample obtained.	0–40	20—50	50–100	85—120	100—150	0—20	40–60	80—100	120–140	0—20	0–10	30—50	80—100	0—10	30—70	80—120
Temperature of the water.						16.6 14.0	11.2 9.5	8.8 7.2	6.3 6.0	14.5	13.0 14.7	11.1 8 7	5 7 5.65	9.2 12.4	14 3 12 2	8.5 7.0
Salinity of the water ‰.						16 0 29 0	31.5 32 3	33.0 34.2	34.6 34.8	26.13	20.3 28.7	32.4 33.0	34.0 34 5	14.2 27.7	32.4 34.0	34.1 34.9
Weight in gram.	1.97	0.43	0.34	0.21	0.34	1.78	0.18	0.03	0.05	4.21	3.92	0.13	0.19	0 75	0.95	0.30
Cilioflagellata.																
Ceratium tripos	c	+		+	r	c	+	r	r	+	+	+	+	c	r	+
— — v. macroceros						r								c	+	
— — v longipes		r	r	+			r									+
— — v. bucephala		c		+		r										+
— fusus	cc	c	+	+	+	cc	c	+	+	+	cc	c	c	c	+	+
— furca	r		r	r	r	c	+	r	r	+	+	+	+	r	+	+
Peridinium divergens	c	c		c	r	+	+	+	+	r	+	r	+			
Dinophysis acuta		r				r	r			+	+	+				
Prorocentrum micans						r					+					
Bacillariaceæ.																
a) Oceanic forms.																
Coscinodiscus oculus iridis							r									
— radiatus		r		r			r									
Rhizosolenia alata	r									r				+	r	r
Chætoceras boreale										r					r	
— danicum										r						
— decipiens													r		r	
Thalassiothrix Frauenfeldii										+				+		
b) Neritic forms.																
Skeletonema costatum										+						
Thalassiosira gelatinosa	r															
Leptocylindrus danicus										r				r		
Chætoceras Weissflogii	+									r						
— contortum	+									c	c			cc	c	c
— didymum	+									c	+			r	r	
— laciniosum																r
— curvisetum	c					+				cc	c	r	+	+	r	+
— Schüttii	c	r				c				cc	+	r	r	+	+	r
— coronatum										r						
— seiracanthum	r									+	+			+	+	r
— anastomosans	r					r				r				+		
— radians										+	c		r	+		
Eucampia Zoodiacus														+		
Biddulphia mobiliensis										r						
Ditylum Brightwellii										+				+		r
Asterionella glacialis										r				r		
Silicoflagellata.																
Dictyocha fibula	r															
Distephanus speculum										r						